markus'academy


What if Germany is cut off from Russian oil and gas?

David Baqaee
UCLA

Ben Moll
LSE

07. April 2022
Markus Brunnermeier

PRINCETON

- Bachman, Baqaee, Bayer, Kuhn, Löschel, Moll, Peichl, Pittel, Schularick (2022)

	market	Substitute with	Russia's escape
Coal	world	Other supplier	Simply sell to other customer, (China, India, …)
Oil	world	Other supplier	Simply sell to other customer, (China, India, …)
Natural gas	local	Different energy (hydrogen)	

- Low cost ⇒ low effectiveness vs. High ….

PRINCETON

Timing: Blitz sanctions vs. sustained sanctions

- "Blitz/Cold turkey sanctions"
  - More effective as Russia can't adjust
    - Quick military withdrawal if one hits hart(?)
  - More costly for the West as it can't adjust
    - Less resilience? Might not be sustained (during winter)

- Sustained sanctions
  - Build up reserves to sustain sanctions
    - What is Trump is re-elected in 2024 and has not interest in NATO?
    - Chechen War took many years

PRINCETON

2 Types of studies

- Macro approach
  - Substitutability across sectors
    - estimate

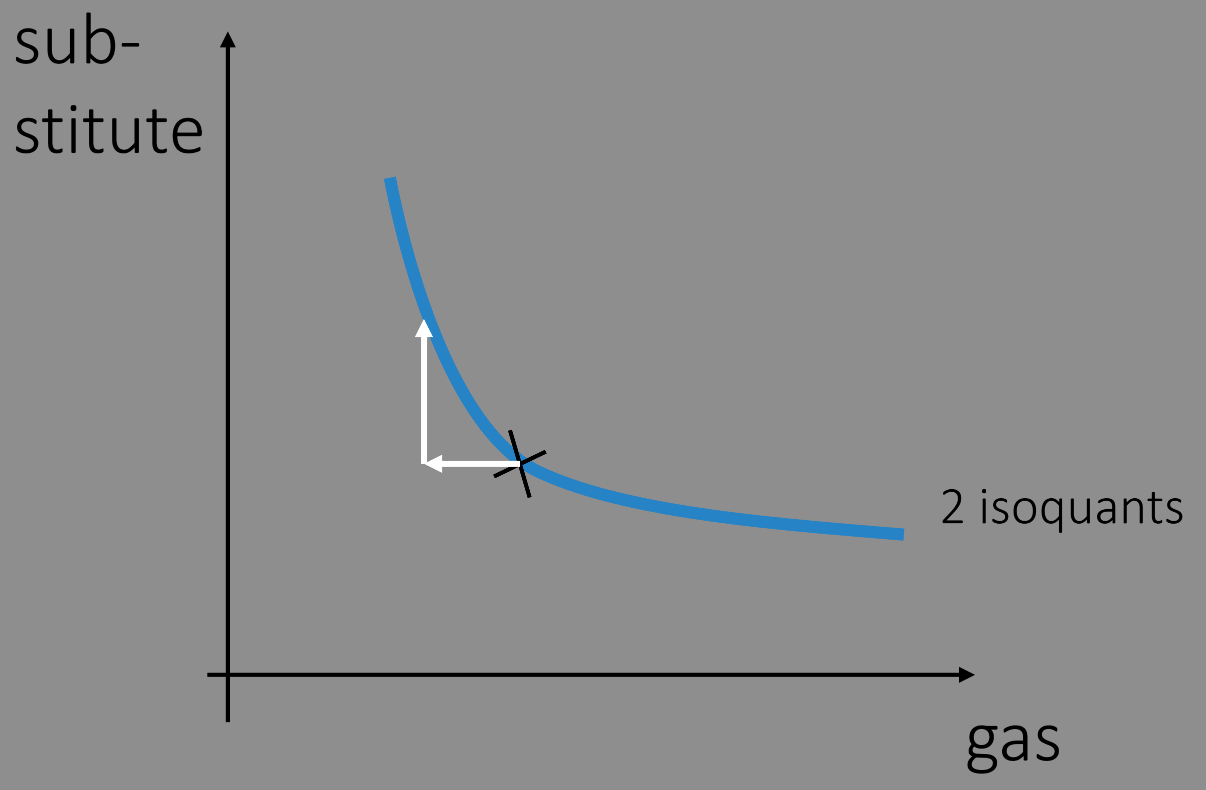
- Detailed approach
  - Gas pipeline/transport matters
  - Gas pressure matters

Next week with
Elina Ribakova

- Unintended consequences
  - Ukrainian diesel comes from Poland, which relies on Russian oil

