The GTAP Energy Data Set

Presented by
Huey-Lin Lee

Center for Global Trade Analysis (GTAP)

Purdue University

Based on McDougall and Lee (2006): Chapter 17 of the GTAP Ver. 6 Data Base Documentation

Available at:
https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1951

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Why having special treatment for energy in GTAP?

- **Users' concern about apparent divergences of energy data in earlier GTAP releases from International Energy Agency (*IEA*) data**
  - **Babiker and Rutherford (1997)**
- **IEA Energy Balances, Prices/Taxes data and from other sources (e.g., ADB, TEDDY)**
  - **E\$ = EV * (EP + ET)**
- **Modify the I-O, tariff, and trade data of energy in GTAP.**

Energy data items in GTAP DB

- **Money value: as in the I-O, adjusted.**
- **Physical unit flows: gsdvole.har**
  - **Based on the IEA Extended Energy Balances**
- **Energy consumption**
  - **Unit: mote**
  - **6 energy commodities (EGY): coal, oil, nat. gas, petroleum prod., electricity, gas distribution.**
  - **87 regions (REG)**
  - **57 producing sectors: header "EVF"**
  - **1 household sector: header "EVH"**
- **Bilateral energy trade**
  - **Unit: mtoe**
  - **EGY * REG * REG**
  - **Header "EVT"**

Energy related modules in the GTAP DB construction procedure

- **Starting from GTAP v4-E by R. McDougall**
  - Sponsored by U.S. DOE
- **Energy Module: to assemble E$**
- **Fit-E Module: to fit I-O Tables to E$**
- **Sometimes the construction procedure aborted**
  - Need special treatment
  - E.g., Russia, commodity tax
  - Research Memorandum: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1369

GTAP Energy Volume Data

File   Contents   Edit   Sets   Export   Import   History   Search   Aggregation   Programs   Help

	Header	Type	Dimension	Coeff	Name
1	DREL	1C	1 length 36		GTAP data release identifier
2	DVER	RE	1		Format of GTAP Data
3	EGY	1C	6 length 12		energy commodities
4	EVF	RE	EGY_COMM*TRAD_COMM*REG	EVF	volume of input purchases by firms (Mtoe)
5	EVH	RE	EGY_COMM*REG	EVH	volume of purchases by households (Mtoe)
6	EVT	RE	TEGY_COMM*REG*REG	EVT	volume of bilateral trade (Mtoe)

Double-Click on an item to view it (or arrow keys + space bar)

GTAP Energy Volume Data: Firm

File Contents Edit Sets Export Import History Search Aggregation Programs Help

None ▼ | 0 ▼ | | All EGY_COMM ▼ | All TRAD_COMM ▼ | 6 jpn ▼

EVF	31 ppp	32 p_c	33 crp	34 nmm	35 i_s	36 nfm	37 fmp	38 mvh	39 otn	40 ele	41 ome	42 omf	43 ely	44 gdt	45 wtr	46 cn
1 ecoa	1	44	1	5	1	0	0	0	0	0	0	0	46	0	0	
2 eoil	0	198	0	0	0	0	0	0	0	0	0	0	4	0	0	
3 egas	0	2	3	0	2	0	1	0	0	0	1	0	47	0	0	
4 ep_c	3	45	40	5	8	1	1	0	0	1	1	1	21	0	0	
5 eely	4	1	6	2	7	2	1	2	0	2	1	1	6	0	1	
6 egdt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	9	290	51	13	17	3	2	2	0	3	3	1	123	1	1	

EVF   Size: EGY_COMM * TRAD_COMM [* jpn] volume of input purchases by firms (Mtoe)

GTAP Energy Expenditure Data

BaseView.har in D:\C_dell\GTAP6fin\V6_UNAGG\gtp57_87

File   Contents   Edit   Sets   Export   Import   History   Search   Aggregation   Programs   Help

T | None ▼ | 0 ▼ | | 37 p_c | ▼ | All PROD_COMM ▼ | 6 jpn ▼ | All DIR ▼ | Sum PURCHVALUE ▼

