Indirect Energy Costs and Comparative Advantage

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Motivation

- The motivation for trade or comparative advantage is that countries have a lower 'cost' in producing certain goods. For example:
  - Property rights / contract intensity (Nunn, 2007)
  - Water endowment / intensity (Debaere, 2014)
  - Interpersonal trust (Cingano and Pinotti, 2016)
- The same logic should also imply costs of **intermediates** would also affect exports or competitiveness for industries
- Yet limited empirical evidence on whether indirect input costs can act as a source of comparative advantage

Motivation

The case for energy

- Substantial amount of energy embedded in the supply chain

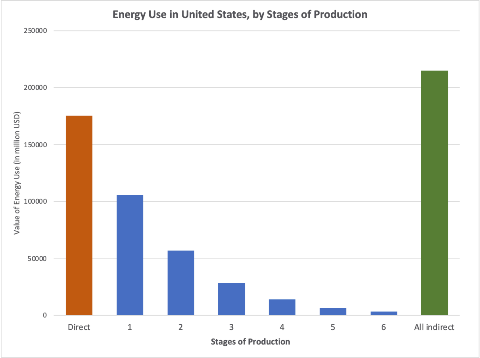
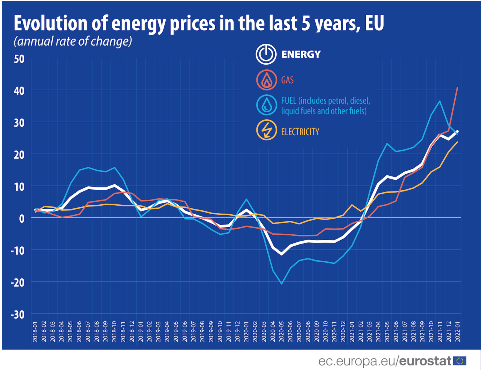


Figure: Energy use in US manufacturing, by stages of production, 2002

Motivation

The case for Europe

- Both electricity and natural gas prices have increased substantially in most European countries from 2000
- Integrated EU markets may lead to substantial indirect energy costs



This paper

- In this paper, we test if indirect energy costs are a source of comparative advantage. Specifically we ask:
  1. How do energy price differences across countries directly *and* indirectly affect their pattern of exports?
  2. Do industries structure their supply chains to mitigate indirect energy costs?
- Methodology based on Rajan-Zingales difference-in-differences where we compare a cross-section of countries and industries
- We illustrate the impact of direct and indirect energy costs by simulating the increase in energy prices in the EU in 2010

Contributions to existing literature

- Sources of comparative advantage (e.g., Romalis, 2004; Nunn, 2007; Manova, 2008; Cunat and Melitz, 2012; Manova, 2013; Debaere, 2014; Cingano and Pinotti, 2016; Cai and Stoyanov, 2016)
  ⇒ we show how indirect costs *per se* can be a source of comparative advantage

- Global value chains (e.g., Miroudot et al., 2009; Johnson and Noguera, 2012; Baldwin, 2013) and intra-firm trade (e.g., Antrás and Chor, 2013; Alfaro et al., 2019)
  ⇒ we demonstrate how the cost of producing intermediate goods can act as a source of comparative advantage in the trade of downstream goods

- Energy costs and trade (e.g., Aldy and Pizer, 2015; Arezki et al., 2017)
  ⇒ we highlight the role of intermediate goods in shaping trade composition

Data

- Bilateral trade data: COMTRADE
  - Benchmark year: 2012
- Energy prices
  - Energy price index: Sato et al. (2019)
  - Electricity and natural gas prices: IEA
- Factor intensities: US BEA input-output table
  - Implicitly assumed no factor intensity reversals
- Aggregate (and indirect costs) calculated by

$$\overrightarrow{AggCost} = (1 - \mathbf{A})^{-1} \overrightarrow{Cost} \tag{1}$$

where matrix **A** is the industry-by-industry total requirement matrix

  - Indirect costs = Aggregate costs - direct costs

Empirical methodology

Direct and indirect energy price differences

- Rajan-Zingales diff-in-diff: compares the propensity to export manufacturing goods in countries with high or low energy prices, and in energy-intensive industries or non-energy-intensive industries
  - cross-sectional variation across countries in the pattern of specialization
- Explicitly:

$$\log(Exports)_{ik} = \beta_1 (EnergyPriceIndex)_i \times (EnergyIntensity)_k + \lambda X_{ik} + \alpha_i + \alpha_k + v_{ik} \quad (2)$$

where α_i is an exporter fixed effect and α_k is an industry fixed effect

- X_{ik} includes physical and human capital interactions; robust to including more sources of comparative advantage

