China and Energy

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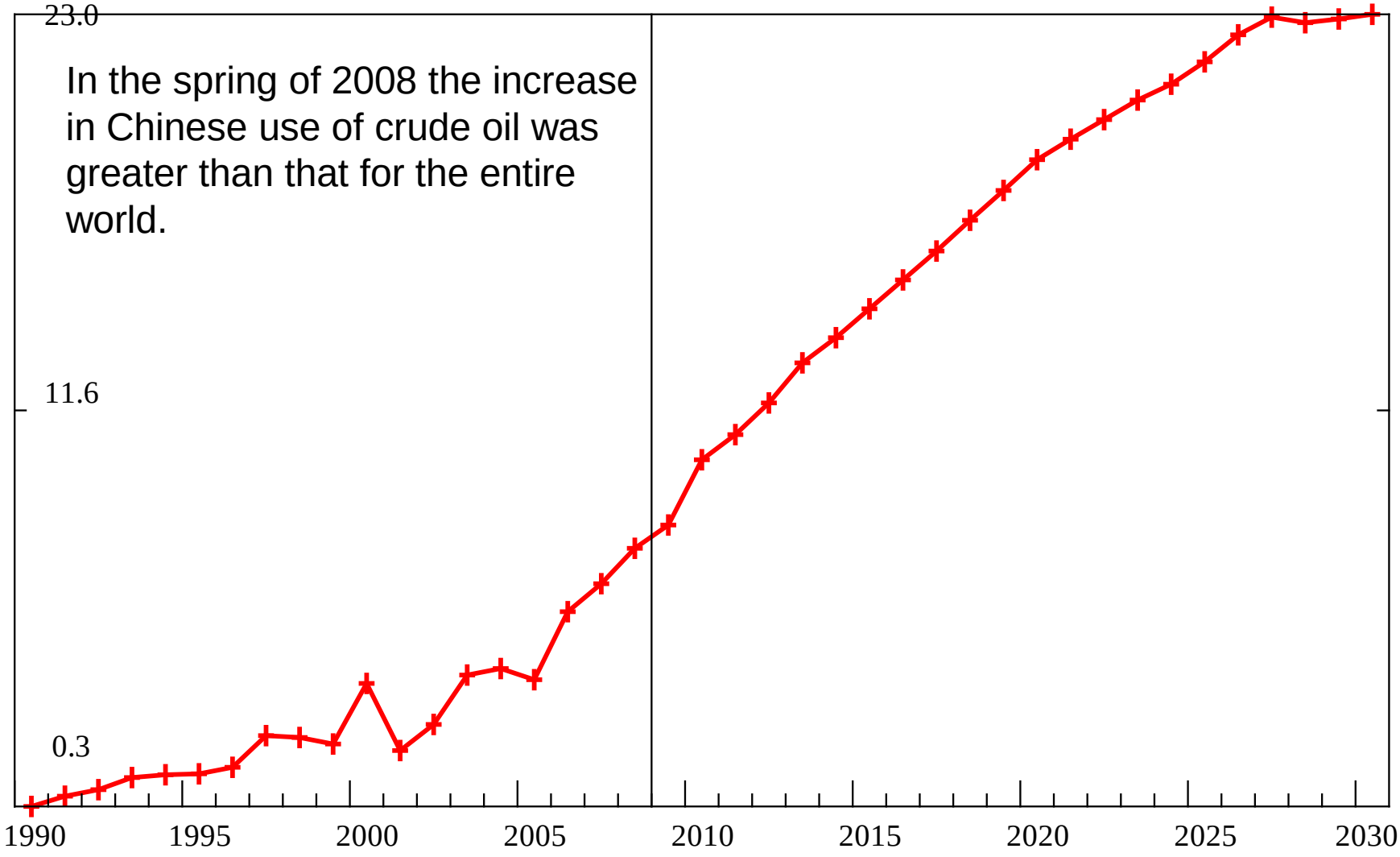
China and Energy

- Chinese use of Energy has increased at a great rate in the last 10 years
- China is a rapidly developing nation
- Chinese industry is rapidly modernizing
- Chinese production is rapidly changing as agriculture gives way to industry and services and within industry from apparel to electronics

Chinese Crude Oil Imports

Percent of World Total



Focus of this study

- Chinese use of coal, refined petroleum, natural gas and electricity
- Study of how efficiency gains are mixed with changing production technologies
- Sensitivity of energy use to prices

Basic Data Set

- Chinese Statistical Yearbook has a chapter on energy use.
- Energy balances for each type of fuel are presented in physical units.
- Domestic production, exports, imports, use by major industry, changes in inventories, losses in production
- Detailed tables of energy use for years 1995-2007

Energy Consumption by Sector in 2007

Source: CSY Table 7-9

Sector	Coal Consumption (10 000 tons)	Coke Consumption (10 000 tons)	Crude Oil Consumption (10 000 tons)	Diesel Oil Consumption (10 000 tons)	Fuel Oil Consumption (10 000 tons)	Natural Gas Consumption (100 million cu.m)	Electricity Consumption (100 million kwh)
Total Consumption	**258641**	**30337**	**34032**	**12493**	**4077**	**695**	**32712**
Primary Industry	**2338**	**82**		**1875**	**1**		**979**
Mining	**17660**	**217**	**1204**	**326**	**42**	**96**	**1614**
Mining and Washing of Coal	16518	75		57	6	5	609
Manufacturing	**94188**	**29826**	**32655**	**1118**	**1983**	**333**	**18106**
….other manufacturing industries							
Manufacture of Paper and Paper Products	3379	5	1	22	32	1	442
Electric Power, Gas and Water Production and Supply	**133424**	**39**	**9**	**279**	**609**	**80**	**4911**
Production and Supply of Electric Power and Heat Power	131923	7	8	267	604	71	4642
Production and Supply of Gas	1471	32	0	9	6	9	46
Production and Supply of Water	31	0	0	2	0	0	224
Construction	**565**	**17**		**434**	**16**	**2**	**309**
…other services							
Household Consumption	**8101**	**76**		**205**		**133**	**3623**

