

## Supplementary materials

**Table S1.** Some abbreviations appeared in this paper and demonstrations.

Abbreviation	Demonstration
AAC	Annual Average Concentration
ATE	Annual Total Emission
AISE	Annual Industrial Source Emission
ISV	Industrial Shipment Value
GDP	Gross Domestic Product
IPV	Industrial Product Value
IR	Isozu region
SO <sub>2</sub>	Sulfur Dioxide
SCE	Standard Coal Energy
MAC	Monthly Average Concentration
PM <sub>2.5</sub>	Fine Particulate Matter
PM <sub>10</sub>	Particulate Matter
NO <sub>2</sub>	Nitrogen Dioxide
O <sub>3</sub>	Ozone
CO	Carbon Monoxide
SPM	Suspended Particulate Matter
BTH	Beijing-Tianjin-Hebei region
EKC	Environmental Kurznets Curve
URS	Urban Residential Source
CTFS	Centralized Treatment Facilities

**Table S2.** Elementary conditions and SO<sub>2</sub> related fundamentals of Yokkaichi (by 2018)

Item	Yokkaichi's condition
Area (km <sup>2</sup> )	206.48
Population (2018)	311 795
Population Density (2018)	1510/km <sup>2</sup>
Transportation	port, airport, train stations
GDP (2018)	1867.1 billion JPY
GDP per Capita (2018)	3.8 million JPY
Industry Development	Figure above
Air Pollutants Monitoring Stations	11
Original Sources of pollutants	coal
Main Sources of Air Pollution period	crude oil
Dominating industry during pollution process	petrochemical industry, mechanical industry, textile industry
Main pollutants in Early period	SO <sub>2</sub>

**Table S3.** Elementary conditions and SO<sub>2</sub> related fundamentals of Tianjin (by 2018)

Item	Tianjin's fundamental condition
Area (km <sup>2</sup> )	11966.5
Population	15 618 300
Population Density	1305/km <sup>2</sup>
Transportation	port, airport, train stations
GDP	21674.6 billion JPY <sup>1</sup>
GDP per Capita	1.4 million JPY
Industry Development	Figure above
Air Pollutants Monitoring Stations	27
Original Sources of pollutants	Coal
Main Sources of Air Pollution period	Coal, crude oil
Dominating industry in pollution period	Petrochemical industry, mechanical industry
Main pollutants in early period of pollution	SO <sub>2</sub> , PM <sub>2.5</sub>

**Table S4.** Summary of related important law, policies, regulations, and activities against Yokkaichi Air Pollution.

Time	Policies and Regulations		Citizens' Activities and Movements
	Local government	Central government	
1960.4			The Shiohama Self-governing Union filed complaints
1962.2			The Shiohama Area Union filed requests to the government
1962.6		The announcement of "Law about regulation of discharge of smoke"	
1962.7			The Shiohama Area Union filed requests once again to prefecture government
1963-			Citizen movements against pollution activated

---

1963.11	“Yokkaichi area air pollution special investigative committee” started a field investigation against Yokkaichi Air Pollution	
1966.10	“Yokkaichi antipollution measure council ordinance” established	
1967.7	Announcement of “Mie Prefecture pollution control ordinance”	
1967.8	Announcement and implement of “Basic law for environmental pollution control”	
1967.9		9 patients of Yokkaichi Asthma co-filed lawsuit against 6 companies in complex
1968.6	Announcement of “Air pollution control law”	
1969.2	“Sulfur oxide general emission standard” was approved	
1970.4	“Pollution Session of Diet”	
1972.4	Amendment and implement of “Mie Prefecture pollution control ordinance”	

---

1972.7	Yokkaichi pollution event of damages judgment	
1993		Announcement of "Basic Environment Law"
1993		The concept of "Sustainable Development"

