EVALUATION OF DECOUPLING OF GDP, ENERGY, AND CO_2 EMISSIONS IN CENTRAL ASIA

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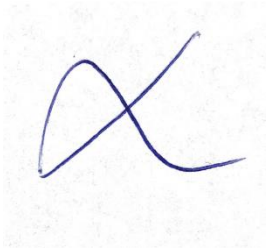
DECLARATION

I hereby, declare that this manuscript, entitled "*Evaluation of decoupling of GDP, energy, and CO_2 emissions in Central Asia"*, is the result of my own work except for quotations and citations which have been duly acknowledged.

I also declare that, to the best of my knowledge and belief, it has not been previously or concurrently submitted, in whole or in part, for any other degree or diploma at Nazarbayev University or any other national or international institution.



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Abstract

Economic growth generally causes enhanced energy consumption, which in turn will lead to a rise in carbon dioxide emissions. The concept used to destroy the relationship between energy consumption and economic growth which is called decoupling have attracted the attention of scholars. This paper investigates the decoupling relationship between energy consumption and economic growth in each of five Central Asian countries from 1990 to 2014. We analyzed our data in the framework of two decoupling models: the Tapio model and the OECD decoupling model. In general, most Central Asian countries' total energy consumption and GDP initially dropped and followingly raised over the period of 1993-2010. Change of the republican system of government to the independent country after the collapse of the USSR and difficulties that appeared during the transition of the planned economy to a market economy in the economic sector were two main driving above mentioned phenomenon. We established the popular four decoupling statues: **expansive negative decoupling**, **weak decoupling**, **strong decoupling**, and **expansive coupling**. Based on data consolidation calculation it is clearly shown that there exists a significant environmental pressure on economic growth in Central Asia. However, in order to get full information, we have to investigate decoupling analysis per country separately.

Keywords: decoupling, environmental pressure, economic growth, decoupling statues, Central Asia, energy consumption, GDP

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List of Abbreviations & Symbols

OECD	Organisation for Economic Co-operation and Development
TPES	Total primary energy supply
Mtoe	mega tonnes of oil equivalent
ΔG	the changes in GDP growth
GDP	Gross domestic product
μ	the decoupling elasticity indicator
RD	recessive decoupling
WND	weak negative decoupling
WD	weak decoupling
SD	strong decoupling
END	expensive negative decoupling
RC	recessive coupling
EC,	expansive coupling
ND	non-decoupling
RD	relative decoupling
AD	absolute decoupling

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Chapter 1 – Introduction

1.1 Justification of the study

The primary goal and essentials for civilization is economic growth [1]. However, economic activities have come along with hazards to the environment [2]. For example, land and water resources are the main requirements for activities such as raw materials extraction and processing, transformation in consumer goods, distribution, use of goods and services, and discarding and even more these activities lead to waste production and greenhouse gas emissions [3].

A series of natural resources build the fundamentals of the global economy. It includes unrenewable like fossil fuels, which are a significant input in energy production manner [4]. Nonetheless, natural deposits have in dual manner effects on economic development because the intensity of their use increases output and rises its depletion time simultaneously. Moreover, a high level of material throughput causes issues in environments such as global warming, loss of biodiversity, species extinction and scarcity of water .

The development of the global economy has gone in hand with the stable rise in global material use and even more, it reaches a level that causes threats to the functioning of the earth ecosystem in a sustainable manner [4]. Nowadays people continue to determine economic growth as a key component of development. A discussion about the above-mentioned issue has attracted the attention of politicians and it also is included the Sustainable Development Goals which says the need for harmonization between environmental aims and economic goals [5].

A lessen use of natural resources for in-progress economic practices represents the most noticeable idea to the success in both environmental goals and economic aims. In more details, to breaking the link between “environmental bads” and “economic good”. Here, "decoupling" process means the rise of the economy without damage to the environment and even more development of humankind in the framework of earth restrictions [6].

1.2 Description of the case study region

Central Asia includes five countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan (see Figure 1). Countries are disparate and diversity between countries in the region is both considerable and constant over a time period. A large population and half of the total energy consumption and total CO_2 emissions among Central Asia countries belong to Uzbekistan and Kazakhstan. Kyrgyzstan, Tajikistan and Turkmenistan have a low population, energy intensity and carbon emissions (see Table 1) [7].

Also essential difference can be noted in income, especially more than ten times smaller per capita GDP of Tajikistan (436 USD) compared to per capita GDP of Kazakhstan (4734 USD). A World Bank classified that Kazakhstan and Turkmenistan are upper-middle-income economies, Uzbekistan as lower-middle-income economies, and Kyrgyzstan and Tajikistan as low-income economies [8]. The diversity can be also shown in countries' economic structure level, for example, primary sectors account starting 12% up to 26% in three countries of Central Asia such as Kyrgyzstan, Tajikistan, and Uzbekistan, while Kazakhstan possesses a large share of industry, approximately 45%.

Figure 1: A map of Central Asia

These structural differences are also reflected in significant disparities in terms of energy consumption and CO_2 emissions. Similarly also carbon intensity across the region varied by a factor of 5 ranging from 0.86 tons of CO_2 per unit of GDP in Tajikistan to 4.66 in Uzbekistan

(global average in 2010 was 0.59). The considerable carbon intensity is the result of the significance of coal in many post-soviet republics, as well as the existence of energy-intensive industries. These disparities among countries have only increased over the last 20 years [9].

Global equity has two important indicators as per capita energy consumption and per capita carbon emissions; however, the difference in above mentioned two indicators among Central Asia countries are even higher in comparison to the energy and carbon intensity. Two countries with exceptionally high per capita TPES (above 4 TOE/cap) are Turkmenistan and Kazakhstan. These countries also have the highest per capita CO_2 emissions exceeding 10 t CO_2, while for most of the countries per capita CO_2 emissions are below the global average of 4.4 t CO_2 (lowest being 0.4 t CO_2 per capita in Tajikistan, the poorest country in the region) [8].

Carbon intensity of energy varies much less than other intensities and ranges between 1.18 tons of CO_2 per TOE in Tajikistan and 3.09 tons for Kazakhstan. Kazakhstan and Kyrgyzstan is heavily dependent on coal as its primary energy source and natural gas is widely used in the region as well .

Table 1: Characteristics of the Central Asia, 2010 [7]

Countries	Population (millions	TPES (MTOE)	GDP per capita (constant 2005 US$)	CO_2 (million tons) Sectoral approach	Per capita CO_2	TPES per capita	Energy intensity	Carbon intensity	Carbon intensity of energy	Changes in CO_2 emissions
Kazakhstan	16.32	75.01	4734	232.12	14.23	4.60	0.97	3.00	3.09	-2%
Uzbekistan	28.16	43.79	763	100.22	3.56	1.55	2.04	4.66	2.29	-16%
Kyrgyzstan	5.37	2.92	565	6.98	1.30	0.54	0.96	2.31	2.39	-69%
Tajikistan	6.88	2.31	463	2.73	0.40	0.34	0.72	0.86	1.18	-75%
Turkmenistan	5.04	21.31	2660	52.68	10.45	4.23	1.59	3.93	2.47	15%
Total	61.77	145.34	2296.25[a]	394.73	5.988[b]	2.252[b]	1.256[b]	2.952[b]	2.855[b]	-29
World	0.89%	1.14	7464	1.3%	4.44[b]	1.87[b]	0.25[b]	0.59[b]	2.37[b]	45%

b- Average.

1.3 Thesis organization and objectives

Harmonizing of economic and environmental goals can be done either by reducing energy demand or by using energy more efficiently, or by combining both, but this does not affect growth and economic stability. This can be achieved through the decoupling of energy from the economic development of countries. Here, the word "decoupling" means the destruction of negative factors on the environment and the initiation of growth of positive factors for the development of the economy [10]. In addition, decoupling of energy consumption from economic growth will determine the future of climate policy and energy security of desired study region, so it is important to gain in-depth understanding of relationship between energy and economic sectors.

While there has been much on energy consumption or economic development of Central Asia in general, none of these has focused specifically on how growth rate of the environmental pressure is related to the growth rate of the economic driving force. The aim of this work is to investigate the energy dependence, energy security and economic development in Central Asia which includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan from 1990 to 2014. This paper reviews recent advancements that applied decoupling theory to analyze the relationship between energy consumption and economic growth to demonstrate the connection between energy consumption and carbon dioxide emissions and economic growth in five different Central Asia countries.

