CAN PRICE CONTROLS BE OPTIMAL? THE ECONOMICS OF THE ENERGY SHOCK IN GERMANY

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Tom Krebs[1], University of Mannheim

Isabella Weber[2], University of Massachusetts, Amherst

Abstract

In the wake of the global energy crisis, many European countries used energy price controls to fight inflation and to stabilize the economy. Despite its wide adoption, many economists remained skeptical. In this paper, we argue that price controls should be part of the policy toolbox to respond to shocks to systemically important sectors because not using them can have large economic and political costs. We put forward our arguments in two steps. In a first step, we analyze the impact on the German economy and society of the global energy crisis that followed Russia's attack on Ukraine in February 2022. Our analysis shows that energy shocks matter. Specifically, the one-year GDP loss of the energy crisis 2022 amounts to 4 percent and is comparable to the short-run output losses during the COVID-19 crisis 2020 and the global financial crisis 2008. In addition, during the energy crisis 2022 inflation rates rose dramatically and real wages dropped more than in any other year in post-war Germany. There are also clear signs that the crisis is causing severe long-term economic damage (hysteresis effects). At the beginning of 2024, GDP is 7 percent and real wages are 10 percent below the pre-COVID-19 trend. We argue that the German government handled the immediate response to the energy shock well, but subsequently waited too long to introduce an energy price brake in 2022. This failure to act decisively in response to heightened economic insecurity coincided with a strong rise of the approval rates of the far-right AfD in the summer of 2022. We also show that the German energy price brake was an effective price stabilization policy for households, but did not protect the industrial base appropriately making it more likely that the German economy will continue to stagnate. In a final step, we turn to the use of price controls as an optimal policy response to an energy shock within a general equilibrium framework. We develop a simple production model with an energy sector and shows that price controls are socially optimal whenever self-fulfilling expectations generate endogenous price uncertainty in the wake of an energy shock. We also link our analysis to the so-called sunspot literature that was developed in the 1980s as a response to the rational-expectations revolution in macroeconomics. Finally, we use our theoretical analysis to shed some light on the economic policy debate and the resistance of German mainstream economists to the introduction of energy price controls in 2022.

JEL codes: D52, D84, E12, E32, E64, Q43, Q48

Keywords: global energy crisis, German economy, endogenous uncertainty, price controls, inflation, stabilization policy

[1] Department of Economics, L7, 3-5, 68131 Mannheim, Germany. E-Mail: tkrebs@uni-mannheim.de. Further affiliations: Forum New Economy, HCEO, IMK, IZA, ZEW.

[2] Department of Economics, 219 Gordon Hall, 418 North Pleasant Street, Amherst, MA 01002. E-Mail: imweber@umass.edu. Further affiliations: IMK, PERI, Fairbank Center.

1. INTRODUCTION

The recent high-inflation episodes in many advanced economies have called into question the conventional wisdom on economic stabilization policy. Faced with an unprecedented surge in energy prices after the Russian attack on Ukraine, several European countries introduced national price controls and the European Union agreed on a general price cap for natural gas (European Council, 2022). In addition, leading economists supported the use of price controls to combat the consequences of an energy shock (Blanchard, 2022; Galbraith, 2022; Krugman; 2022; Stiglitz, 2022). However, most economists never lost their unease about a policy tool that changes market prices (Chicago Booth, 2022), and when strategic price controls were first suggested as an emergency tool in the fight against inflation (Weber, 2021), the reaction of the economics community was for the main part a kneejerk rejection (Carter, 2023; Rodrik, 2022).

In this paper, we argue that economists' fear of price controls is unwarranted and can have disastrous economic and political consequences in the context of major shocks to systemically significant prices when no other shock absorbers like strategic reserves are available.[3] A simple-minded focus on lump-sum transfers is only plausible in a world in which endogenous price uncertainty driven by self-fulfilling expectations plays no role and markets are always efficient, which are both implausible assumptions in the context of major shocks like the energy crisis. In other words, the outright rejection of any type of price controls by many economists seems to be rooted in what we might call "market fundamentalism" (Stiglitz, 2008; Oreskes and Conway, 2023). There are sound economic reasons for using prices controls in an emergency like the energy crisis 2022, and not using this policy instrument can have large economic and political costs.

We put forward our arguments in the context of the global energy crisis and its impact on the German economy. Germany provides an important case study since its economy was heavily dependent on Russian natural gas imports and hence was directly hit by the "energy shock". In addition, German mainstream economists downplayed the impact of the energy shock and they fiercely opposed any policy that would directly control energy price inflation. Clearly, this makes Germany in 2022/2023 a useful starting point for the study of price controls and market fundamentalism in the context of a major shock to a systemically important sector.

Our analysis of the energy crisis in Germany shows that energy shocks matter. In Germany, the short-run economic consequences of the energy crisis 2022 were comparable to those of the COVID-19 crisis 2020 and the financial crisis 2008, if we use GDP as a yardstick. Specifically, the

[3] Systemically significance is here defined as referring to sectoral prices that have an outsized potential to destabilize the general price level when they spike due to their importance in the production structure, in commercial infrastructure or for human livelihoods (Weber et al., 2024)

energy crisis led to a one-year output loss of about 4 percent mainly by impeding the recovery after the COVID-19 crisis.[4] If we use real wages as a yardstick, the energy crisis 2022 has been the worst economic crisis in Germany since WWII. In 2022, the German inflation rate approached 1970s levels by far outpacing nominal wage growth, which led to the largest drop in real wages in German post-war history. The unprecedented income losses, in combination with a high degree of uncertainty, go a long way towards explaining the economic anxiety felt by German wage earners.