NVFA	31 ppp	32 p_c	33 crp	34 nmm	35 i_s	36 nfm	37 fmp	38 mvh	39 otn	40 ele	41 ome	42 omf	43 ely	44
1 domestic	1599	9128	13098	2515	4031	672	228	9	3	340	324	246	5261	
2 imported	136	2170	7683	186	90	47	31	1	0	13	26	20	135	
Total	1735	11298	20781	2701	4121	719	260	10	3	353	350	266	5396	

SF01 Size: [p_c] * PROD_COMM [* jpn] * DIR [* Sum over PURCHVALUE] Cost structure of firms - VFA

GTAP Energy Volume Data: Household

File Contents Edit Sets Export Import History Search Aggregation Programs Help

None ▼ | 0 ▼ | | All EGY_COMM ▼ | 6 jpn ▼

EVH	EVH
1 ecoa	0
2 eoil	0
3 egas	4
4 ep_c	50
5 eely	23
6 egdt	3
Total	80

EVH   Size: EGY_COMM [* jpn] volume of purchases by households (Mtoe)

GTAP Bilateral Energy Volume Data: Import, by source

File Contents Edit Sets Export Import History Search Aggregation Programs Help

None ▼ 0 ▼   All TEGY_COMM ▼ All REG ▼ 6 jpn ▼

EVT	1 aus	2 nzl	3 xoc	4 chn	5 hkg	6 jpn	7 kor	8 twn	9 xea	10 idn	11 mys	12 phl	13 sgp	14 tha	15 vnm	16 xse	17 bgd	1
1 ecoa	59	1	0	17	0	0	0	0	0	11	0	0	0	0	1	0	0	
2 eoil	1	0	0	2	0	0	0	0	0	7	1	0	0	0	2	1	0	
3 egas	10	0	0	0	0	0	0	0	0	20	11	0	0	0	0	7	0	
4 ep_c	1	0	0	1	0	0	11	0	0	2	1	0	1	0	0	0	0	
5 eely	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	71	1	0	20	0	0	11	0	0	39	12	0	1	0	3	9	0	

EVT   Size: TEGY_COMM * REG [* jpn] volume of bilateral trade (Mtoe)

GTAP Bilateral Energy Trade Data: Import, by source

None ▼ | 0 ▼ | | 15 coa ▼ | All NREG ▼ | 6 jpn ▼ | All YRS ▼

FVTTS	28 Y1992	29 Y1993	30 Y1994	31 Y1995	32 Y1996	33 Y1997	34 Y1998	35 Y1999	36 Y2000	37 Y2001	38 Y2002	To
1 aus	3127	3125	2940	3272	3415	3523	3224	2445	3190	3647	3660	70
2 nzl	28	20	21	26	32	36	21	18	41	42	42	
3 xoc	0	0	0	0	0	0	0	0	0	0	0	
4 chn	299	292	302	369	472	541	485	393	500	859	1067	7
5 hkg	0	0	0	0	0	0	0	1	0	0	0	
6 jpn	0	0	0	0	0	0	0	0	0	0	0	
7 kor	0	0	0	0	0	0	1	0	0	0	0	
8 twn	0	0	1	0	0	0	0	0	0	0	0	
9 xea	18	20	17	17	19	18	15	9	12	14	12	
10 idn	243	278	348	450	508	489	497	353	454	572	640	5
11 mys	3	4	2	2	3	0	0	0	0	0	0	
12 phl	0	0	0	0	0	0	0	0	0	0	0	
13 sgp	0	0	0	0	0	0	0	0	0	0	0	
14 tha	0	0	0	0	0	0	1	0	0	0	0	

VTTS Size: [coa] * NREG [* jpn] * YRS Time Series Trade Data

Greenhouse Gases Emissions Data

- **CO_2 emissions:**
  - **Tier 1 method of the revised 1996 IPCC Guideline**
  - **Special treatment for non-emitting activities**
    - **Country-specific sectoral feedstock use ratios**
    - **Energy transformation: e.g., coal used to produce coal products**
- **CH_4, N_2O, and F-gases emissions:**
  - **IPCC Tier 1 and Tier 2 methods**
  - **Mapping emissions sources to GTAP sector activities**