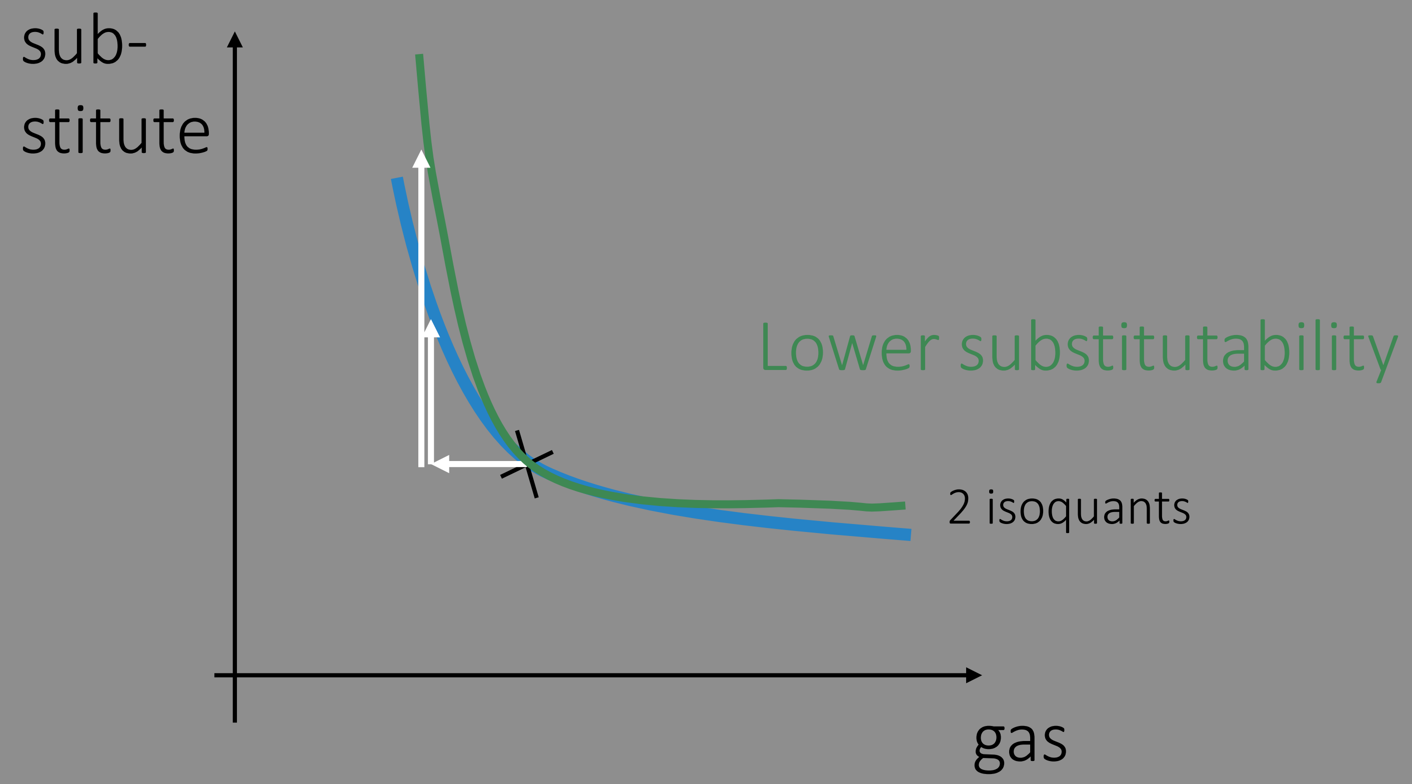
PRINCETON

Substitutability



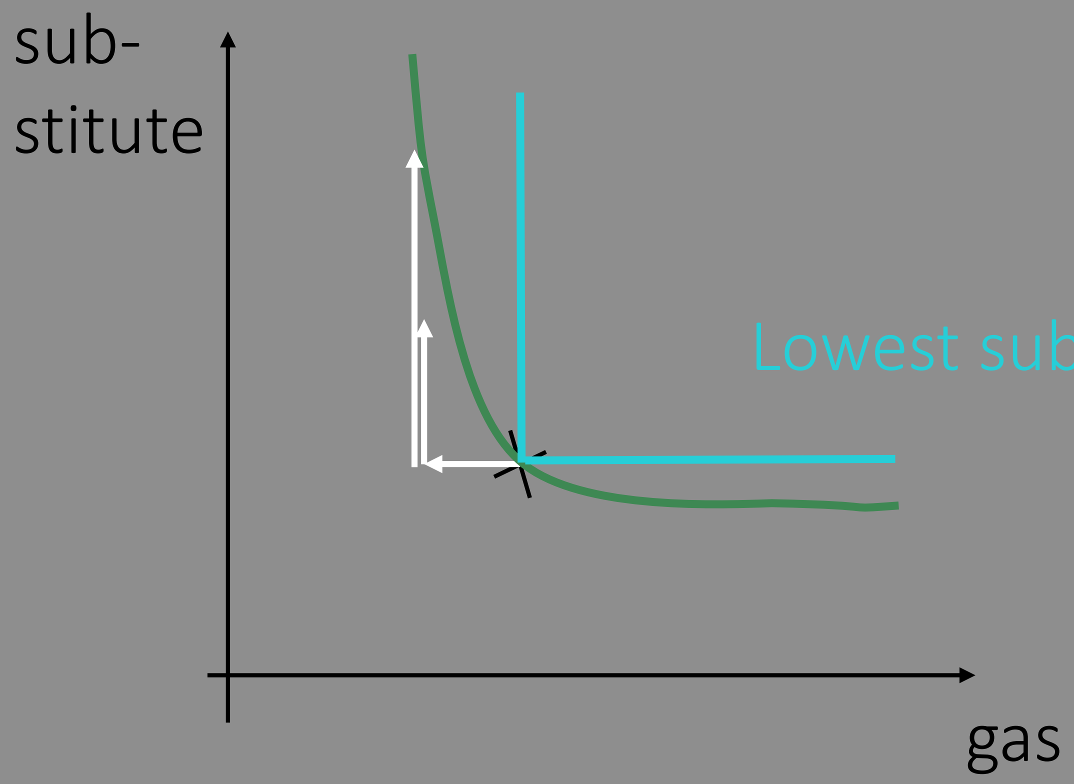
PRINCETON

Substitutability

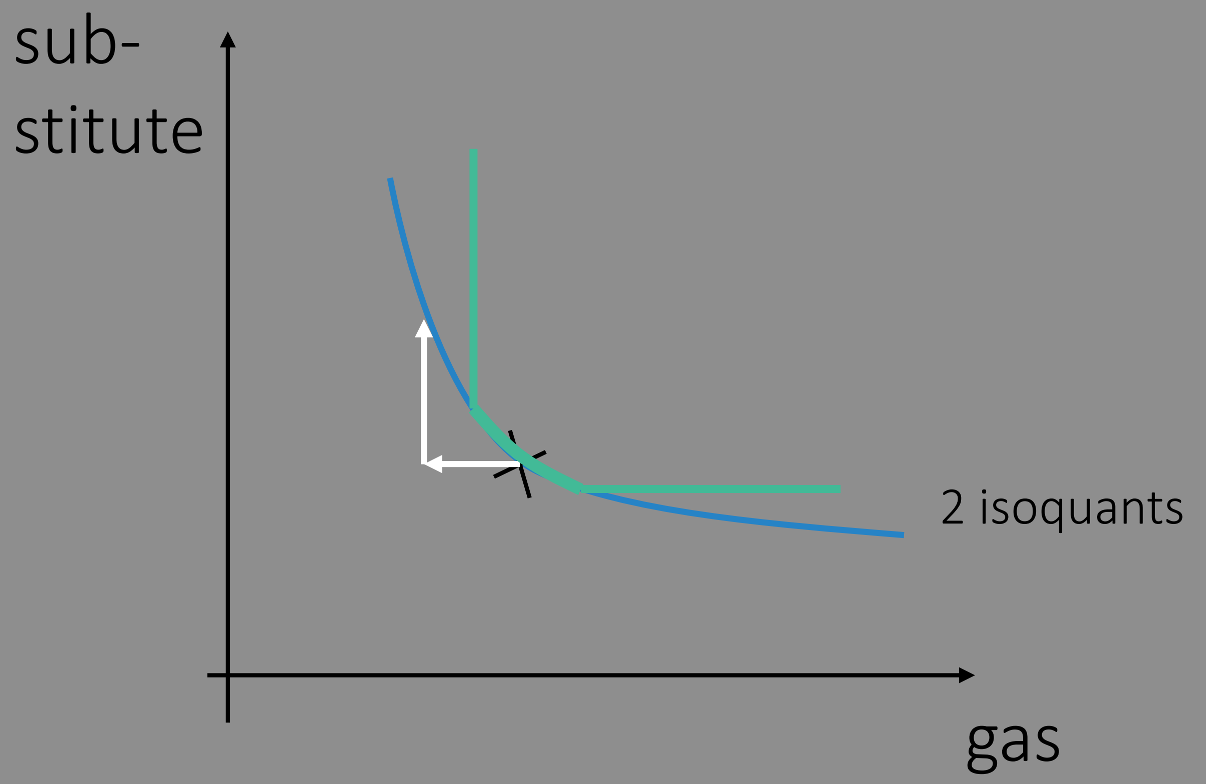


PRINCETON

Substitutability



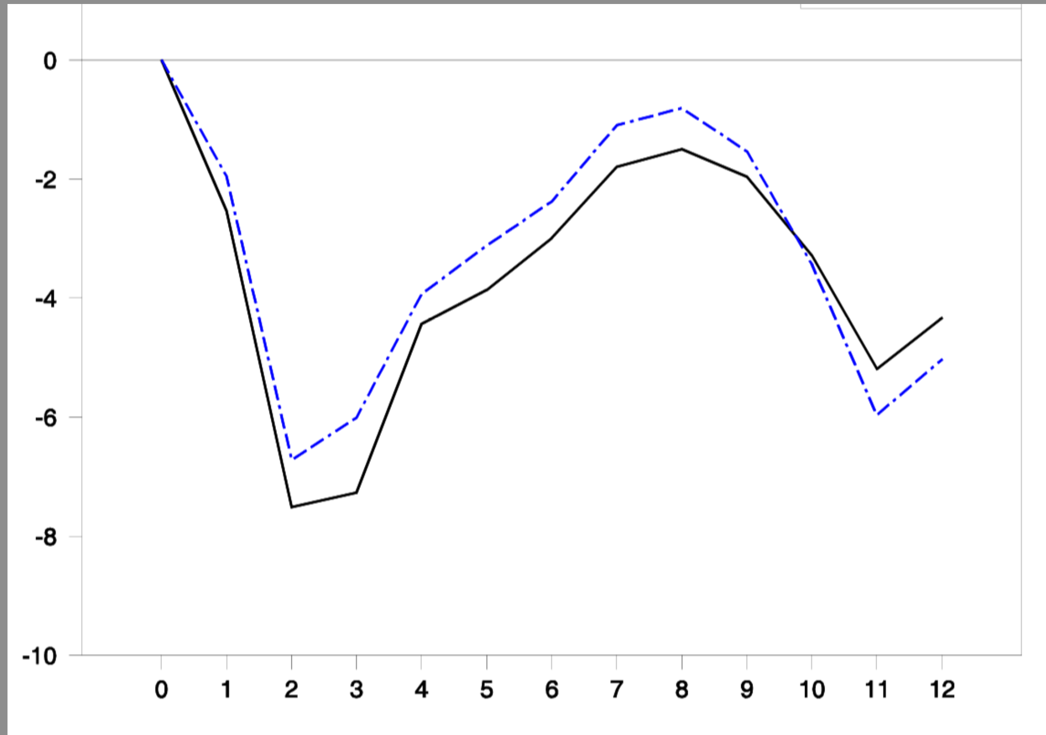
Substitutability – Nonlinearity (estimation challenge)