In addition to large short-run losses, signs are mounting that the energy crisis is also causing long-run damage to the German economy. The recovery from the energy shock is very weak and output is currently about 7 percent below the pre-COVID-19 trend. According to the IMF (2024), Germany was the only advanced economy with negative GDP growth in 2023 while the projections for 2024 and 2025 are lower than for any comparable country. In other words, there is preliminary evidence that hysteresis effects have set in, by which we mean that short-run fluctuations in economic output have long-run consequence for employment or output (Blanchard and Summer, 1986; Blanchard, Cerutti, and Summers, 2015). There is a real danger that the 2020s could become a lost decade for Germany and Europe.[5] We argue that the energy price brake for households protected people from the shock after being introduced with a delay, but the government failed to shield the industrial base with an appropriately designed energy price brake. Together with the decision to start tightening fiscal policy in 2023, this has made a stagnation scenario much more likely

The economic consequences of the energy shock have been immense, but the political consequences are just as worrying. Consistent with the literature that links the rise of right-wing populism to the failure of governments to act decisively in response to heightened economic insecurity, the approval rates for the far-right Alternative for Germany (AfD) strongly increased when energy prices were exploding in the summer of 2022, but the German government rejected the use of price caps. Indeed, despite rising discontent about declining living standards and the overwhelming popularity of energy price caps, the German government initially prepared legislation for a gas price levy (Gasumlage) consistent with the advice of German mainstream economists (Bachmann et al., 2022). The steady rise in approval ratings for the AfD only stalled after the government made a 180-degree

[4] These short-run output losses take into account all direct and indirect effects of the respective crisis as well as the policy response (monetary and fiscal policy), and this should be kept in mind when interpreting the results. Note that these output losses occurred even though a worst-case scenario with a gas shortage in the winter 2022/23 could be avoided. In such a worst-case scenario, short-run output losses could have been much larger – see section 3.1 for details.

[5] This bleak economic outlook contrasts sharply with the experience of the Germany economy following the global financial crisis 2008, when growth quickly rebounded after the crisis and remained strong until 2019. In a certain sense the German experience is the mirror image of the US experience. In the US, the recovery after the financial crisis was weak and never fully back to trend, whereas the recovery after the COVID-19 crisis was quick and fully back to trend.

turn-around and announced the introduction of an energy price brake as part of a larger stabilization package in fall 2022 – the so-called "Doppel-Wumms" (Bundesregierung, 2022).[6]

In the second part of the paper, we turn to a theoretical analysis of price controls as an economic policy instrument in an energy crisis. To this end, we provide a theoretical welfare analysis based on a general-equilibrium framework that is firmly rooted in mainstream economics. We show that price controls are an optimal policy response to an energy shock if endogenous price uncertainty and self-fulfilling expectations lead to an overreaction of energy markets and inefficient fluctuations in real economic activity. In other words, market fundamentalists rule out endogenous uncertainty by assumption, and then conclude that price controls are always sub-optimal. In contrast, we argue that endogenous price uncertainty plays an important role in the context of a geopolitical mega shock like the Russian attack on Ukraine, and that price controls should therefore be part of the policy toolbox of any government that needs to respond to shocks to systemically important sectors. We also provide some arguments in this paper why the endogenous-uncertainty approach provides a more convincing theory of existing market economies in times of economic crises, but clearly more research is needed on this issue.

The notion of self-fulfilling expectations, originally a Keynesian insight ("animal spirit"), has been formalized in various strands of the mainstream economics literature. In this paper, we focus on the so-called sunspot-theory (Azariadis, 1981; Cass, 1989; Cass and Shell, 1983) that was developed in the 1980s as a response to the rational-expectation revolution in macroeconomics and the corresponding real business-cycle literature (Cherrier and Saïdi, 2018). This literature has shown that standard general-equilibrium models are consistent with the idea that signal variables unrelated to fundamentals (i.e. sunspot variables) generate endogenous price uncertainty and inefficient fluctuations in economic activity. Subsequent work in the area has further shown that sunspot-equilibria and therefore market inefficiency are in a certain sense the rule, not the exception (Cass, 1992; Krebs, 1997; Woodford, 1990). Clearly, there are additional strands of the economics literature that formalize the idea that self-fulfilling expectations can be a driver of inefficient movements in real economic activity, and we mention some of them in our concluding remarks.

Our theoretical analysis is based on a simple-two period model of a production economy with an energy sector that clarifies the link between the general inefficiency results of the sunspot literature and the optimality of energy price controls in the specific context of an energy shock. The model

[6] A second strong surge of the AfD in the polls occurred between May and July 2023, when the government tried to introduce new climate legislation for the housing sector ("Heizungsgesetz") without ensuring affordability due to premature fiscal tightening, which was rationalized by the faulty assumption that market adjustment had been smooth and the energy crisis had ended (Lindner, 2023a,b).

analysis illustrates the economic trade-off many European countries were facing in 2022. These countries had to reduce energy use thereby causing a fall in production in 2022, in order to increase gas storage and therefore reduce the likelihood of a gas shortage in 2023. We show that the market does not resolve this inter-temporal tradeoff efficiently in a sunspot-equilibrium. Specifically, endogenous uncertainty about future energy and goods prices (inflation uncertainty) causes current energy prices to overreact so that firms reduce production by more than is socially desirable. Further, energy price controls can restore efficiency and make everybody better off (Pareto improvement). Put differently, when faced with a shock to an essential input like energy the first-best solution is to use price controls to eliminate movements in real economic activity that are driven by sunspot-beliefs (animal spirit).

