

CO2 Emisyonlarının Ekonomik Büyümeden Ayrışması: Malzemenin Rolü

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CO₂, Malzeme, Enerji ilişkisi?



MODEL



BULGULAR



SONUÇ

Bu alıřma “**Malzeme Talebi ve Malzeme Verimliliđinin Sürdürülebilirlik Açısından Analizi: Ülkeler Arası Karşılařtırmalı bir Analiz ve Türkiye için Deđerlendirmeler**” başlıklı 221K082 numaralı TÜBİTAK projesi kapsamında hazırlanmıřtır ve **TÜBİTAK tarafından desteklenmektedir.**

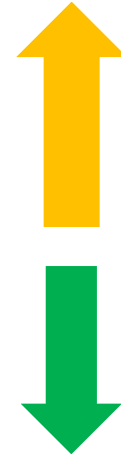
ÇALIŞMANIN AMACI



CO2 emisyonları ile ekonomik büyüme (GDP) arasındaki ilişkiyi ayırma(decoupling) yöntemine dayalı olarak analiz etmek

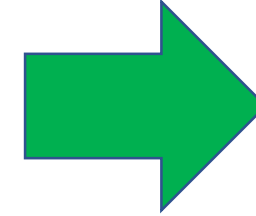


enerji tüketiminin yanı sıra malzeme tüketimini de dikkate alarak, ayırma durumunu etkileyen faktörleri ortaya koymaktır.



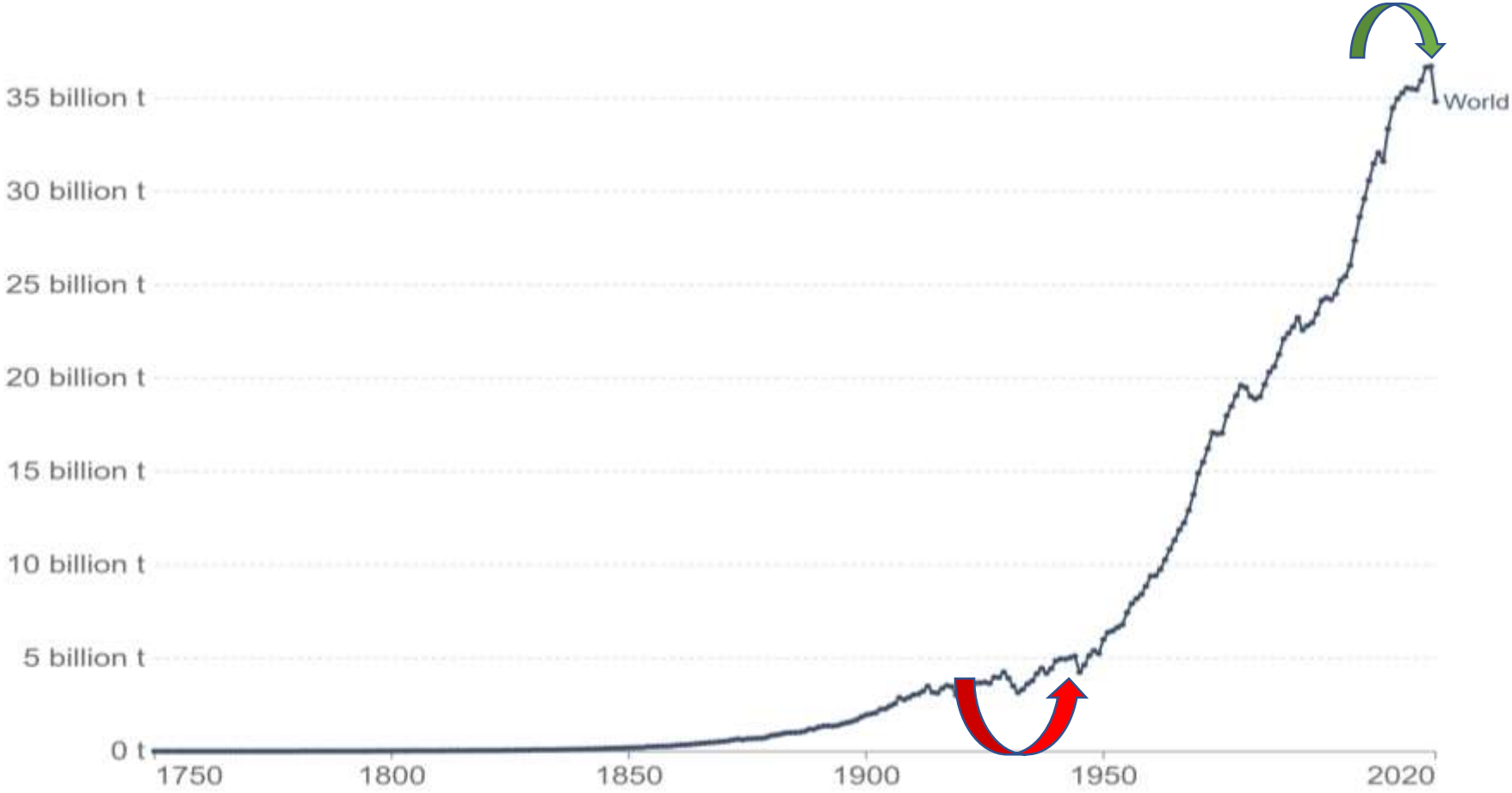
EKONOMİK BÜYÜME

KARBON EMİSYONLARI



DECOUPLİNG

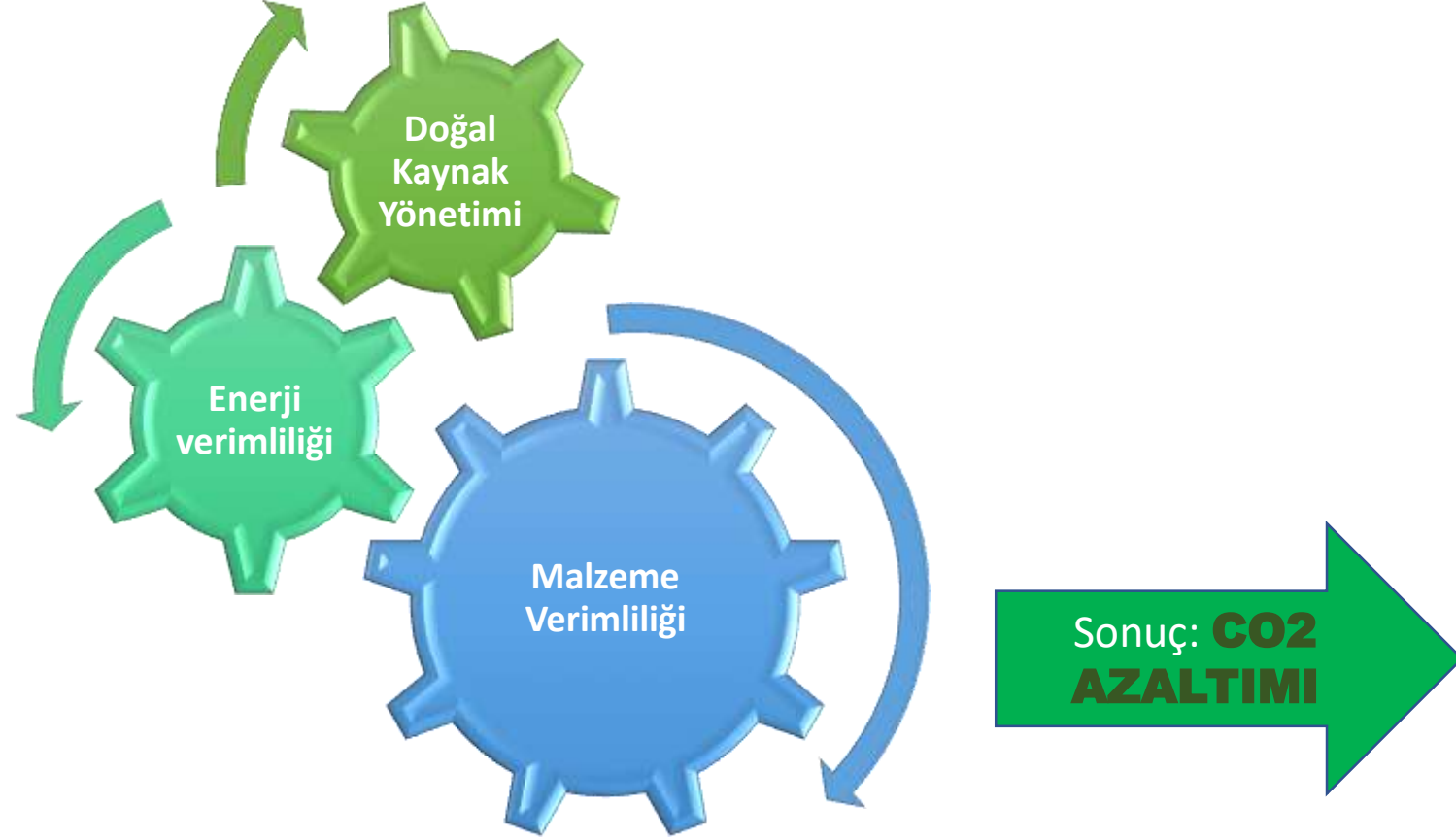
CO2 Emisyonları?