- Locally high substitutability (estimated)
- Different for large shocks
- No resilience in substitutability

OPEC 1973 shock

- 2022: Russia's world oil supply 13%
- 1973: OPEC reduction in world oil supply 7%



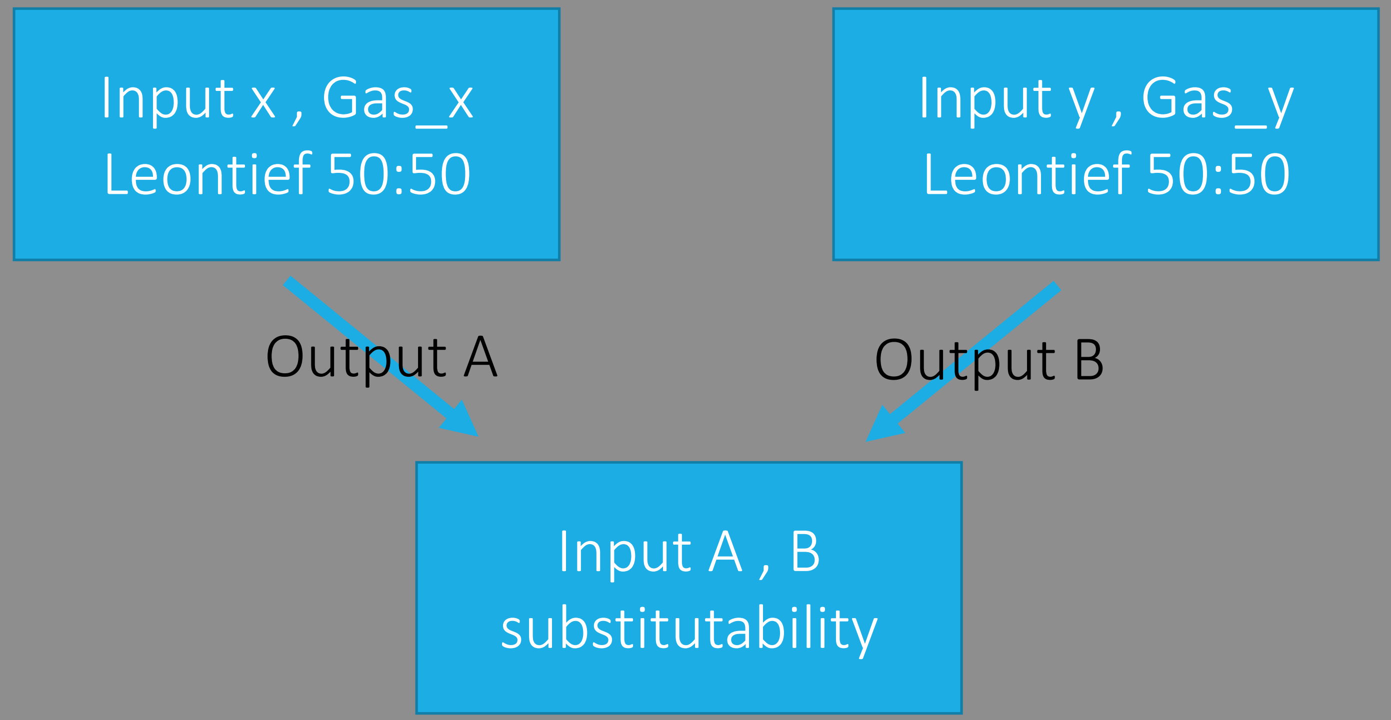
OAPEC embargo: Oil production after Sept 1973 Arab-Israeli War.