GTAP CO$_2$ Emissions Data

File Contents Edit Sets Export Import History Search Aggregation Programs Help

None ▼ | 0 ▼ | | CO2 ▼ | All EGY_COMM ▼ | Sum SRC ▼ | All ALLSEC ▼ | 6 jpn ▼

EGHG	31 ppp	32 p_c	33 crp	34 nmm	35 i_s	36 nfm	37 fmp	38 mvh	39 otn	40 ele	41 ome	42 omf	43 ely
1 coa	5722	0	5573	21126	2007	650	596	99	47	85	946	833	177578
2 oil	0	0	75	0	0	0	0	0	0	0	0	0	12271
3 gas	1133	5378	7587	945	4631	764	1626	37	7	465	1359	163	108718
4 p_c	10216	0	5529	15903	24262	4233	1566	119	36	2135	2045	1564	63453
5 ely	0	0	0	0	0	0	0	0	0	0	0	0	0
6 gdt	256	0	16	2	109	20	87	1	0	92	76	0	0
Total	17327	5378	18780	37977	31009	5667	3875	255	89	2776	4426	2560	362020

EGHG Size: [CO2] * EGY_COMM [* Sum over SRC] * ALLSEC [* jpn] GHG emissions (Gg) from burning enrg e of src s l

CO$_2$ emissions data: share of world total, by activity and fuel

GTAP sectors	Coal	Crude oil	Natural gas	Petroleum products	Gas	Activity Total
Petroleum, coal products	0.00	0.00	0.01	2.58	0.00	2.60
Chemical, rubber,	1.39	0.19	0.91	1.31	0.65	4.44
Mineral products n.e.c.	1.97	0.00	0.19	0.55	0.22	2.93
Ferrous metals	2.29	0.00	0.27	0.31	0.32	3.20
Electricity	27.13	0.33	4.15	3.98	4.26	39.85
Trade	0.05	0.00	0.06	3.47	0.26	3.84
Transport n.e.c.	0.06	0.00	0.12	6.99	0.03	7.21
Water transport	0.00	0.00	0.00	1.10	0.00	1.10
Air Transport	0.00	0.00	0.01	2.77	0.00	2.78
Household consumption	1.50	0.00	0.63	11.65	2.62	16.41
Other sectors	3.27	0.04	1.58	6.44	4.31	15.65
Fuel Total	37.66	0.56	7.93	41.17	12.68	100.00

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Further info about the GTAP Energy/GHG/Land Use Data Sets

- **GTAP Energy Project webpage:**
  https://www.gtap.agecon.purdue.edu/models/energy/default.asp
- **GTAP CO_2 emissions data webpage:**
  https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1143
- **GTAP non-CO_2 emissions data webpage:**
  https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1186
- **GTAP Land Use/Land Cover data webpage:**
  https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1900
  - **GTAP Technical Paper No. 25 (Lee et al., 2005)**

Mapping of CH_4 emission sources to GTAP sectors

Sources of CH_4 emissions	Activities/drivers	Mapping to GTAP sectors
Stationary Sources	Households burning wood	Households
Mobile Sources	Driving (vehicles running on gasoline/diesel fuel)	Households and transport sector
Coal Mining	Coal production	"15 COL": coal sector
Natural Gas Systems (exploitation/mining)	Natural Gas production	"17 GAS": natural gas sector
Petroleum Systems (exploitation/mining)	Crude Oil production	"16 OIL": crude oil sector
Waste Water treatment	Sanitary service sector output	"56 OSG": sanitary service sector
Rice Cultivation	Harvested area of flooded rice paddies	"1 PDR": paddy rice sector
Enteric Fermentation	Population of ruminants	"9 CTL": cattle, horses, sheep sectors "11 RMK": dairy sector
Ag Residue/Biomass Burning	Crop production	"1 PDR": paddy rice "2 WHT": wheat "3 GRO": other grains "6 C_B": sugar cane and beet
Manure Management	Population of animals	"9 CTL", "10 OAP" ,"11 RMK"
Landfills	Sanitary service sector output	"56 OSG": sanitary service sector