Chapter 2 - Literature review

2.1 Introduction

Advancing human wellbeing can be achieved by economic growth [11]. Economic growth has environmental impacts such as the use of unrenewable resources, turning of raw materials into products, pollution, waste production and greenhouse emissions [12]. The most potential strategy to succeed in both economic and environmental plans is to achieving high economic output without damaging the environment [13]. Particularly, to cut the relationship between “environmental bad” and “economic good” [14]. This decoupling concept represent a prosperity of the economic sector without including environmental hazards and even more development of humanity, taking into account the fact that the planet has limits [15].

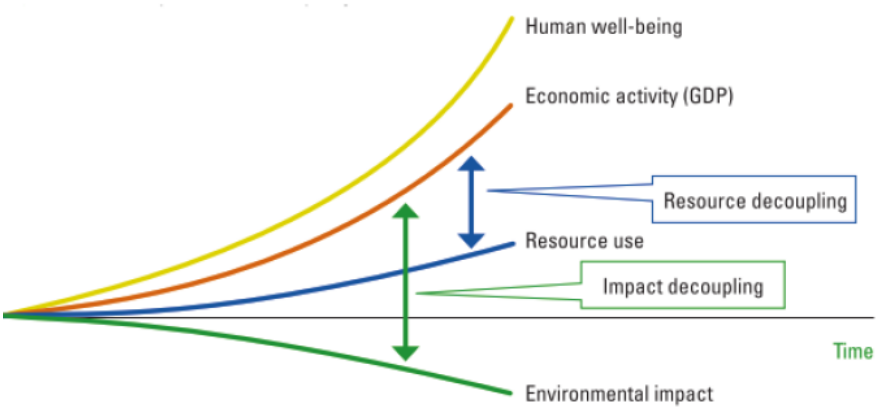

Figure 2: The decoupling concept [14]

There exist two types of methods resource decoupling and environmental decoupling. Resource decoupling is about the cutting the relationship between resource use and economic growth, while environmental decoupling is breaking the link between environmental pressure and economic growth (see Figure 2). Evaluation of decoupling trends can be differentiated into two types: economic growth has a higher rate than the growth rate of environmental pressure (relative decoupling) and rise of the economy while reducing environmental pressure simultaneously (absolute decoupling). Despite the fact, both decoupling types result in success in environmental goals, however only the last one can be considered a way to lead to mitigating environmental pressure. Nowadays standard measure techniques are not developed yet, a range of indicators and databased are applied for monitoring trends in decoupling [16].

The literature review part investigates and observes the latest research on decoupling analysis of environmental pressure and economic growth for Central Asian countries such as Kazakhstan, Kyrgyzstan, Turkmenistan, Tajikistan, and Uzbekistan.

2.2 Recent research works

Decoupling of carbon emissions, energy consumption from economic development is a less investigated topic in Central Asia. There exist only two academic papers dedicated to this topic (see Table 2). The first paper conducted relationship analysis, decoupling relationship analysis, and trend analysis to study the link between energy consumption and the economic growth in Kazakhstan for the time period between 1993 and 2010 [16]. The second paper studied identifying factors of carbon emissions by applying the Logarithmic mean Divisia Index (LMDI) decomposition method for the time period of 1992 and 2004 [17]. Moreover, results obtained from the LMDI method used to analyze the decoupling of carbon dioxide emissions from economic developments. Despite the fact that only two academic works done on decoupling theory, these two papers provide valuable information for further investigations such as evaluating current trend in decoupling of energy sector or gaseous emissions from the economic sector or what exact decoupling method is applicable to possible data that exist for Central Asian countries.

Table 2: Recent research works on decoupling analysis between environmental pressure and economic growth in Central Asia [16], [17]

Authors/ Year of Publication	Research Question	Materials/ Methods	Key Finding	Notes
Xiong et al.,/ 2015	1. Is there exist a connection between energy consumption and CO_2 emissions, economic growth, and energy export in Kazakhstan? 2. Does Kazakhstan achieve energy consumption goal by 2020?	Data on energy sector was acquired from the Statistical Yearbook of Kazakhstan and data on GDP for Kazakhstan were obtained from World Bank. Methods: 1. The Decoupling method 2. The elastic analysis method	(1) The relationship between energy consumption and GDP in Kazakhstan demonstrated a "U" – type curve for the time period between 1993 and 2010. Transformation of Kazakhstan from republic to independent country and change of the economy from planned to a market were two main reasons for above observations. Followingly, the economic system obtained stability and there was rapid increase in industrial production as a result of effective policy directed to financial, monetary and industrial sectors for the period between 2000 and 2010. (2) The link between energy consumption and carbon dioxide emissions, growth of the economy and energy exports were connected. Energy consumption has mainly resulted carbon dioxide emissions. There observed gradual increase on reliance of economy sector on energy exports for the period between 1993 and 2010. Before 2000, the relation between growth of the economy and energy consumption corresponded to the recessional decoupling state as a result of recession in a economy. After 2000, this connection shifted to strong and weak decoupling conditions as a result of rise in price of the crude oil on international arena and great increase in export field of the energy each year.	The establishment of related policies in the energy field in the rest of Central Asia can implementation of above-mentioned strategy into reality, however, there lack such investigation of other members of Central Asia. The main gap identified in this paper is the time period. Paper took into account change in GDP and energy consumption only up to 2010. Next, further investigations can be done on what kind of changes occurred next 10 years up to nowadays. The current paper investigates only Kazakhstan. Furthermore, the analysis of this paper can be extended to other countries in Central Asia.
Jiaxiu et al.,/ 2019	1. What are the main influence factors of energy related CO2 emissions in Central Asia? 2. What is relationship that exists between CO_2 emissions and economic growth in Central Asia?	All data of CO_2 emissions, energy use and GDP for every country of Central Asia were got from the World Bank, while energy consumption data were obtained from Carbon Dioxide Information Analysis Center. Methods: 1. Decoupling Elasticity 2. LMDI decomposition method 3. Decoupling index method	1. Both crisis in financial plan as a results of collapse of the Soviet Union cause decrease in total carbon dioxide emissions from 1992 to 1998. Then, reforms in economic market gave a start to slow increase in total carbon dioxide emissions in parallel with growth on economic sector. 2. They identified four main factors of carbon dioxide emissions: economic activity effect, population effect, energy intensity effect and energy carbon structure effect. It was investigated that carbon dioxide emissions cause by energy-related class rosed in 5 different countries of Central Asia. In more detail, population effect and economic activity effect were identified as main drivers of gaseous emissions. In contrast, energy carbon structure effect and energy intensity effect were recognized as main two inhibiting factors of gaseous emissions. It was calculated that 11.80%, 39.08%, –44.82% and –4.32% were percentages f contribution to above mentioned four factors respectively economic activity effect, population effect, energy intensity effect and energy carbon structure effect. 3. Due to economic developments of Kazakhstan, Uzbekistan and Turkmenistan are heavily dependent on high-carbon energies these countries were recognized as main contributors to total carbon dioxide emissions (189.69×106, 45.55×106 and 115.38×106 t, respectively) 4. Finally, the decoupling indices clarified the relationship between CO_2 emissions and economic growth, highlighting the occurrence of a "weak decoupling" between these two variables in Central Asia.	The main gap of this paper is also the timeline studied. It covered only from 1992 to 2004. Applied methods to study the decoupling of carbon emissions from economic development are limited. Further investigations can be directed into applying other decoupling methods.

2.3 Decoupling analysis model applied in recent research papers

2.3.1 The decoupling index method

The following table characterizes delinking index between energy consumption and economic growth.

Table 3: The decoupling index method [18]

Formulae:	Notations	Meaning:
$\mathrm{DIn} = \frac{\mathrm{EIn}}{\mathrm{GIn}}\ (Eq\ 1)$	DIn	decoupling index between energy consumption and economic growth at time *n*
$\mathrm{EIn} = \frac{\mathrm{En}}{\mathrm{Eo}}\ (Eq\ 2)$	EIn	energy consumption index at time *n*
$\mathrm{GIn} = \frac{\mathrm{GDPn}}{\mathrm{GDPo}}\ (Eq\ 3)$	GIn	growth index at time *n*
	Eo and En	the total energy consumption at the base time and the total energy consumption at time n respectively
	GDPo and GDPn	GDP at the base time and the GDP at time *n* respectively

When Decoupling Index (DI) is higher or equal to the 1, it states that there exists synchronicity between growth rate of the energy consumption and growth rate of the economy or growth rate of the energy consumption is higher than the growth rate of economy. In more detail, it shows that there is no appearance of decoupling and it is noted as the absolute hook. The case in which DI is between zero and one corresponds to the relative decoupling or growth rate of the economy is higher than growth rate of the energy consumption [19].