- Jim Hamilton's webinar
- 2022: Less oil dependent economy
  - … but squeezed out last efficiency unit already

PRINCETON

Aggregating substitutabilities – Production chain

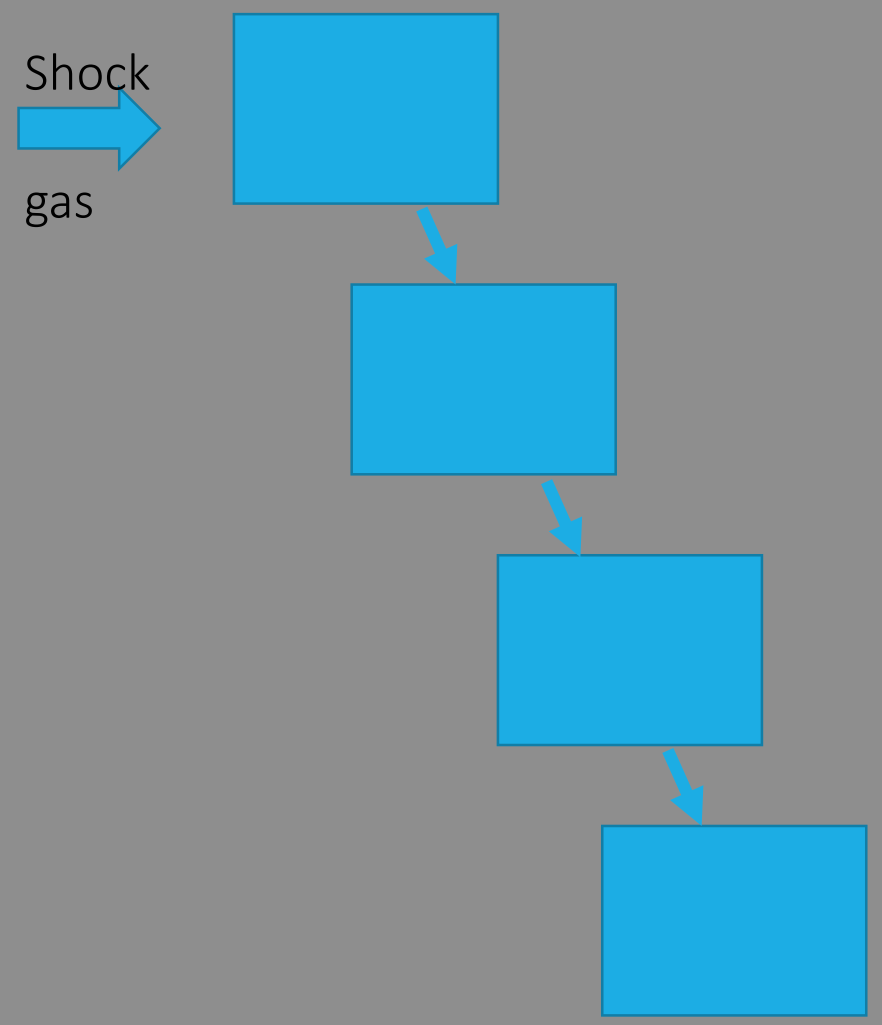
- Upstream: Leontief, substitutability downstream



- Aggregated substitutability:
  - Case 1: 50:50 ⇨ Leontief
  - Case 2: 60:40, 50:50 ⇨ substitutability
- Gas_x ≠ Gas_y if transport challenge!

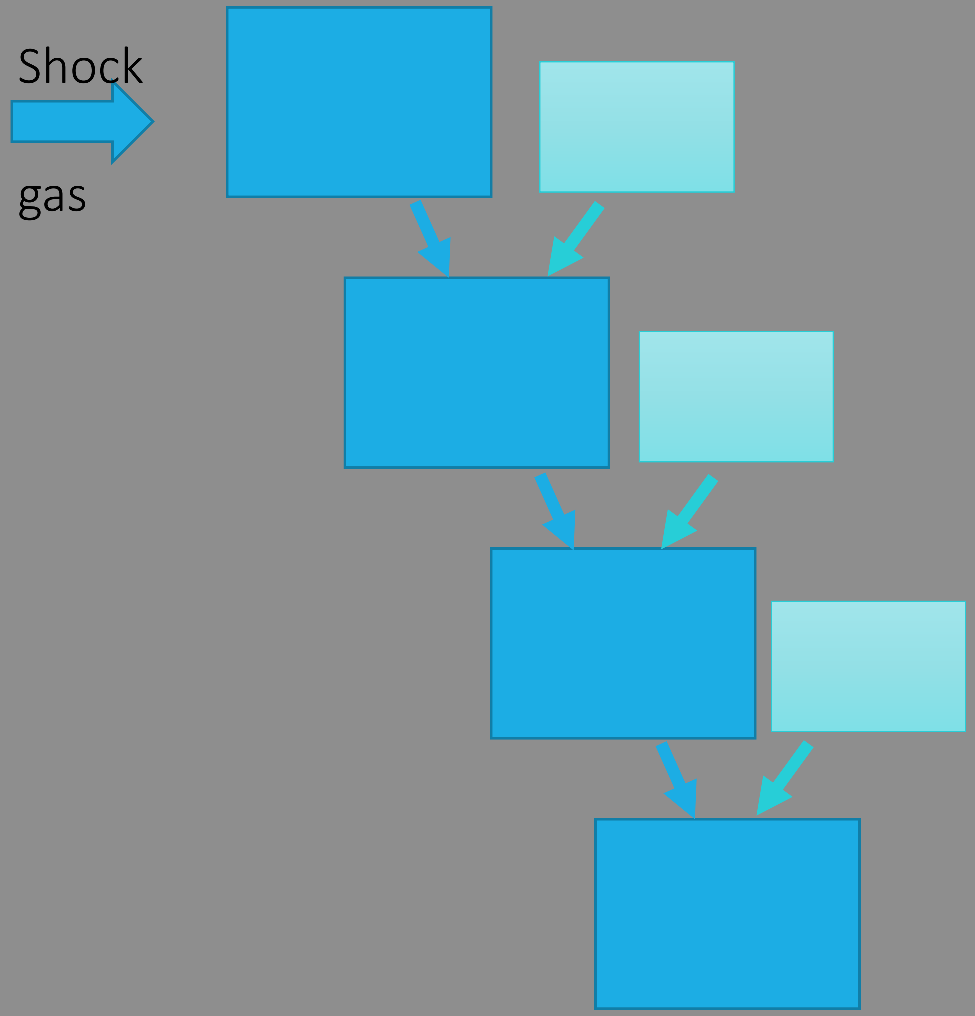
Production chain: Ukraine vs. Covid

- O-ring theory (Leontief)