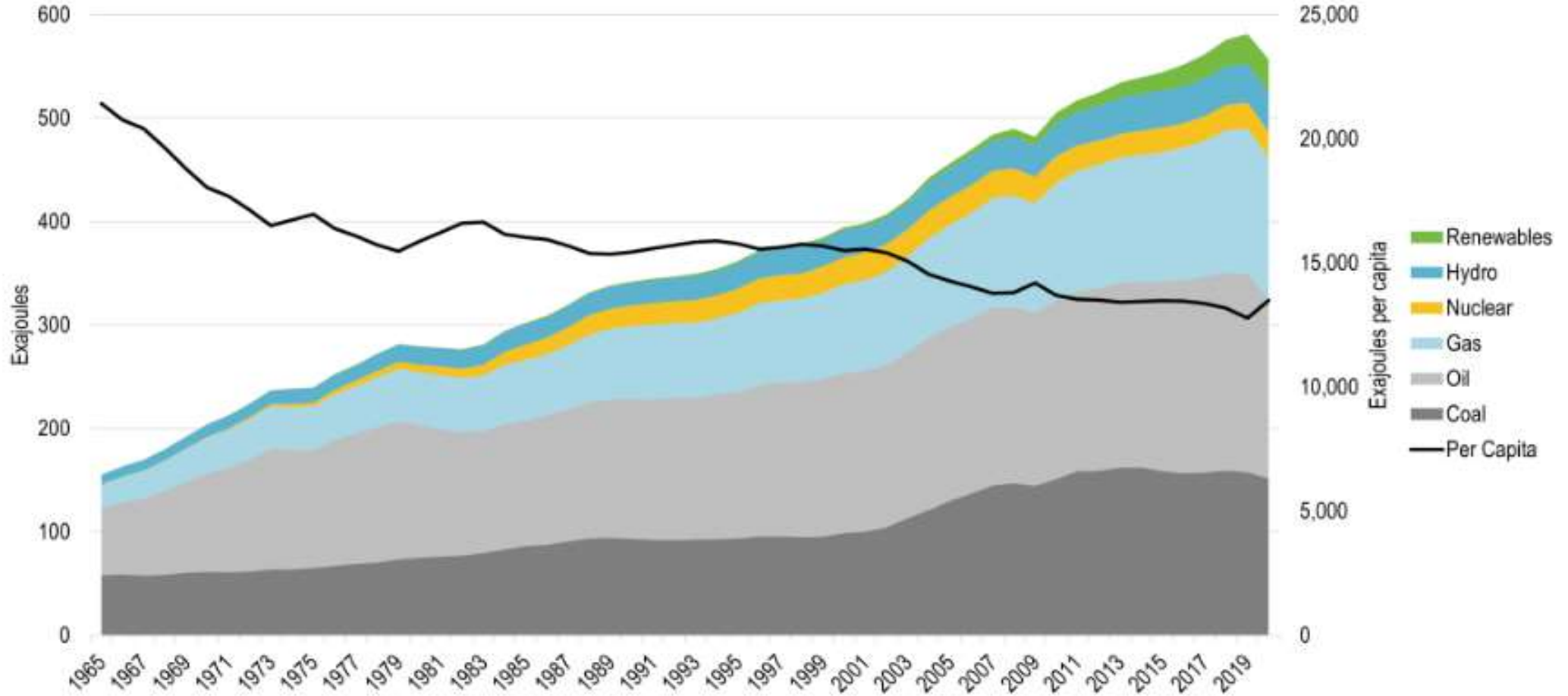
Source: Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

ÇÖZÜM?



Küresel Enerji Tüketimi?

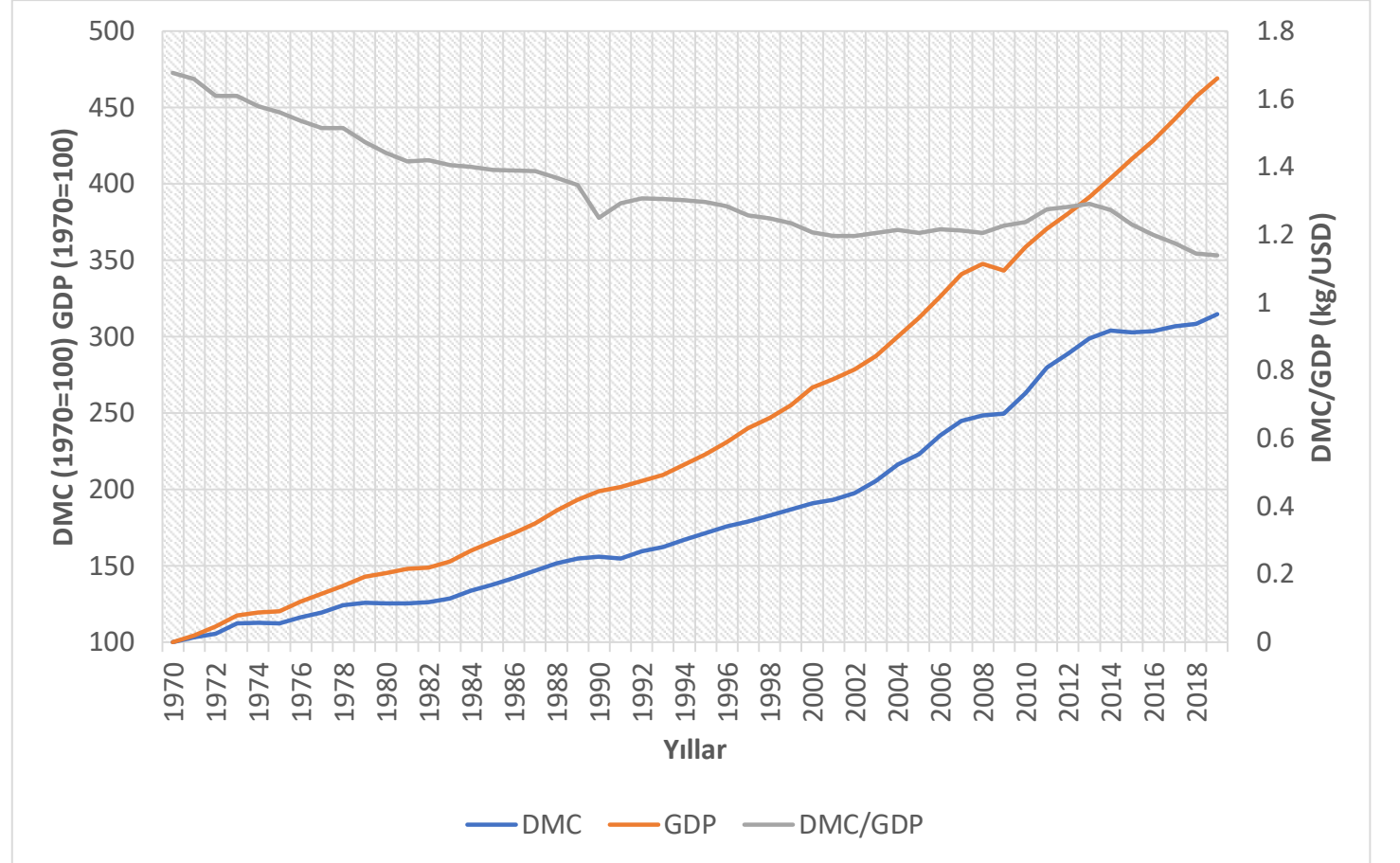


Küresel Yurtiçi Malzeme Tüketimi (DMC), GDP ve Malzeme Yoğunluğu (DMC/GDP)- 1970-2019

DMC 3 katına çıktı!!! (1970 seviyesinden)

Emisyonlara ilave %43 yük!!

GDP-CO2 ayrışmasına çok az katkı sağlıyor!

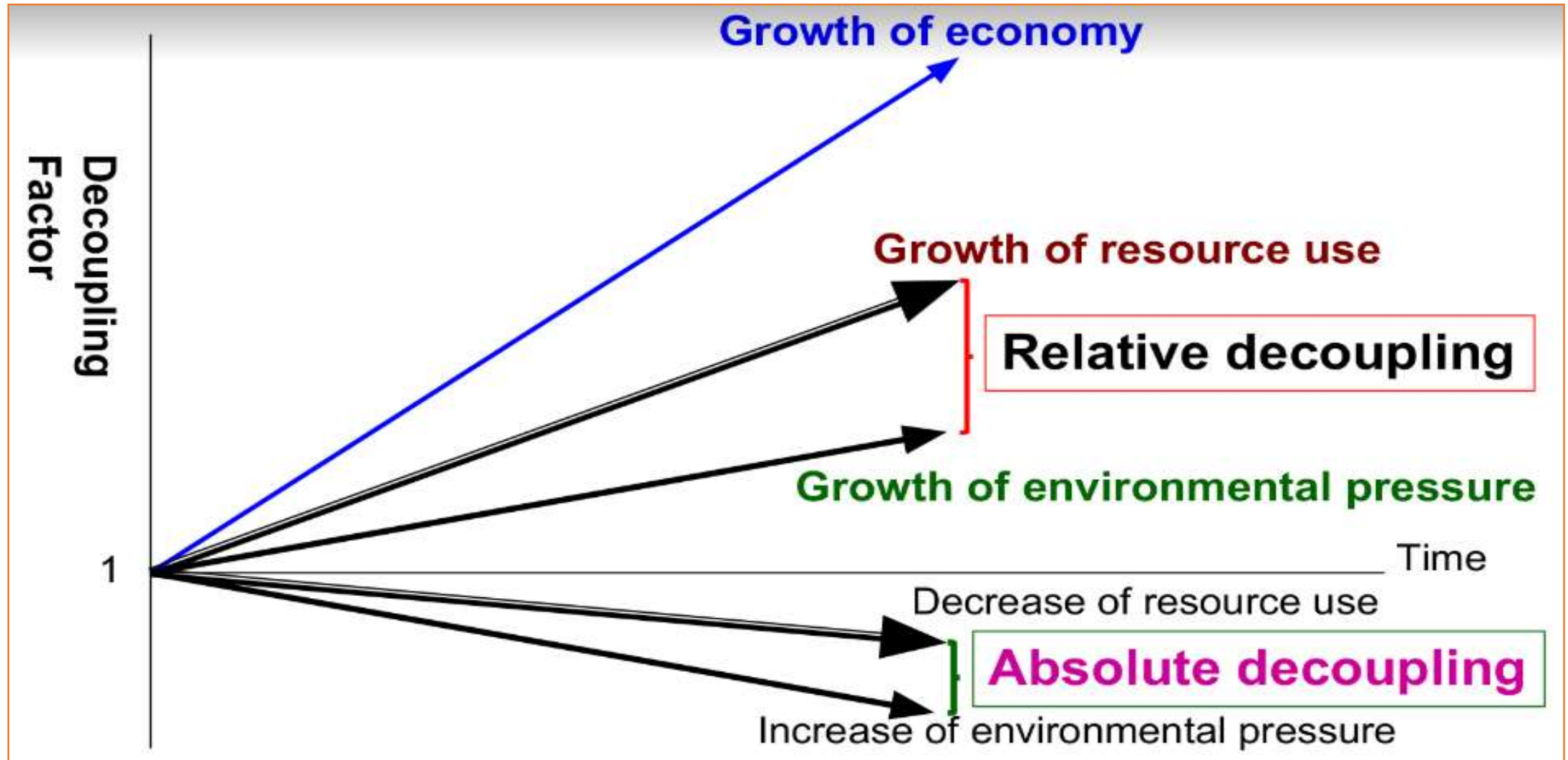


DECOUPLING (Ayrışma)?