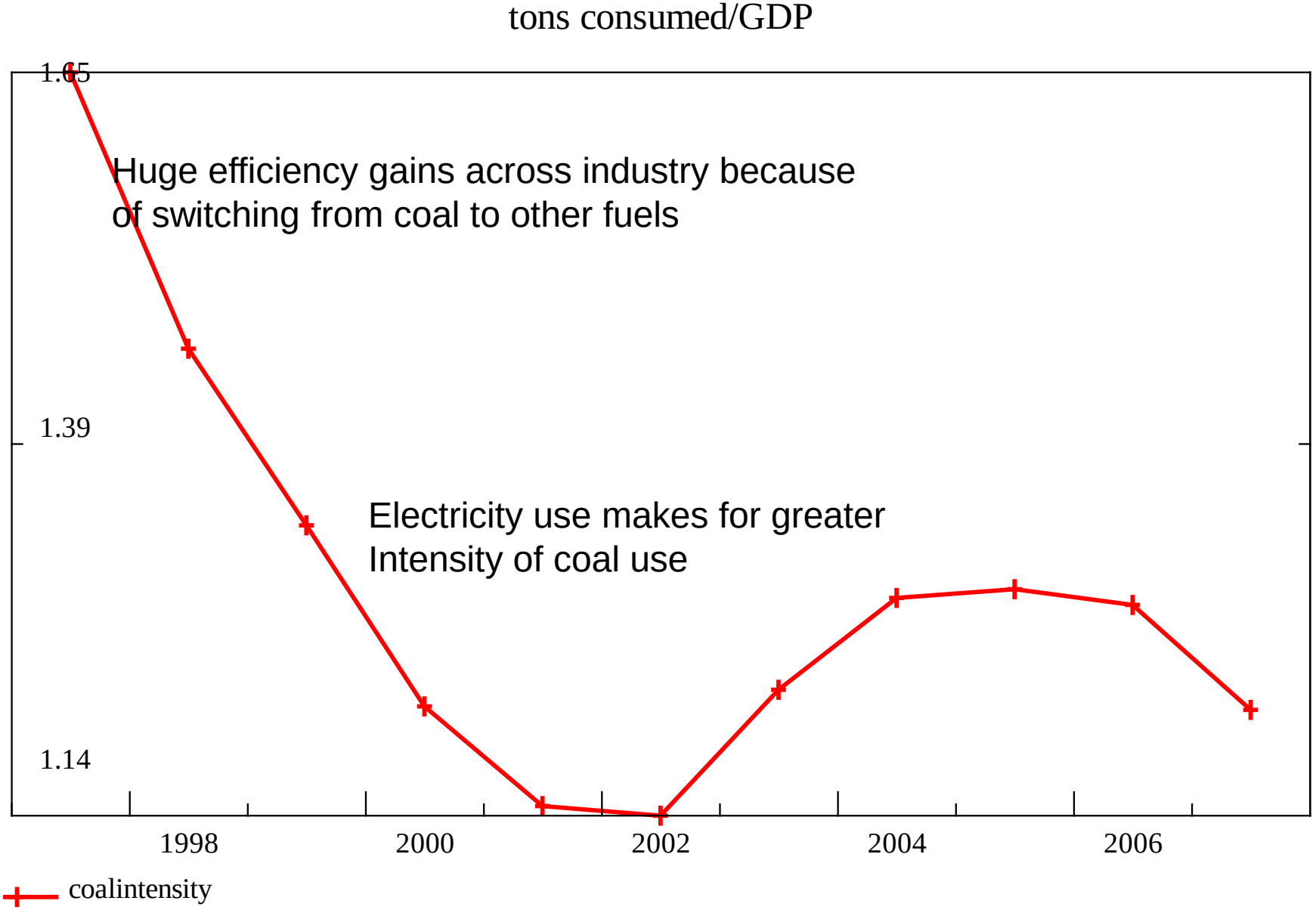
Energy Data in Input-Output

- Physical units correspond directly into I-O model
- We have for example coal use (in tons) per million kilowatt hours of electricity production
- We use the above ratio to estimate the direct coefficient in constant prices