**Table S5.** Summary of related important law, policies, regulations, and activities against air pollution in China.

Time	Policies and Regulations		Citizens' Activities and Movements
	Local government	Central government	
1988		Announcement of "Law of China on the Prevention and Control of Atmospheric Pollution"	
1998	"Coal to Gas" Project initiated in Beijing		
2003		Announcement of "The Environmental Impact Assessment Law of China"	
2008			"Beijing Olympics" and Discussion over "Political Blue Sky" Concept
2013		Implementation of "Air Pollution Prevention and Control Action Plan"	Public discussion over PM <sub>2.5</sub>
2014	Implementation of "Beijing-Tianjin-Hebei Integration Development Strategy"		
2015	Implementation of "Air Pollution Prevention Regulations of Tianjin"		Public discussion over PM <sub>2.5</sub> (second time)
2016		Amendment of "Law of China on the Prevention and Control of Atmospheric Pollution"	
2017	"Coal to Gas" project promoted to Beijing-Tianjin-Hebei area		

**Table S6.** Standards for 6 main pollutants in Japan

Pollutant	Averaging period	Concentration	Unit
SO <sub>2</sub>	1 hour	0.1	ppm
	24 hours	0.04	
CO	8 hours	20	ppm
	24 hours	10	
SPM	1 hour	0.20	mg/m <sup>3</sup>
	24 hours	0.10	
NO <sub>2</sub>	24 hours	0.04-0.06	ppm
O <sub>3</sub>	1 hour	0.06	
PM <sub>2.5</sub>	24 hours	35	μ g/m <sup>3</sup>
	1 year	15	

Source: <https://www.env.go.jp/kijun/taiki.html>

**Table S7.** Legal standards for 6 main pollutants' concentration in China

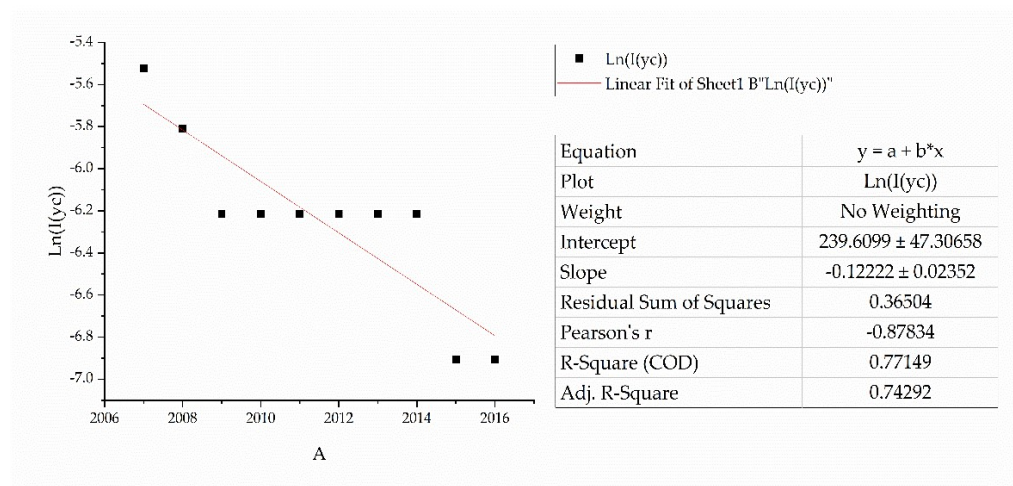
Pollutant	Averaging period	Concentration		Unit
		Level 1	Level 2	
SO <sub>2</sub>	1 year	20	60	μ g/m <sup>3</sup>
	24 hours	50	150	
	1 hour	150	500	
NO <sub>2</sub>	1 year	40	40	μ g/m <sup>3</sup>
	24 hours	80	80	
	1 hour	200	200	
CO	24 hours	4	4	mg/m <sup>3</sup>
	1 hour	10	10	
O <sub>3</sub>	8 hours	100	160	μ g/m <sup>3</sup>
	1 hour	160	200	
PM <sub>10</sub>	1 year	40	70	μ g/m <sup>3</sup>
	24 hours	50	150	
PM <sub>2.5</sub>	1 year	15	35	μ g/m <sup>3</sup>
	24 hours	35	75	