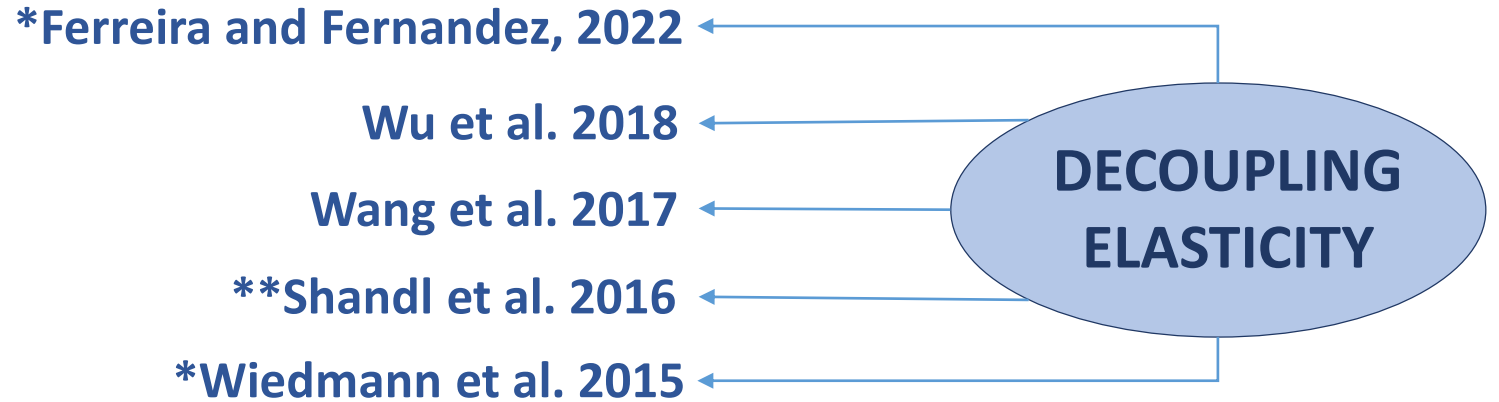
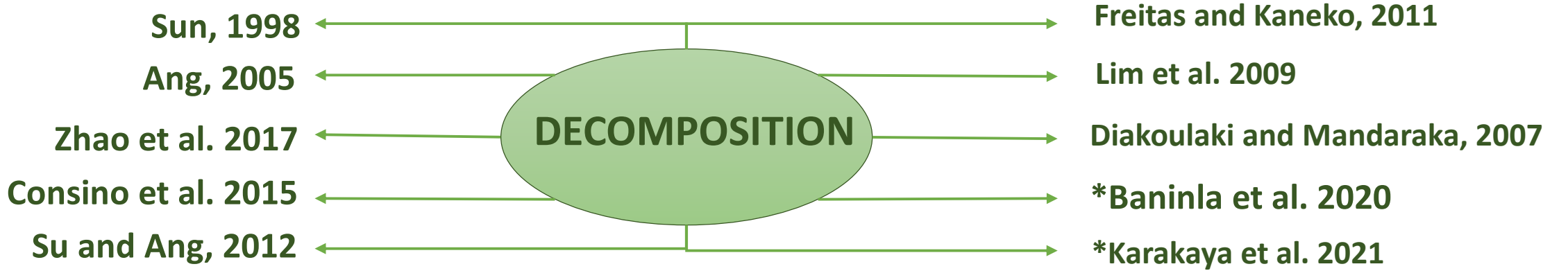
Çevresel baskılar ile ekonomik büyüme arasındaki ayrışmayı sağlamak anlamında kullanılmaktadır.

Sürdürülebilir kalkınmanın gerçekleştirilmesinde OECD çevre stratejilerinin ana hedeflerinden biridir.

DECOUPLING TÜRLERİ?



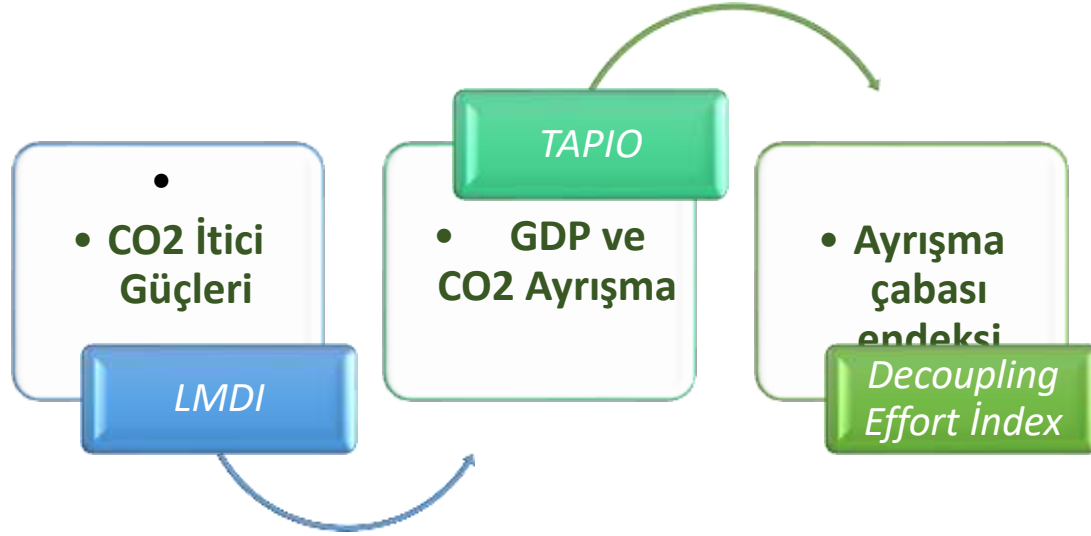
LİTERATÜR



*malzeme

**malzeme ve enerji ile ilgili çalışmalar

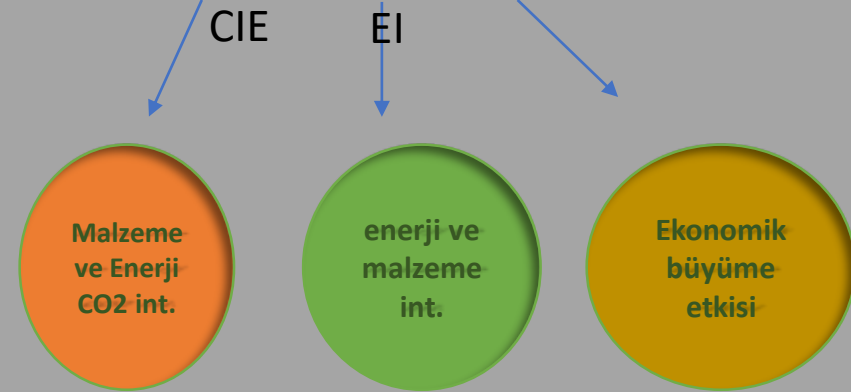
Model



• LMDI

$$CO_2 = \frac{CIM}{MC} \times \frac{MI}{GDP} \times \frac{ACT}{POP} \times POP$$

$$CO_2 = \frac{CO_2}{EC} \times \frac{EC}{GDP} \times \frac{GDP}{POP} \times POP$$



TAPIO ve Decoupling Effort Index (DEI)

• TAPIO model

$$\bullet \quad \varepsilon_{CO_2, GDP} = \frac{\Delta CO_2 / CO_2}{\Delta GDP / GDP} = \frac{\frac{\Delta CIM + \Delta MI + \Delta ACT + \Delta POP}{CO_2}}{\frac{\Delta GDP}{GDP}}$$

$$\bullet \quad = \frac{\frac{\Delta CIM}{CO_2}}{\frac{\Delta GDP}{GDP}} + \frac{\frac{\Delta MI}{CO_2}}{\frac{\Delta GDP}{GDP}} + \frac{\frac{\Delta ACT}{CO_2}}{\frac{\Delta GDP}{GDP}} + \frac{\frac{\Delta POP}{CO_2}}{\frac{\Delta GDP}{GDP}}$$

$$\bullet \quad = \Delta \varepsilon_{CIM} + \Delta \varepsilon_{MI} + \Delta \varepsilon_{ACT} + \Delta \varepsilon_{POP}$$

$$\bullet \quad \varepsilon_{CO_2, GDP} = \frac{\Delta CO_2 / CO_2}{\Delta GDP / GDP} = \frac{\frac{\Delta CIE + \Delta EI + \Delta ACT + \Delta POP}{CO_2}}{\frac{\Delta GDP}{GDP}}$$

$$\bullet \quad = \frac{\frac{\Delta CIE}{CO_2}}{\frac{\Delta GDP}{GDP}} + \frac{\frac{\Delta EI}{CO_2}}{\frac{\Delta GDP}{GDP}} + \frac{\frac{\Delta ACT}{CO_2}}{\frac{\Delta GDP}{GDP}} + \frac{\frac{\Delta POP}{CO_2}}{\frac{\Delta GDP}{GDP}}$$

$$\bullet \quad = \Delta \varepsilon_{CIE} + \Delta \varepsilon_{EI} + \Delta \varepsilon_{ACT} + \Delta \varepsilon_{POP}$$