2.3.2 The elastic analysis method

The elastic analysis methodology is mostly used to calculate to what extent elastic is decoupling. This method was developed for delinking analysis of traffic and GDP [19]. The following table characterizes delinking elasticity formula between energy consumption and economic growth.

Table 4: The elasticity decoupling method [20]

Formula	Notations	Meaning
$eg = \frac{\Delta E}{\Delta GDP} = \frac{En}{(Eo-1)} \Big/ \frac{GDPn}{(GDPo-1)}$ *(Eq 4)*	eg	decoupling elasticity index
	ΔE	the change in energy consumption from the base time to time *n*
	ΔGDP	the difference in GDP from the base time to time *n*
	Eo	the total energy consumption at the base time
	En	the total energy consumption at time *n*
	GDPo	the GDP at the base time
	GDPn	the GDP at time *n*

There are possibly six different types of decoupling elasticity indices [17]. First, strong decoupling is associated with a decrease in energy consumption and an increase in the economy. Second, strong negative decoupling is linked with an increase in energy consumption and a decrease in the economy. Third, weak decoupling stands for an increase in both economy and energy consumption, however, the rate of growth of the energy consumption is lower than the rate of growth of the economy. Fourth, expansive negative decoupling is connected with rising in both economy and energy, however, the rate of growth of the energy consumption is higher than the rate of growth of the economy. Fifth, weak negative decoupling is about a decrease in both economy and energy consumption, however the rate of growth of the energy consumption is higher than the rate of growth of the economy. Six, recessionary decoupling stands for the decrease in both economy and energy consumption, however the rate of growth of the energy consumption is lower than the rate of growth of the economy [21].

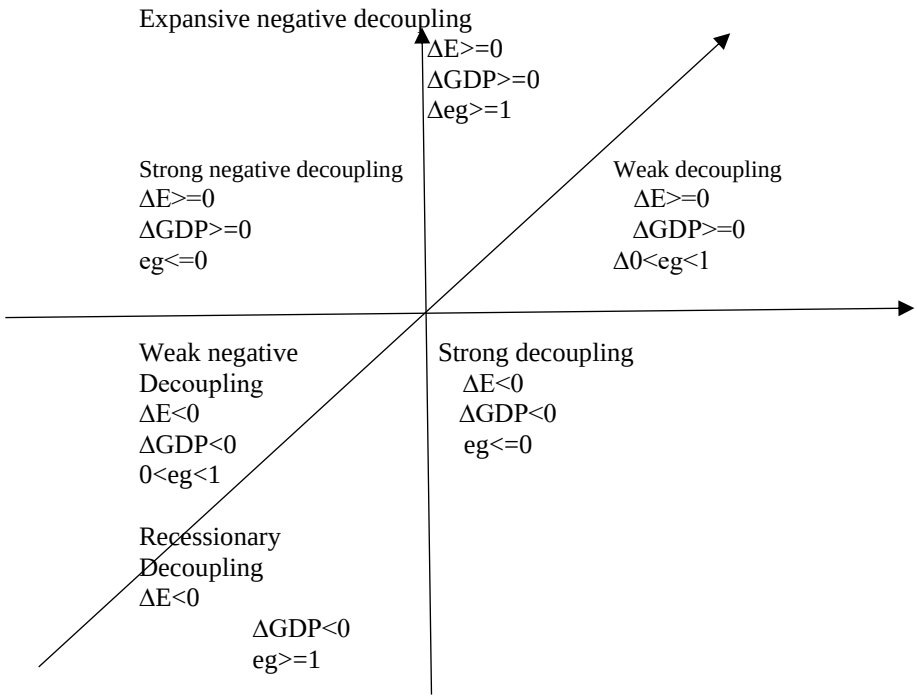

Figure 3: Six possible outcomes of decoupling elastic analysis

Chapter 3 – Materials and Methods

3.1 Data and Variables

This research work includes 5 Central Asian countries: Kazakhstan, Kyrgyzstan. Tajikistan, Turkmenistan and Uzbekistan.

The study period covers timespan from 1990 to 2014 and interpret data for total primary energy supply (further TPES), gross domestic product (further GDP), and total CO_2 emissions per kWh of electricity from the IKE *World Energy Balances*. Economic growth is indicated by GDP variable. It can be characterized as the Gross Domestic Product at market constant prices of 2010. These data are normalized to the price levels of 2010 and then converted to US dollars based on yearly average 2010 purchasing power parities (PPPs). Environmental pressure is expressed in terms of indicator total primary energy supply, TPES. Another indicator to show environmental pressure is total carbon emissions per kWh of electricity.

3.2 Methods

In order to solve emerging problems as a result of dependence of economic development and energy consumption scientists have proposed decoupling theory [5]. According to the World Bank's definition, dematerialization and depollution is main components of the decoupling concept and it is all about process which includes gradual reduction of the impacts of the economic actions to the environment [22]. However, decoupling concept introduced by Organization for Economic Cooperation and Development has gained more citations. According to the OECD decoupling concept can be understood as rupture of the relationship between economic goods and environmental bads. Here, the word "decoupling" means the destruction of negative factors on the environment and the initiation of growth of positive factors for the development of the economy In 1990, it was first time when OECD implemented decoupling concept into reality, especially research dedicated to the agricultural policy. Nowadays, it is extended to all over fields.

Comprehensive analysis, the elastic analysis and the decoupling index and descriptive statistics analysis are the main decoupling measurement methods [22].

Two methods applied to analyze relationship between environmental pressure and economic growth is ***OECD decoupling index*** and ***Tapio decoupling model***.

3.2.1 OECD decoupling Index

OECD decoupling method investigates the decoupling relationship between energy consumption and economic growth. The formulae to calculate:

$$Df = 1 - \frac{\left(\frac{EP}{DF}\right)t}{\left(\frac{EP}{DF}\right)0} \ (Eq\ 5)$$

where Df stands for decoupling factor, which range is (-∞; 1]; EP is to express environmental pressure, we use TPES to show EP; DF is used as index for driving force, we use GDP to reveal it. Base period and reporting period is indicated by subscripts 0 and t, respectively [22].

Table 2: OECD decoupling method [22]

Range	Interpretation	State
(0,1]	CO_2 emissions has higher rate of growth compared to the growth of the economy	Relative
		Absolute
(-∞; 0]	economy has higher rate of growth compared to the growth of the CO_2 emissions	Non-decoupling

3.2.2 Tapio decoupling model

During 1970 -2001 Tapio investigated the volume of European transportation and decoupling standards for carbon emissions and developed elastic analysis called Tapio decoupling model [23]. The flexibility index is basis for Tapio decoupling model and can be measured by following equation:

$$\mu(TPES, GDP) = \frac{\frac{\Delta TPES}{TPES}}{\frac{\Delta GDP}{GDP}} \ (Eq\ 6)$$

where $\mu(TPES, GDP)$ stands for elasticity of decoupling indicators between total primary energy supply and economic growth. It shows effects of TPES to economic growth. Table 6 represents eight outputs of decoupling developed by Tapio. The advantages of this method is it is not affected by changes of statistical dimensions.

First, strong decoupling is associated with a decrease in energy consumption and an increase in the economy. Second, strong negative decoupling is linked with an increase in energy consumption and a decrease in the economy. Third, weak decoupling stands for an increase in both economy and energy consumption, however, the rate of growth of the energy consumption is lower than the rate of growth of the economy. Fourth, expansive negative decoupling is connected with rising in both economy and energy, however, the rate of growth of the energy consumption is higher than the rate of growth of the economy. Fifth, weak negative decoupling is about a decrease in both economy and energy consumption, however the rate of growth of the energy consumption

is higher than the rate of growth of the economy. Six, recessionary decoupling stands for the decrease in both economy and energy consumption, however the rate of growth of the energy consumption is lower than the rate of growth of the economy [10].