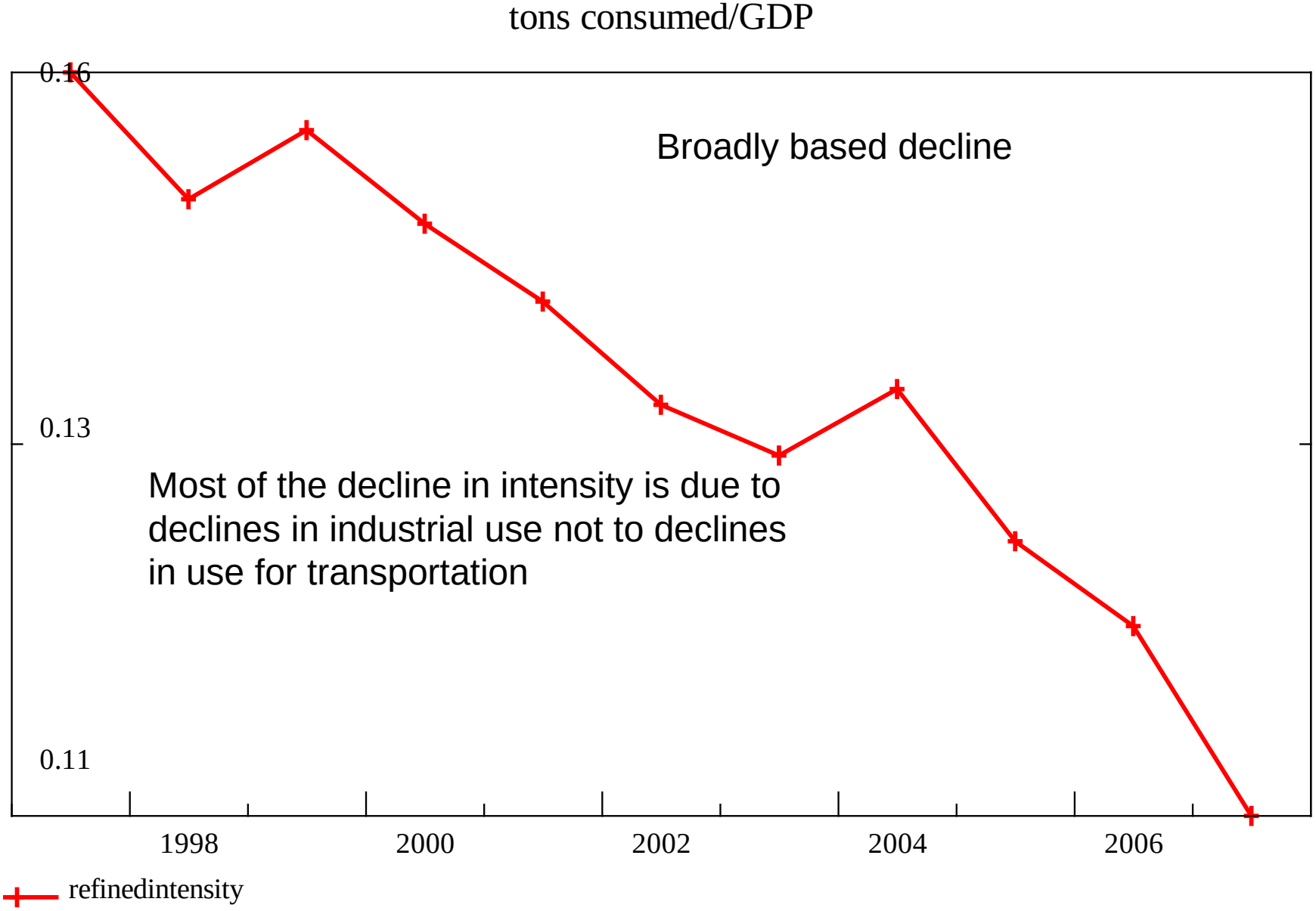
Example of Refined Use

Refined Petroleum	1997	2000	2002	2003	2007
output (2002 prices): 100M yuan	4271	5674	6085	6741	9113
Domestic Consumption	5006	5783	6241	6923	9433
Units of 10,000 tons					
Consumption in Tons	13133	15022	16211	17624	23333
Consumption/real GDP	0.16	0.15	0.13	0.13	0.11
Prices 2002 = 1.0					
Domestic Price	0.72	1.06	1.00	1.15	1.89
Domestic User Price	0.75	1.07	1.00	1.15	1.88
Domestic User Price relative to GDP deflator	0.80	1.11	1.00	1.13	1.56