• DEI Model

$$\bullet \quad \Delta CO_{2,Z} = \Delta CO_2 - \Delta ACT = \Delta CIM + \Delta MI + \Delta POP$$

$$\bullet \quad \Delta CO_{2,Z} = \Delta CO_2 - \Delta ACT = \Delta CIE + \Delta EI + \Delta POP$$

$$\bullet \quad \delta = -\frac{\Delta CO_{2,Z}}{\Delta GP} = -\frac{\Delta CIM}{\Delta ACT} - \frac{\Delta MI}{\Delta ACT} - \frac{\Delta POP}{\Delta ACT}$$

$$\bullet \quad = \delta_{CIM} + \delta_{MI} + \delta_{POP}$$

$$\bullet \quad \delta = -\frac{\Delta CO_{2,Z}}{\Delta ACT} = -\frac{\Delta CIE}{\Delta ACT} - \frac{\Delta EI}{\Delta ACT} - \frac{\Delta POP}{\Delta ACT}$$

$$\bullet \quad = \delta_{CIE} + \delta_{EI} + \delta_{POP}$$

Data

Table 1: Information about data

Data	Source	Unit
Energy-related CO_2 emissions	British Petroleum (BP)	million tonnes
Primary Energy Consumption	British Petroleum (BP)	TWh
Domestic Material Consumption	Global Material Flows	t
Gross Domestic Product	World Bank	constant 2015 US\$
Population	World Bank	total

ÜLKE ADI	ULUSLARARASI ÜLKE KODU
AUSTRALIA	AUS
BRAZIL	BRA
CANADA	CAN
CHINA	CHN
GERMANY	DEU
INDIA	IND
INDONESIA	IDN
IRAN	IRN
ITALY	ITA
JAPAN	JPN
MEXICO	MEX
POLAND	POL
RUSSIAN FEDERATION	RUS
SAUDI ARABIA	SAU
SOUTH AFRICA	ZAF
SOUTH KOREA	KOR
TURKEY	TUR
UNITED KINGDOM	GBR
UNITED STATES	USA

