Energy use in U.S. manufacturing and increasing imports from China

- 미국내 중국 수입침투율 증가에 따른 미국 제조업의 에너지 수요영향 분석 –

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Introduction

- Research question
  - *Estimate the effect of increased Chinese import penetration on energy use as a factor of production in U.S. manufacturing*
  - *Decompose the effect into factor substitution effects and output scale effects*
- Background
  - *Since 1990s, the emergence of China, a huge trading partner*
    - Change the industrial structure of its other trading partners
  - *Energy use is also related to environmental issues*
  - *Traditional trade theory(factor abundant) vs. New trade theory(economies of scale)*

Introduction

- Previous studies
  - *Antweiler, Copeland and Taylor (2001), Cole (2006)*
  - *Feng et al. (2012), Omri and Nguyen (2014)*
  - *Bernard, Jensen and Schott (2006)*

- Contribution
  - *the impact of increase imports from China on the U.S. manufacturing sector, rather than the impact of trade liberalization in general on national energy use*

Methodology: Data

- A balanced panel data
  - *1997~2005 U.S. manufacturing industries (obs:3,438)*
    - The annual survey of manufacturers(ASM) : 473 industries
    - Trade data for U.S. manufacturing: 385 industries

	Mean	Std. Dev.	Min.	Max
Energy Use (in trillion Btu.)				
Total (*eneQ*)	32.3171	118.6422	0.0708	1760.7000
Fuels (*fuelQ*)	25.6514	104.6339	0.0418	1607.3550
Electricity (*ectQ*)	6.6657	17.1415	0.0000	206.6052
Import penetration from China (*IP_c*)	0.0499	0.1154	0.0000	0.9126
Ratio of labour to capital (*LK*)	0.4593	0.3010	0.0128	2.1171
Value of shipment (in billion of real USD) (*vship*)	9.4725	23.2710	0.1012	877.9968

Methodology: Conceptual framework

- Trade based on comparative advantage
  - *It is expected that products in U.S. manufacturing move towards energy-intensive industries and result in using more energy in U.S. manufacturing.*
- New trade theory
  - *Trade leads to increased competition, that encourages firms to innovate and adopt new technologies, and the results are increased energy efficiency and less energy use.*
- Different types of energy inputs

→ Decomposition of trade effect: scale of production and factor substitution

Methodology: Empirical strategy

- Empirical equation

$$E_{i,t} = \alpha_0 + \alpha_1 * IP_{i,t}^c + \alpha_2 LK_{i,t} + \alpha_3 Vship_{i,t} + \alpha_4 \left(Vship_{i,t}\right)^2 + \alpha_5 LK_{i,t} Vship_{i,t}$$
$$+\alpha_6 IP_{i,t}^c LK_{i,t} + \alpha_7 IP_{i,t}^c Vship_{i,t} + \alpha_8 IP_{i,t}^c \left(LK_{i,t}\right)^2 + \alpha_9 IP_{i,t}^c \left(Vship_{i,t}\right)^2 + \varepsilon_{it}$$

- Endogeneity problem
  - *unobserved shocks that simultaneously related to energy use among domestic firms in an industry and imports from China*
  - *Instrumental Variable: the Chinese trade share of world trade*
- Others
  - *cross-sectional dependence test, panel unit root test, cointegration test*

Results: Marginal effects

- Estimation results by OLS and IV with fixed effects
- Marginal effects

		Fixed Effects			IV Fixed Effects		
		A	B	C	A	B	C
eneQ	IP_c	0.010	0.008	0.005	0.095***	0.088***	0.085***
	IP_c*LK	0.012	0.003	0.001	0.012	0.008	0.007
	IP_c*vship		0.024***	0.098***		0.011	0.027
fuelQ	IP_c	0.008	0.006	0.001	0.080***	0.068***	0.060***
	IP_c*LK	−0.002	−0.013	−0.016*	−0.012	−0.019*	−0.020**
	IP_c*vship		0.027***	0.128***		0.018**	0.075***
ectQ	IP_c	0.010	0.009	0.008	0.075***	0.076***	0.082***
	IP_c*LK	0.026***	0.021**	0.012**	0.033***	0.034***	0.035***
	IP_c*vship		0.014**	0.039		−0.001	−0.045

Conclusion

- The opposite of the factor substitution effect for fuels and electricity
  - *Labor intensive industries with high Chinese import penetration use less fuels and more electricity.*
  - *Electricity could have the potential to easily replace labor.*
- Implications
  - *Depending on the characteristics of major trading partners and factors of production, the policy responses will need to be different.*
  - *As the underlying cause of the most-profile environmental problems, proper understandings of fuels and electricity as a factor of production in manufacturing is required.*

Tests

- Cross-sectional dependence test: Pesaran (2015)

	eneQ	fuelQ	ectQ	IP_c	LK	vship
Statistics	56.018	101.881	94..965	488.177	207.866	118.508
P-value	0.000	0.000	0.000	0.000	0.000	0.000

- Panel unit root test

: ADF-F and PP-F

	Level		1st difference	
	ADF-F	PP-F	ADF-F	PP-F
eneQ	1092.9464***	682.2482	1803.0962***	2773.7727***
fuelQ	918.8958***	705.0313	2313.2275***	3102.1555***
ectQ	1104.1974***	676.7761	2005.4868***	2619.4791***
IP_c	544.3059	346.7891	1204.5107***	2187.4352***
LK	1396.6928***	1186.0991***	1616.7172***	2509.5905***
vship	726.8733	529.2215	1331.6991***	2503.7818***

Tests

- Cointegration test: Kao (1999)

	MDF		DF		ADF	
Dep. Var.	Statistics	p-value	Statistics	p-value	Statistics	p-value
eneQ	9.813	0.000	6.848	0.000	3.337	0.000
fuelQ	9.226	0.000	7.021	0.000	3.503	0.000
ectQ	11.181	0.000	8.837	0.000	7.808	0.000

Results

- Dependent variable: *eneQ*

	Fixed Effects			IV Fixed Effects		
VARIABLES	A	B	C	A	B	C
IP_c	0.022	−0.186***	−0.807***	0.107***	0.002	−0.130
	(0.016)	(0.051)	(0.210)	(0.021)	(0.074)	(0.234)
LK	−0.099	−0.301	−0.399	−0.194	−0.286*	−0.307*
	(0.252)	(0.258)	(0.243)	(0.161)	(0.168)	(0.168)
vship	1.447***	1.484***	2.256***	1.462***	1.477***	1.627***
	(0.285)	(0.276)	(0.313)	(0.158)	(0.158)	(0.256)
sqvship	−0.055***	−0.050***	−0.097***	−0.054***	−0.051***	−0.060***
	(0.016)	(0.015)	(0.018)	(0.009)	(0.009)	(0.015)
LK*vship	0.031	0.051	0.062**	0.042**	0.051***	0.054***
	(0.030)	(0.031)	(0.029)	(0.018)	(0.019)	(0.019)
IP_c*LK	0.012	0.003	0.001	0.012	0.008	0.007
	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.008)
IP_c*vship		0.024***	0.173***		0.011	0.042
		(0.006)	(0.048)		(0.007)	(0.050)
IP_c*sqvship			−0.009***			−0.002
			(0.003)			(0.003)
Year Dummy	Y	Y	Y	Y	Y	Y
Observations	3,303	3,303	3,303	3,194	3,194	3,194
R-squared	0.402	0.413	0.422	0.349	0.367	0.372