We use our theoretical analysis to shed light on the economic policy debate in Germany in 2022. Following the Russian invasion of Ukraine in February 2022, European natural gas prices increased more than tenfold within the time span of a few months and, after a long back and forth, the German government decided to initiate a so-called energy price brake in September 2022.[7] At that time, we put forward the argument that energy price controls should be designed so that they give firms an incentive to continue producing (Krebs, 2022a,b Weber 2022), which – as we show in this paper – is an optimal policy in a world in which energy markets overreact due to endogenous price uncertainty. In contrast, German mainstream economists strongly opposed anything that would go beyond lump-sum transfer payments (Bayer et al., 2022a; Grimm, 2022a), and publicly lectured anybody – including Chancellor Olaf Scholz – who begged to differ (Bachmann, 2022; Moll, 2022). Indeed, the possibility that energy markets could be inefficient was not even considered a point worthy of discussion – market fundamentalism dominated the policy debate until the government grasped the urgency of the situation.

We stress that we do not propose using strategic price controls to eliminate the entire rise in energy or goods prices in response to a shock. Clearly, a significant part of the hike in energy prices in 2022 was driven by the fundamental energy supply shock following the Russian invasion of Ukraine. However, we do ascertain that during the energy crisis 2022, as in many other crises, additional uncertainty was endogenously created by market participants leading to an overreaction of market prices to the original shock. In such a situation, it is socially optimal to dampen the effect on the real economy of the market price hike using price controls, even though it is usually not optimal to fully eliminate the increase in market prices – policy making becomes the art of finding the right balance in an uncertain and often chaotic world. To navigate this uncertainty and strike this balance,

[7] Of course, countries like Spain introduced energy price controls much earlier than Germany, which is one of several reasons why the Spanish economy performed much better than the German economy during the energy crisis.

non-linear pricing can be a helpful tool since it preserves some marginal price incentives while protecting the larger parts of demand against overblown market price increases (Dullien and Weber, 2022a,b; Stiglitz, 2022).

We also emphasize that the public control of prices should be a policy instrument of last resort. The first-best policy choice is preparedness, which in the case of critical inputs that are storable, durable goods means public stockholding for example in the form of strategic reserves (Weber et al., 2024). Yet, when storage is insufficient to prevent endogenous uncertainty, suitably designed price controls are welfare enhancing – they can "buy time" (Galbraith, 1980). Further, the monitoring of prices for critical sectors and the pre-crisis design of emergency plans can help facilitate a timely intervention. We believe these insights to go beyond the recent experience with the global energy shock. While the energy crisis in the wake of the Russian attack on Ukraine has been historic, the world continues to be faced with the overlapping emergencies of climate change and heightened geopolitical tensions that make shocks to systemically important sectors more likely (Weber et al., 2024). In this sense, we consider our paper a first step towards a broader research agenda that studies the policy implications of endogenous uncertainty in times of shocks to essential sectors.

2. GLOBAL ENERGY CRISIS IN GERMANY

2.1. The energy shock and successful energy-supply management

The energy crisis 2022 was mainly driven by a negative shock to the supply of natural gas that Germany and Europe used to import from Russia. This crisis had far-reaching consequences for demand patterns and trading relationships worldwide (IEA, 2023), but the most direct impact of the energy shock was felt in Germany and Europe. In Germany, about half of the natural gas used in 2021 was imported from Russia via pipelines (AGEB, 2023, BDEW, 2023). Further, half of all households use natural gas for heating, energy companies use natural gas to generate electricity and many manufacturing companies use natural gas to generate process heat or as a basic input (AGEB, 2023, BDEW, 2023). In addition, the gas price also affects electricity prices through the merit-order system in European/German electricity markets. This strong reliance on natural gas in Germany and Europe means that we can expect movements in the supply and price of natural gas to have substantial effects on the economy.

The beginning of the global energy crisis 2022 is usually dated February 24, 2022, when the Russian army invaded Ukraine. The war called into question the security of the energy supply in Europe, and most EU countries followed a two-layer strategy of energy supply management to reduce the size of the supply shock hitting the domestic economy. First, imports of natural gas from Russia were continued (no immediate embargo). Second, governments purchased natural gas on "world markets" to replace the decline in Russian gas imports driving up global energy prices. In the case of

Germany, the second leg of the strategy meant that direct imports from Norway were ramped up and imports of liquefied natural gas (LNG) via Belgium and Netherland increased substantially (AGEB, 2023, BDEW, 2023). Thus, the most important player in compensating the supply shortfall was not some abstract market sending price signals, but the German government that pursued a price-inelastic 'whatever it costs' strategy in buying up gas.

The following table summarizes the effect of the energy crisis on the quantity of natural gas imported, exported, and consumed in Germany. It shows that the strategy of the German government to reduce the effective supply shock hitting the German economy was quite successful – imports in 2022 declined only moderately relative to 2021 and exports decreased more than imports so that net imports even increased slightly.