Coal (tons) and GDP

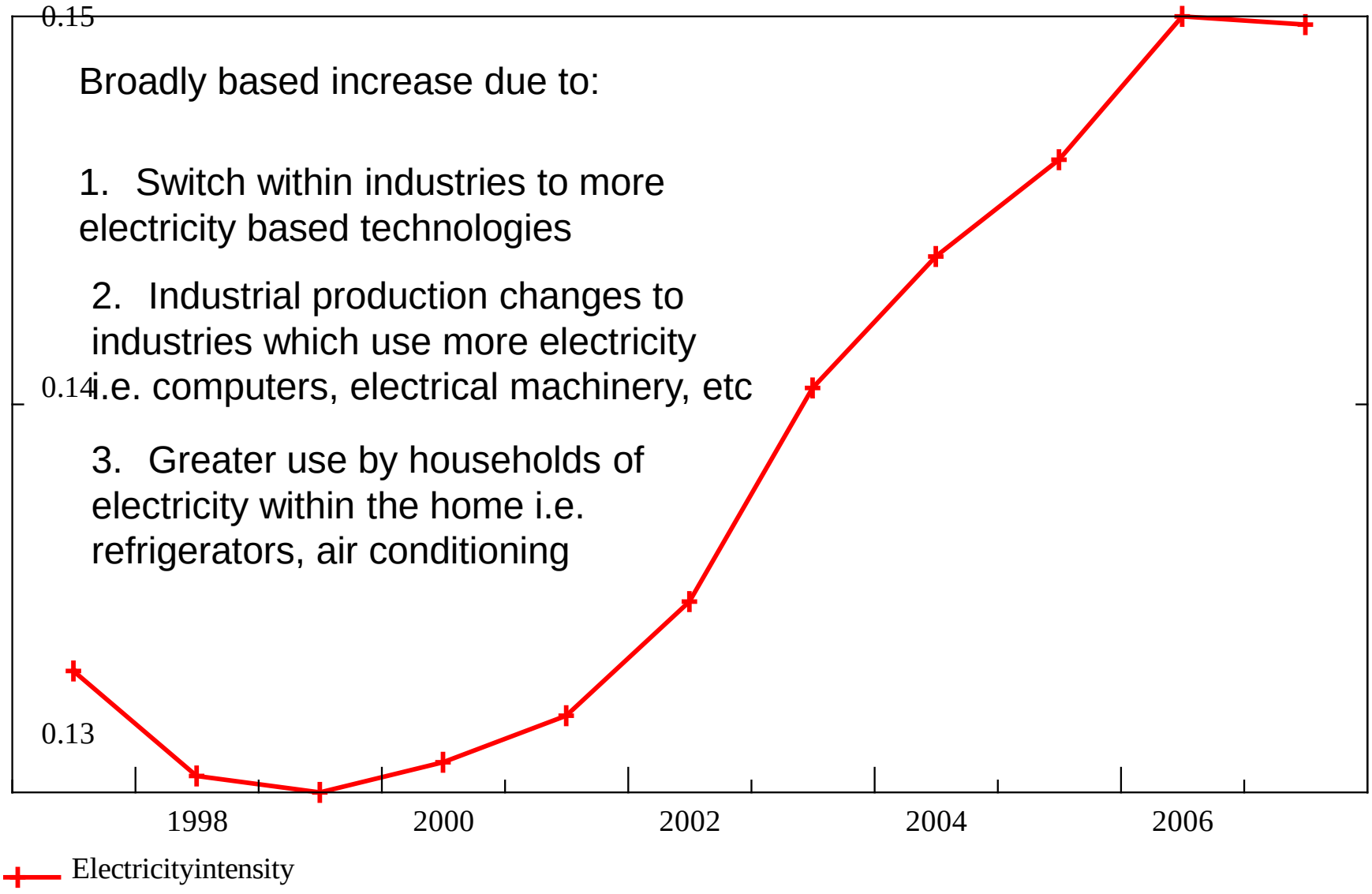


RefinedPetroleum (tons) and GDP



Electricity (kwh) and GDP

kwh consumed/GDP



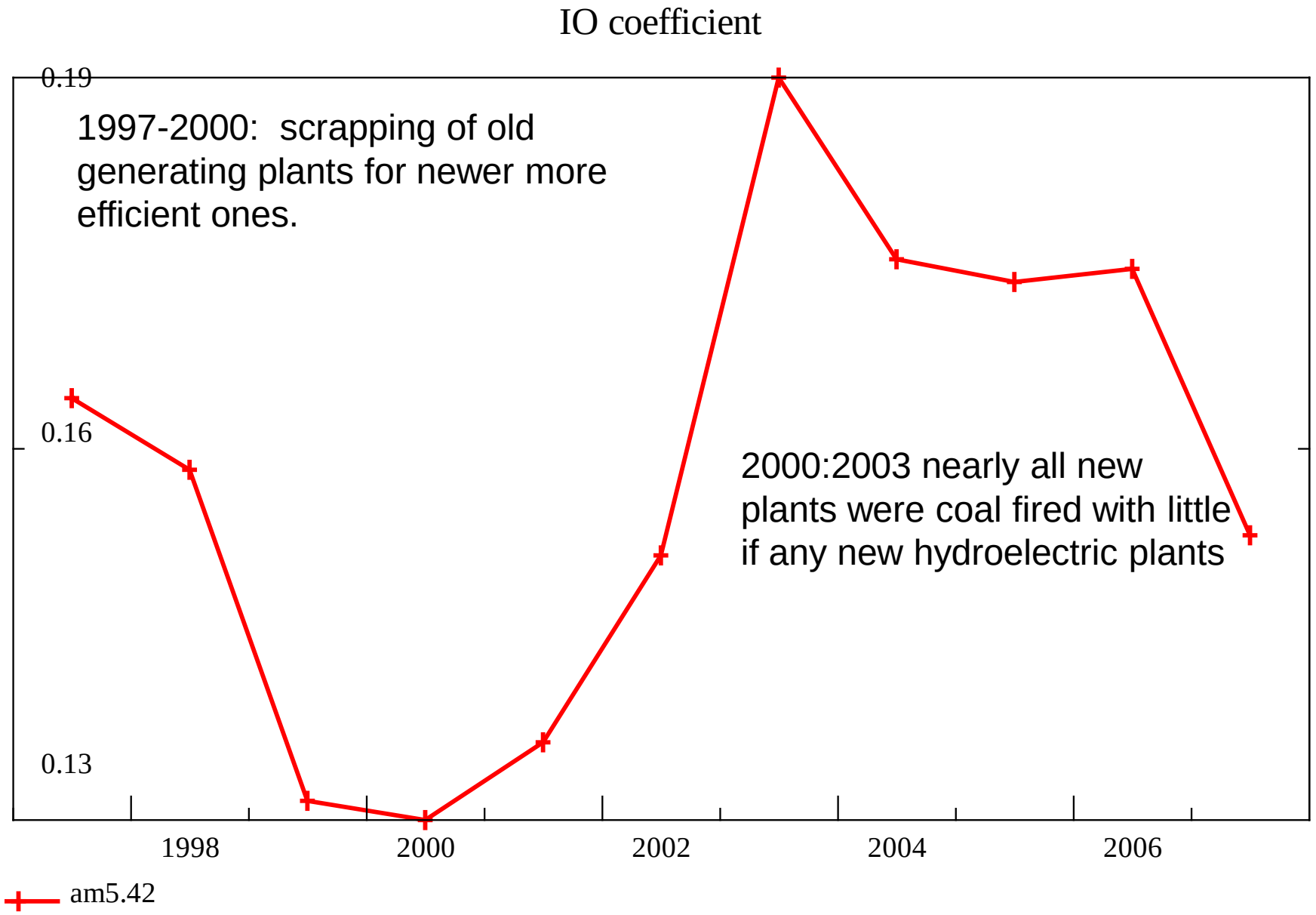
Broadly based increase due to:

1. Switch within industries to more electricity based technologies

2. Industrial production changes to industries which use more electricity i.e. computers, electrical machinery, etc

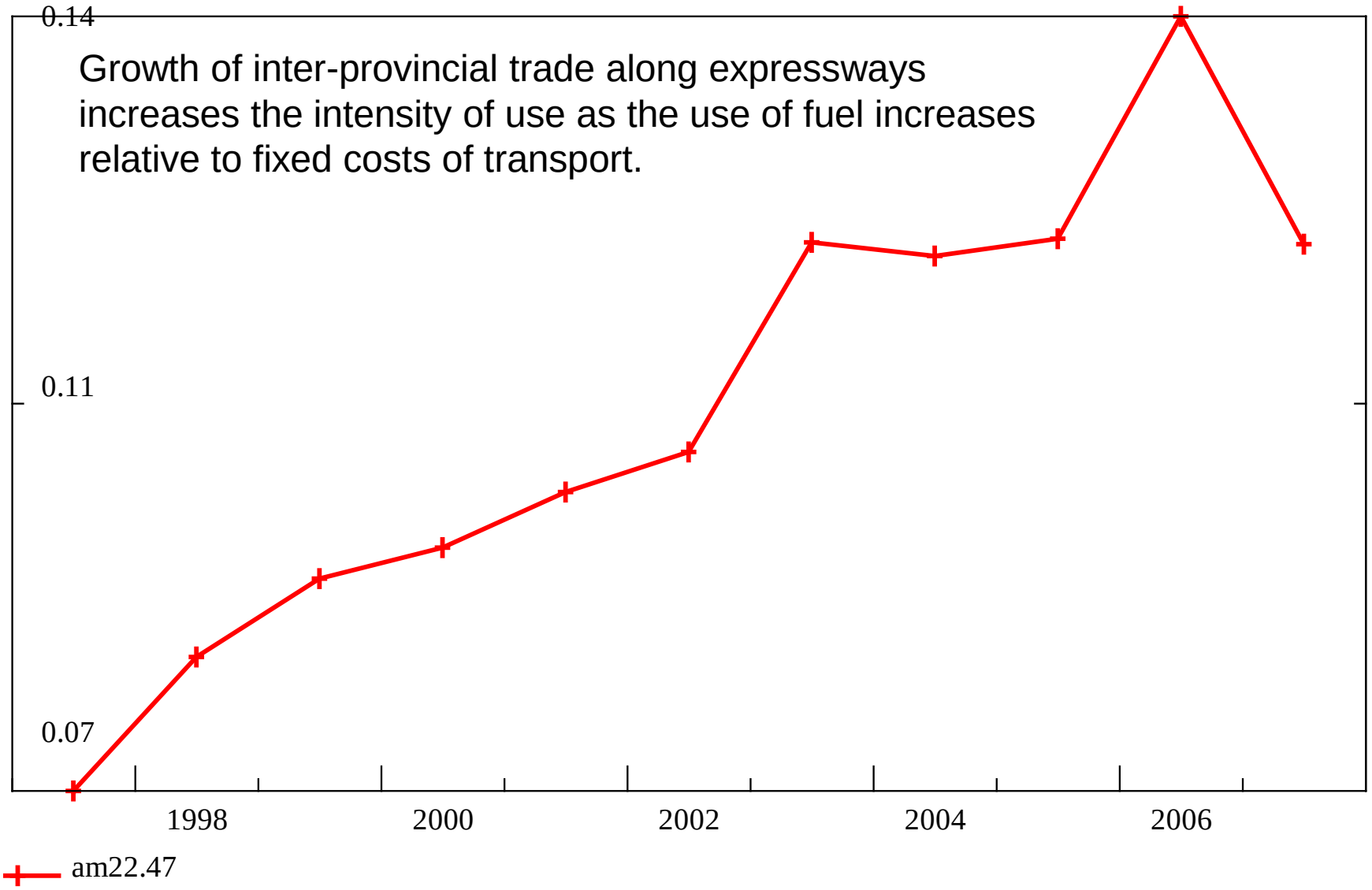
3. Greater use by households of electricity within the home i.e. refrigerators, air conditioning