Production chain: Ukraine vs. Covid

- Substitute at every level



Financial Frictions

- Adjustment frictions
  - Company A using gas scales back
  - Company B using renewables scales up
- Financial frictions:
  - Company A goes bankrupt
  - Company B can't raise funds

P R I N C E T O N

Poll

1. Following an import stop of Russian energy, by how much will German GDP decline relative to a "do nothing" baseline scenario?
   a. less than 1% d. 5%-10%
   b. 1%-3% e. more than 10%
   c. 3%- 5%
   d. 5% - 10%
2. If the EU were to impose a 40% tariff on all Russian energy, by how much …?
   a. less than 1% d. 5%-10%
   b. 1%-3% e. more than 10%
   c. 3%- 5%
3. Import stop of Russian energy … by how much will the German inflation rate increase …?
   a. a. less than 2% c. 4%-6%
   b. 2%- 4% d. more than 6%

P R I N C E T O N

What if . . . ? The Economic Effects for Germany of a Stop of Energy Imports from Russia

Bachmann, Baqaee, Bayer, Kuhn, Löschel, Moll, Peichl, Pittel, Schularick

Markus' Academy

April 7, 2022

Objectives

Assess economic consequences for Germany of cut-off from Russian energy imports

- either embargo by Germany/EU
- or stop of deliveries by Russia

Worst-case scenario of cold turkey complete import stop

- arguably bounds other scenarios, say tariff
- less extreme policies may trigger full stop by Russia

Get sense of rough magnitudes of economic losses relative to “do nothing” baseline

1. Small GDP decline, say 0.5-1%, perhaps not even a recession?
2. Like Covid = 4.5% decline in German GDP?
3. Like Spain or Portugal during Euro crisis (5.1% & 7%)?
4. “Mass unemployment and poverty” so perhaps like Great Depression?

Takeaways

Economic losses relative to "do nothing" baseline?

1. Small GDP decline, say 0.5-1%, perhaps not even a recession?
2. Like Covid = 4.5% decline in German GDP?
3. Like Spain or Portugal during Euro crisis (5.1% & 7%)?
4. "Mass unemployment and poverty" so perhaps like Great Depression?

Headline numbers: **GDP decline between 0.5% and 3%**

Takeaways

1. Import stop likely somewhat less severe than Covid recession
2. That was a recession in which we were able to provide insurance & socialize costs

Not in paper but will talk about it

- Effects of import stop on inflation

German primary energy usage

	Oil	Gas	Coal	Nuclear	Renew.	Rest	Total
TWh	1077	905	606	209	545	45	3387
%	31.8	26.7	17.9	6.2	16.1	1.3	100
of which Russia	34%	55%	26%	0%	0%	0%	30%

Oil and coal have **global market** (+ a strategic reserve)

Gas much trickier due to pipeline network, small LNG supplies $\Rightarrow$ **focus on gas**

Size of the gas shock

Lose 55% of gas but some substitution possible (Bruegel, 2022, and others)

- Relevant time horizon: roughly until next winter (seasonality of gas demand)
- Increase gas imports from NOR, NL,...
- Substitute some gas in electricity generation (lignite, hard coal, nuclear)
- Lose 55% of gas, import or substitute 25% $\Rightarrow$ gas $\downarrow$ 30%
- $\Rightarrow$ energy shock: gas $\downarrow$ 30% or equivalently energy (gas+oil+coal) $\downarrow$ 8%

Plan for remainder of talk

1. Some facts about German economy and its energy dependence
2. Starting from facts, map energy shock into GDP/GNE losses using macro models
   - simplest model: importance of substitutability
   - sufficient statistics formula for richer models with supply chains (Baqaee-Farhi)
   - model simulations: supply chains and international trade
3. Mechanisms outside models and other studies
4. France and other EU countries, embargo vs tariff

Facts I: Energy Dependence of German Economy

1. Consumption of gas, oil and coal: 4% of GNE
2. Imports of gas, oil and coal: 2.5% of GNE
3. Consumption of gas (also = imports): 1.2% of GNE
4. Gas usage and economic importance of broad economic sectors

	Households	Industry	Services, T&C	Electricity Gen.	Other
Gas usage (%)	30.8	36.9	12.8	12.6	6.9
Employment (%)		22.6	72.8	0.6	2.9
Gross Value Added (%)		25.9	69.7	2.2	2.3

Sources: BDEW (2021) and Eurostat (2020)
https://ec.europa.eu/eurostat/databrowser/view/NAMA_10_A64_E__custom_2410757/default/table?lang=en
https://ec.europa.eu/eurostat/databrowser/view/NAMA_10_A64__custom_2410837/default/table?lang=en

Numbers in 1.-3. small. But energy = critical input $\Rightarrow$ amplification important.

Facts II: Hardest Hit Industries

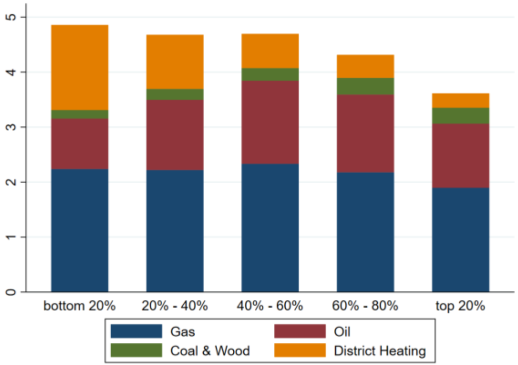
	2022 Crisis (Import Stop)			2020 Crisis (Covid-19)		
	Chemicals	Food+	Metal	Air Trans.	Hosp.	Entert.
Employees (in 1,000)	352	941	271	66	1894	693
Employees (% of total)	0.78	2.08	0.60	0.15	4.18	1.53
GVA (in €bln)	46	47	21	7	51	43
Gross Output (in €bln)	137	195	104	25	104	69
Share males (in %)	74	52	88	46	47	49
Share gas (%)	37	12	10			

Source: Volkswirtschaftliche Gesamtrechnungen (2019)

3 hardest hit sectors:

- Make up 59% of industrial gas usage
- In terms of GVA, wages, and employees comparable to hardest hit sectors in 2020
- Big difference in gender to sectors shut down in 2020

Facts III: Direct exposure across the income distribution



- Expenditure shares for heating between 3-5%
- Relatively flat in income (=declining income share)
- Larger households have smaller heating shares (not shown)
- Gradient in income the same across household sizes
- Share of car fuels (not shown): inverse U-shape in income

Macro models

- Starting from facts, map energy shock into GDP/GNE losses using macro models
- e.g. recall gas $= 1.2\%$ of GNE/GDP, gas shock $= -30\%$
- Two extreme non-sensical calculations that are inconsistent with data
  - GDP loss $= 1.2\% \times -30\% = -0.3\%$
    (Summers: financial crisis $\Leftrightarrow$ electricity `http://larrysummers.com/page/5/?s=secular+stagnation`)
  - no substitutability whatsoever: GDP falls one for one with gas, i.e. -30%
- Our results: large amplification rel. to naive 0.3% calc but by factor of 10 not 100

Simplest model: CES production function

$$Y = \left[(1-\alpha)^{\frac{1}{\sigma}} F(K,L)^{\frac{\sigma-1}{\sigma}} + \alpha^{\frac{1}{\sigma}} Gas^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

- Key parameters: elasticity of substitution σ, gas share α
- Two extreme cases above are Cobb-Douglas, $\sigma = 1$, and Leontief, $\sigma = 0$

Elasticities of substitution and substitution more generally

Time dependence (le Chatelier)

- Very short run elasticity $<<$ long run elasticity
- Relevant horizon for import stop: until next winter (seasonality of gas demand)

Micro vs macro elasticities

- macro: substitution across production processes / firms (extensive margin)

Role of supply chains

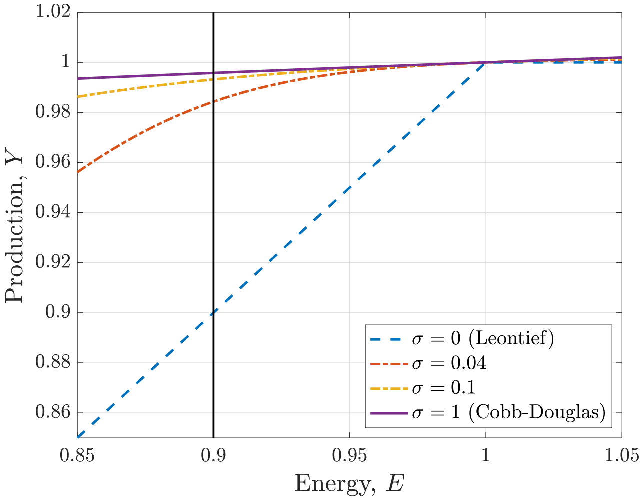
- long supply chains create bottlenecks ...
- ... but also: the longer the chain, the more substitution possibilities

Substitution via imports

- substitute intermediate goods that become too expensive with imports
- gas $\rightarrow$ ammonia $\rightarrow$ fertilizer $\rightarrow$ ...
- import fertilizer to preserve downstream production

See `https://benjaminmoll.com/RussianGas_Substitution/` for more

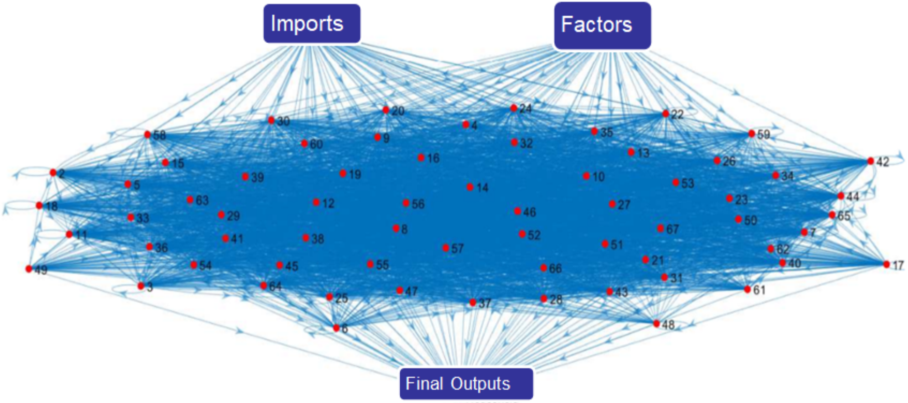
Output losses for different elasticities of substitution



Small gas share $\alpha \Rightarrow$ even with very low σ output losses potentially far from Leontief

Richer models with supply chains and international trade

- Complex production network, i.e. supply chains/production cascades
  $\Rightarrow$ allows for spill-overs and increased damages
- Multi-country $\Rightarrow$ substitution via imports possible, e.g. import energy-intense products instead of energy (e.g. basic chemicals, raw metals)



Conceptual Framework

- Two objects of interest:
  - German real consumption – real GNE, W
  - German real production – real GDP, Y
- GDP includes production of exports, GNE includes consumption of imports
- We assume that initial equilibrium German production network is efficient

Conceptual Framework – Second-Order Approximation

- Real consumption change

$$\Delta \log W \approx \sum_{j\in \text{imports}} \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i\in \text{exports}} \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f\in \text{factor}} \frac{w_f L_f}{GNE} \Delta \log L_f$$
$$+ \frac{1}{2} \left[\sum_{j\in \text{imports}} \Delta \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i\in \text{exports}} \Delta \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f\in \text{factors}} \Delta \frac{p_f L_f}{GNE} \Delta \log L_f \right].$$

Real production change

$$\Delta \log Y \approx \sum_{f\in \text{factor}} \frac{w_f L_f}{GDP} \Delta \log L_f + \frac{1}{2} \sum_{f\in \text{factor}} \Delta \frac{w_f L_f}{GDP} \Delta \log L_f .$$

Conceptual Framework – Key Quantities

$$\Delta \log W \approx \sum_{j \in \text{imports}} \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in \text{exports}} \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in \text{factor}} \frac{w_f L_f}{GNE} \Delta \log L_f$$
$$+ \frac{1}{2} \left[\sum_{j \notin D} \Delta \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in D} \Delta \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in F} \Delta \frac{p_f L_f}{GNE} \Delta \log L_f \right].$$

- Key uncertainties:
  - $\Delta \log m$: size of the shock — reduction in energy imports.