Source: Ministry of Ecology and Environment of the People's Republic of China

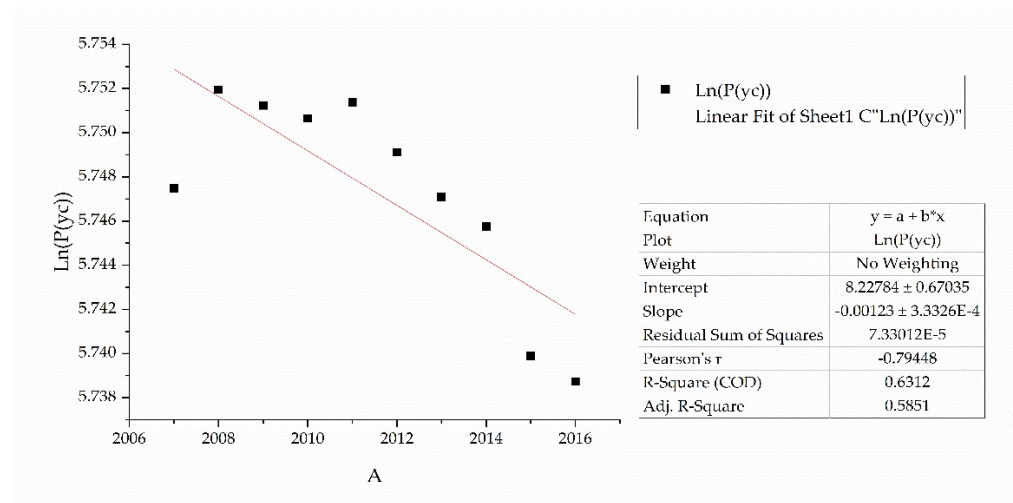
## Supplementary tables and figures for Yokkaichi linear analysis:

**Table S8.** Detailed linear fitting analysis data for evaluating dataset of Yokkaichi for **Table 6**.

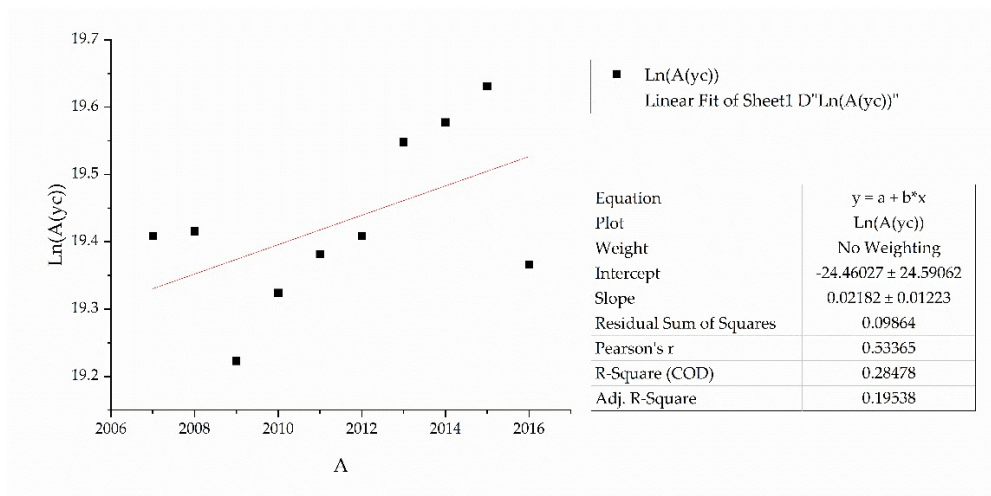
Variable	Ln ( <i>I</i> (yc))	Ln ( <i>P</i> (yc))	Ln ( <i>A</i> (yc))	Ln ( <i>T</i> (yc))	Ln ( <i>B</i> (yc))	Ln ( <i>S</i> (yc))
N total	10	10	10	10	10	10
Mean	-6.24338	5.74733	19.42844	-3.11459	4.29667	-0.84157
Standard Deviation	0.42131	0.0047	0.12379	0.04697	0.39139	0.15325
Mean absolute Deviation	0.26575	0.00357	0.09437	0.03799	0.27034	0.13631
Minimum	-6.90776	5.73874	19.22298	-3.18885	3.43399	-1.03564
Median	-6.21461	5.74831	19.40839	-3.10675	4.27667	-0.83298
Maximum	-5.52146	5.75195	19.63141	-3.04834	4.80402	-0.65201
Range	1.38629	0.01321	0.40843	0.14051	1.37003	0.38363