Table 1. Imports, exports, and use of natural gas in Germany

	2021	2022	Change
Production	45.8	42.7	- 6.6 %
Imports	1,510	1,306.4	- 13.5 %
Exports	693.8	484.1	- 30.2 %
Net imports	816.2	822.3	+ 0.7 %
Total Use	917.4	773.0	- 15.7 %
Industrial Use	331.5	274.2	- 17.3 %

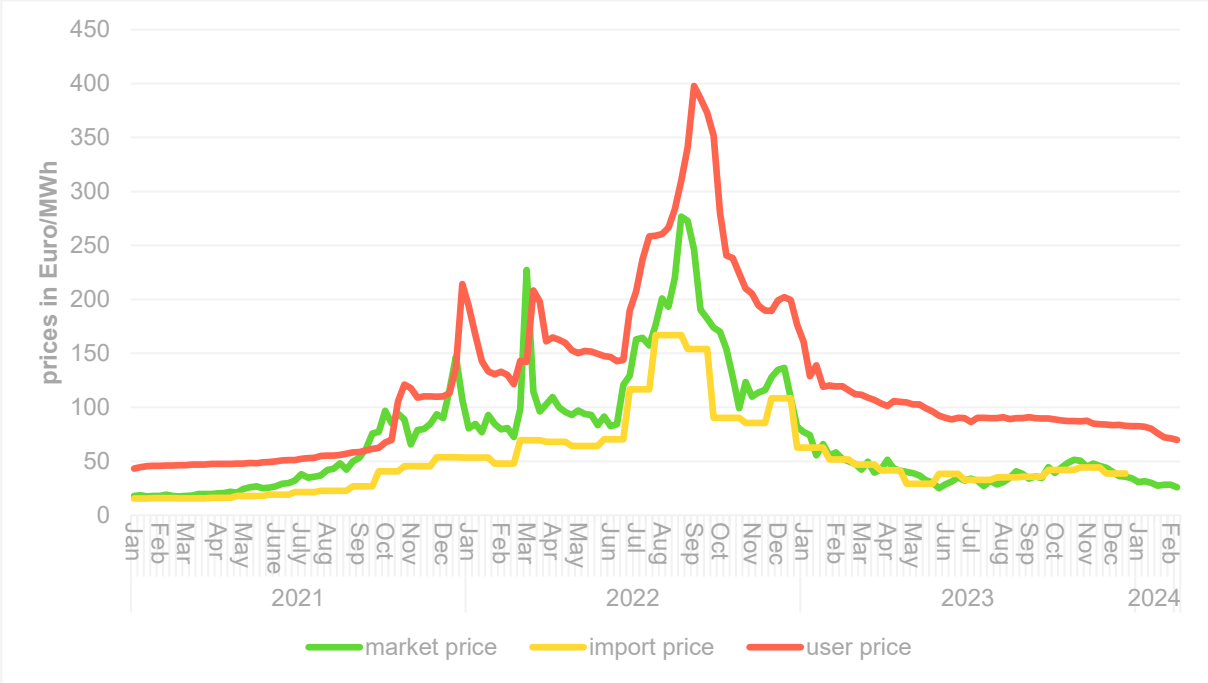
Note: Quantities are expressed in terawatt-hours. *Source:* AGEB (2023).

Table 1 shows that natural gas use decreased by around 16 percent in 2022. Some part of this decline can be attributed to a relatively mild winter, but most of the reduction in natural gas use in 2022 is the response of households and firms to rising energy prices as well as concerted savings efforts on the part of public institutions and a general public alertness.[8] The table also shows that German produces very little natural gas and the level of production barely changed. Note that the reduction in gas use in combination with almost unchanged net imports and production means that natural gas storage increased in 2022, which was the desired outcome of the policy of the German government.

The next figure shows the development of three prices for natural gas: The price in the European gas market, the price paid by companies importing gas to Germany, and the price paid by German end users with new contracts.

[8] For example, the German Federal Network Agency reports a reduction of natural gas consumption of 17.6 percent in 2022 relative to 2021, but only a reduction of 14 percent relative the four-year average in 2018-2021 (Federal Network Agency, 2023).

Figure 1. Natural gas prices in Europe/Germany



Note: All prices are monthly averages and expressed in euro per megawatt-hour. Market price is the price for a contract with deliver next month on the Dutch TTF (European market). Import price is the average price German importers have paid for natural gas. User (retail) price is the price end users (households and small businesses) pay for new contracts in Germany. Sources: Statista, Federal Statistical Office (destatis), Verivox.

The figure underscores the well-known fact that import prices and user prices follow market prices with a lag, though in this case the lag is quite short. Further, market prices are more volatile than import prices and user prices. However, prices for new users/contracts are almost as volatile as market prices, which shows how changes in market conditions directly affected households and companies in Germany. Of course, the retail price for all end users, which contains all existing contracts, is much less volatile and much more sluggish. The figure also shows that European natural gas prices have increased dramatically in 2022, but also fell very quickly after reaching the peak in August. In addition, market prices were still three times higher in 2023 (on average) than their pre-crisis level at the beginning of 2021. Thus, the energy price shock had a transitory component that was very large but relatively short-lived, and a substantial persistent component.[9]