Coal used by Electric Utilities



Trucking use of Refined

IO coefficient



Growth of inter-provincial trade along expressways increases the intensity of use as the use of fuel increases relative to fixed costs of transport.

$$\ln c_{i,k,t} = b_0 + b_1 t + b_2 \ln\left(\sum_{j=0}^{j=4} (pricei_{t-j} / pgdp_{t-j})/5.\right.$$

- where
- c is the coefficient of fuel type i (row of the input-output table) used by sector k in year t;
- time is a specially created time variable to reflect the rapid changes taking place in the first part of the estimation period as old factories were closed (values were 1995=1972; 2000= 1994; 2002= 1998.32; 2004=2002.64; 2007= 2006.7);
- price is the price of domestically used energy type i in year t-j; and
- pgdp is the gross domestic product deflator for year t-j.

Refined Petroleum

		Time Trend	Mexval	Price Elasticity	Mexval	Rbarsq
1	Farming	0.03	19.2	-0.33	1.7	0.63
22	Petroleum refineries and coking products	-0.01	0.2	-1.63	6.0	0.76
23	Chemical industries	0.02	15.0	-1.76	83.1	0.89
27	Plastic products	0.02	6.4	-0.64	5.5	-0.13
28	Building materials and non-metallic mineral p	0.05	71.5	-2.75	144.3	0.87
29	Primary iron and steel manufacturing	0.01	0.7	-2.70	94.6	0.95
30	Primary non-ferrous metals manufacturing	0.00	0.0	-0.47	3.0	0.17
31	Metal products	0.03	18.0	-0.93	15.3	0.08
32	Machinery	0.01	4.1	-2.42	99.3	0.94
38	Electric machinery and equipment	0.00	0.7	-1.36	60.4	0.91
42	Electricity, steam and hot water	0.00	0.0	-0.77	5.5	0.45
45	Construction	0.02	23.3	-0.08	0.5	0.72
47	Highway transportation	0.05	61.7	-0.61	14.2	0.76
48	Water transportation	0.00	2.8	-0.55	110.2	0.95
49	Air transportation	0.03	29.2	-1.07	30.4	0.25
51	Post and communications	0.04	46.4	-1.31	34.0	0.44
52	Commerce	0.02	10.1	-0.19	1.0	0.24

Coal

		Time Trend	Mexval	Price Elasticity	Mexval	Rbarsq
19	Paper and paper products	0.03	12.9	-0.45	322.7	-0.27
22	Petroleum refineries and coking products	0.13	769.4	-0.45	1733.2	0.98
28	Building materials and non-metallic mineral p	-0.02	4.8	-0.56	5.2	0.20
29	Primary iron and steel manufacturing	0.01	1.1	-0.50	483.4	-0.47
30	Primary non-ferrous metals manufacturing	0.02	9.1	-0.45	351.5	-0.28
42	Electricity, steam and hot water	0.03	35.6	-0.25	270.6	0.20

Electricity

		Time Trend	Mexval	Price Elasticity	Mexval	Rbarsq
16	Leather, fur and their products	0.02	85.6	-0.49	158.4	0.59
17	Sawmills and bamboo etc. products	0.08	153.6	-1.31	179.9	0.79
19	Paper and paper products	0.01	27.9	-0.49	118.3	0.11
27	Plastic products	0.06	184.1	-2.00	496.2	0.82
28	Building materials and non-metallic mineral p	0.01	5.2	-0.74	147.0	-0.39
32	Machinery	0.01	56.8	-0.75	323.0	0.40
33	Railway Equipment	-0.04	146.6	-0.74	190.2	0.80
39	Electronic and communication equipment	-0.02	28.2	-0.75	112.7	0.26
40	Instrument, meters and office machinery	-0.01	8.8	-0.74	86.8	-0.14
52	Commerce	0.03	499.8	-1.30	1635.6	0.96
53	Restaurants	0.01	80.5	-0.75	409.2	0.51
58	Scientific research and polytechnic services	-0.03	284.6	-0.75	445.1	0.92
59	Public administration and others	-0.03	278.4	-0.75	429.1	0.92

Energy Equations in Mudan

- To exercise the model we propose raising indirect taxes in each of the energy sectors (coal, refined petroleum, and natural gas distribution) by the following percent *per unit value*

Year	Amount
2012	5%
2015	8%
2020	10%
2025-2030	12%

Results:

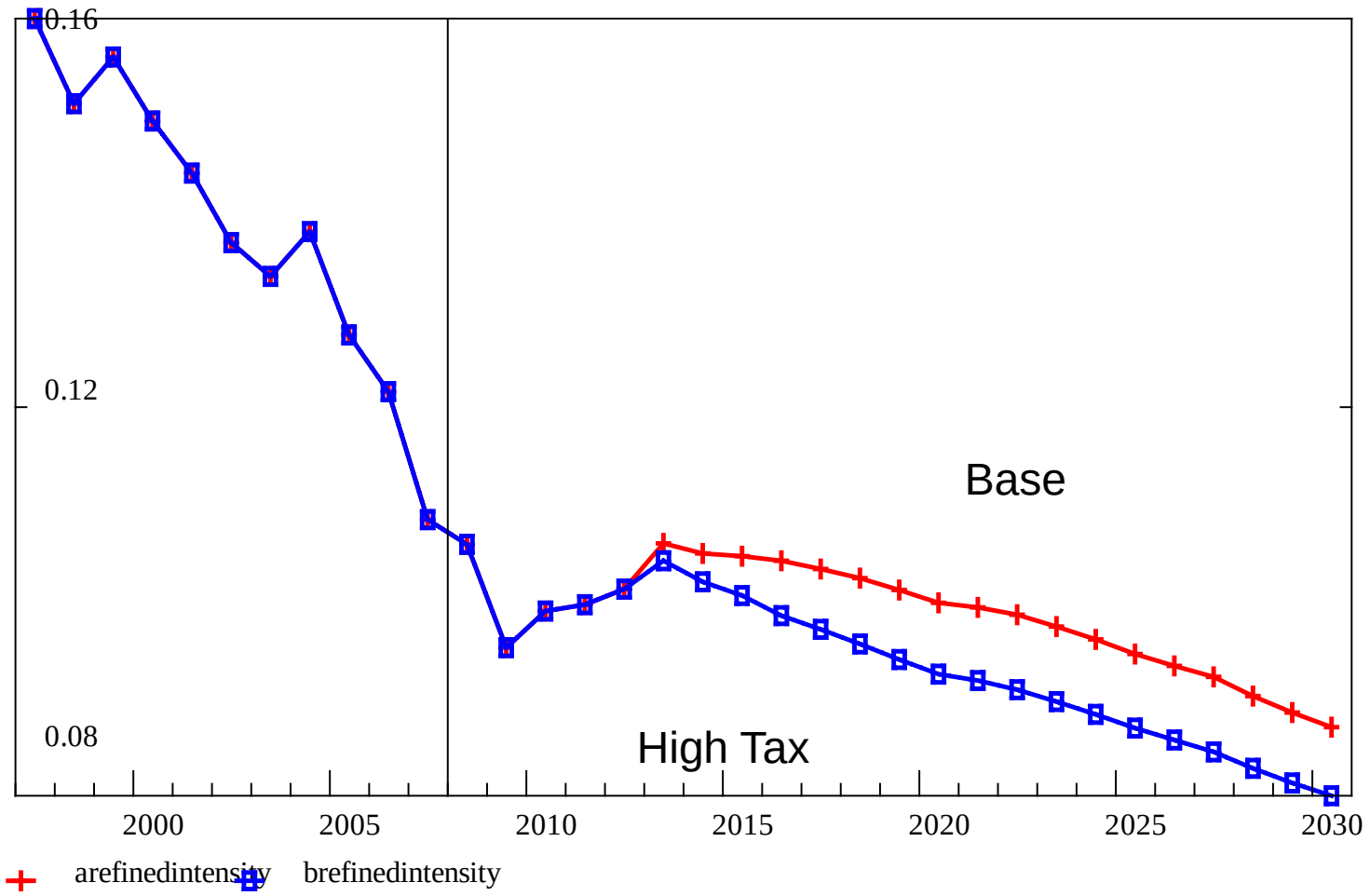
- What does government do with the revenue collected?
- In this case we have reduced personal income taxes. We could have increased infrastructure spending; increased health care spending for the poor; reduced other indirect taxes or even just kept the money.

	2007	2011	2012	2015	2020	2025	2030
Values in 2002 prices, 100M yuan							
Gross Domestic Product	214148	279829	301017	368682	510128	700005	914656
	0	0	1030	1901	3442	5632	5732
Private Consumption	72509	99364	103855	124025	160974	206877	261034
	0	0	619	1307	2261	3571	4208
Employment (millions)	555	512	514	520	543	577	607
	0	0	2	2	2	3	2
Value added, current prices, 100M yuan	257319	339401	371713	464829	651751	894615	1241481
	0	0	3836	5800	7865	11637	14080
Depreciation	40035	69160	77280	101215	150447	213241	302515
	0	0	427	700	879	1357	1874
Wages	103966	139640	150251	191370	273836	385600	546808
	0	0	102	-130	-452	-672	-335
Profits	73534	73328	80862	92577	110247	128127	152415
	0	0	378	-20	-379	-1582	-3727
Taxes	39783	56156	62245	79646	117591	168569	242285
	0	0	2865	5159	7706	12443	16063
Household Sector 100M Yuan, Current Prices							
total disposable income	136009	171576	184461	228622	314545	429100	603535
	0	0	2245	3905	5879	9317	12386
household consumption	88512	124627	132385	161132	216914	286401	388995
	0	0	1431	2502	3714	5519	7332
savings	47496	46949	52076	67490	97631	142699	214540
	0	0	814	1403	2165	3798	5054
Government Sector							
indirect taxes on production, net	39289	55458	61471	78655	116129	166473	239272
	0	0	2829	5095	7611	12289	15863
government savings	16628	20384	22903	29791	44073	65901	89046
	0	0	672	873	1033	1649	1633

	2007	2011	2012	2015	2020	2025	2030
Coal							
output (2002 prices)	7342	9843	10622	12448	13555	16021	16898
	0	0	35	-201	-552	-663	-691
Domestic Consumption	7282	9880	10686	12598	13861	16630	17853
	0	0	35	-202	-560	-678	-721
Consumption in Tons	258641	357688	386125	452305	459312	501978	442643
	0	0	1197	-7247	-18610	-19948	-17474
Consumption/GDP	1.21	1.28	1.28	1.23	0.90	0.72	0.48
	0.00	0.00	0.00	-0.03	-0.04	-0.03	-0.02
Domestic Price	1.63	1.68	1.72	1.77	1.82	1.83	1.94
	0.00	0.00	0.05	0.16	0.22	0.19	0.14
User Price	1.63	1.69	1.73	1.78	1.83	1.86	1.99
	0.00	0.00	0.05	0.15	0.21	0.19	0.13
Price relative to GDP deflator	1.36	1.39	1.40	1.41	1.43	1.46	1.47
	0.00	0.00	0.03	0.11	0.16	0.14	0.09
Coal Current Prices							
Profits	2094	3311	3924	4815	4966	5633	5726
	0	0	-438	-205	-157	-1129	-2190
Taxes	113	67	50	-21	-164	-321	-481
	0	0	946	1881	2631	3716	4030
Total Value Added	5420	7577	8404	10229	11401	13420	14831
	0	0	505	1618	2287	2350	1592
Output in Current Prices	11952	16563	18255	22011	24606	29380	32818
	0	0	612	1545	1849	1772	914