Table 3: Eight decoupling states developed by Tapio [24]

		Environmental Pressure	Economic Growth	Elasticity, μ
Negative Decoupling	Expansive Negative Decoupling	(0; +∞)	(0; +∞)	(1.2; +∞)
	Strong Negative Decoupling	(0;+ ∞)	(-∞;0)	(-∞;0)
	Weak Negative Decoupling	(-∞;0)	(-∞;0)	(0;0.8)
Decoupling	Weak Decoupling	(0;+ ∞)	(0;+ ∞)	(0;0.8)
	Strong Decoupling	(-∞;0)	(0;+ ∞)	(-∞;0)
	Recessive Decoupling	(-∞;0)	(-∞;0)	(1.2; +∞)
Coupling	Expansive coupling	(0;+ ∞)	(0;+ ∞)	(0.8;1.2)
	Recessive coupling	(-∞;0)	(-∞;0)	(0.8;1.2)

Chapter 4 – Results and Discussion

4.1 Approximate relationship analysis

From 1990s, energy sector of Central Asian countries have demonstrated various changes in total primary energy supply (further TPES) (see Figure 4). The World Bank Data determined that a strong decrease in TPES occurred in Kazakhstan, especially indicators stabilized and regained levels before the USSR collapse approximately after 2010. Speaking of Uzbekistan, indicators of TPES had fluctuations period and it should note output in 2014 was below 1990s output. Turkmenistan spent seventeen years for recovery to the values of 1990 and it seems like raised by 30-40% towards 2014. From graph it is clearly shown that no noticeable changes in TPES happened in two countries, Kyrgyzstan and Tajikistan [9].

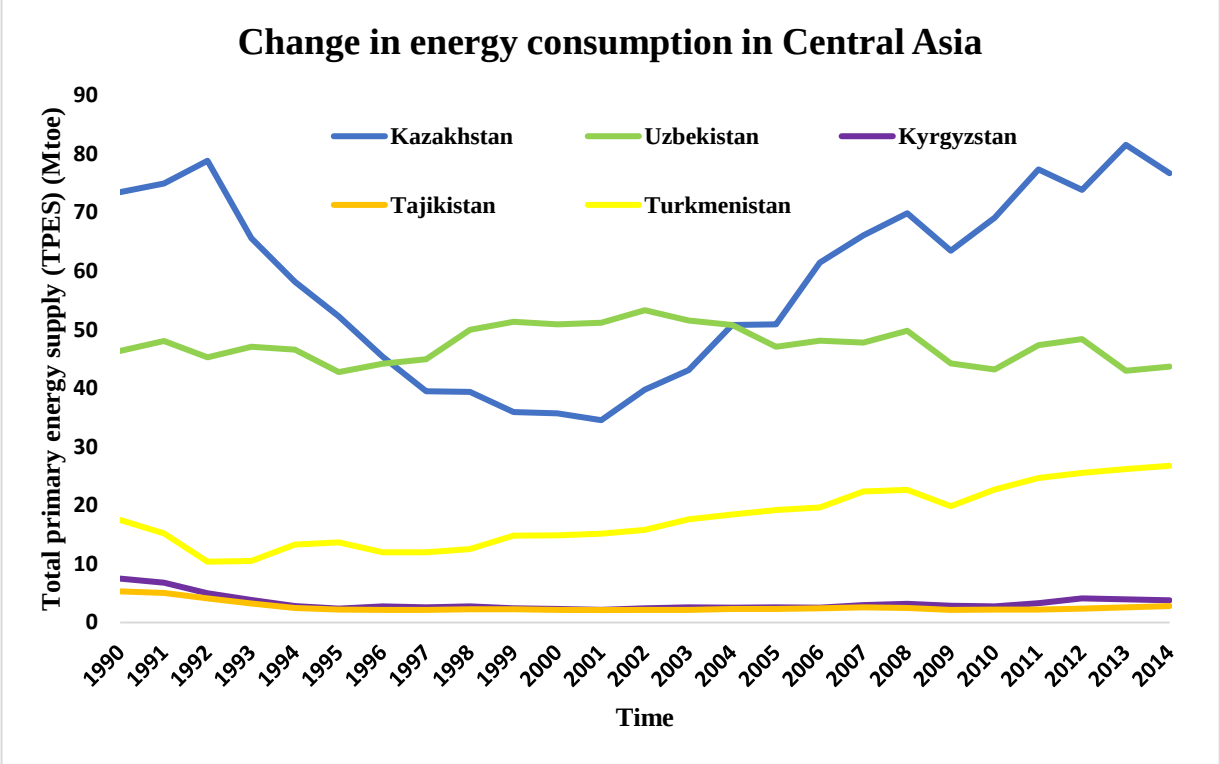

Figure 4: Change in energy consumption in Central Asia

According to the economic development (see Figure 5), Kazakhstan and Uzbekistan seems like leaders in the Central Asia. The economy of Turkmenistan shows robustness due to the natural resources, especially oil and gas sectors. After collapse of USSR all five countries had undergo recession period; however economy of Kyrgyzstan and Tajikistan have faced additional hard times as a results of revolution and civil war respectively [9].

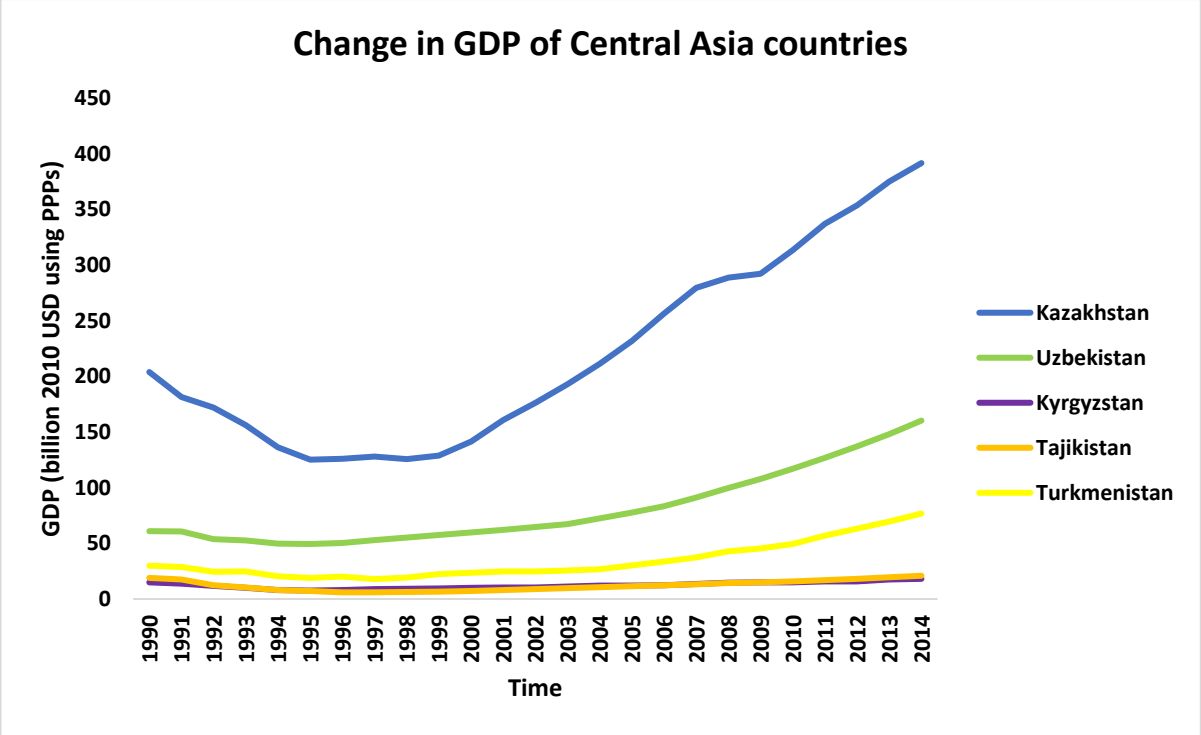

Figure 5: Change in GDP of Central Asia countries (OECD, 2002)

4.2 Decoupling Analysis of Central Asia

4.2.1 Kazakhstan

Results of calculation of the data consolidation in framework two decoupling methods demonstrated various decoupling statues between energy consumption and economic growth in Kazakhstan. The patterns in data revealed two phases of changes in both the energy and economic sector in Kazakhstan.

During first phase, according to the Tapio decoupling model, the first two years of the researched period began at a strong negative decoupling state with ΔTPES/ TPES being>0, ΔGDP/GDP<0 and index<0. Up to 2001 decoupling calculations indicated ΔTPES/ TPES <0, ΔGDP/GDP<0 and decoupling index<0, showing moderate decoupling of the energy sector from economic sector except for 1997-1998 and 1997-1998, recessive coupling and weak negative decoupling states respectively. Results of OECD decoupling method shares possibly same decoupling patterns, however this method could not provide deep information due to the limited number of statues. This time period in Kazakhstan experienced a profound transformation such as the transition from the level of a republican country to an independent country, after which the industrial and local economy went through hard times [9].