Mapping of N_2O emission sources to GTAP sectors

Sources of N_2O emissions	Activities/drivers	Mapping to GTAP sectors
Stationary Sources	Fuel combustion	All sectors that burn fuels
Mobile Sources	Driving (vehicles running on gasoline/diesel fuel)	Households and transport sector
Industrial Process	Chemical production	"33 CRP": chemicals sector
Ag. Soils Management	Agriculture production (fertilizer application)	GTAP sector 1 to 8 (crop sectors)
Manure Management	Population of animals	"9 CTL": cattle, horse, sheep sector "10 OAP": other animals sector "11 RMK": dairy sector
Ag. Residue Burning	Crop production	"1 PDR": paddy rice sector "2 WHT": wheat sector "3 GRO": other grains sector "6 C_B": sugar cane and beet
Human Sewage	Sanitary service output	"56 OSG": sanitary service sector

Mapping of F-gases emission sources to GTAP sectors

|		F-gases			
		HFC-134a	CF4	HFC-23	SF6
A. Emissions are released due to use of "inputs" which contain ODS substitutes					
	Emissions of F-gases due to use of refrigeration application				
1	Refrigeration/AC (Gg HFC-134a Eq)	HH; IND's			
	Emissions of F-gases due to use of ODS substitutes as INPUTs to industrial production				
2	Aerosols (MDI) (Gg HFC-134a Eq)	33 crp			
3	Aerosols (Non-MDI) (Gg HFC-134a Eq)	33 crp			
4	Solvents (Gg HFC-134a Eq)	33 crp			
5	Foams (Gg HFC-134a Eq)	33 crp			
6	Fire Extinguishing (Gg HFC-134a Eq)	33 crp			
7	Semiconductors				
8	*CF4 (PFC) (Gg CF4 Eq)*		40 ele		
9	*C2F6 (PFC) (Gg CF4 Eq)*		40 ele		
10	*C3F8 (PFC) (Gg CF4 Eq)*		40 ele		
11	*NF3 (PFC) (Gg CF4 Eq)*		40 ele		
12	*HFC-23 (Gg CF4 Eq)*		40 ele		
13	*SF6 (Gg CF4 Eq)*		40 ele		
16	Magnesium (Gg SF6 Eq)				36 nfm
17	Electric Trans. & Dist. (Gg SF6 Eq)				43 ely
18	Electric GIS Manufact. (Gg SF6 Eq)				
B. Emissions are proportional to sectoral "output".					
	Emissions of F-gases as by-product of industrial production				
14	HCFC-22 Production (Gg HFC-23 Eq)			33 crp	
15	Aluminum (Gg CF4 Eq)		36 nfm		

The GTAP-E model

- **History of GTAP-E development**
  - **Truong (1999):**
    - **substitutability between fuels and capital**
  - **Burniaux and Truong (2001):**
    - **Emissions trading within Annex I countries**
    - **Carbon leakage**
- **GTAP Technical Paper No. 16**
- **Illustrative simulation**
  - **To cut world CO_2 emissions by 20%**

What's in GTAP-E?

- **Aim for climate change policy analysis**
  - **CO_2 emissions abatement**
- **Energy substitution (ES) in GTAP**
  - **Realistic reaction of energy consumers when carbon tax is a must**
- **Additional data needed:**
  - **Substitution elasticities**
  - **Energy volume data**
  - **CO_2 emissions data**
- **Simulations:**
  - **Tax on CO_2 emissions**
  - **Emissions trading at different scale of country participation**
- **Analysis:**
  - **Cost and incidence of abatement, carbon leakage, etc.**