	2007	2011	2012	2015	2020	2025	2030
Refined Petroleum							
output (2002 prices)	9113	10723	11708	14519	19141	24932	29608
	0	0	46	-456	-1137	-1598	-1919
Domestic Consumption	9433	11318	12438	15713	20696	27020	32543
	0	0	53	-513	-1281	-1804	-2207
Consumption in Tons	23333	28259	30838	38895	51602	67488	81978
	0	0	115	-1148	-3031	-4320	-5314
Consumption/GDP	0.11	0.10	0.10	0.11	0.10	0.10	0.09
	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01
Domestic Price	1.89	1.84	1.84	1.86	1.97	2.17	2.54
	0.00	0.00	0.09	0.15	0.19	0.22	0.25
User Price	1.88	1.82	1.81	1.83	1.92	2.11	2.44
	0.00	0.00	0.09	0.14	0.17	0.20	0.22
Price relative to GDP deflator	1.56	1.50	1.47	1.45	1.50	1.65	1.79
	0.00	0.00	0.06	0.10	0.13	0.15	0.15
Refined Petroleum Current Prices							
Profits	231	327	377	746	351	-673	-172
	0	0	-214	-577	-1324	-2977	-4585
Taxes	539	1163	1472	2530	5873	11872	20705
	0	0	1213	2379	4058	7049	9834
Total Value Added	1806	2834	3311	5124	8798	14650	25012
	0	0	1002	1772	2647	3935	5062
Output in Current Prices	17204	19751	21532	27026	37615	54053	75211
	0	0	1153	1249	1159	1658	2048

RefinedPetroleum (tons) and GDP



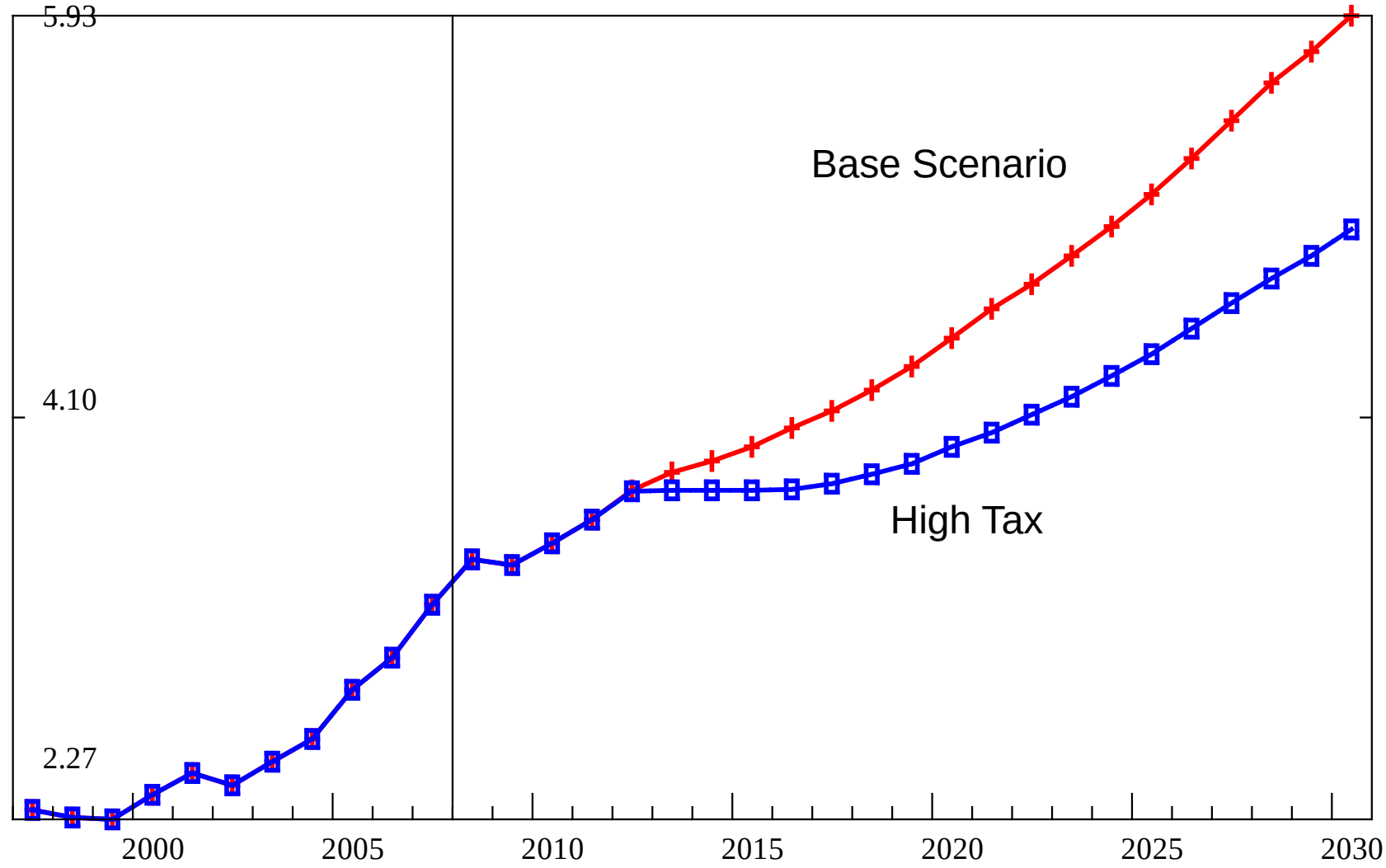
Lessons Learned

- Connect physical units to input-output coefficients
- Energy is connected with technology change and all technology is *not* necessarily energy saving
- Are long run negative profits sustainable in any industry? If not how should we model such properties?

	2007	2011	2012	2015	2020	2025	2030
Natural Gas							
output (2002 prices)	867	1202	1345	1728	2669	4142	6186
	0	0	2	-80	-294	-597	-1053
Domestic Consumption	759	1169	1318	1732	2788	4445	6795
	0	0	2	-86	-318	-654	-1172
Consumption in MCM	695	1016	1134	1462	2276	3578	5422
	0	0	2	-66	-240	-483	-862
Consumption/GDP	0.00	0.00	0.00	0.00	0.00	0.01	0.01
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic Price	1.25	1.31	1.32	1.37	1.41	1.41	1.46
	0.00	0.00	0.05	0.10	0.14	0.16	0.18
User Price	1.19	1.27	1.28	1.33	1.38	1.38	1.44
	0.00	0.00	0.05	0.09	0.13	0.15	0.18
Price relative to GDP deflator	0.99	1.04	1.03	1.06	1.08	1.08	1.06
	0.00	0.00	0.03	0.06	0.10	0.11	0.12
Natural Gas Current Prices							
Profits	16	47	38	45	24	-102	-394
	0	0	-59	-109	-152	-248	-246
Taxes	46	81	94	136	242	401	654
	0	0	95	196	363	649	970
Total Value Added	199	384	426	602	971	1441	2128
	0	0	38	79	162	275	464
Output in Current Prices	1080	1574	1774	2368	3756	5828	9035
	0	0	66	47	-75	-265	-594