Main results

Dep. var.: log of aggregate exports$_{ik}$	(1)	(2)	(3)	(4)
Energy price index$_i$ × Direct energy intensity$_k$	-0.767***		-0.613***	-0.707***
	(0.136)		(0.150)	(0.154)
Energy price index$_i$ × Indirect energy intensity$_k$			-0.360***	-0.232**
			(0.134)	(0.112)
Energy price index$_i$ × Aggregate energy intensity$_k$		-0.813***		
		(0.136)		
Skill abundance$_i$ × Skill intensity$_k$	0.393***	0.400***	0.396***	0.348***
	(0.055)	(0.055)	(0.055)	(0.076)
Capital abundance$_i$ × Capital intensity$_k$	0.559***	0.587***	0.607***	0.271
	(0.166)	(0.166)	(0.166)	(0.179)
Observations	7915	7915	7915	7908
Adjusted R^2	0.719	0.719	0.719	0.781
Exporter Fixed Effects	Yes	Yes	Yes	No
Industry Fixed Effects	Yes	Yes	Yes	Yes
Exporter-by-Sector Fixed Effects	No	No	No	Yes

Empirical methodology

Restructure the supply chain in response to energy price

- To study if industries reorganize their global supply chain to minimize indirect energy costs, we use the World Input-Output Database (WIOD) across 43 countries

- We employ a similar Rajan-Zingales formulation as above:

$$\log(Imports)_{ijkl} = \delta_1(EnergyPriceIndex)_j \times EnergyIntensity_l + \gamma X_{ijkl} + \alpha_{ij} + \alpha_{kl} + \mu_{ijkl} \quad (3)$$

  where $Imports_{ijkl}$ is defined as the value of intermediate goods imported by industry k in country i, from industry l in country j

- We also test if cost difference matters by replacing *EnergyPriceIndex* with $EnergyPriceDiff_{ij} \equiv EnergyPriceIndex_i - EnergyPriceIndex_j$

Results for intermediate goods

Dep. var.: log of intermediates imports$_{ijkl}$	(1)	(2)	(3)	(4)
Energy price index$_j$ $\times$ Energy intensity$_l$	-1.371***	-1.403***		
	(0.067)	(0.067)		
Capital abundance$_j$ $\times$ Capital intensity$_l$		0.088**		
		(0.039)		
Skill abundance$_j$ $\times$ Skill intensity$_l$		0.452***		
		(0.025)		
Energy price index differential$_{ij}$ $\times$ Energy intensity$_l$			0.080***	0.082***
			(0.009)	(0.011)
Capital abundance differential$_{ij}$ $\times$ Capital intensity$_l$				-0.012
				(0.015)
Skill abundance differential$_{ij}$ $\times$ Skill intensity$_l$				-0.177***
				(0.022)
Observations	404028	404028	263088	263088
Adjusted R^2	0.634	0.638	0.587	0.589
Exporter-Importer Fixed Effects	Yes	Yes	Yes	Yes
Industry Pair Fixed Effects	Yes	Yes	Yes	Yes

Robustness and other results

- Electricity and natural gas prices instead of energy price index
  - Similar in magnitudes, results stronger for the difference in natural gas prices
- Other sources of comparative advantages
  - Examples: TFP growth, labor market flexibility, financial development
  - Results on both direct and indirect energy costs are robust
- Robustness across years
  - Effect on indirect energy costs is getting more economically significant over years

Simulations

Methodology

- We simulate the impact of the increase in energy prices observed in the EU from 2004 to 2012 on the equilibrium trade patterns using the two results presented
- Three sets of results:
  1. **Direct impact** of energy prices: assume zero impact of intermediates / indirect energy costs
  2. **Short-run aggregate** impact of energy prices: incorporate the estimated impact of indirect costs
  3. **Long-run aggregate** impact of energy prices: account for the predicted changes in intermediate goods imports

Simulations

Impact of an increase in energy prices in EU – energy price index

Country	Direct	Aggregate SR	Aggregate LR
Belgium	9.48%	21.54%	16.86%
Croatia	6.25%	14.08%	12.34%
Czech Republic	4.46%	9.24%	8.51%
Denmark	5.12%	11.79%	10.39%
Finland	11.84%	25.36%	16.68%
France	5.90%	12.09%	9.76%
Germany	5.23%	10.68%	8.92%
Greece	13.71%	36.83%	18.43%
Hungary	4.47%	10.05%	8.69%
Italy	6.27%	12.85%	9.86%
Netherlands	10.99%	28.77%	17.11%
Poland	5.83%	11.65%	10.45%
Portugal	6.71%	13.77%	11.35%
Romania	5.39%	10.65%	9.41%
Slovakia	6.06%	13.57%	12.78%
Sweden	8.48%	19.16%	17.26%
United Kingdom	7.32%	17.01%	12.14%
EU Total	**6.77%**	**14.99%**	**11.46%**

Conclusions

- We show that both direct and indirect energy costs can explain trade pattern
- The indirect energy channel has a smaller impact but still sizeable compared to physical and human capital
- Energy price differences also explain how countries optimize their intermediate goods
- Our simnulation results show that by incorporating the indirect energy cost channel, the predicted impact of energy price change on manufacturing exports can almost double