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

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07. April 2022
Markus Brunnermeier
Bachman, Baqae, Bayer, Kuhn, Löschel, Moll, Peichl, Pittel, Schularick (2022)

<table>
<thead>
<tr>
<th>market</th>
<th>Substitute with</th>
<th>Russia’s escape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>world</td>
<td>Other supplier</td>
</tr>
<tr>
<td>Oil</td>
<td>world</td>
<td>Different energy (hydrogen)</td>
</tr>
<tr>
<td>Natural gas</td>
<td>local</td>
<td></td>
</tr>
</tbody>
</table>

Low cost $\Rightarrow$ low effectiveness vs. High ....
Timing: Blitz sanctions vs. sustained sanctions

- “Blitz/Cold turkey sanctions”
  - More effective as Russia can’t adjust
    - Quick military withdrawal if one hits hard (?)
  - 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
2 Types of studies

- Macro approach
  - Substitutability across sectors
    - estimate

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

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

Next week with Elina Ribakova
Substitutability

substitute

2 isoquants

gas
Substitutability

Lower substitutability

2 isoquants
Substitutability

substitute

gas

Lowest substitutability (Leontief)
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%

- Jim Hamilton’s webinar
- 2022: Less oil dependent economy
  - ... but squeezed out last efficiency unit already
Upstream: Leontief, substitutability downstream

Aggregated substitutabilities – Production chain

- Input x, Gas_x Leontief 50:50
- Input y, Gas_y Leontief 50:50
- Input A, B substitutability

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
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%  
   b. 1%-3%  
   c. 3%-5%  
   d. 5%-10%  
   e. more than 10%

2. If the EU were to impose a 40% tariff on all Russian energy, by how much ...?
   a. less than 1%  
   b. 1%-3%  
   c. 3%-5%  
   d. 5%-10%  
   e. more than 10%

3. Import stop of Russian energy ... by how much will the German inflation rate increase ...?
   a. less than 2%  
   b. 2%-4%  
   c. 4%-6%  
   d. more than 6%
What if . . . ? The Economic Effects for Germany of a Stop of Energy Imports from Russia

Bachmann, Baqae, 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

<table>
<thead>
<tr>
<th></th>
<th>Oil (TWh)</th>
<th>Gas (TWh)</th>
<th>Coal (TWh)</th>
<th>Nuclear (TWh)</th>
<th>Renew. (TWh)</th>
<th>Rest (TWh)</th>
<th>Total (TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWh</td>
<td>1077</td>
<td>905</td>
<td>606</td>
<td>209</td>
<td>545</td>
<td>45</td>
<td>3387</td>
</tr>
<tr>
<td>%</td>
<td>31.8</td>
<td>26.7</td>
<td>17.9</td>
<td>6.2</td>
<td>16.1</td>
<td>1.3</td>
<td>100</td>
</tr>
<tr>
<td>of which Russia</td>
<td>34%</td>
<td>55%</td>
<td>26%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>30%</td>
</tr>
</tbody>
</table>

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

Gas much trickier due to pipeline network, small LNG supplies ⇒ **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% ⇒ gas ↓ 30%
- ⇒ energy shock: gas ↓ 30% or equivalently energy (gas+oil+coal) ↓ 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 (Baqae-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

<table>
<thead>
<tr>
<th></th>
<th>Households</th>
<th>Industry</th>
<th>Services, T&amp;C</th>
<th>Electricity Gen.</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas usage (%)</td>
<td>30.8</td>
<td>36.9</td>
<td>12.8</td>
<td>12.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Employment (%)</td>
<td>22.6</td>
<td>72.8</td>
<td>0.6</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Gross Value Added (%)</td>
<td>25.9</td>
<td>69.7</td>
<td>2.2</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>

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 ⇒ amplification important.
# Facts II: Hardest Hit Industries

<table>
<thead>
<tr>
<th></th>
<th>2022 Crisis (Import Stop)</th>
<th>2020 Crisis (Covid-19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees (in 1,000)</td>
<td>352</td>
<td>941</td>
</tr>
<tr>
<td>Employees (% of total)</td>
<td>0.78</td>
<td>2.08</td>
</tr>
<tr>
<td>GVA (in €bln)</td>
<td>46</td>
<td>47</td>
</tr>
<tr>
<td>Gross Output (in €bln)</td>
<td>137</td>
<td>195</td>
</tr>
<tr>
<td>Share males (in %)</td>
<td>74</td>
<td>52</td>
</tr>
<tr>
<td>Share gas (%)</td>
<td>37</td>
<td>12</td>
</tr>
</tbody>
</table>

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% × −30% = −0.3%
    (Summers: financial crisis ⇔ 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 \(\sigma\), gas share \(\alpha\)
- 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 $\sigma$ output losses potentially far from Leontief
Richer models with supply chains and international trade

- Complex production network, i.e. supply chains/production cascades ⇒ allows for spill-overs and increased damages
- Multi-country ⇒ substitution via imports possible, e.g. import energy-intensive 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

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

Key uncertainties:

- \( \Delta \log m \): size of the shock — reduction in energy imports.
\[ \Delta \log W \approx \sum_{j \in \text{imports}} \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in \text{exports}} \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in \text{factor}} \frac{w_f L_f}{GNE} \Delta \log L_f \\
+ \frac{1}{2} \left[ \sum_{j \notin D} \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in D} \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in F} \Delta \frac{p_f L_f}{GNE} \Delta \log L_f \right]. \]