Conceptual Framework – Key Quantities

$$\begin{aligned}\Delta \log W \approx & \sum_{j\in\text{imports}} \frac{p_j m_j}{GNE}\Delta \log m_j - \sum_{i\in\text{exports}} \frac{p_i x_i^X}{GNE}\Delta \log x_i^X + \sum_{f\in\text{factor}} \frac{w_f L_f}{GNE}\Delta \log L_f \\ & + \frac{1}{2}\left[\sum_{j\notin D} \Delta \frac{p_j m_j}{GNE}\Delta \log m_j - \sum_{i\in D} \Delta \frac{p_i x_i^X}{GNE}\Delta \log x_i^X + \sum_{f\in F} \Delta \frac{p_f L_f}{GNE}\Delta \log L_f\right].\end{aligned}$$

- Key uncertainties:
  - $\Delta \log m$: size of the shock — reduction in energy imports.
  - $\Delta \frac{p_j m_j}{GNE}$: change in expenditures — complementarities/essentialness.

Conceptual Framework – Key Quantities

$$\Delta \log W \approx \sum_{j \in \text{imports}} \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in \text{exports}} \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in \text{factor}} \frac{w_f L_f}{GNE} \Delta \log L_f$$
$$+ \frac{1}{2} \left[\sum_{j \notin D} \Delta \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in D} \Delta \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in F} \Delta \frac{p_f L_f}{GNE} \Delta \log L_f \right].$$

- Key uncertainties:
  - $\Delta \log m$: size of the shock — reduction in energy imports.
  - $\Delta \frac{p_j m_j}{GNE}$: change in expenditures — complementarities/essentialness.
  - $\Delta \log L_f$: unemployment — principally due to negative aggregate demand effects.

Conceptual Framework – Key Quantities

$$\Delta \log W \approx \sum_{j \in \text{imports}} \frac{p_j m_j}{GNE} \Delta \log m_j + \frac{1}{2} \sum_{j \notin D} \Delta \frac{p_j m_j}{GNE} \Delta \log m_j + \sum_{f \in \text{factor}} \frac{w_f L_f}{GNE} \Delta \log L_f .$$

- Key uncertainties:
  - $\Delta \log m$: size of the shock — reduction in energy imports.
  - $\Delta \frac{p_j m_j}{GNE}$: change in expenditures — complementarities/essentialness.
  - $\Delta \log L_f$: unemployment — principally due to negative aggregate demand effects.

Order of Magnitudes Calculation

- Suppose reduction in gas $\Delta \log m$ is -30%.
- Gas share of GNE/GDP is 1.2%.
- Suppose expenditure share quadruples (comparable to oil crisis in 70s).
- Then

$$\Delta \log W \approx \frac{p_j m_j}{GNE} \Delta \log m_j + \frac{1}{2} \Delta \frac{p_j m_j}{GNE} \Delta \log m_j$$

$$= 1.2\% \times \log(0.7) + \frac{1}{2} \times 3.6\% \times \log(0.7) \approx -1\%$$

- To go further, use a series of structural models.

The Numbers

	Baqaee-Farhi suff. statistic	Baqaee-Farhi simulation	Simplest model 10% energy $\downarrow$	Simplest model 30% gas $\downarrow$
GNE Loss, in %	< 1	< 0.3	1.5	2.3
As % of GDP	< 1	< 0.3	1.3	2.2
Per capita	€400	€100	€600	€900

- All Models use conservative elasticity estimates
- Simplest model (= production fn) abstracts from trade/substitution downstream

What is missing from calculations on previous page?

Business Cycle amplification effects

- Additional real and nominal frictions:
  - E.g. wage and price stickiness, financial frictions
  - $\Rightarrow$ Contracts aggregate demand $\Rightarrow \Delta \log L < 0$
- **Compensate lack of such frictions** with pessimistic calibration throughout:
  - Halve elasticities
  - Round up headline number (e.g. from 2.2 to 3%)
  - Focus on simple model where import substitution is absent
- **But**, note that:
  1. BF model has adjustments costs (fixed K and L)
  2. Run pessimistic sticky price scenarios in BF:
     $\Rightarrow$ amplification by at most $\times 2$
  3. Policy response can potentially attenuate significant part of amplification

Since business cycle amplification effects were missing ...

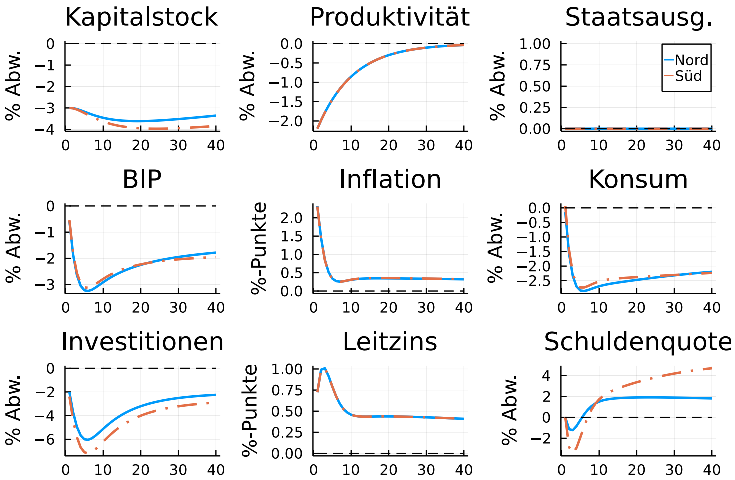
Model

- Keynesian model with heterogeneous households
- Work by Bayer, Kriwoluzky, Seyrich & Müller (DIW, 2022)

The shock

- 3% of capital become obsolete (depreciation shock)
- TFP drops initially by 2.2%

Business Cycle Effects



- Assumption is lenient fiscal policy
- ECB increases interest rates to “lean against" rising inflation

Other studies: overview by German Council of Economic Experts

↘ TABLE 3

Selected scenarios on the consequences of an intensification of the conflict for the economic outlook