For second phase, both energy and economic sector have undergone major remodeling in Kazakhstan for time span covering 2002 – 2014. Consequently, the rates of economic growth and energy demand resulted a various decoupling and non-decoupling outcomes. Noteworthy, we can

observe from table years 2008 - 2009, 2011-2012, and 2013-2014 distinguished with positive end results by demonstrating ΔTPES/TPES <0, ΔGDP/GDP>0 and decoupling index<0 which corresponds mostly to the strong decoupling states. That is not because of Kazakhstani people start to use less energy. This is because of list of events such as growth of the net energy export, one of tenths of GDP comes from oil and gas sector and lack of cooperation between development of energy sector and other industrial sectors [24]. Nonetheless, global crisis of 2008 (ΔTPES/ TPES >0, ΔGDP/GDP>0 and decoupling index>1,2 – expansive negative decoupling) has not spared Kazakhstan and cascade of negative consequences such as limited flow of cash into country, stopped growth of the credit lead to the drop price of oil which in turn decreased Kazakhstani net energy export [25]. In terms of results of the OECD Decoupling analysis it seems like similar patterns can be observed; however it limited with general overview of the situation. It does not provide full information to understand a reasons behind each decoupling statues.

Table 4: Results Decoupling analysis of energy consumption and economic growth in Kazakhstan for time period 1990-2014: Tapio model and OECD model

Time	ΔTPES/ TPES	ΔGDP/GDP	μ	Status Tapio model	TPES vs GDP	Decoupling factor	Status OECD model
1990-1991	0,020	-0,110	-0,186	SND	-0,147	1,116	ND
1991-1992	0,052	-0,053	-0,979	SND	-0,111	1,037	ND
1992-1993	-0,168	-0,092	1,822	RD	0,083	1,021	0
1993-1994	-0,114	-0,126	0,905	RC	-0,014	1,920	ND
1994-1995	-0,101	-0,082	1,237	RD	0,021	0,731	0
1995-1996	-0,132	0,005	-26,207	SD	0,136	1,013	AD
1996-1997	-0,129	0,017	-7,597	SD	0,144	0,899	AD
1997-1998	-0,004	-0,019	0,200	WND	-0,015	1,052	ND
1998-1999	-0,087	0,027	-3,219	SD	0,111	0,944	AD
1999-2000	-0,007	0,098	-0,068	SD	0,095	1,149	AD
2000-2001	-0,032	0,135	-0,237	SD	0,147	0,684	AD
2001-2002	0,151	0,098	1,537	END	-0,048	1,099	ND
2002-2003	0,085	0,093	0,909	EC	0,008	0,889	RD
2003-2004	0,178	0,096	1,858	END	-0,075	0,820	ND
2004-2005	0,002	0,097	0,018	WD	0,087	0,912	RD
2005-2006	0,207	0,107	1,938	END	-0,091	1,310	ND
2006-2007	0,076	0,089	0,852	EC	0,012	0,724	RD
2007-2008	0,057	0,033	1,729	END	-0,023	0,802	ND
2008-2009	-0,091	0,012	-7,631	SD	0,102	0,770	AD
2009-2010	0,089	0,073	1,219	END	-0,015	0,865	ND
2010-2011	0,119	0,075	1,586	END	-0,041	0,981	ND
2011-2012	-0,045	0,050	-0,897	SD	0,090	1,021	AD
2012-2013	0,104	0,060	1,731	END	-0,041	1,003	ND
2013-2014	-0,060	0,044	-1,357	SD	0,099	0,985	AD

Note: ΔTPES, the changes in total primary energy supply(Mtoe); ΔG, the changes in GDP growth (billion 2010 USD using PPPs); μ, the decoupling elasticity indicator of energy consumption and economic growth; RD, recessive decoupling; WND, weak negative decoupling; WD, weak decoupling; SD, strong decoupling; END, expensive negative decoupling; RC, recessive coupling; EC, expansive coupling and ND, non-decoupling; RD, relative decoupling; AD, absolute decoupling.

4.2.2 Kyrgyzstan

The decoupling analysis of environmental stress and economic growth in Kyrgyzstan in the framework of Tapio and OECD decoupling models showed three stage of changes.

First stage, from 1991 to 1995 the relationship between environmental stress and economic growth demonstrated recessive decoupling indicating $\Delta TPES/ TPES < 0$, $\Delta GDP/GDP < 0$ and $\mu > 1.2$. In the 1990s, the republic experienced de-industrialization and a large decline, even by Central Asian standards: Kyrgyzstan's GDP in 1990-2001 decreased by 10.35 times [26]. Unfortunately, due to the low quality of data, OECD model generated null data for this time period.

Second stage, time period between 1995-2001 results illustrated consecutive two decoupling statues: expansive negative decoupling and strong decoupling. According to the OECD model, years distinguished with expansive negative decoupling state resulted non-decoupling status, while years with strong decoupling states corresponds to the absolute decoupling. Again, calculation of the same data range in the framework of both models can generate positive or negative decoupling states, however, the OECD model is limited to further analyze the obtained result, while the Tapio model can be further interpreted, to be more specific, positive decoupling states can be further divided into three categories. In more detail, results for the timespan between 1995 and 2001 can be interpreted as a strong decoupling state which means the rise of the economy and drop of the energy sector. The main difference between two statues: opposite value of change of energy consumption, although positive economic growth. Here, opposite value of energy consumption means disruption of fuels and raw materials, and disappearance of Soviet markets lead to the sharp reductions significant decline in the efficiency of the industry sector during the post-Soviet time [27]. However, end of 1990's and start of next decade revealed strong decoupling which means less environmental pressure and slow economic growth. This is because of industry and manufacturing sector has started slowly development from previous reductions if gold production is neglected [28].

Third stage, from 2002 to 2014 environmental sector has impacted economic growth mostly in three modes: expansive negative decoupling, strong negative decoupling and strong decoupling except for 2002-2003 and 2009-2010 where expansive coupling and recessive decoupling can be shown from the table. Firstly, expansive negative decoupling state stand for increase in both energy consumption and economy, although energy consumption has higher rate of growth compared to the economy and occurred during the years 2006-2007 and 2010-2011, which corresponds to the situation within country: in 2011, the volume of migrant remittances amounted to 29% of the country's GDP [27]. Secondly, strong negative decoupling means a decrease in the economy and increase of the energy consumption and occurred during 2001-2002,

2004-2005, and 2011-2012, which also correlates with the situation within the country: widespread corruption blocked the performance of the economy, in additional investment from foreign countries stayed at low levels and instability at the regional level [27]. Thirdly, strong decoupling is decrease of energy consumption and increase of economy and happened in 2003-2004, 2005-2006, 2008-2009, and 2012-2014 which matches with the decline in coal production from about 2 million to 400 000 tons, and stagnation of electricity industry in those [28]. In terms of OECD models, possibly same decoupling and non-decoupling states obtained; however results are limited for further investigation.

Table 5: Results Decoupling analysis of energy consumption and economic growth in Kyrgyzstan for time period 1990-2014: Tapio model and OECD model

Time	ΔTPES/ TPES	ΔGDP/GDP	μ	Status Tapio model	TPES vs GDP	Decoupling factor	Status OECD model
1990-1991	-0,0935	-0,0783	1,194	RC	0,984	0,016	0
1991-1992	-0,2666	-0,1393	1,913	RD	0,852	0,148	0
1992-1993	-0,2229	-0,1543	1,445	RD	0,919	0,081	0
1993-1994	-0,2791	-0,2014	1,386	RD	0,903	0,097	0
1994-1995	-0,1470	-0,0537	2,737	RD	0,901	0,099	0
1995-1996	0,1597	0,0712	2,241	END	1,083	-0,083	ND
1996-1997	-0,0616	0,0985	-0,625	SD	0,854	0,146	AD
1997-1998	0,0656	0,0213	3,081	END	1,043	-0,043	ND
1998-1999	-0,1268	0,0362	-3,501	SD	0,843	0,157	AD
1999-2000	-0,0373	0,0551	-0,678	SD	0,912	0,088	AD
2000-2001	-0,0690	0,0532	-1,296	SD	0,884	0,116	AD
2001-2002	0,1204	-0,0010	-126,269	SND	1,121	-0,121	ND
2002-2003	0,0661	0,0706	0,936	EC	0,996	0,004	RD
2003-2004	-0,0155	0,0704	-0,220	SD	0,920	0,080	AD
2004-2005	0,0118	-0,0017	-7,093	SND	1,013	-0,013	ND
2005-2006	-0,0156	0,0309	-0,504	SD	0,955	0,045	AD
2006-2007	0,1660	0,0858	1,936	END	1,074	-0,074	ND
2007-2008	0,0712	0,0835	0,853	EC	0,989	0,011	RD
2008-2009	-0,0886	0,0289	-3,068	SD	0,886	0,114	AD
2009-2010	-0,0451	-0,0047	9,647	RD	0,959	0,041	0
2010-2011	0,2036	0,0598	3,407	END	1,136	-0,136	ND
2011-2012	0,2477	-0,0006	-390,924	SND	1,249	-0,249	ND
2012-2013	-0,0436	0,1091	-0,400	SD	0,862	0,138	AD
2013-2014	-0,0380	0,0360	-1,054	SD	0,929	0,071	AD