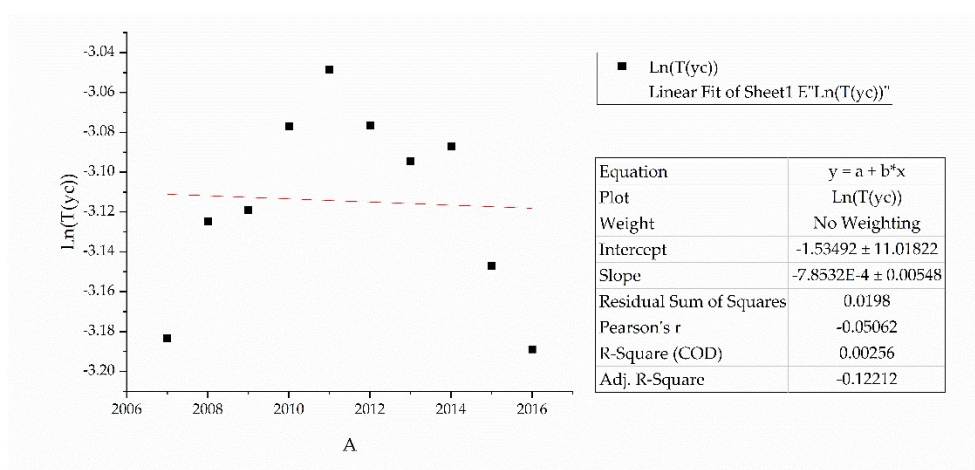
**Figure S1.** Linear regression of Year- $\text{Ln}(I(yc))$ .



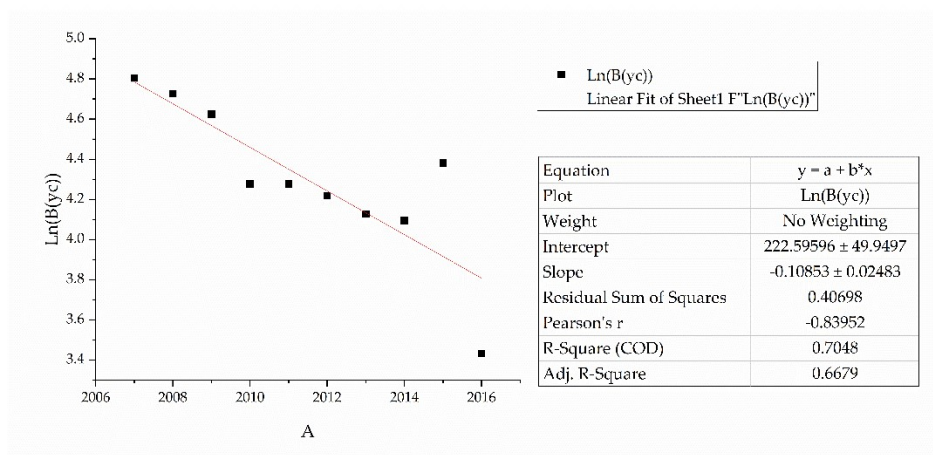
**Figure S2.** Linear regression of Year- $\text{Ln}(P(yc))$ .



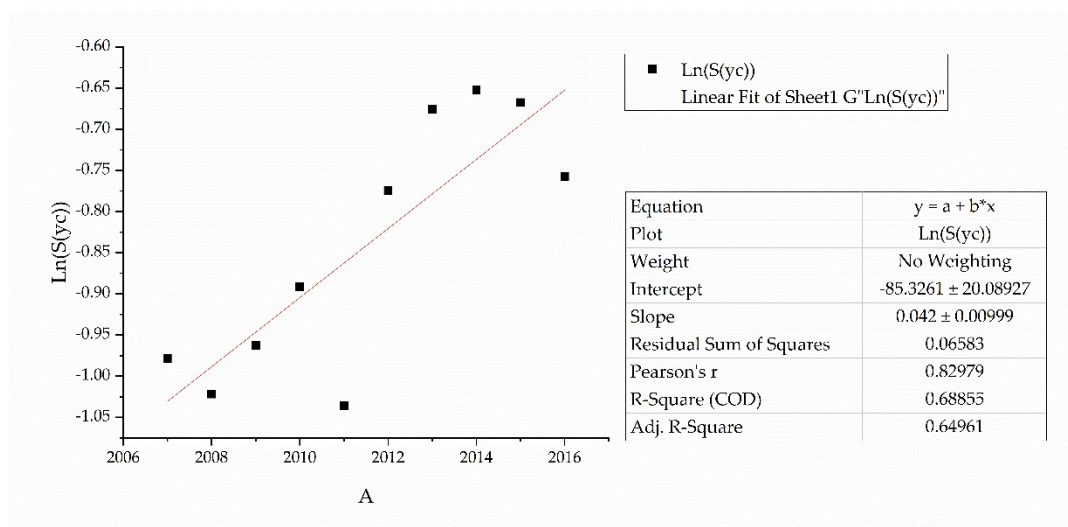
**Figure S3.** Linear regression of Year- $\text{Ln}(A(y))$ .



