The Power of Substitution
The Great German Gas Debate in Retrospect

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Moritz Schularick
Georg Zachmann

Brookings Papers on Economic Activity, Fall 2023
What this paper is about
Background: German primary energy consumption in 2021

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>Gas</th>
<th>Coal</th>
<th>Nuclear</th>
<th>Renew.</th>
<th>Rest</th>
<th>Total</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>

Source: Bachmann et al. (2022a)
Embargo debate after Russian invasion of Ukraine

Money for Russian gas imports

660 million euros a day – this is how we finance Putin’s war

Gas from Russia: For President Putin, gas exports are currently the most important source of foreign exchange. Photo: Dselby Lovetsky / dpa

BASF boss warns of destruction of the "entire economy"

Oil and gas are central to the chemical industry. Should their imports from Russia be stopped, BASF boss Martin Brudermüller predicts the “worst crisis since the end of the Second World War”.

Putin is swimming in our money

Ohne bezahlbare Energie droht Deutschlands Wirtschaft der Infarkt.
Our March 2022 “what if?” paper and the gas cut-off

Published 7 March 2022. Team: Rüdiger Bachmann, David Baqae, Christian Bayer, Andreas Löschel, Moritz Kuhn, Ben Moll, Andreas Peichl, Karen Pittel, Moritz Schularick

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Soon after: cut-off happens because Russia weaponizes gas supplies

• June 2022: drastically cuts supplies, particularly via Nord Stream
• August 2022: completely halt Nord Stream flows (destroyed 4 weeks later)
This paper: adjustment of German economy after cut off

“Destruction of economy”? Instead: **mini recession** (last 3 Q’s: −.4%, −.1%, ±0%)

Other main results:

- Large movements in both gas demand and supply (imports from 3rd countries)
- Evidence for “cascading effects” along supply chains? No, instead “decoupling”
- In line with theory: a bit of substitutability goes a long way (σ = 0.05 vs σ = 0)
Plan

1. The core argument: the power of substitution

2. How the adjustment happened: adaptation and substitution
   • today: focus on industry

3. Could Germany have withstood an earlier gas cut-off?

4. Political economy of decision making in times of crisis

More in paper:
• Adaptation by households
• Keynesian demand amplification (= omission from “what if?” paper)
• Why was gas cut-off less costly than 1970s oil shocks?
• Did Germany simply get lucky due to a mild winter etc? No
• Online appendix: 36 concrete cases of substitution and demand reduction
The Core Argument:
The Power of Substitution
Illustration using aggregate production function: $\sigma = 0.05$ vs $\sigma = 0$

$$Y = \left[ \alpha \frac{1}{\sigma} \text{Gas} \frac{\sigma - 1}{\sigma} + (1 - \alpha) \frac{1}{\sigma} \text{(Other Inputs)} \frac{\sigma - 1}{\sigma} \right] \frac{\sigma}{\sigma - 1} \quad \text{and} \quad \text{Gas} \downarrow 20\%$$

- Output losses for different elasticities of substitution $\sigma$ and $\alpha = 1\%$:

  - Leontief $\sigma = 0$ $\Rightarrow$ production drops one-for-one with gas usage $= 20\%$
  - Even with $\sigma = 0.05$, output losses much smaller $= 2.7\%$ (almost $10\times$)
Modeling supply chains and international trade: “cascading effects” and substitution via imports

- We used model and sufficient statistics approach of Baqee-Farhi
- Predictions from previous slide carry over (e.g. Leontief ⇒ 1-for-1 drop)
- Additional role for substitution of gas-intensive products via imports
- Noteworthy: DE manufacturing = “only” 23% of employment, 25% of VA
How the Adjustment Happened
Large adjustments on both demand- and supply side

German Natural Gas, change in % of previous consumption (2019-21 average)