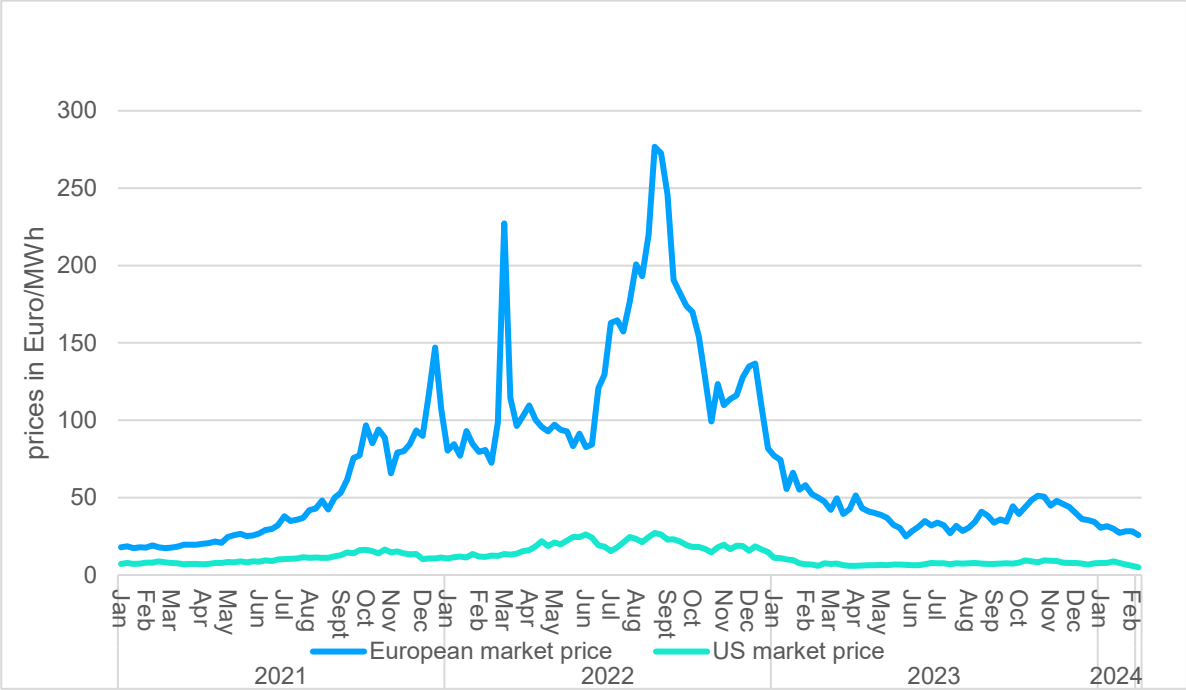
Figure 1 depicts two turning points of market prices in August 2022 and December 2022. These two turning points are associated with two specific events. First, the price decline starting towards the end of August happened when it became clear that storage tanks for natural gas are filling

[9] Figure 1 illustrates that natural gas prices in Europe increased strongly after the Russian invasion of Ukraine on February 24, 2022, but the figure also shows that natural gas prices already started to rise in the summer of 2021. The price increase in 2021 is to a certain extent also related to the war in Ukraine. Specifically, the threat of a Russian invasion has been debated since the early summer of 2021, which explains part of the increase in gas prices that began in May 2021 – market participants are forward-looking taking into account the possibility of future events. For example, when Russia started amassing troops at the Ukrainian border at a large scale in December 2021, prices in the gas market spiked.

up quickly and the German government decided to ease up on its strategy of buying natural gas at *any price* via the Trading Hub Europe GmbH (Business Insider, 2022). In addition, after some back and forth, the German government finally announced its decision to implement an energy price brake in September 2022 – see chapter 3 below for details. This change of mind also paved the way for an EU-level intervention, and in December 2022 EU member countries finally agreed to introduce a common gas price cap at 180 euros per megawatt-hour (European Council, 2022, Guardian, 2022, Reuters, 2022).

It is worth pointing out that the market for natural gas is partially segmented, and in this sense, there is no integrated "world market". In particular, the US market for natural gas was affected much less than the European gas market since most of the natural gas consumed in the US is domestically produced or imported via pipelines from Canada. Consequently, the global energy crisis 2022 did not affect the US economy to the extent it affected the European economy. The next figure underscores this point. It depicts the development of the price of natural gas in European markets and US markets, and shows that the US only experienced moderate price increases compared to gas importing European countries like Germany.