**Figure S4.** Linear regression of Year- $\text{Ln}(T(y))$ .



**Figure S5.** Linear regression of Year- $\text{Ln}(B(y))$ .



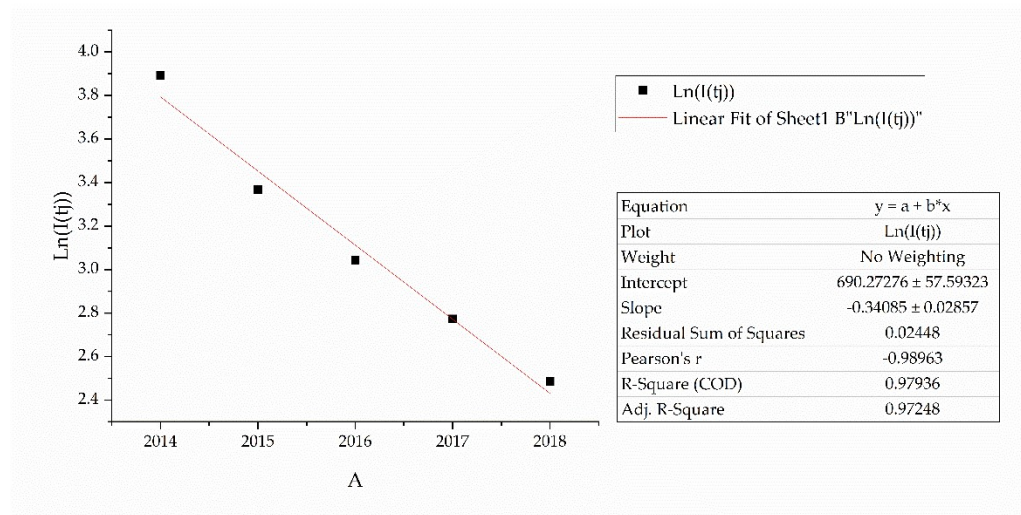
**Figure S6.** Linear regression of Year-Ln(S(yc)).



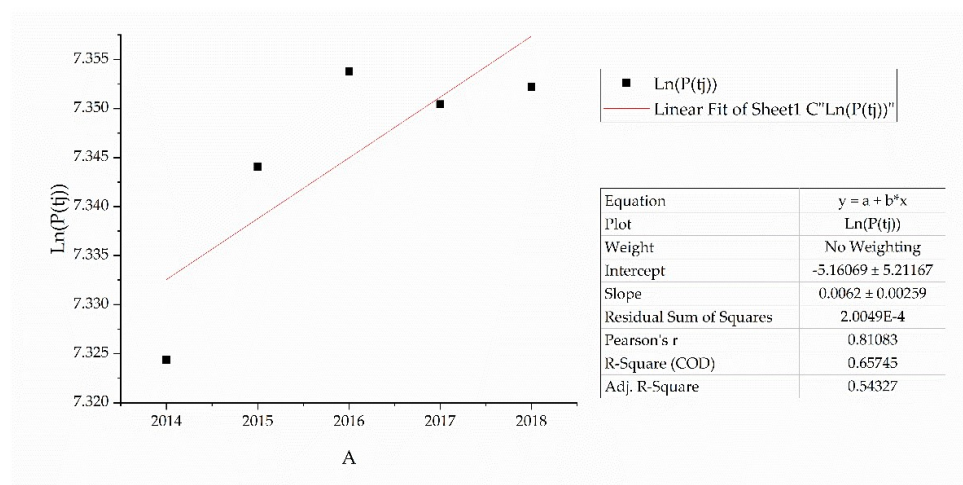
## Supplementary tables and figures for Tianjin linear analysis:

**Table S9.** Detailed linear fitting analysis data for evaluating dataset of Tianjin for **Table 9**.

Variable	$\text{Ln}(I(tj))$	$\text{Ln}(P(tj))$	$\text{Ln}(A(tj))$	$\text{Ln}(T(tj))$	$\text{Ln}(B(tj))$	$\text{Ln}(S(tj))$
N total	5	5	5	5	5	5
Mean	3.11223	7.34496	13.46135	-4.53735	4.46668	-0.861
Standard Deviation	0.54459	0.0121	0.02914	1.04421	0.56528	0.06177
Mean Absolute Deviation	0.41387	0.00861	0.0243	0.74324	0.43706	0.04358
Minimum	2.48491	7.32436	13.4306	-5.12854	3.71357	-0.90387
Median	3.04452	7.35043	13.45349	-4.89605	4.57471	-0.89404
Maximum	3.89182	7.3538	13.49691	-2.67925	5.18178	-0.75502
Range	1.40691	0.02943	0.06631	2.44929	1.46821	0.14885



**Figure S7.** Linear regression of Year- $\text{Ln}(I(tj))$ .



**Figure S8.** Linear regression of Year- $\text{Ln}(P(tj))$ .

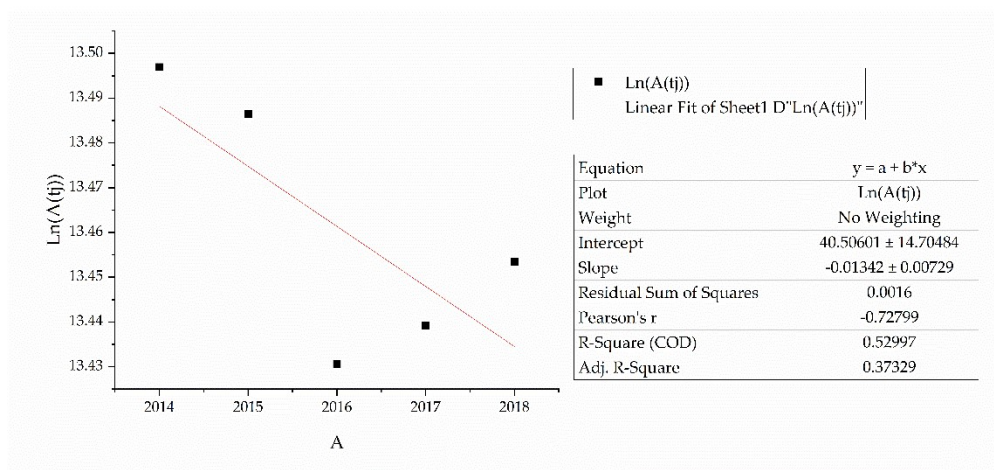


Figure S9. Linear regression of Year- $\ln(A(tj))$ .