Note: ΔTPES, the changes in total primary energy supply(Mtoe); ΔG, the changes in GDP growth (billion 2010 USD using PPPs); μ, the decoupling elasticity indicator of energy consumption and economic growth; RD, recessive decoupling; WND, weak negative decoupling; WD, weak decoupling; SD, strong decoupling; END, expensive negative decoupling; RC, recessive coupling; EC, expansive coupling and ND, non-decoupling; RD, relative decoupling; AD, absolute decoupling.

4.2.3 Tajikistan

Decoupling analysis of the relationship between environmental pressure and economic growth in Tajikistan can be divided into 3 phases: instability period no.1, decoupling period and instability period no.3.

Instability period no.1, from 1990-1996, in the first years after gaining independence in 1991, there was a deep economic crisis [29]. In 1993, GDP fell by 16% (in constant prices), in 1994 - by 24%, in 1995 - by 12%, in 1996 - by 17%. GDP in 1995 was only 41% of 1991 [24]. After the collapse of the USSR emerged civil conflict caused a delayed drop in both energy supply and total final consumption from 1990 to 1995 [29]. All these events caused that the initial two years of the investigated time period corresponds drop in both energy consumption and economy, in more detail rate of energy consumption showed higher rate compared to the rate of economic growth: weak negative decoupling except for 1993-1995.

Decoupling period covers 1997-2006 years: relationship between energy consumption and economy was in initially in strong decoupling, then weak decoupling state. The main difference between two states is that weak decoupling is characterized as growth in both economic and energy sector, while strong decoupling is about decrease in energy and rise in economy. Since 1997, GDP began to grow, and in 2000 the growth rate increased. In 2003, agriculture accounted for 30.8% of GDP, industry - 29.1%, and services - 40.1%. From 1995 energy demand quite raised until 2008, in more detail total primary energy supply increased by about 10% [30].

Instability period no.2, from 2006 up to 2014 a range of decoupling and coupling states can be observed from table. The reason behind that electricity is the most important sector of the country's socio-economic complex and dominant contributor to total primary energy production (59% in 2010). Next, oil and gas the second main components of TPES, respectively 23% and 13%. During the first decade of 2000, hydro did not loss its share if not counting alterations due to the precipitation. While natural gas's share declined two times in 2000 and decreased further as a result of Uzbekistan activities by cutting gas supplies in 2010 [31]. During all the period, OECD model resulted same decoupling or non-decoupling outputs, however outputs are not enough informative for further analysis.

Table 6: Results Decoupling analysis of energy consumption and economic growth in Tajikistan for time period 1990-2014: Tapio model and OECD model

Time	ΔTPES/ TPES	ΔGDP/GDP	μ	Status Tapio model	TPES vs GDP	Decoupling factor	Status OECD model
1990-1991	-0,0452	-0,0710	0,6365	WND	1,028	-0,028	ND
1991-1992	-0,1834	-0,2898	0,6330	WND	1,150	-0,150	ND
1992-1993	-0,2174	-0,1647	1,3203	RD	0,937	0,063	0
1993-1994	-0,2315	-0,2125	1,0893	RC	0,976	0,024	0
1994-1995	-0,1044	-0,1245	0,8384	RC	1,023	-0,023	ND
1995-1996	-0,0359	-0,1660	0,2162	WND	1,156	-0,156	ND
1996-1997	-0,0047	0,0167	-0,2781	SD	0,979	0,021	AD
1997-1998	0,0514	0,0526	0,9766	EC	0,999	0,001	RD
1998-1999	-0,0044	0,0375	-0,1185	SD	0,960	0,040	AD
1999-2000	-0,0402	0,0828	-0,4851	SD	0,886	0,114	AD
2000-2001	-0,0140	0,1015	-0,1374	SD	0,895	0,105	AD
2001-2002	0,0047	0,1073	0,0440	WD	0,907	0,093	RD
2002-2003	0,0188	0,1106	0,1698	WD	0,917	0,083	RD
2003-2004	0,0783	0,1027	0,7630	WD	0,978	0,022	RD
2004-2005	0,0000	0,0670	0,0000	0	0,937	0,063	AD
2005-2006	0,0299	0,0707	0,4232	WD	0,962	0,038	RD
2006-2007	0,0705	0,0774	0,9111	EC	0,994	0,006	RD
2007-2008	-0,0504	0,0794	-0,6344	SD	0,880	0,120	AD
2008-2009	-0,1306	0,0378	-3,4515	SD	0,838	0,162	AD
2009-2010	0,0235	0,0648	0,3621	WD	0,961	0,039	RD
2010-2011	0,0000	0,0742	0,0000	0	0,931	0,069	AD
2011-2012	0,0780	0,0750	1,0402	EC	1,003	-0,003	ND
2012-2013	0,1064	0,0741	1,4350	END	1,030	-0,030	ND
2013-2014	0,0769	0,0670	1,1486	EC	1,009	-0,009	ND

Note: ΔTPES, the changes in total primary energy supply(Mtoe); ΔG, the changes in GDP growth (billion 2010 USD using PPPs); μ, the decoupling elasticity indicator of energy consumption and economic growth; RD, recessive decoupling; WND, weak negative decoupling; WD, weak decoupling; SD, strong decoupling; END, expensive negative decoupling; RC, recessive coupling; EC, expansive coupling and ND, non-decoupling; RD, relative decoupling; AD, absolute decoupling.

4.2.4 Turkmenistan

Decoupling analysis of energy consumption and economic growth for Turkmenistan can be divided into two time period.

During first time period, the years from 1991-2001, relative, weak and strong decoupling were most popular decoupling trend in the relationship between energy consumption and economic growth. In detail, initial two years of independence can be described as decline in economy sector and decrease in energy consumption, however rate of energy consumption was lower than the rate of economic growth which corresponds to the relative decoupling. Next year, 1997-1998 and 1999-2001 is characterized as weak decoupling which means increase on both economy and energy consumption, however energy consumption has lower rate compared to the rate of economy. It should be noted consequence years 1993-1995 and 1996-1997 showed same strong negative decoupling state which means economy drop and energy consumption increase. Turkmenistan faces the first decade after the break up of the Soviet Union with same economic problems such as abnormal inflation, half de-industrialization, and fall down of the USSR welfare systems [31].

Second time period started at expansive negative decoupling state for two years in consequence from 2001 to 2003. Here, expansive strong decoupling stands for increase in both energy and economic sector, even more rate of energy consumption is higher than rate of economic growth. The reason behind that could be Turkmenistan developed commodity-based growth strategies for 2000-2005 [31]. Fortunately, positive decoupling trends took place during 2004-2006 and 2010-2014 except for years with expansive coupling, strong decoupling and even more expansive negative decoupling. The reason behind the interference of such outliers states need investigation which is out of scope of this research. Here, weak decoupling means rise of both economic sector and energy sector, but growth of energy sector is dominant rather than economic field. The decoupling analysis from 1990 to 2014 results moderate outputs, however for the future it is really hard to forecast. Because, over the past ten years, Ashgabat has become more dependent on Beijing: China today is the only real export market for Turkmen gas [32]. In addition, China is the country's largest overseas creditor. Both of these factors determine the strongest influence of the China on Turkmenistan. Outstanding debt to China, low hydrocarbon prices that are unlikely to rise anytime soon, and competition from other gas producing countries suggest that the economic situation in Turkmenistan will only get worse.