Figure 2. Natural gas prices in Europe and the US

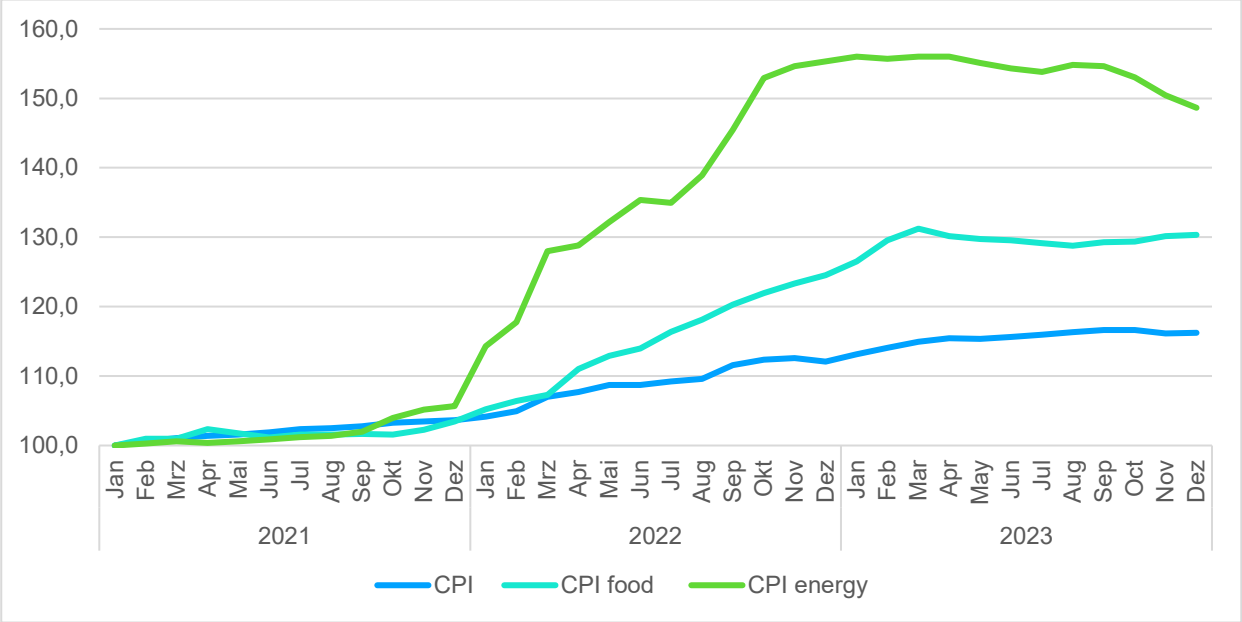


Note: All prices are monthly averages and expressed in euro per megawatt-hour. European market price is the price for a contract with deliver next month on the Dutch TTF. US market price is the price for a contract with delivery the following month on the Henry Hub; dollar prices are converted at a fixed exchange rate using average rate in January 2021. Sources: Statista, Energy Information Administration.

2.2. Inflation surge and an unprecedented drop in real wages

The rise in natural gas prices depicted in figure 1 also led to a large increase in electricity prices in Germany and Europe.[10] Thus, the natural gas price shock depicted in figure 1 generated an energy price shock that went beyond the direct effect of natural gas prices on the energy price index. Rising energy costs in turn led to higher prices for all goods and services. Put differently, the energy shock that hit the European economy in 2022, as a terms of trade shocks, was a main driver of inflation in 2022 (Dao et al., 2023; Pallotti, 2023). Of course, another important driver of inflation was the disruption of global supply chains following the COVID-19 pandemic, but in Germany these effects were mostly felt in 2021 and already waning in 2022 – see the discussion in section 2.3. Benefitting from temporarily heightened pricing power, profit margins increased sharply in 2022 for the second year in a row and unit profits accounted for the larger share of inflation in 2021 and 2022 (Bundesbank, 2023). In other words, Germany experienced sellers' inflation (Weber and Wasner, 2023) on top of a large terms-of-trade shock.[11]

Figure 3. Consumer prices in Germany



Note: CPI is the consumer price index; CPI food is the consumer price index for food; CPI energy is the consumer price index for energy. *Source:* Federal Statistical Office (destatis).

The next figure shows the development of energy prices, food prices, and a general index of consumer prices in Germany since January 2021. It illustrates the strong rise in energy prices and the

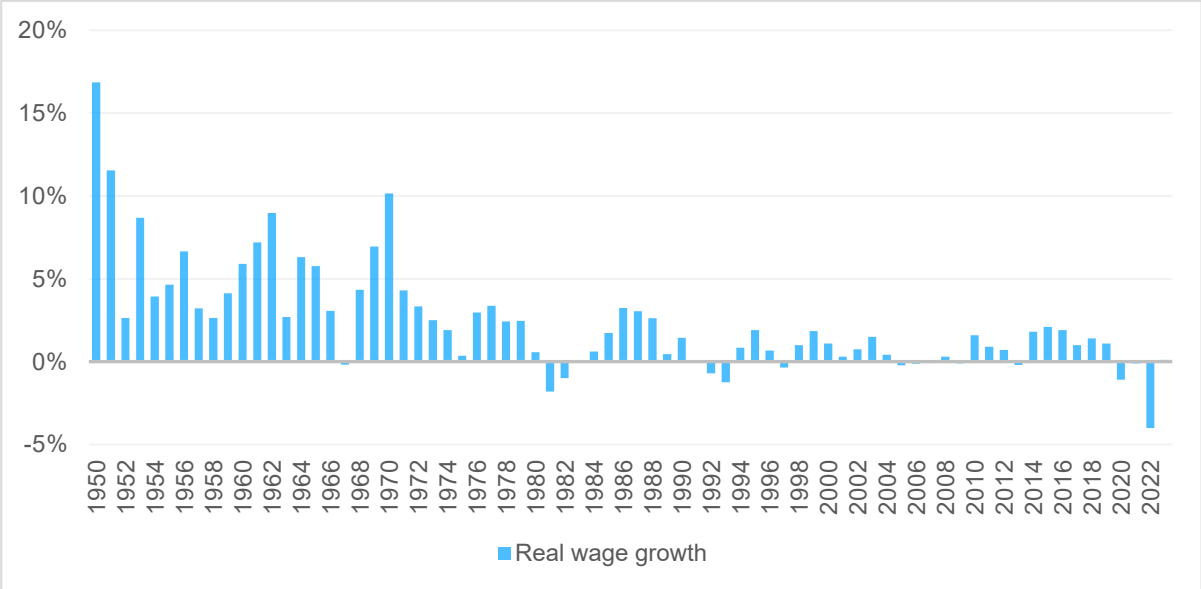
[10] This is an outcome of market design of the European electricity market, where the price is determined by the so-called merit-order principle. In 2022, this market system often implied that daily electricity prices were driven by the high marginal costs of gas-based power plants.