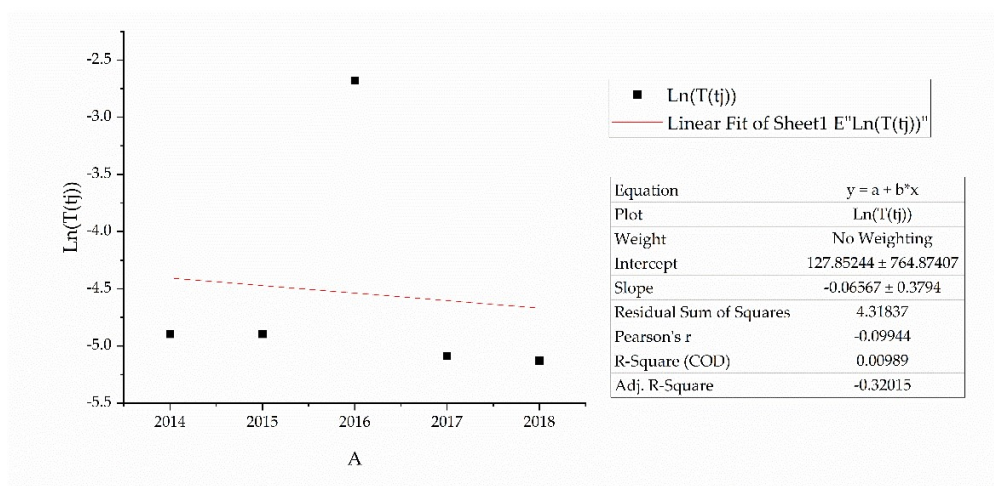


Figure S10. Linear regression of Year- $\ln(T(tj))$

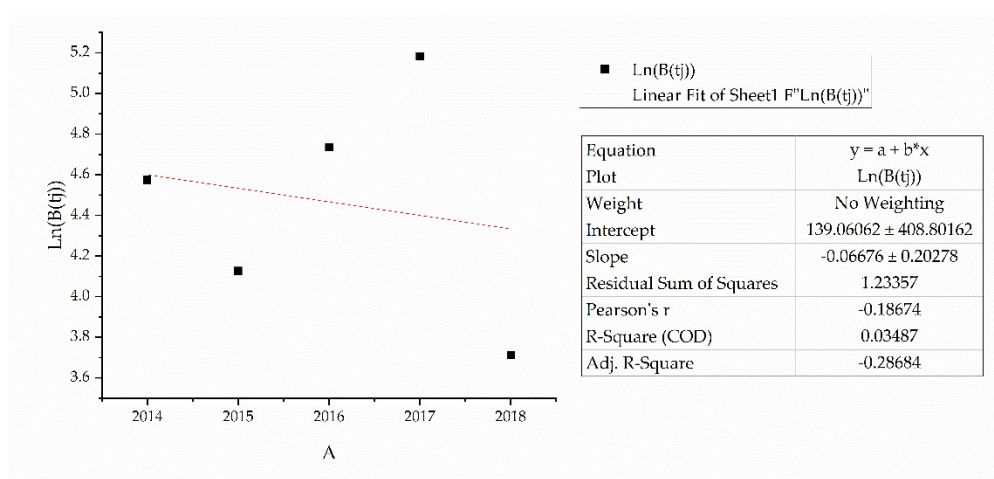
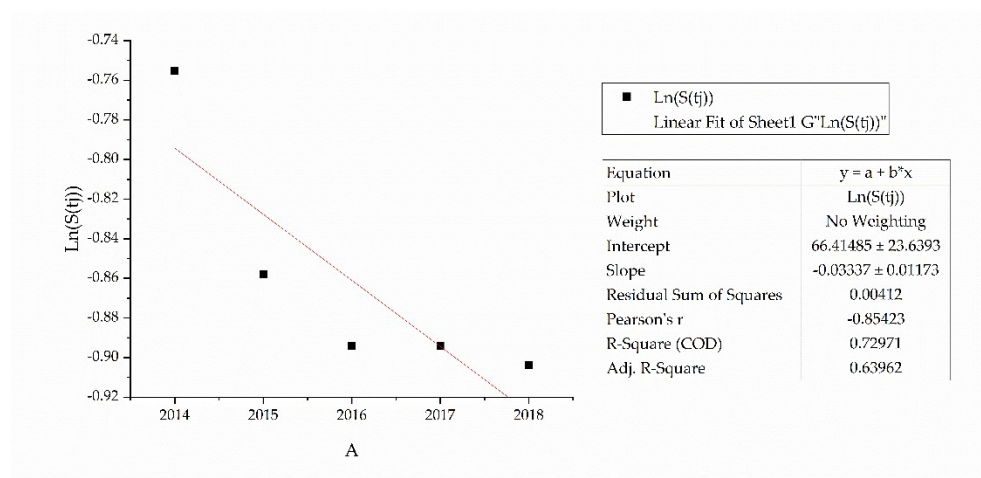


Figure S11. Linear regression of Year- $\ln(B(tj))$ .



**Figure S12.** Linear regression of Year- $\text{Ln}(S(tj))$ .