Production Structure: GTAP-E

= GTAP + energy substitution (inter-KE and inter-fuel)
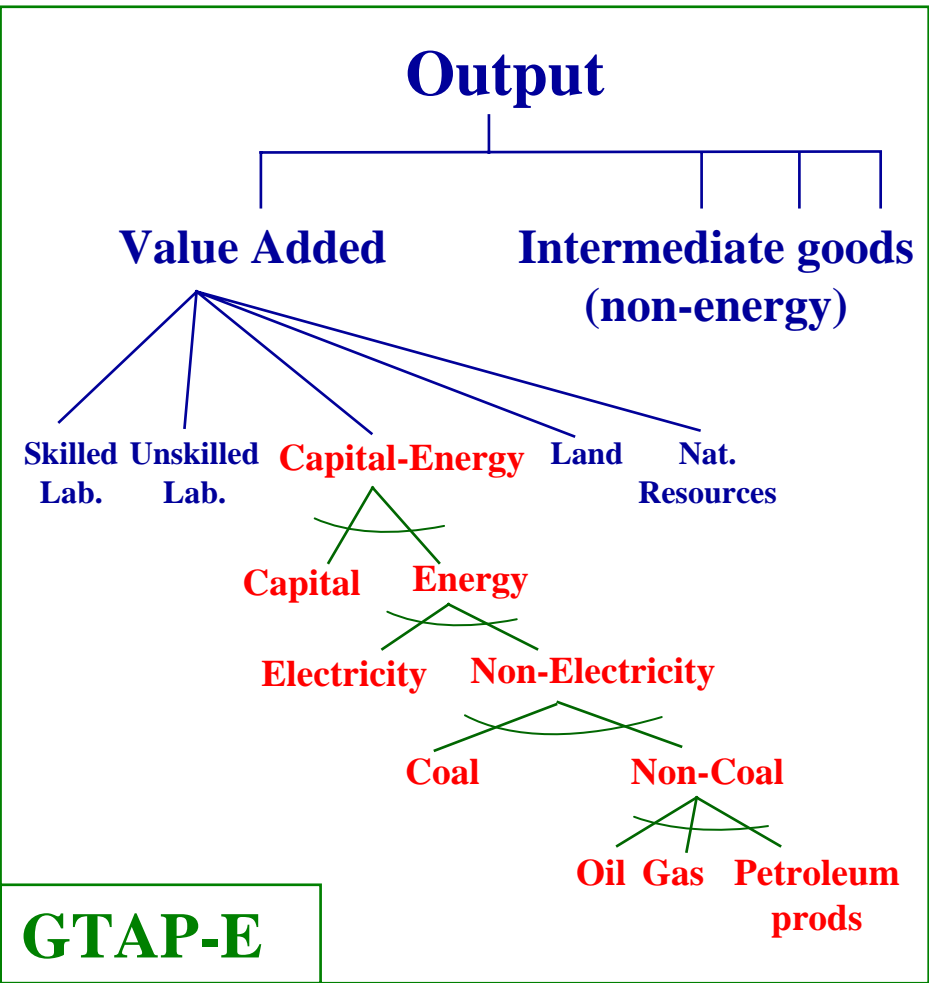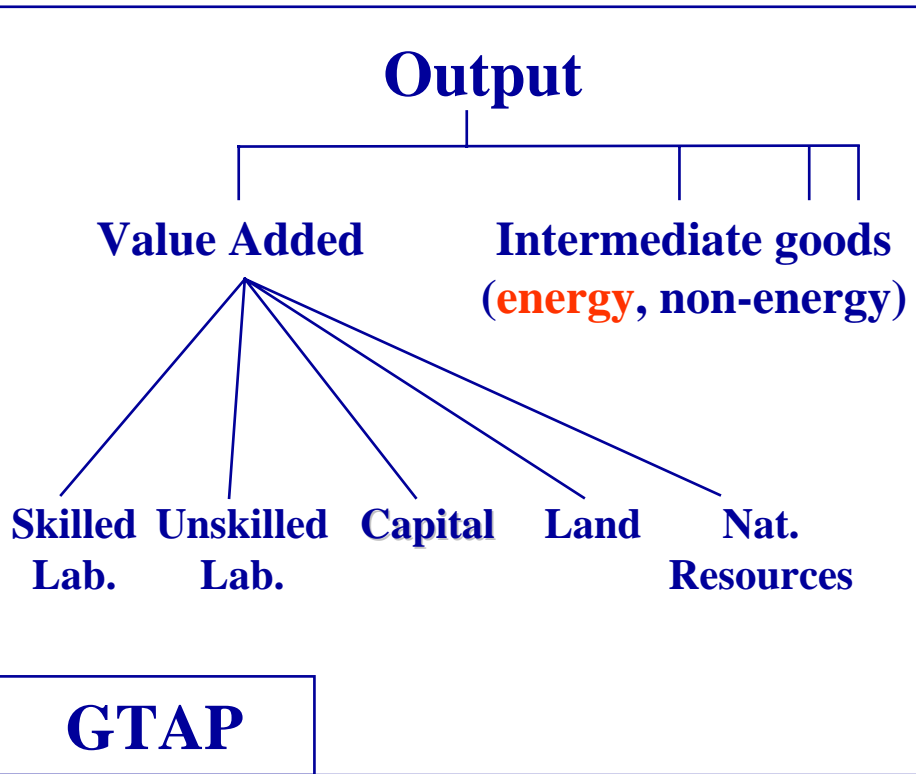
Introducing Carbon Tax Variables