[11] Further evidence that part of the inflation was driven by rising profits is that the German corporate sector saw pre-tax gross operating surplus increase by 8.6 percent at the height of the energy crisis (Ragnitz, 2022).

subsequent rise in food prices and prices for all consumption goods. Overall, energy prices rose by about 50 percent and food prices by close to 30 percent in a time span of two years.

at the real wage data explains why most people in Germany felt that the energy crisis 2022 was a full-blown economic crisis that had large, negative consequences for their standard of living.

Figure 4. Real Wages in Germany since 1950



Note: Annual percentage change of real wages; real wage index is constructed using nominal wage data (Index der durchschnittlichen Bruttomonatsverdienste) and consumer price index from the Federal Statistical Office. Values from 1950 to 1990 refer to West Germany and values from 1992 to 2022 refer to (unified) Germany. Value of real wage change for 1991 is omitted because of the structural data break in the transition from 1990 to 1991. *Source:* destatis.

Across different groups of wage earners the inflation burden has been heterogeneous. Figure 3 shows that energy and food prices rose more quickly than the average price level. In general, this type of inflation hurts low- and middle-income workers disproportionally since they use a larger share of their income for the purchase of energy and food. Pallotti et al. (2023) demonstrate that lower income groups have carried a higher inflation burden, though fixed rent payments served as a hedge and softened this effect. In addition, the regressive effect of inflation was counteracted to some extent by a disproportioned increase of wages in the low-wage sector due to a rise of the federal minimum wage from 10.45 Euro to 12 Euro in 2022. Thus, in Germany we could observe a certain type of wage compression at the lower tail of the distribution, similar to the US (Autor, Dube, McGrew, 2023), but in Germany this occurred behind the backdrop of large average real wage losses.

Beyond functional and personal income effects there is another way to assess the income loss due to the energy shock in 2022: Germany's national income declined. Germany imports a large part of its energy from abroad, as can be seen from table 1. This implies that an increase in energy prices as depicted in figure 1 leads to a loss of national income as long as the reduction in energy use is not sufficient to compensate for the increase in prices. In 2022, energy consumption declined by 5.4

percent, whereas the cost of net energy imports increased by 95 percent from 70 billion euro to 137 billion euro, where the main part of this increase is due to the rise in natural gas prices (AGEB, 2023). As a result, the direct effect of rising energy prices was a loss of about 2 percent of national income.

The effect of this energy cost shock on aggregate output and income could be smaller or larger than 2 percent of national income depending on the strengths of the various adjustment channels and government policy. For example, if companies can easily save energy without reducing production, then we would expect the final output loss to be smaller than the direct income loss. In contrast, the final output loss can be larger than the direct income loss if rising energy costs lead energy-intensive firms to reduce production, and this initial production loss gets amplified via either aggregate demand effects (workers with less income buy fewer goods) or aggregate supply effects (rising prices or availability of energy-intensive products forces other producers along the production network to reduce output). In the next section, we show that the one-year loss of aggregate output loss in the energy crisis was about 4 percent, which suggests an amplification of the initial cost shock by roughly a factor of two.

2.3. Large short-run output (GDP) losses

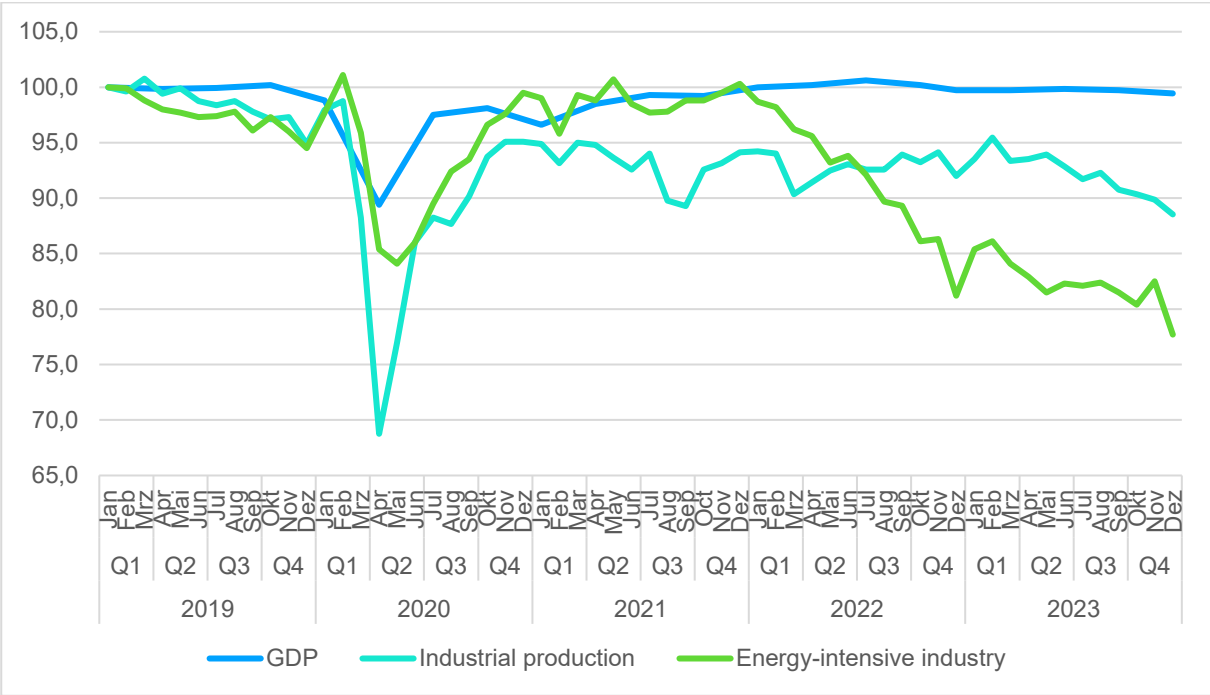
We next turn to a discussion of development of production and output during the energy crisis. The next figure depicts the time path of aggregate production (real GDP), industrial production, and production of the energy-intensive manufacturing sectors since January 2019.