Figure 1: 1990-2019

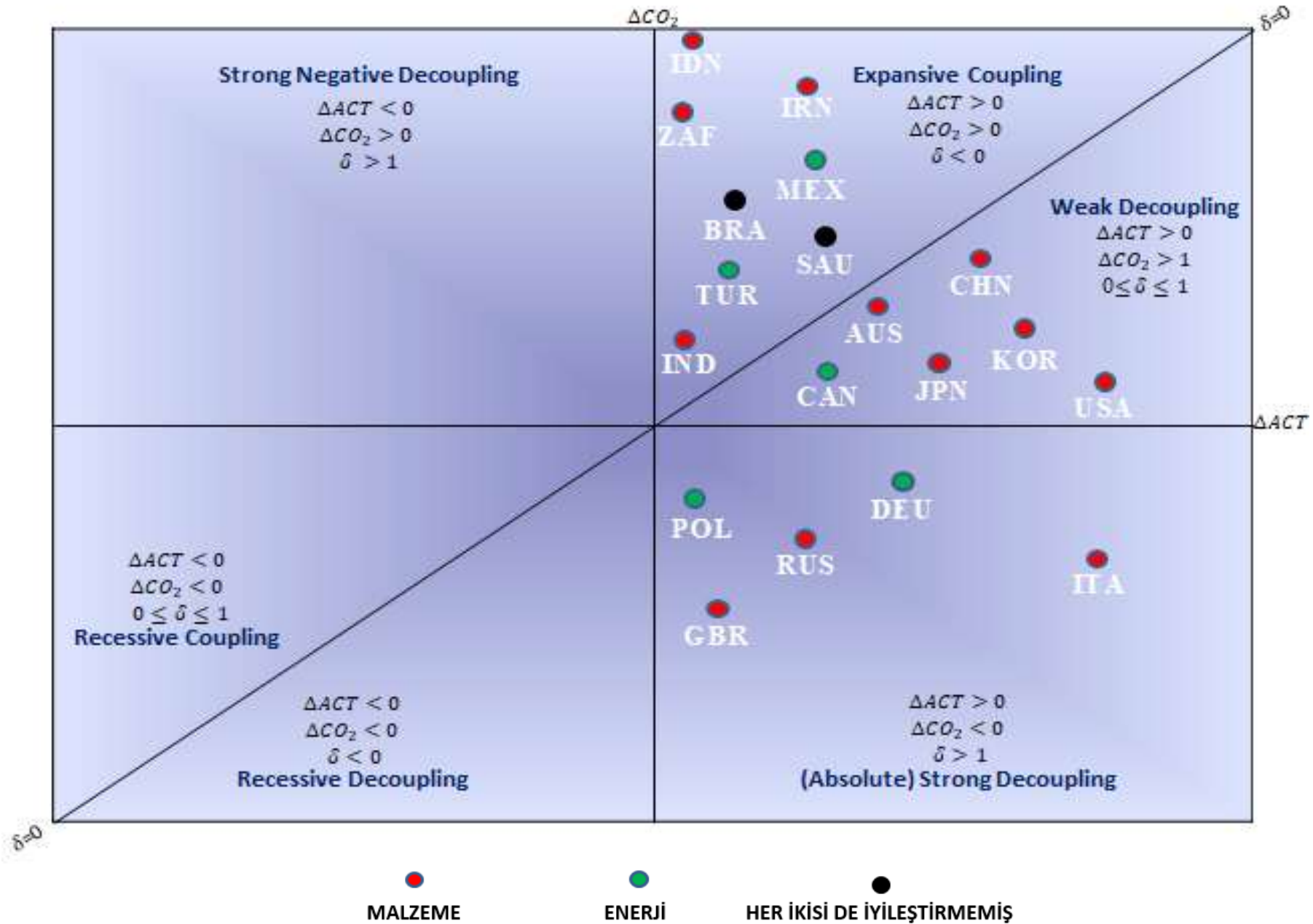


Figure 2: 1990-1995

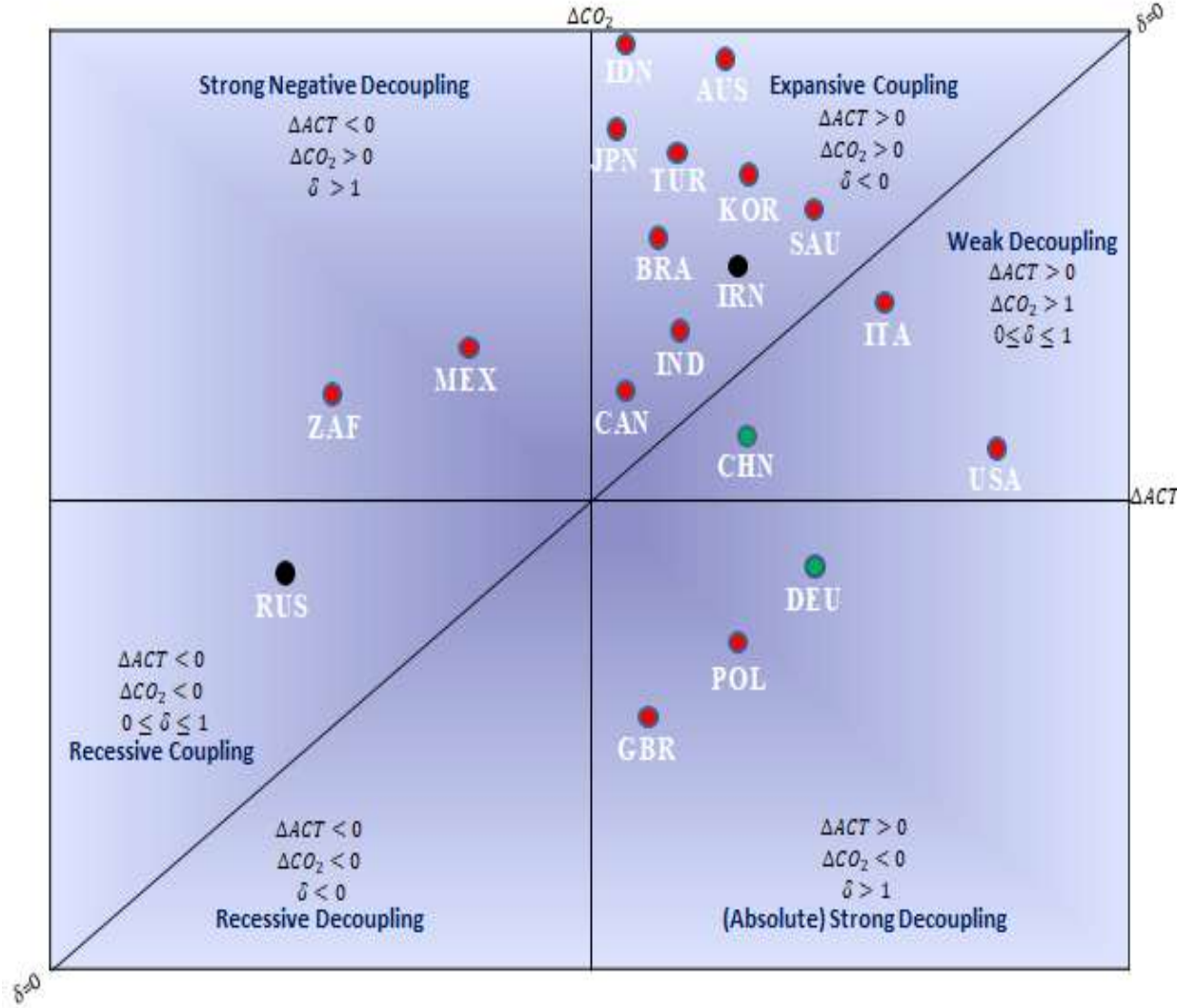
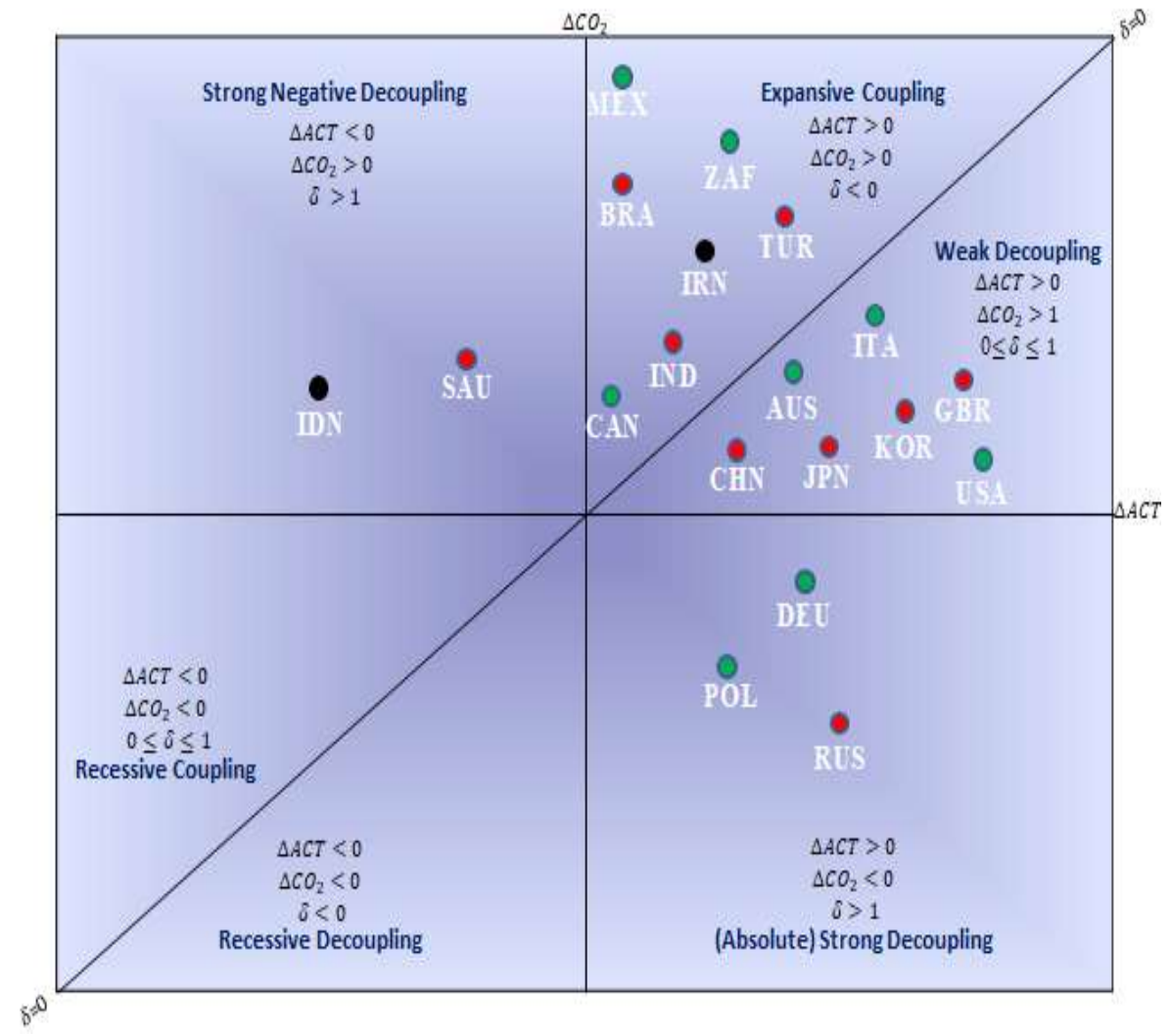


Figure 3: 1995-2000



MALZEME

ENERJİ

HER İKİSİ DE İYİLEŞTİRMEMİŞ

Figure 4: 2000-2005

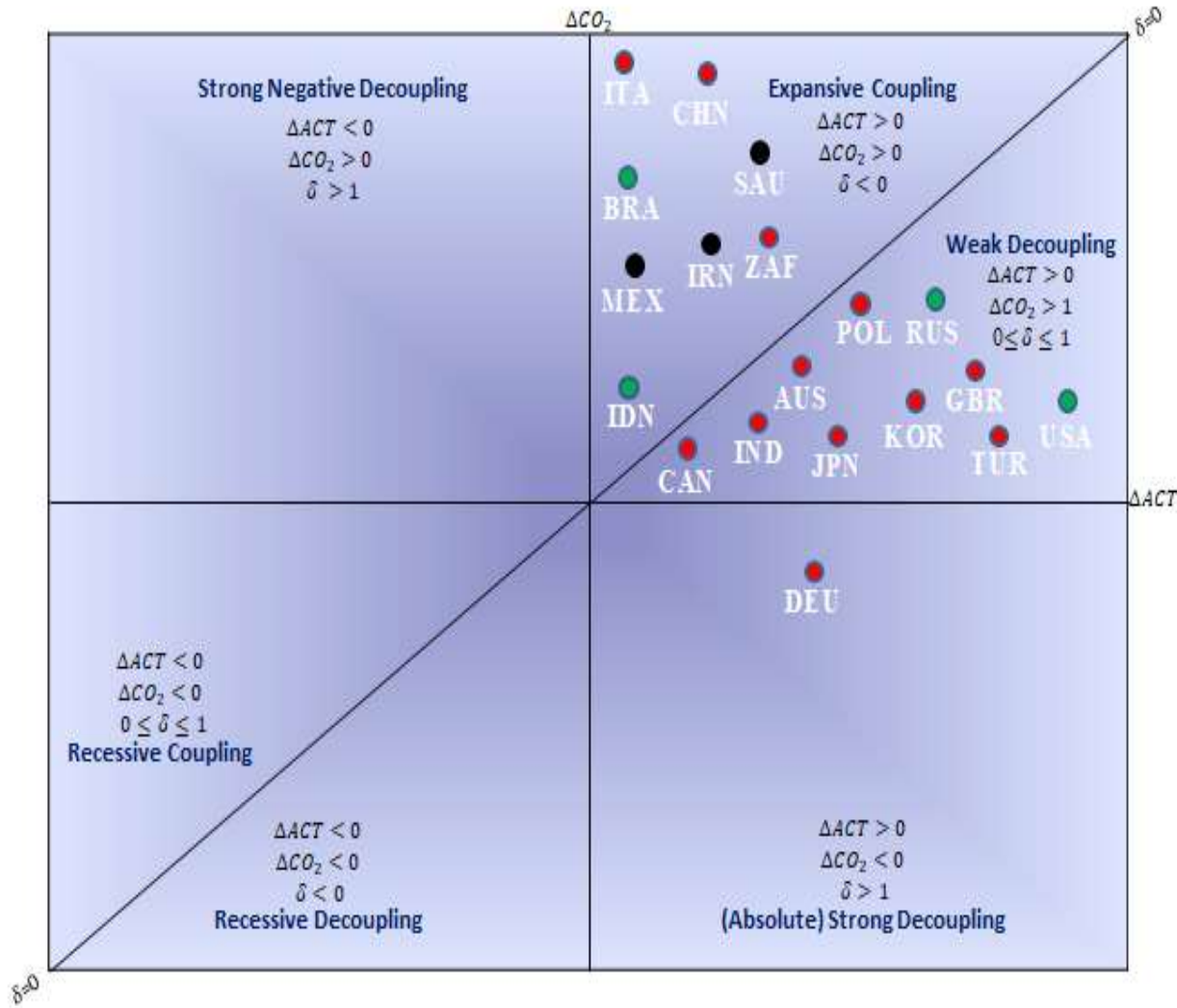
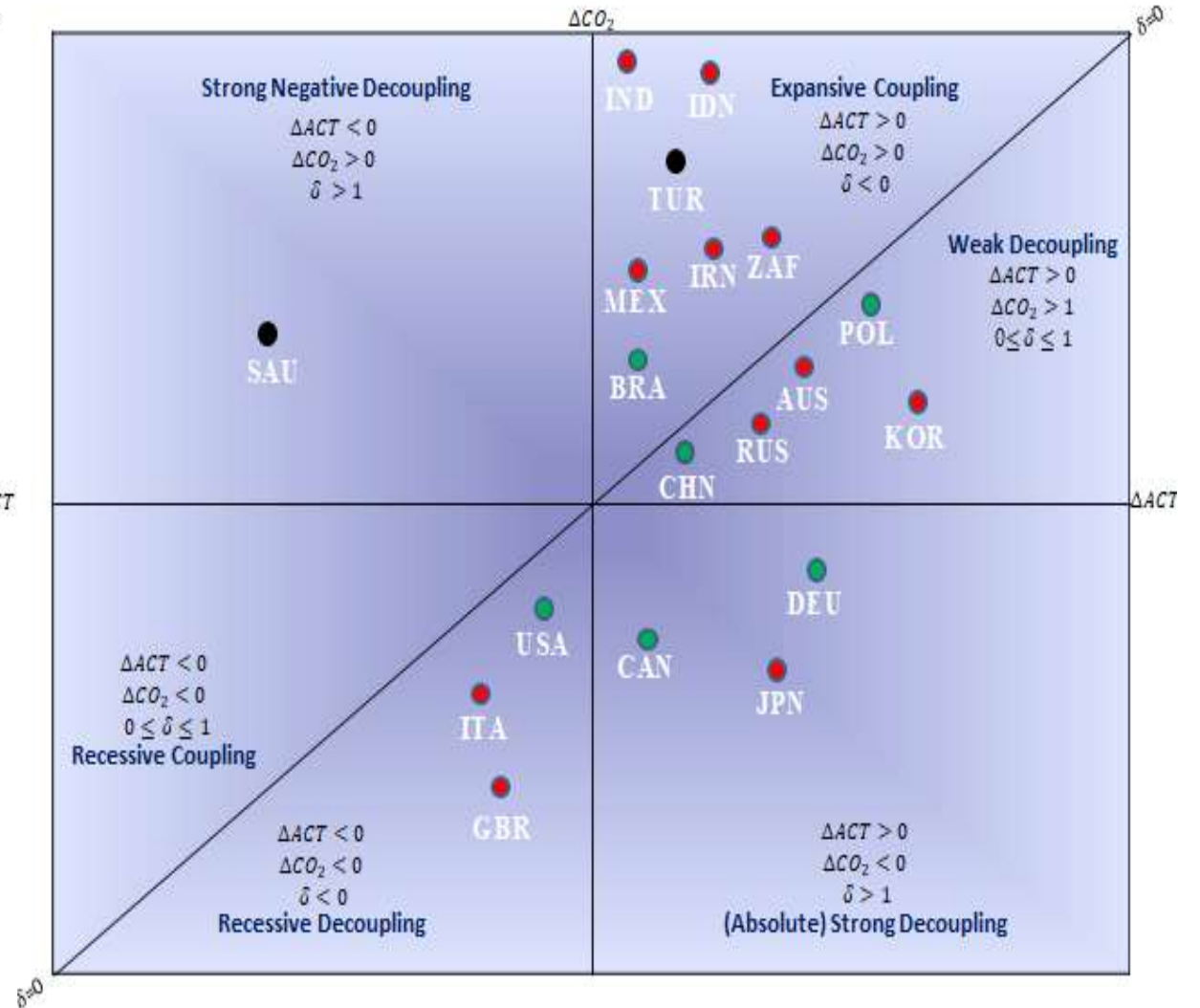