- **Firm price of domestically-produced intermediate inputs:**

  $pfd(i,j,r) = tfd(i,j,r) + pm(i,r);$ **! In standard GTAP !**

  $pfd(i,j,r) = tfd(i,j,r) + pm(i,r) + dcwfd(i,j,r);$ **! In GTAP-E !**

- **Private household price of imported commodities:**

  $ppm(i,r) = atpm(i,r) + pim(i,r);$ **! In standard GTAP !**

  $ppm(i,r) = atpm(i,r) + pim(i,r) + dcwpi(i,r);$ **! In GTAP-E !**

Equations of CO_2 Emissions

- **CO_2 emissions closely related to energy consumption (at home)**

$$DCVOL(r,i)*gco2(r,i) =$$
$$DVOL(r,i)*qo(i,r) + MVOL(r,i)*qim(i,r) - XVOL(r,i)*qxw(i,r);$$

  - Fuel-specific CO_2 emissions coefficient is constant across all regions
    - 1 kg of Indian coal emits the same amount of CO_2 as 1 kg of US coal

- **World total CO_2 emissions**

$$MARKCO2T*gmarkco2t =$$
$$Sum\{r,REG, Sum(i,EGYCOM, CO2(r,i)*gco2(r,i))\};$$

Substitution Elasticities

ESUBVA, btwn factor and K-E composite	**~1.2**
ELKE, btwn capital and energy composite	**0.5**
ELELY, btwn electricity and fossil fuels	**1.0**
ELCO, btwn non-electricity fossil fuels	**0.5**
ELFU, btwn non-coal fossil fuels	**1.0**

From Keller (1980):

$$SIG_{KE\text{-}outer} = [\ SIG_{KE\text{-}inner} - SIG_{VAE}\ ]/S_{KE} + SIG_{VAE}/S_{VAE}$$

ELKE < ESUBVA → K-E complementary

An Illustrative Simulation

To reduce world total CO_2 emissions by 20 %:

Assuming that emissions trading is allowed among all regions,

what is the required uniform CARBON TAX to be imposed on energy consumption in all regions?

World total CO_2 emissions:

      MARKCO2T*gmarkco2t=
Sum{r,REG, Sum(i,EGYCOM, CO2(r,i)*gco2(r,i))};