Institution	Scenario	Assumptions	GDP-deduction[1]	Additional inflation[1]	Region
Effects relative to a baseline scenario incorporating the state of the conflict and sanctions at time of publication					
Deutsche Bank Research[2]	Negative scenario with a temporary import stop of natural gas and oil from Russia	Sharply higher energy prices (Oil 140 US-$/barrel; natural gas 150 €/MWh)	1.5	1–1.5	Germany
ECB[2]	Adverse scenario	Sharp temporary increase of natural gas prices and increase of oil prices	1.2	0.8	Euro area
ECB[2]	Severe scenario	Sharper and longer increase of natural gas and oil prices; strong second round effects	1.4	2.0	Euro area
Oxford Economics[2]	Stop of Russian natural gas imports for 6 months	Oil price between 100 and 115 US-$/barrel, natural gas price at 190 €/MWh	1.5	2.6	Euro area
Goldman Sachs[2]	Stop of russian natural gas imports		2.2	–	Euro area
Effects relative to a baseline scenario not incorporating the state of the conflict and sanctions at time of publication					
EcoAustria[2] (Köppl-Turyna et al.)	Increase of natural gas prices and stop of exports to Russia	Natural gas price of 172 €/MWh and no exports to Russia and to Ukraine	1.3	–	Austria
NIESR[2] (Liadze et al.)		Oil price at 140 US-$/barrel higher public spending	0.8	2.5	Euro area
Estimates of Bachmann et al. (2022)					
Bachmann et al.[3]	Cessation of trade between Russia and the EU	Introduction of trade barriers in the model of Baqaee and Farhi (2021), which lead to a stop of all imports from Russia to the EU	0.2–0.3	–	Germany
Bachmann et al.[4]	Stop of Russian natural gas imports	30 % decline of natural gas imports; elasticity of substitution between natural gas and other inputs of 0.1	2.2	–	Germany
Bachmann et al.[5]	Stop of Russian energy imports	30 % decline of energy imports; change of the cost share of energy imports in the GNE by 5 percentage points to 7.5 %	1.4	–	Germany

Report by German Council of Economic Experts

Very well done. Highly recommended.

- German version: `https://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/Konjunkturprognosen/2022/KJ2022_Kasten3.pdf`
- Shortened English version: `https://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/Konjunkturprognosen/2022/KJ2022_Box3_Excerpt.pdf`

No bottom line numbers in text but Volker Wieland clarified they mean 3-5% GDP loss

- too pessimistic for our taste but it's their job to be pessimistic

Shoutout not just to the "sages" but also the team (Niklas Garnadt, Lars Other & co)

Criticisms we haven't discussed yet

Krebs (2022)

- should have separate elasticity of substit'n for chemical industry, lower than 0.05
- can potentially use Baqaee-Farhi sufficient statistics formula to do this
- ignore "no chemical industry" rhetoric `https://twitter.com/ben_moll/status/1511351172363390976`

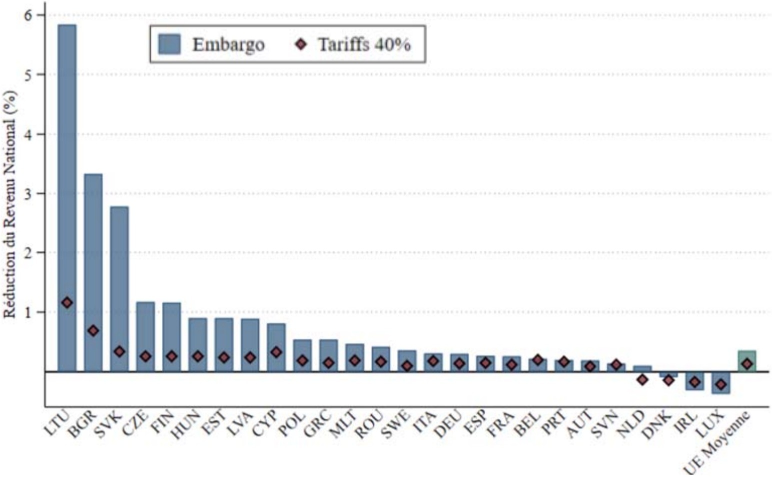
Scholz (2022) and Habeck (2022)

- "where is the gas actually supposed to run through, where are the pipelines, what is the regasification capacity,..."
- "sheer physics stands in the way of these macroeconomic models, the time it takes to build the pipes, pipes that haven't been built yet, ships that aren't there yet..."
- large part does not seem to be about the macro models
  (which do respect physics = resource constraints, production functions,...)
  - but that import/substitution of 25% gas, hence 30% gas shock too optimistic?
  - or perhaps want spatial model w transport costs à la Rossi-Hansberg, Redding, ...?
- My sense (w/o having done it): such extensions unlikely to drastically ↑ numbers

France and other EU countries, embargo vs tariff

Report for French CEA w Landais & Martin https://www.cae-eco.fr/staticfiles/pdf/cae-focus84.pd

b. Impact of a complete ban vs a 40% tariff on Russian energy imports the most pessimistic calibration in terms of substitution



Conclusion

Costs of Embargo

- Estimated costs are substantial, but not catastrophic.
- Ballpark: somewhat smaller than COVID, worst-case 3% GDP on impact.
- Estimate is conservative
  (halved Elasticities, no import substitution on impact, rounding up)
- Distribution of costs: relatively equal across the income distribution.

Conclusion

Policy

- Make sure the price mechanism works, want people to substitute
- Prevent shock from falling entirely on industry or households, see appendix
- Monetary policy: raise interest rates to control inflation
- Bad fiscal policies: tax subsidies on energy, ...
- Make use of policies applied during COVID to socialize losses:
  bailouts, furlough ("Kurzarbeit"), all to avoid financial spillovers
- Substantial inflation effects might require adjustment of tax and transfer schedules

Some words of caution

What we do not say

- Embargo is the only or best policy option

What we do say

- Embargo in size comparable to COVID recession
- That was a recession in which we were able to provide insurance and socialize costs

Distribution of Gas Shock: Industry vs Rest?

Important question: which sector absorbs reduction in gas supplies?

Approximately 1000 TWh of gas, falls by 300 TWh = 30%

Current gas use across sectors (numbers rounded to ease calculation)

	Gas use in TWh
Industry	300
Households, services, electricity etc	700

Scenario 1 (extreme): gas reduction falls entirely on industry. Ind. gas $\downarrow$ by 300 TWh (100%)

Scenario 2 (extreme): gas reduction falls entirely on rest. Industrial gas does not fall at all.

Scenario 3: households etc save/substitute 100 TWh. Industrial gas $\downarrow$ by 200 TWh (66%)

Scenario 4: even distribution. Gas in all sectors falls by 30%

We assume either scenario 4 or that prices efficiently allocate shortfall

- depends on policy choices, more at end of presentation

Recall main results

	Baqaee-Farhi suff. statistic	Baqaee-Farhi simulation	Simplest model 10% energy $\downarrow$	Simplest model 30% gas $\downarrow$
GNE Loss, in %	< 1	< 0.3	1.5	2.3
As % of GDP	< 1	< 0.3	1.3	2.2
Per capita	€400	€100	€600	€900

- Instead in scenario 3 in which shock falls largely on industry (simple model): industrial gas $\downarrow$ 66% $\Rightarrow$ 33% (!) loss of industrial output
- Prevent shock from falling entirely on industry (or households)