Figure 5: 2005-2010



HER İKİSİ DE İYİLEŞTİRMEMİŞ

Figure 6: 2010-2015

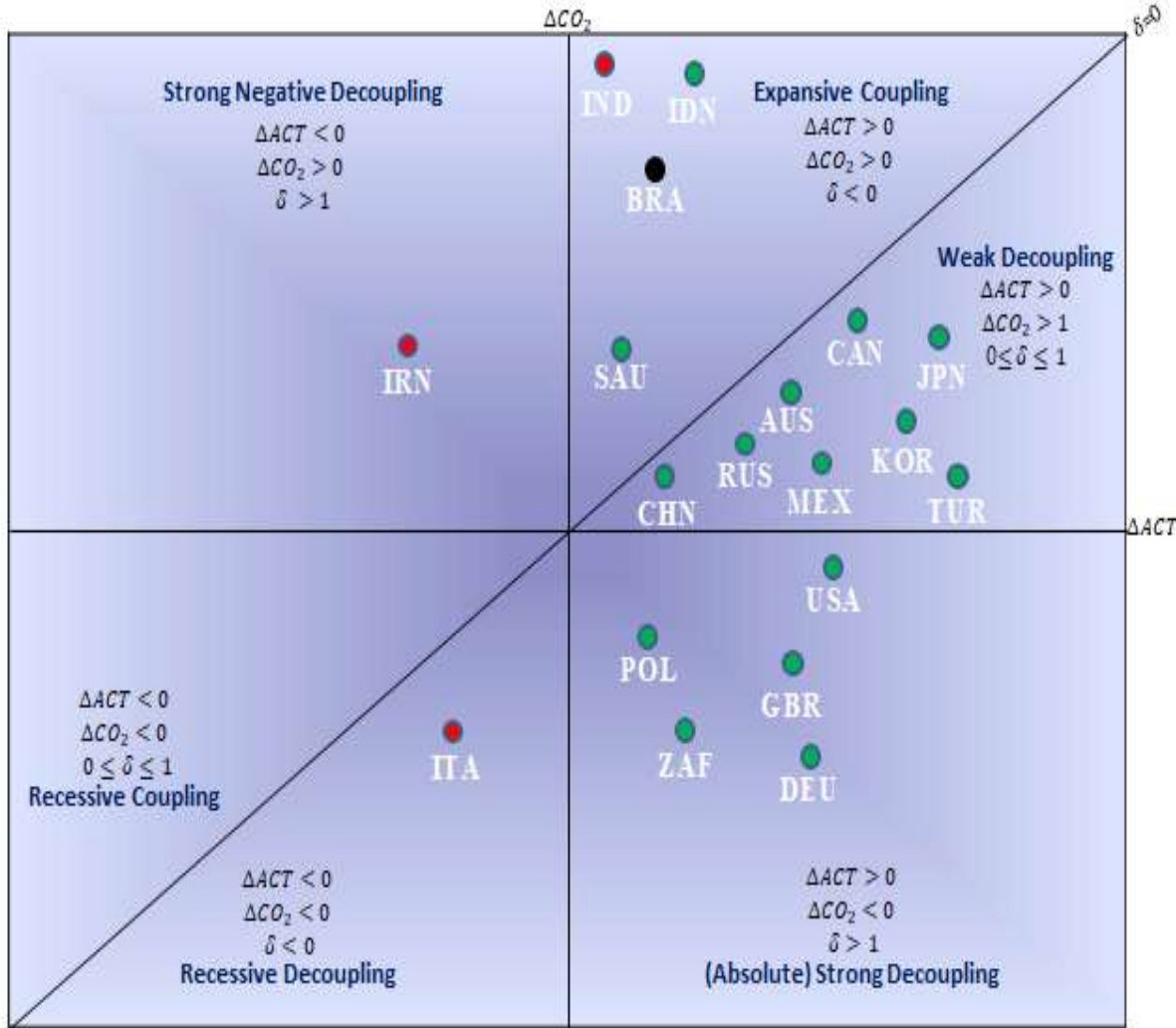
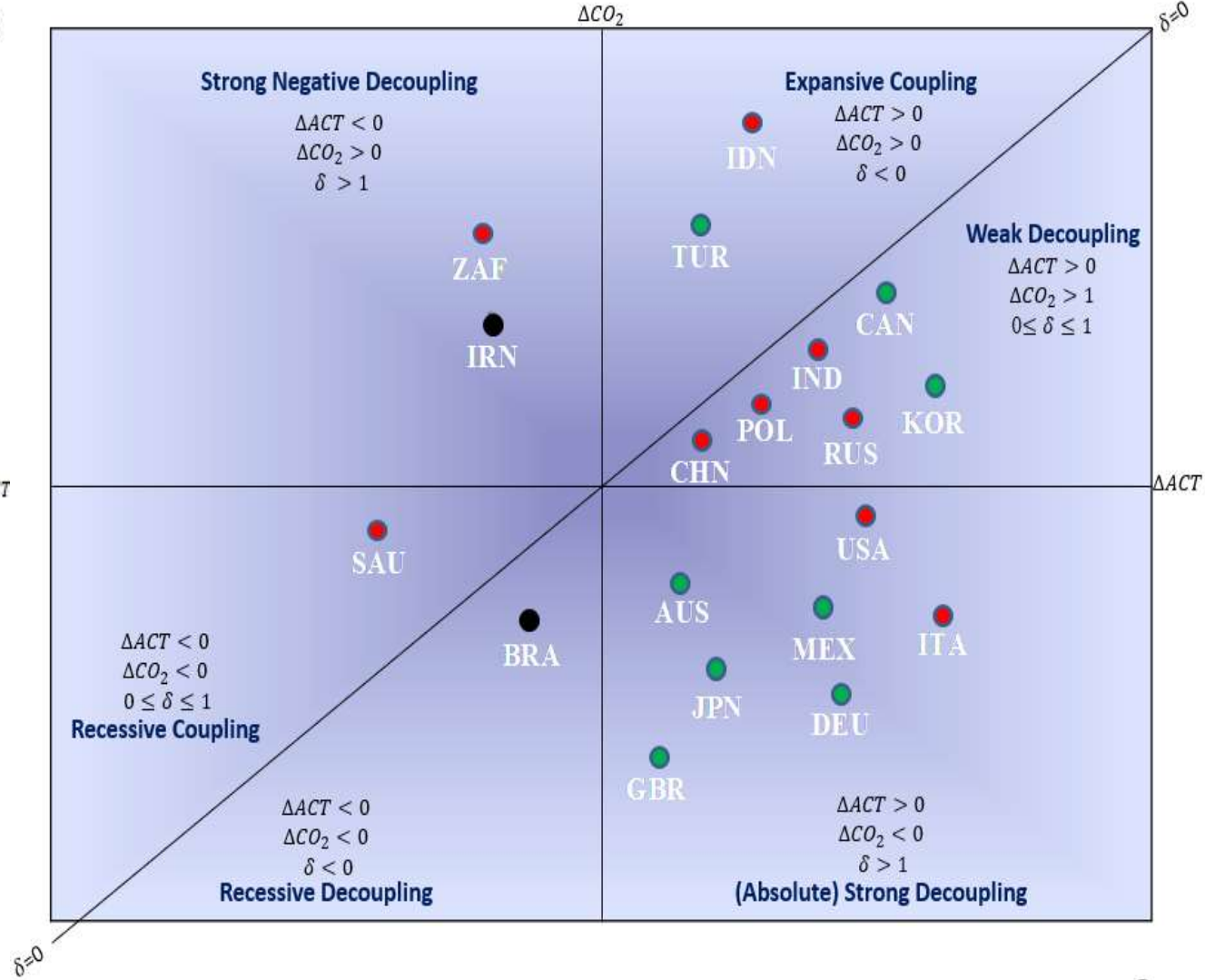