Figure 4: Germany’s changing gas balance

Notes: The figure compares German natural gas imports, consumption, and storage change for the period July 2022 - March 2023, to the corresponding average from 2019 to 2021 using data from Eurostat (database code nrg_ti_gasm), McWilliams and Zachmann (2023), and AGSI. On the supply side, we take into account not only direct imports to Germany but also indirect imports via third countries as well as re-exports within Europe. More details, including on sources, are in appendix B.
Large demand reduction by industry and households

<table>
<thead>
<tr>
<th></th>
<th>2022/23 consumption</th>
<th>Baseline consumption</th>
<th>Reduction rel. to baseline</th>
<th>Percentage reduction</th>
<th>Bachmann et al. (August 2022)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>642 TWh</td>
<td>799 TWh</td>
<td>157 TWh</td>
<td>20%</td>
<td>25%</td>
</tr>
<tr>
<td>Industry</td>
<td>276 TWh</td>
<td>373 TWh</td>
<td>98 TWh</td>
<td>26%</td>
<td>26%</td>
</tr>
<tr>
<td>Households</td>
<td>281 TWh</td>
<td>339 TWh</td>
<td>58 TWh</td>
<td>17%</td>
<td>16%</td>
</tr>
<tr>
<td>Power</td>
<td>85 TWh</td>
<td>87 TWh</td>
<td>1 TWh</td>
<td>2%</td>
<td>45%</td>
</tr>
</tbody>
</table>

**Table 2: Large demand reduction by industry and households**

Notes: The table summarizes gas consumption over the period July 2022 to March 2023 (“2022/23 consumption”) and compares it to average consumption in the same months in the years 2019 to 2021 (“baseline consumption”).
Industrial production in Germany and Europe looks nothing like Leontief

Recall: Leontief $\Rightarrow$ should have seen 20-30% drop in industrial production

(a) German industrial production

(b) Change in Manufacturing Output and Industrial Gas Consumption, 2022-04 to 2023-03
Decoupling: large cuts in energy-intensive sectors but not rest = polar opposite of “cascading effects”

Production index for energy-intensive industries
2015=100; seasonally and calendar adjusted (X13 JDemetra+)

Source: Destatis
BASF’s ammonia production (= very gas-intensive): when gas prices ↑

- drastically cut ammonia production in Luwigshafen, Germany
- But BASF has plant in U.S. ⇒ produce ammonia there, ship it to Germany

Substitution via imports can happen even within same company

Bad for German ammonia production but kills cascading effects
Could Germany have withstood an earlier cut-off as well?
Yes, Germany could have withstood cut-off at end of March

- Gas in storages at end of heating period = 160 TWh (65% of capacity)
- Gas imported from Russia Apr-Aug 2022 = 100 TWh (10% of yearly cons.)
- Assuming identical consumption, would still have had 60 TWh (25%) left

Storage evolution

- Storage level in TWh
- Storage level as % of maximum capacity

Actual storage evolution

Counterfactual storage evolution (April 1 cut-off)
Political economy of decision making in times of crisis
Two political problems with lessons for future crises

1. Policymakers turned to business leaders & their associations for advice
   • “expertise on the ground” but also clear incentive to talk up dependence
   • striking divergence: claimed dependence vs observed substitution (BASF)

2. Strategic use of special-interest-financed think-tanks to increase uncertainty

Head of Chancellery Econ Division: “We will never ever be able to determine whether this has a 2% or 10% GDP impact. We are simply trying to take the pragmatic middle course.”
Key Takeaways

Germany blunted Putin’s energy weapon using two margins of adjustment:

- **Supply side:** gas imports from 3rd countries ↑ (insurance through trade)
- **Demand side:** demand ↓ 20% driven by industry (26%), households (17%)

Key lesson: **the power of substitution**

- A bit of substitution goes a long way: \( \sigma = 0.05 \) very different from \( \sigma = 0 \)
- Large number of examples how this works in practice – see appendix

**Decoupling** from energy-intensive industries rather than cascading effects

In retrospect, even immediate gas import stop (embargo) was feasible

Not implementing sanctions against Russia sooner and more decisively = major missed opportunity to help avert enormous human suffering in Ukraine
Thank you!