Natural Gas and GDP

TCM consumed/GDP

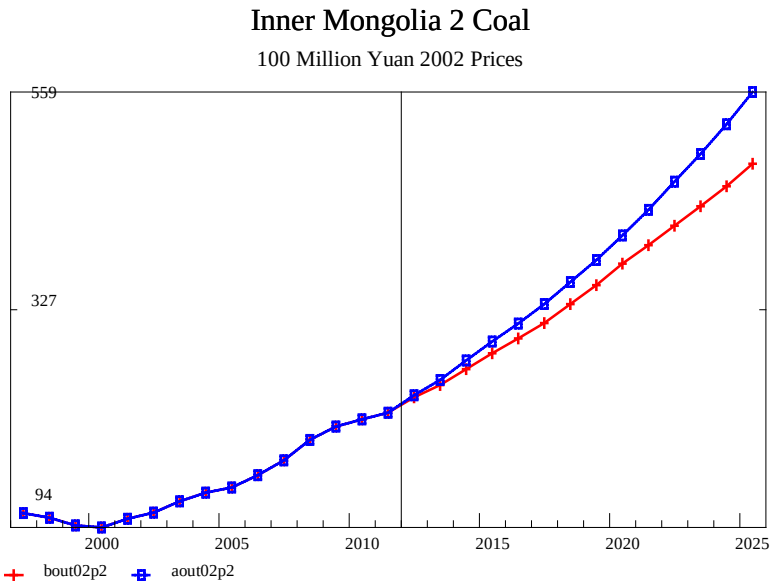


Provincial Effects: Coal

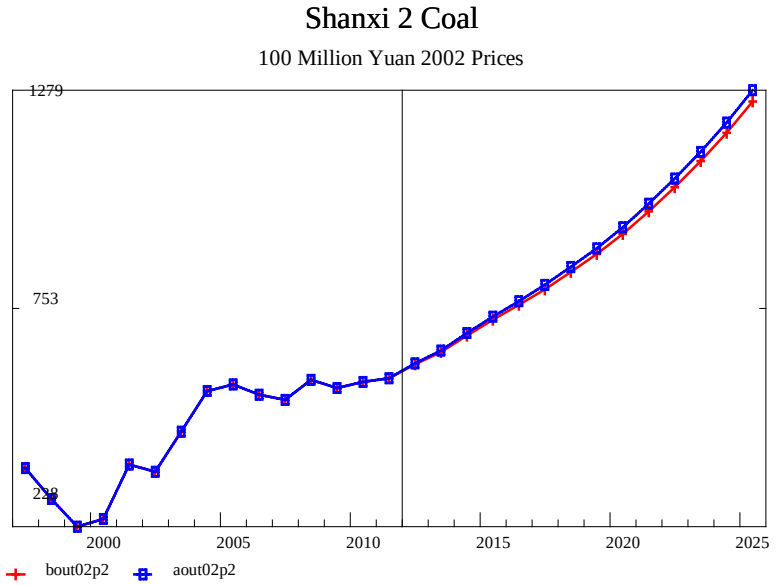
Percent Difference from Base

	2012	2015	2020	2025
Hebei	171	205	276	378
	0	-2	-4	-6
Shanxi	620	733	948	1279
	0	-1	-2	-2
InnerMongolia	235	293	406	559
	-1	-4	-7	-14
Liaoning	177	208	269	351
	0	-1	-2	-3
Heilongjiang	184	214	274	358
	-1	-3	-5	-9
Shandong	905	1090	1464	2011
	-1	-2	-3	-4
Henan	628	750	1017	1412
	0	-1	-2	-3
Xinjiang	43	50	63	83
	-1	-2	-4	-7

Most coal is used for industry within the province



Electricity generating plants in other provinces keep demand steady



Provincial Effects: Refined Pet

Percent Difference from Base

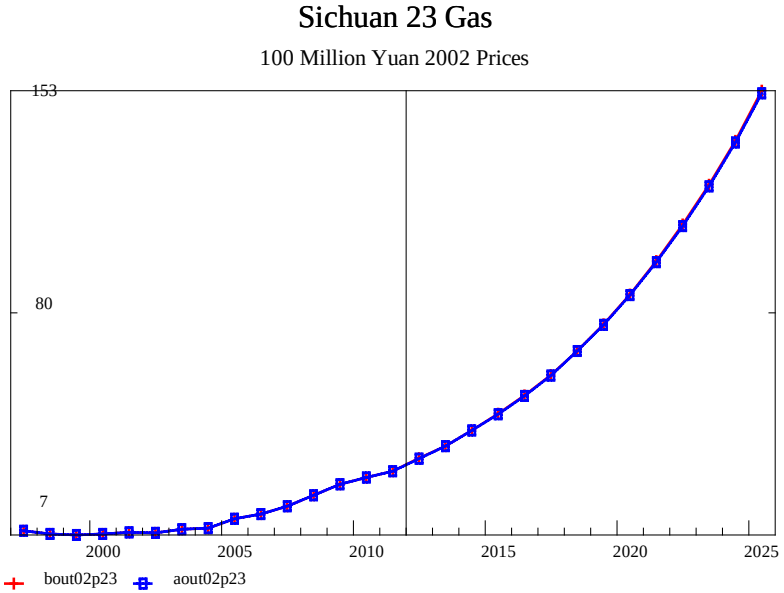
	2012	2015	2020	2025
Liaoning	934	1139	1586	2188
	-1	-2	-2	-2
Jiangsu	384	479	709	1042
	-1	-1	-2	-2
Shandong	484	588	825	1175
	-2	-3	-3	-4
Guangdong	480	614	841	1154
	-2	-4	-5	-5
Gansu	155	185	255	353
	-2	-3	-3	-3

Provincial Effects: Gas

Percent Difference from Base

	2012	2015	2020	2025
Liaoning	39	50	76	112
	-2	-5	-9	-14
Shanghai	59	80	127	193
	-2	-3	-6	-9
Jiangsu	92	114	164	238
	-4	-9	-17	-27
Fujian	13	16	23	33
	-4	-11	-22	-36
Shandong	30	43	73	121
	-1	-1	-1	0
Sichuan	32	47	86	152
	0	0	0	1

Nearly all gas is used for industry where output increases balance the smaller coefficients



Most gas used here is for households where the price elasticity is fairly high