Table 7: Results Decoupling analysis of energy consumption and economic growth in Turkmenistan for time period 1990-2014: Tapio model and OECD model

Time	ΔTPES/ TPES	ΔGDP/GDP	μ	Status Tapio model	TPES vs GDP	Decoupling factor	Status OECD model
1990-1991	-0,132	-0,046	2,881	RD	0,909	0,091	0
1991-1992	-0,317	-0,150	2,117	RD	0,803	0,197	0
1992-1993	0,012	0,015	0,761	WD	0,996	0,004	RD
1993-1994	0,267	-0,173	-1,540	SND	1,532	-0,532	ND
1994-1995	0,029	-0,072	-0,408	SND	1,109	-0,109	ND
1995-1996	-0,126	0,067	-1,888	SD	0,819	0,181	AD
1996-1997	0,002	-0,114	-0,015	SND	1,131	-0,131	ND
1997-1998	0,046	0,071	0,643	WD	0,976	0,024	RD
1998-1999	0,184	0,165	1,112	EC	1,016	-0,016	ND
1999-2000	0,003	0,055	0,062	WD	0,952	0,048	RD
2000-2001	0,019	0,043	0,435	WD	0,977	0,023	RD
2001-2002	0,044	0,003	15,312	END	1,041	-0,041	ND
2002-2003	0,115	0,032	3,551	END	1,080	-0,080	ND
2003-2004	0,044	0,050	0,869	EC	0,994	0,006	RD
2004-2005	0,042	0,130	0,321	WD	0,922	0,078	RD
2005-2006	0,024	0,110	0,219	WD	0,923	0,077	RD
2006-2007	0,140	0,110	1,263	END	1,026	-0,026	ND
2007-2008	0,012	0,147	0,079	WD	0,882	0,118	RD
2008-2009	-0,122	0,061	-1,998	SD	0,828	0,172	AD
2009-2010	0,141	0,092	1,535	END	1,045	-0,045	ND
2010-2011	0,088	0,147	0,597	WD	0,948	0,052	RD
2011-2012	0,035	0,111	0,314	WD	0,931	0,069	RD
2012-2013	0,026	0,102	0,253	WD	0,931	0,069	RD
2013-2014	0,021	0,103	0,204	WD	0,926	0,074	RD

Note: ΔTPES, the changes in total primary energy supply(Mtoe); ΔG, the changes in GDP growth (billion 2010 USD using PPPs); μ, the decoupling elasticity indicator of energy consumption and economic growth; RD, recessive decoupling; WND, weak negative decoupling; WD, weak decoupling; SD, strong decoupling; END, expensive negative decoupling; RC, recessive coupling; EC, expansive coupling and ND, non-decoupling; RD, relative decoupling; AD, absolute decoupling.

4.2.5 Uzbekistan

Decoupling analysis of relationship between energy consumption and economy in Uzbekistan demonstrated two phase of changes.

First phase, the years between 1990 and 1998, the relationship between energy consumption and economic growth was in all three negative decoupling states: expansive, strong and weak negative decoupling states. After the collapse of the USSR, economic reforms were not fully implemented in Uzbekistan, conditions were not created for the development of medium and small businesses, corruption took root and unemployment increased. Both energy consumption and economy have undergone free fall between 1990 and 1995 [32].

Second phase, from 1998 to 2014, decoupling of energy consumption from economic growth occurred mostly in two modes: weak decoupling and strong decoupling. Here, weak decoupling means an increase in both energy consumption and economy with the difference in the rate of change in favor of the economy, while strong decoupling stands for rising of the economy and decrease in energy consumption. 1998-2001 have distinguished with weak decoupling statues, exactly during these period total primary energy consumption increased from 49,97 Mtoe to 51,19 Mtoe, while economy of country raised by 11% [33]. On other hand, strong decoupling corresponds to the years 2002-2004, 2005-2007, 2008-2010. Uzbekistan had possessed a total primary energy supply (TPES) of 53,31 Mtoe in 2002, however this value dropped approximately by ten units in 2010 [24].

Table 8: Results Decoupling analysis of energy consumption and economic growth in Uzbekistan for time period 1990-2014: Tapio model and OECD model

Time	ΔTPES/ TPES	ΔGDP/GDP	μ	Status Tapio model	TPES vs GDP	Decoupling factor	Status OECD model
1990-1991	0,04	0,00	-7,49	SND	1,042	-0,042	ND
1991-1992	-0,06	-0,11	0,52	WND	1,060	-0,060	ND
1992-1993	0,04	-0,02	-1,75	SND	1,065	-0,065	ND
1993-1994	-0,01	-0,05	0,20	WND	1,044	-0,044	ND
1994-1995	-0,08	-0,01	9,13	RD	0,926	0,074	0
1995-1996	0,03	0,02	2,00	END	1,017	-0,017	ND
1996-1997	0,02	0,05	0,33	WD	0,967	0,033	RD
1997-1998	0,11	0,04	2,59	END	1,066	-0,066	ND
1998-1999	0,03	0,04	0,62	WD	0,984	0,016	RD
1999-2000	-0,01	0,04	-0,23	SD	0,955	0,045	AD
2000-2001	0,01	0,04	0,15	WD	0,966	0,034	RD
2001-2002	0,04	0,04	1,04	EC	1,001	-0,001	ND
2002-2003	-0,03	0,04	-0,79	SD	0,928	0,072	AD
2003-2004	-0,01	0,08	-0,19	SD	0,915	0,085	AD
2004-2005	-0,07	0,07	-1,05	SD	0,866	0,134	AD
2005-2006	0,02	0,07	0,30	WD	0,952	0,048	RD
2006-2007	-0,01	0,10	-0,07	SD	0,907	0,093	AD
2007-2008	0,04	0,09	0,45	WD	0,952	0,048	RD
2008-2009	-0,11	0,08	-1,38	SD	0,822	0,178	AD
2009-2010	-0,02	0,09	-0,27	SD	0,901	0,099	AD
2010-2011	0,10	0,08	1,15	EC	1,012	-0,012	ND
2011-2012	0,02	0,08	0,27	WD	0,945	0,055	RD
2012-2013	-0,11	0,08	-1,41	SD	0,822	0,178	AD
2013-2014	0,02	0,08	0,21	WD	0,941	0,059	RD

Note: ΔTPES, the changes in total primary energy supply(Mtoe); ΔG, the changes in GDP growth (billion 2010 USD using PPPs); μ, the decoupling elasticity indicator of energy consumption and economic growth; RD, recessive decoupling; WND, weak negative decoupling; WD, weak decoupling; SD, strong decoupling; END, expensive negative decoupling; RC, recessive coupling; EC, expansive coupling and ND, non-decoupling; RD, relative decoupling; AD, absolute decoupling.

4.3 Decoupling Analysis of CO_2 emissions and economic growth across Central Asia

4.3.1 Background information on CO_2 emissions in Central Asia

The chart illustrates changes of total carbon dioxide emissions per kWh of electricity across Central Asia countries for the time period between 1991 and 2014. Based on the trends in change, two outliers are Tajikistan and Kyrgyzstan and the other three members of Central Asia underwent almost the same scenarios of revamping carbon dioxide emissions.

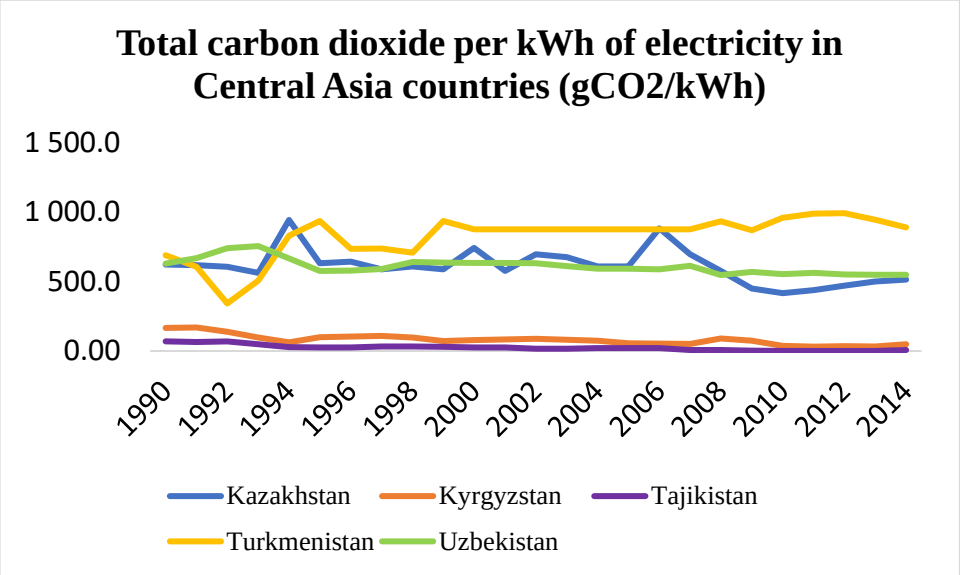

Figure 6: Total carbon dioxide per kWh of electricity in Central Asia countries (gCO_2/kWh)

Soviet Collapse and the Asian financial crisis in 1998 are the main causes of the decline of carbon dioxide emission per kWh electricity at the start of the chosen study period. In addition, low production capacity and absence of necessary equipment of Central Asian countries minorly upgraded industrial sector to next level. Also, the indicators energy consumption showed not the best results attributed to economic recession and emigration of the population [24].