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.
Conceptual Framework – Key Quantities

\[ \Delta \log W \approx \sum_{j \in \text{imports}} \frac{p_j m_j}{GNE} \Delta \log m_j - \sum_{i \in \text{exports}} \frac{p_i x_i^X}{GNE} \Delta \log x_i^X + \sum_{f \in \text{factor}} \frac{w_f L_f}{GNE} \Delta \log L_f \]

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

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- **Key uncertainties:**
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  - \( \Delta \frac{p_j m_j}{GNE} \): 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

<table>
<thead>
<tr>
<th></th>
<th>Baqee-Farhi suff. statistic</th>
<th>Baqee-Farhi simulation</th>
<th>Simplest model 10% energy ↓</th>
<th>Simplest model 30% gas ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNE Loss, in %</td>
<td>&lt; 1</td>
<td>&lt; 0.3</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>As % of GDP</td>
<td>&lt; 1</td>
<td>&lt; 0.3</td>
<td>1.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Per capita</td>
<td>€400</td>
<td>€100</td>
<td>€600</td>
<td>€900</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Institution</th>
<th>Scenario</th>
<th>Assumptions</th>
<th>GDP-dec.</th>
<th>Additional infl.</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deutsche Bank Research(^2)</td>
<td>Negative scenario with a temporary import stop of natural gas and oil from Russia</td>
<td>Sharply higher energy prices (Oil 140 US-$/barrel; natural gas 150 €/MWh)</td>
<td>1.5</td>
<td>1-1.5</td>
<td>Germany</td>
</tr>
<tr>
<td>ECB(^2)</td>
<td>Adverse scenario</td>
<td>Sharp temporary increase of natural gas prices and increase of oil prices</td>
<td>1.2</td>
<td>0.8</td>
<td>Euro area</td>
</tr>
<tr>
<td>ECB(^2)</td>
<td>Severe scenario</td>
<td>Sharper and longer increase of natural gas and oil prices; strong second round effects</td>
<td>1.4</td>
<td>2.0</td>
<td>Euro area</td>
</tr>
<tr>
<td>Oxford Economics(^2)</td>
<td>Stop of Russian natural gas imports for 6 months</td>
<td>Oil price between 100 and 115 US-$/barrel, natural gas price at 190 €/MWh</td>
<td>1.5</td>
<td>2.6</td>
<td>Euro area</td>
</tr>
<tr>
<td>Goldman Sachs(^2)</td>
<td>Stop of russian natural gas imports</td>
<td></td>
<td>2.2</td>
<td>-</td>
<td>Euro area</td>
</tr>
</tbody>
</table>

### Effects relative to a baseline scenario incorporating the state of the conflict and sanctions at time of publication

<table>
<thead>
<tr>
<th>Institution</th>
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<th>Assumptions</th>
<th>GDP-dec.</th>
<th>Additional infl.</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>EcoAustria(^2)</td>
<td>Increase of natural gas prices and stop of exports to Russia</td>
<td>Natural gas price of 172 €/MWh and no exports to Russia and to Ukraine</td>
<td>1.3</td>
<td>-</td>
<td>Austria</td>
</tr>
<tr>
<td>NIESR(^2)</td>
<td>Oil price at 140 US-$/barrel, higher public spending</td>
<td></td>
<td>0.8</td>
<td>2.5</td>
<td>Euro area</td>
</tr>
</tbody>
</table>

### Effects relative to a baseline scenario not incorporating the state of the conflict and sanctions at time of publication

- Based on a production function approach with conservatively estimated elasticities of substitution, without common macroeconomic amplification mechanisms.
- Approximation of the GNE loss based on a sufficient statistic. Lemma 1 in Bachmann et al. (2022) derives the approximation in the general model of Baqaee and Farhi (2021). The approach does not incorporate common macroeconomic amplification mechanisms.

Very well done. Highly recommended.

- **German version:** [https://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/Konjunkturprognosen/2022/KJ2022_Kasten3.pdf](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](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 Baqee-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

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

Figure 2. Estimated output losses from a stop of Russian energy imports for EU country (excl. Croatia): Simulations from Baqaee‐Farhi (2021) model

a. Impact of a complete ban on Russian energy imports for different calibrations

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)

<table>
<thead>
<tr>
<th></th>
<th>Gas use in TWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>300</td>
</tr>
<tr>
<td>Households, services, electricity etc</td>
<td>700</td>
</tr>
</tbody>
</table>

Scenario 1 (extreme): gas reduction falls entirely on industry. Ind. gas ↓ 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 ↓ 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

<table>
<thead>
<tr>
<th></th>
<th>Baqee-Farhi suff. statistic</th>
<th>Baqee-Farhi simulation</th>
<th>Simplest model 10% energy ↓</th>
<th>Simplest model 30% gas ↓</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNE Loss, in %</td>
<td>&lt; 1</td>
<td>&lt; 0.3</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>As % of GDP</td>
<td>&lt; 1</td>
<td>&lt; 0.3</td>
<td>1.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Per capita</td>
<td>€400</td>
<td>€100</td>
<td>€600</td>
<td>€900</td>
</tr>
</tbody>
</table>

- Instead in scenario 3 in which shock falls largely on industry (simple model): industrial gas ↓ 66% ⇒ 33% (!) loss of industrial output

- Prevent shock from falling entirely on industry (or households)