Figure 7: 2015-2019



● MALZEME

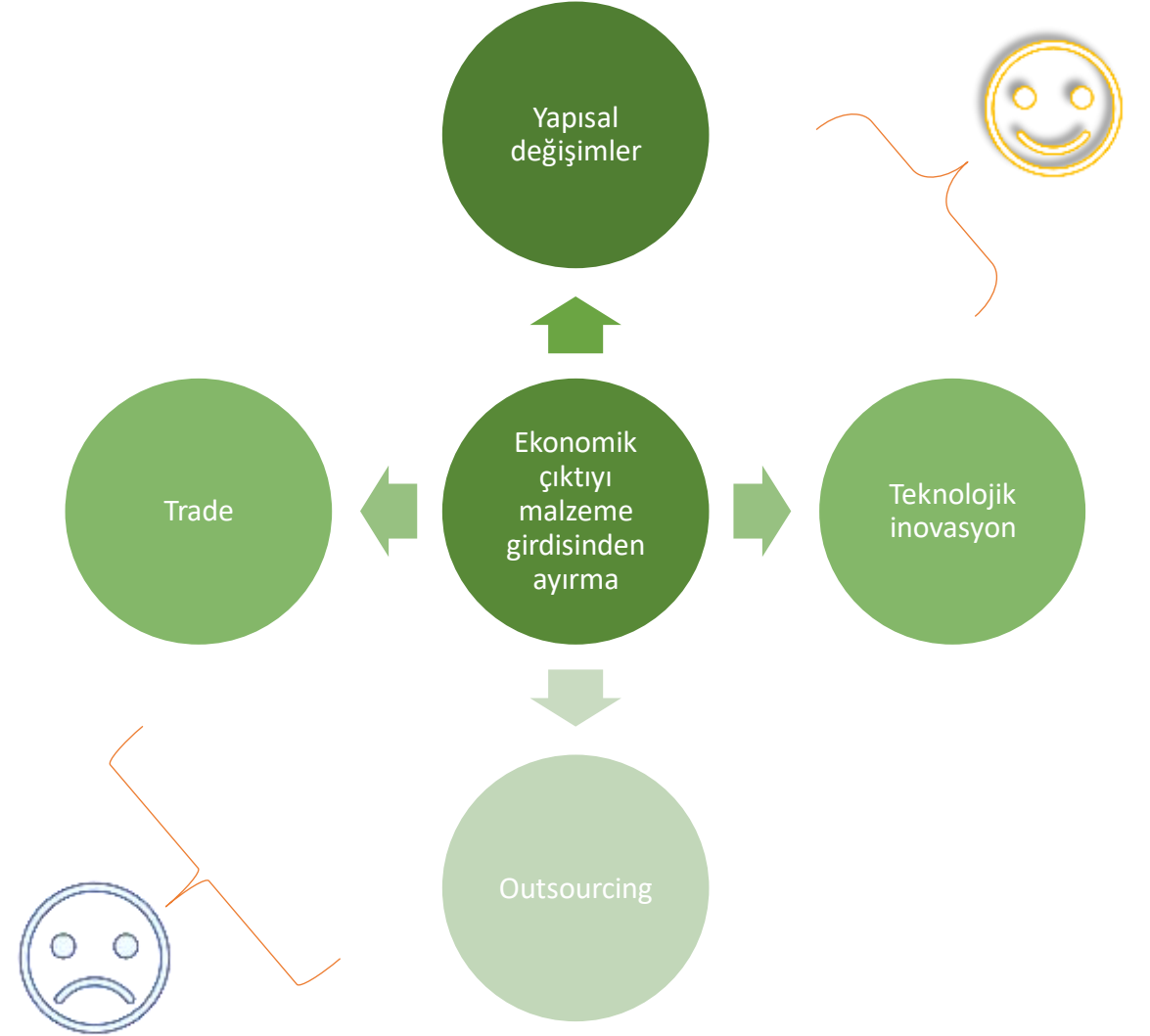
● ENERJİ

● HER İKİSİ DE İYİLEŞTİRMEMİŞ

SONUÇ

- Enerjinin yanı sıra malzeme verimliliğin sağlanması GSYİH ile CO2 ayrışmasında önemli rol oynamaktadır..

- Sürdürülebilir bir çevre
- Sürdürülebilir kalkınma açısından büyük önem arz etmektedir..



**DİNLEDİĞİNİZ İÇİN TEŞEKKÜR
EDERİM...**

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Decomposition Analiz Sonuçları (China)

		China					decomposition check											
		ΔCEC	ΔEG	ΔGP	ΔP	TOTAL							decoupling check					
							δC_{cec}	δC_{eg}	δC_p	DEI	$DI=(CO_2, G) \epsilon C_{cec} \quad \epsilon C_{eg} \quad \epsilon C_{gp} \quad \epsilon C_p$							
ENERGY IMPACT	1990-2019	-762,25	-5380,6	12582,6	1119,91	7559,73	1990-2019	0,06058	0,42762	-0,089	0,39919	1990-2019	0,25352	-0,0256	-0,1804	0,42197	0,03756	
	1990-1995	0,00729	-827,8	1370,71	157,458	700,371	1990-1995	-5E-06	0,60392	-0,1149	0,48905	1990-1995	0,38761	4E-06	-0,4581	0,75861	0,08714	
	1995-2000	-81,766	-909,46	1161,73	148,321	318,821	1995-2000	0,07038	0,78285	-0,1277	0,72556	1995-2000	0,20671	-0,053	-0,5897	0,75321	0,09617	
	2000-2005	116,168	500,93	1988	146,181	2751,28	2000-2005	-0,0584	-0,252	-0,0735	-0,3839	2000-2005	1,38756	0,05859	0,25264	1,00262	0,07372	
	2005-2010	-225,95	-1509,9	3596,81	181,455	2042,43	2005-2010	0,06282	0,41978	-0,0504	0,43216	2005-2010	0,47395	-0,0524	-0,3504	0,83465	0,04211	
	2010-2015	-570,18	-1628,9	3034,88	268,759	1104,51	2010-2015	0,18787	0,53674	-0,0886	0,63606	2010-2015	0,2929	-0,1512	-0,432	0,8048	0,07127	
	2015-2019	-460,16	-1345,7	2257,23	190,943	642,323	2015-2019	0,20386	0,59617	-0,0846	0,71544	2015-2019	0,23808	-0,1706	-0,4988	0,83664	0,07077	
		decomposition check					decomposition check											
		ΔCMC	ΔMCG	ΔGP	ΔP	TOTAL	δCMC	δMCG	δP	DEI	$DI=(CO_2, G) \epsilon C_{cmc} \quad \epsilon C_{mcg} \quad \epsilon C_{gp} \quad \epsilon C_p$							
MATERIAL IMPACT	1990-2019	-438,27	-5704,5	12582,6	1119,91	7559,73	1990-2019	0,03483	0,45337	-0,089	0,39919	1990-2019	0,25352	-0,0147	-0,1913	0,42197	0,03756	
	1990-1995	-472,47	-355,33	1370,71	157,458	700,371	1990-1995	0,34469	0,25923	-0,1149	0,48905	1990-1995	0,38761	-0,2615	-0,1967	0,75861	0,08714	
	1995-2000	-43,907	-947,32	1161,73	148,321	318,821	1995-2000	0,03779	0,81544	-0,1277	0,72556	1995-2000	0,20671	-0,0285	-0,6142	0,75321	0,09617	
	2000-2005	1174,45	-557,36	1988	146,181	2751,28	2000-2005	-0,5908	0,28036	-0,0735	-0,3839	2000-2005	1,38756	0,59232	-0,2811	1,00262	0,07372	
	2005-2010	-909,77	-826,06	3596,81	181,455	2042,43	2005-2010	0,25294	0,22967	-0,0504	0,43216	2005-2010	0,47395	-0,2111	-0,1917	0,83465	0,04211	
	2010-2015	-666,92	-1532,2	3034,88	268,759	1104,51	2010-2015	0,21975	0,50486	-0,0886	0,63606	2010-2015	0,2929	-0,1769	-0,4063	0,8048	0,07127	
	2015-2019	545,848	-2351,7	2257,23	190,943	642,323	2015-2019	-0,2418	1,04185	-0,0846	0,71544	2015-2019	0,23808	0,20232	-0,8717	0,83664	0,07077	

Decomposition Analiz Sonuçları (Germany)