Illustrative Simulation Results

Carbon tax required to reduce the world CO_2 emission level by 20%
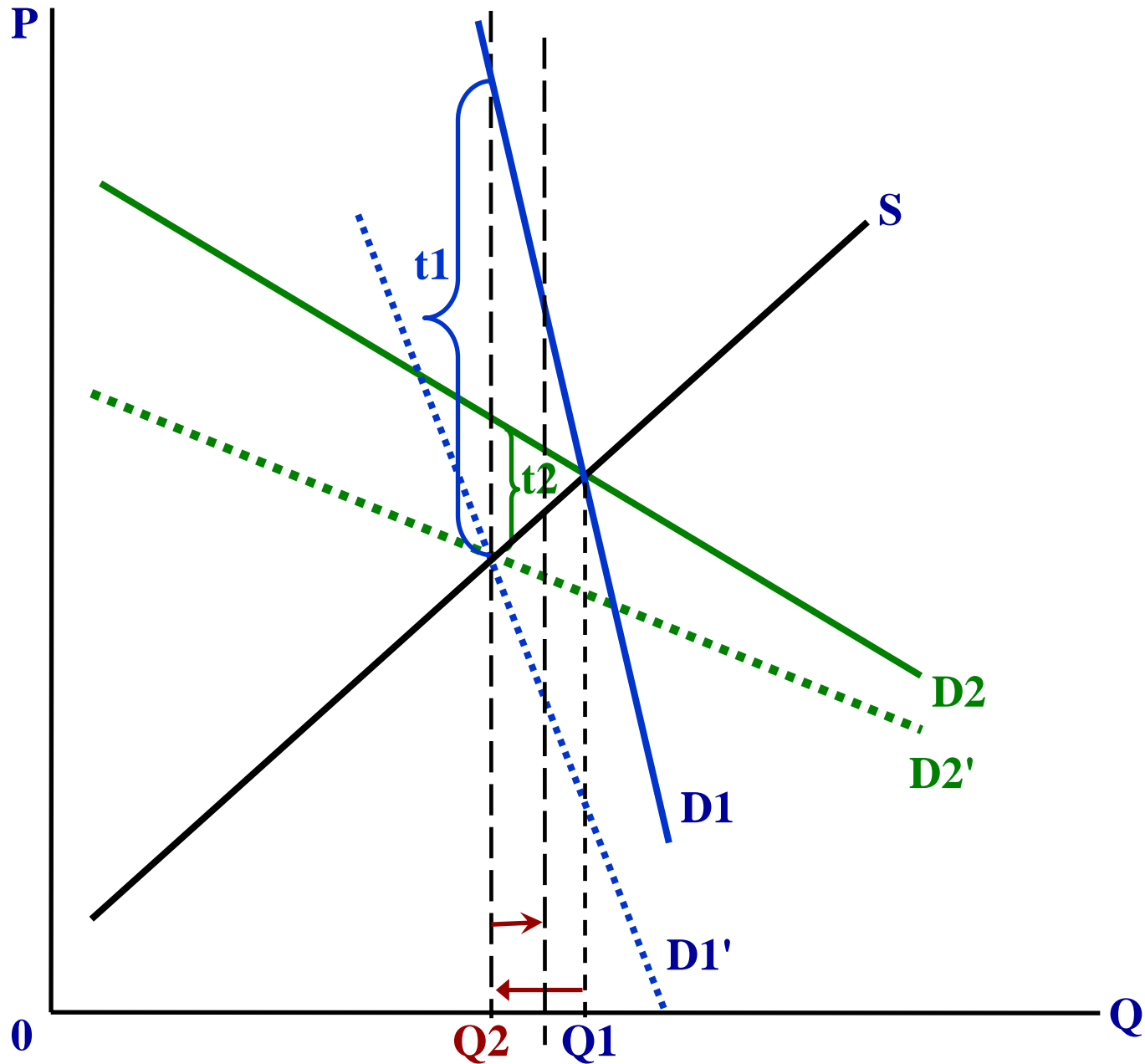
	GTAP-E model (i.e. WITH energy substitution)	Standard GTAP model (i.e. WITHOUT energy substitution)
	$/ton of CO_2	$/ton of CO_2

Energy demand is more elastic in GTAP-E ➔ lower tax

P

S

t1

t2

D2

D2'

D1

D1'

0

Q2 Q1

Q

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Why Results Differ?

- **CO_2 emission can be reduced through energy substitution as well as through output contraction.**

- **Greater substitutability in GTAP-E implies less reliance on output contraction to achieve the same CO_2 abatement target.**

- **The carbon tax required in GTAP-E is thus much less than that in GTAP.**

Questions?!