The following years stand out for sharp increase in release of the carbon dioxide associated with generation of kWt of electricity as a result of transformation to the market economic reform. Consequently, the great decrease occurred during 2008 - 2010 accounted for global crisis. The next phase continued with increase after establishing of international macro-economy and financial environment. Last, implementation of environmental protection policies lead to the smooth decline in carbon dioxide emissions [28].

According to the Dorian et al. top 100 countries highest emitters of carbon dioxide includes Kazakhstan, Turkmenistan and Uzbekistan. Sharing of significant shares of world energy resources and aggressive directing of these resources for evolution energy based industry makes

them to contribute worldwide emissions in large extents. It is clearly seen from the table that Kyrgystan and Tajikistan are outliers in terms of total CO_2 emissions per kWh of electricity and the reason behind that attributed to the weak growth of the industry and country economy are directly linked to the agricultural sector.

4.3.2 Decoupling analysis between CO_2 emissions and economic growth across Central Asia

Decoupling analysis of the relationship between CO_2 emissions and economic growth was studied by applying to the total CO_2 per kWh of electricity and GDP (billion 2010 USD using PPPs) Tapio decoupling model and OECD decoupling model (see Table 12). The most decoupling states for investigated timespan are negative decoupling (*expansive negative decoupling, weak negative decoupling*) and decoupling (*weak decoupling, recessive decoupling and strong decoupling*). In more detail, initial years: 1991-1995 of study period is distinguished with recessive decoupling states. During these years consequences of collapse of USSR affected each country in different manner, especially break up of union is mostly characterized as decrease of the industrial output and carbon dioxide emissions [28]. Weak decoupling is detected years covering 2002-2003, 2010-2011 and 2013. This decoupling state can be characterized as growth of both economy and carbon dioxide emissions; however rate of carbon dioxide emissions was lower than rate of economic growth. Most of other years of the investigated timespan showed strong decoupling state which means rise of the economy and decrease of the CO_2 emissions.

Table 9: Results of decoupling analysis between CO2 emissions and economic growth across Central Asia from 1990 to 2014

Time	KAZ	KYR	TAJ	TUR	UZB
1990-1991	RD-ND	SND-ND	WND-ND	RD-0	SND-ND
1991-1992	WND-ND	RD-0	SND-ND	RD-0	SND-ND
1992-1993	RD-ND	RD-0	RD-0	END-ND	SND-ND
1993-1994	SND-ND	RD-0	RD-0	SND-ND	RD-0
1994-1995	RD-0	SND-ND	RC-ND	SND-ND	RD-0
1995-1996	EC-ND	WD-RD	SND-ND	SD-AD	WD-RD
1996-1997	SD-AD	WD-RD	END-ND	SND-ND	WD-RD
1997-1998	WD-ND	SD-AD	SD-AD	SD-AD	END-ND
1998-1999	SD-AD	SD-AD	SD-AD	END-ND	SD-AD
1999-2000	END-ND	END-ND	SD-AD	SD-AD	SD-AD
2000-2001	SD-AD	END-ND	SD-AD	0-AD	SD-AD
2001-2002	END-ND	SND-ND	SD-AD	0-AD	SD-AD
2002-2003	SD-AD	SD-AD	WD-RD	WD-RD	SD-AD
2003-2004	SD-AD	SD-AD	END-ND	SD-AD	SD-AD
2004-2005	SD-AD	RD-0	SD-AD	WD-RD	SD-AD
2005-2006	END-ND	SD-AD	WD-RD	SD-AD	SD-AD
2006-2007	SD-AD	SD-AD	SD-AD	0-AD	WD-RD
2007-2008	SD-AD	END-ND	SD-AD	WD-RD	SD-AD
2008-2009	SD-AD	SD-AD	SD-AD	SD-AD	WD-RD
2009-2010	SD-AD	RD-0	SD-AD	EC-ND	SD-AD
2010-2011	WD-RD	SD-AD	EC-ND	WD-RD	WD-RD
2011-2012	EC-ND	SND-ND	END-ND	WD-RD	SD-AD
2012-2013	WD-ND	SD-AD	SD-AD	SD-AD	SD-AD
2013-2014	WD-RD	END-ND	END-ND	SD-AD	SD-AD

Note: RD, recessive decoupling; WND, weak negative decoupling; WD, weak decoupling; SD, strong decoupling; END, expensive negative decoupling; RC, recessive coupling; EC, expansive coupling and ND, non-decoupling; RD, relative decoupling; AD, absolute decoupling.

5 - Conclusion

This paper represents data-driven research on the relationship between energy consumption and economic growth for Central Asia from 1990 to 2014. In general, most Central Asian countries total energy consumption and GDP initially dropped and followingly raised over the period of 1993-2010. Change of the republican system of government to the independent country after the collapse of the USSR and difficulties that appeared during the transition of the planned economy to a market economy in the economic sector were two main driving above mentioned phenomenon.

The relationship between energy consumption and economic growth was analyzed in the framework of two decoupling methods: the Tapio decoupling method and OECD decoupling index method. We established the main four decoupling statues: ***expansive negative decoupling, weak decoupling, strong decoupling and expansive coupling***. Based on data consolidation calculation it is clearly shown that there exist a significant environmental pressure on economic growth in Central Asia. However, in order to get full information, we have to investigate decoupling analysis per country separately.

For Kazakhstan, the results of the decoupling analysis of the relationship between energy consumption and economic growth can be divided and interpreted into two stages. During the first stage from 1990 to 2000, the initial two years were at a strong negative decoupling state, followed by recessional decoupling and finished by showing strong decoupling. During the second stage 2001-2014, an interesting point, we observed expansive negative decoupling state appeared every two years in pair with expansive coupling, weak decoupling, and strong decoupling.

For Kyrgyzstan, the results of the decoupling analysis of the relationship between energy consumption and economic growth can be divided and interpreted into three stages. During first stage, from 1990 to 1995, we observed recessional decoupling state. During second stage from 1995 to 2001, we observed consecutive two decoupling statues: expansive negative decoupling and strong decoupling. During third stage from 2002 to 2014 , expansive negative decoupling, strong negative decoupling and strong decoupling were most popular decoupling states.

For Tajikistan, the results of the decoupling analysis of the relationship between energy consumption and economic growth can be divided and interpreted into three stages. During first stage from 1990 to 1996, results initially showed weak negative decoupling state, then recessional decoupling state and end up again with weak negative decoupling state. During second stage from 1997 to 2006, relationship between energy consumption and economy was in initially in strong decoupling, then weak decoupling state. During third stage from 2006 to 2014, a range of

decoupling and coupling states can be observed: expansive coupling, strong decoupling, weak decoupling and expansive negative decoupling.

For Turkmenistan, the results of the decoupling analysis of the relationship between energy consumption and economic growth can be divided and interpreted into two stages. During the first stage from 1990 to 2001, relative, weak and strong decoupling were most popular decoupling trend in the relationship between energy consumption and economic growth. During the second stage from 2001 to 2014, the most two dominant states were expansive negative decoupling and weak decoupling except for expansive coupling in 2003-2004 and strong decoupling in 2008-2009.

For Uzbekistan, the results of the decoupling analysis of the relationship between energy consumption and economic growth can be divided and interpreted into two stages. During the first stage from 1990 to 1998, the relationship between energy consumption and economic growth was in all three negative decoupling states: expansive, strong and weak negative decoupling states. During the second stage from 1998 to 2014, decoupling of energy consumption from economic growth occurred mostly in two modes: weak decoupling and strong decoupling.

Based on OECD decoupling index method, results shares possibly same decoupling patterns, however this method could not provide deep information due to the limited number of statues. For example, the OECD decoupling index method can interpret obtained results in terms of three decoupling states, while the Tapio model has substates for each of three decoupling states.

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