		Germany																			
		decompositi	ΔCEC	ΔEG	ΔGP	ΔP	TOTAL						δC_{cec}	δC_{eg}	δC_p	DEI	$DI=(CO_2, C$	ϵC_{cec}	ϵC_{eg}	ϵC_{gp}	ϵC_p
		1990-2019	-208,96	-473,52	317,42	37,5293	-327,53	1990-2019	0,6583	1,49178	-0,1182	2,03185	1990-2019	-0,612	-0,3904	-0,8847	0,59306	0,07012			
		1990-1995	-67,151	-143,9	66,4438	26,4015	-118,2	1990-1995	1,01064	2,16573	-0,3974	2,77902	1990-1995	-1,1392	-0,6472	-1,3868	0,64036	0,25445			
		1995-2000	-38	-78,167	75,5184	5,67539	-34,973	1995-2000	0,50319	1,03507	-0,0752	1,4631	1995-2000	-0,4028	-0,4377	-0,9004	0,8699	0,06537			
ENERGY IMPACT		2000-2005	-19,738	-30,758	19,7536	2,63205	-28,111	2000-2005	0,99921	1,5571	-0,1332	2,42307	2000-2005	-1,2186	-0,8556	-1,3334	0,85632	0,1141			
		2005-2010	-16,53	-73,821	53,9811	-6,7843	-43,154	2005-2010	0,30622	1,36753	0,12568	1,79943	2005-2010	-0,8644	-0,3311	-1,4787	1,08127	-0,1359			
		2010-2015	-10,139	-81,791	65,2478	-0,8501	-27,532	2010-2015	0,15539	1,25355	0,01303	1,42196	2010-2015	-0,4026	-0,1483	-1,1961	0,95421	-0,0124			
		2015-2019	-56,742	-66,062	35,0071	12,2424	-75,555	2015-2019	1,62088	1,88711	-0,3497	3,15827	2015-2019	-1,4683	-1,1027	-1,2838	0,6803	0,23791			
		decomposition check																			
			ΔCMC	ΔMCG	ΔGP	ΔP	TOTAL	δCMC	δMCG	δP	DEI	$DI=(CO_2, C$	ϵC_{cmc}	ϵC_{mcg}	ϵC_{gp}	ϵC_p					
		1990-2019	-309,13	-373,35	317,42	37,5293	-327,53	1990-2019	0,97387	1,17621	-0,1182	2,03185	1990-2019	-0,612	-0,5776	-0,6976	0,59306	0,07012			
		1990-1995	-270,47	59,4235	66,4438	26,4015	-118,2	1990-1995	4,07071	-0,8943	-0,3974	2,77902	1990-1995	-1,1392	-2,6067	0,5727	0,64036	0,25445			
MATERIAL IMPACT		1995-2000	-66,729	-49,437	75,5184	5,67539	-34,973	1995-2000	0,88361	0,65464	-0,0752	1,4631	1995-2000	-0,4028	-0,7687	-0,5695	0,8699	0,06537			
		2000-2005	199,011	-249,51	19,7536	2,63205	-28,111	2000-2005	-10,075	12,631	-0,1332	2,42307	2000-2005	-1,2186	8,62714	-10,816	0,85632	0,1141			
		2005-2010	-93,061	2,70969	53,9811	-6,7843	-43,154	2005-2010	1,72395	-0,0502	0,12568	1,79943	2005-2010	-0,8644	-1,8641	0,05428	1,08127	-0,1359			
		2010-2015	-24,571	-67,359	65,2478	-0,8501	-27,532	2010-2015	0,37658	1,03236	0,01303	1,42196	2010-2015	-0,4026	-0,3593	-0,9851	0,95421	-0,0124			
		2015-2019	-70,424	-52,38	35,0071	12,2424	-75,555	2015-2019	2,01171	1,49628	-0,3497	3,15827	2015-2019	-1,4683	-1,3686	-1,0179	0,6803	0,23791			

Decomposition Analiz Sonuçları (Turkey)

TURKEY		decomposition check										decouplin					
		ΔCEC	ΔEG	ΔGP	ΔP	TOTAL		δC_{cec}	δC_{eg}	δC_p	DEI		$DI=(CO_2, C_{cec}$	ϵC_{eg}	ϵC_{gp}	ϵC_p	
	1990-2019	-31,763	-15,396	192,854	104,792	250,487	1990-2019	0,1647	0,07983	-0,5434	-0,2988	1990-2019	0,74901	-0,095	-0,046	0,57668	0,31335
	1990-1995	-9,6635	11,0939	11,3916	12,0535	24,8754	1990-1995	0,8483	-0,9739	-1,0581	-1,1837	1990-1995	1,06627	-0,4142	0,47553	0,4883	0,51667
	1995-2000	8,2769	-0,5377	22,5775	14,2613	44,578	1995-2000	-0,3666	0,02382	-0,6317	-0,9744	1995-2000	1,23699	0,22967	-0,0149	0,6265	0,39573
ENERGY IMPACT	2000-2005	-11,355	-20,898	36,0772	15,3048	19,1291	2000-2005	0,31475	0,57925	-0,4242	0,46977	2000-2005	0,3447	-0,2046	-0,3766	0,65009	0,27579
	2005-2010	-6,8592	19,3951	23,1846	15,7572	51,4777	2005-2010	0,29585	-0,8366	-0,6796	-1,2203	2005-2010	1,35655	-0,1808	0,5111	0,61096	0,41524
	2010-2015	-9,5254	-31,203	79,7146	25,2847	64,2704	2010-2015	0,11949	0,39144	-0,3172	0,19374	2010-2015	0,57112	-0,0846	-0,2773	0,70836	0,22468
	2015-2019	-0,4524	-5,437	30,0637	21,9821	46,1563	2015-2019	0,01505	0,18085	-0,7312	-0,5353	2015-2019	0,87952	-0,0086	-0,1036	0,57287	0,41887
		decomposition check											decoupling check				
		ΔCMC	ΔMCG	ΔGP	ΔP	TOTAL		δCMC	δMCG	δP	DEI		$DI=(CO_2, C_{cmc}$	ϵC_{mcg}	ϵC_{gp}	ϵC_p	
	1990-2019	-69,547	22,3876	192,854	104,792	250,487	1990-2019	0,36062	-0,1161	-0,5434	-0,2988	1990-2019	0,74901	-0,208	0,06694	0,57668	0,31335
	1990-1995	5,14693	-3,7166	11,3916	12,0535	24,8754	1990-1995	-0,4518	0,32626	-1,0581	-1,1837	1990-1995	1,06627	0,22062	-0,1593	0,4883	0,51667
MATERIAL IMPACT	1995-2000	23,3081	-15,569	22,5775	14,2613	44,578	1995-2000	-1,0324	0,68958	-0,6317	-0,9744	1995-2000	1,23699	0,64677	-0,432	0,6265	0,39573
	2000-2005	-6,5017	-25,751	36,0772	15,3048	19,1291	2000-2005	0,18022	0,71378	-0,4242	0,46977	2000-2005	0,3447	-0,1172	-0,464	0,65009	0,27579
	2005-2010	-72,5	85,0359	23,1846	15,7572	51,4777	2005-2010	3,12708	-3,6678	-0,6796	-1,2203	2005-2010	1,35655	-1,9105	2,24088	0,61096	0,41524
	2010-2015	-39,63	-1,0985	79,7146	25,2847	64,2704	2010-2015	0,49715	0,01378	-0,3172	0,19374	2010-2015	0,57112	-0,3522	-0,0098	0,70836	0,22468
	2015-2019	-0,919	-4,9705	30,0637	21,9821	46,1563	2015-2019	0,03057	0,16533	-0,7312	-0,5353	2015-2019	0,87952	-0,0175	-0,0947	0,57287	0,41887

Decomposition Analiz Sonuçları (US)

		US																	
		decomposition check										decouplin							
		ΔCEC	ΔEG	ΔGP	ΔP	TOTAL						δC_{cec}	δC_{eg}	δC_p	DEI	$DI=(CO_2, C_{cec} \epsilon C_{cec} \epsilon C_{eg} \epsilon C_{gp} \epsilon C_p$			
ENERGY IMPACT	1990-2019	-777,51	-2742,6	2166,89	1363,68	10,4566	1990-2019	0,35881	1,26569	-0,6293	0,99517	1990-2019	0,00204	-0,1514	-0,5341	0,42198	0,26557		
	1990-1995	-118,48	-269,93	316,538	329,282	257,402	1990-1995	0,37431	0,85277	-1,0403	0,18682	1990-1995	0,38345	-0,1765	-0,4021	0,47155	0,49053		
	1995-2000	35,343	-680,34	840,252	317,539	512,791	1995-2000	-0,0421	0,80969	-0,3779	0,38972	1995-2000	0,41697	0,02874	-0,5532	0,68324	0,2582		
	2000-2005	54,4089	-660,68	470,244	268,513	132,488	2000-2005	-0,1157	1,40497	-0,571	0,71826	2000-2005	0,17011	0,06986	-0,8483	0,60376	0,34475		
	2005-2010	-177,04	-465,84	-3,8823	259,305	-387,45	2005-2010	-45,6	-119,99	66,7911	-98,798	2005-2010	-1,4336	-0,655	-1,7236	-0,0144	0,95942		
	2010-2015	-300,83	-628,83	389,051	192,361	-348,25	2010-2015	0,77324	1,61631	-0,4944	1,89512	2010-2015	-0,5486	-0,4739	-0,9906	0,61286	0,30302		
	2015-2019	-308,58	-302,74	336,464	118,332	-156,53	2015-2019	0,91713	0,89979	-0,3517	1,46522	2015-2019	-0,3239	-0,6385	-0,6265	0,69623	0,24486		
		decomposition check										decoupling check							
		ΔCMC	ΔMCG	ΔGP	ΔP	TOTAL						δCMC	δMCG	δP	DEI	$DI=(CO_2, C_{cmc} \epsilon C_{cmcg} \epsilon C_{gp} \epsilon C_p$			
MATERIAL IMPACT	1990-2019	-251,02	-3269,1	2166,89	1363,68	10,4566	1990-2019	0,11584	1,50866	-0,6293	0,99517	1990-2019	0,00204	-0,0489	-0,6366	0,42198	0,26557		
	1990-1995	-27,776	-360,64	316,538	329,282	257,402	1990-1995	0,08775	1,13933	-1,0403	0,18682	1990-1995	0,38345	-0,0414	-0,5372	0,47155	0,49053		
	1995-2000	-191,4	-453,6	840,252	317,539	512,791	1995-2000	0,22778	0,53984	-0,3779	0,38972	1995-2000	0,41697	-0,1556	-0,3688	0,68324	0,2582		
	2000-2005	-171,47	-434,79	470,244	268,513	132,488	2000-2005	0,36465	0,92462	-0,571	0,71826	2000-2005	0,17011	-0,2202	-0,5582	0,60376	0,34475		
	2005-2010	955,069	-1597,9	-3,8823	259,305	-387,45	2005-2010	246,004	-411,59	66,7911	-98,798	2005-2010	-1,4336	3,53374	-5,9123	-0,0144	0,95942		
	2010-2015	-633,53	-296,13	389,051	192,361	-348,25	2010-2015	1,62839	0,76116	-0,4944	1,89512	2010-2015	-0,5486	-0,998	-0,4665	0,61286	0,30302		
	2015-2019	-149,02	-462,31	336,464	118,332	-156,53	2015-2019	0,4429	1,37402	-0,3517	1,46522	2015-2019	-0,3239	-0,3084	-0,9566	0,69623	0,24486		