Figure 5a) shows that production of energy-intensive manufacturing dropped by almost 20 percent in the period March 2022 to December 2022. In other words, the energy-intensive industry fell into a deep recession in 2022. However, real GDP and industrial production barely declined in the year after the energy shock hit the economy – the period Q2-2022 until Q1-2023. In the public debate, this has often been interpreted as proof that the energy crisis had only a moderate effect on the German economy – "not even a recession" (Moll, Schularick, and Zachmann, 2023, Tabarrok, 2023).[12] Put differently, according to some economic pundits, the energy shock following the Russian invasion of Ukraine in February 2022 barely mattered since households and firms quickly adjusted to rising and uncertain energy prices. The argument that the energy crisis had little impact on the German economy was also used by the German government to justify their so-called normalization of financial policy in 2023 (Lindner, 2023a,b), which amounted to fiscal tightening in the middle of an economic crisis.

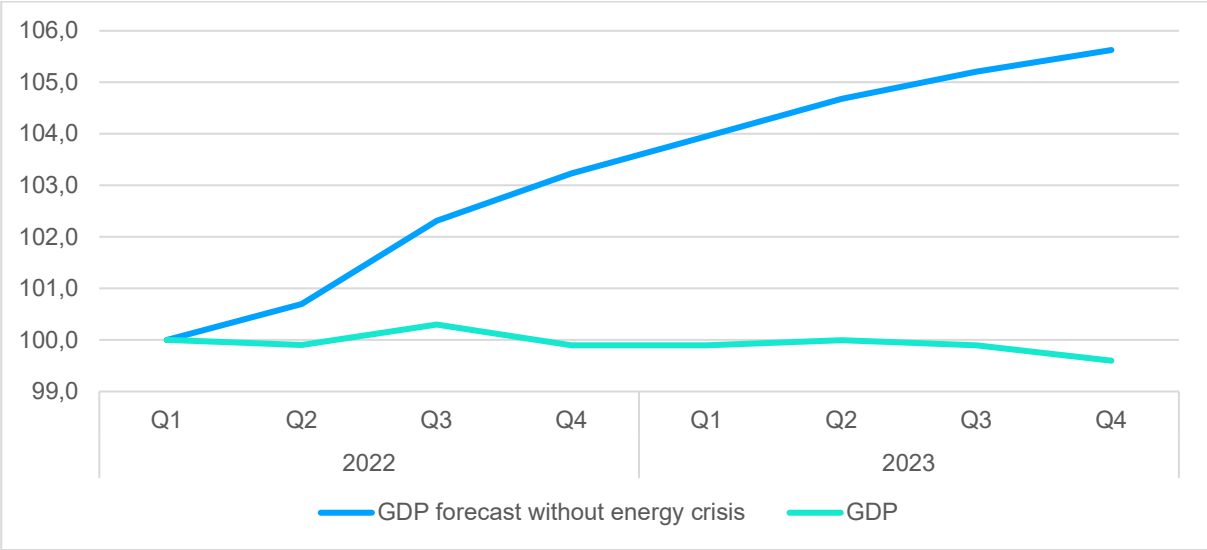
[12] Another often-heard claim is that annual GDP growth in 2022 was 1.8 percent suggesting that the short-run impact of the energy shock cannot have been substantial. This claim demonstrates the danger of the careless use of statistics. Specifically, annual GDP in 2022 was 1.8 percent higher than annual GDP in 2021 because GDP was growing in 2021 and in Q1-2022, but no growth occurred after Q1-2022.

Figure 5: Short-run production loss

a) Aggregate production and industrial production in Germany



b) GDP with and without energy crisis in Germany



Note: a) GDP is the quarterly real gross domestic product. Industrial production is the monthly output of the manufacturing sector and energy-intensive industry is the monthly output of five energy-intensive manufacturing sectors. All variables are normalized to 100 in Q1-2022. b) Quarterly GDP normalized to 100 in Q1-2022. "GDP forecast" is the consensus forecasts of the five economic research institutes in spring 2022 (Joint Economic Forecast, 2022a). *Source:* Federal Statistical Office (destatis).

This simple argument, however, is unconvincing. Specifically, to assess the impact of the energy crisis on real GDP, a simple look at the time path of GDP during the energy crisis is not enough. We need to know the counterfactual, that is, we need to construct the path of GDP in the

hypothetical scenario without an energy crisis. Once we have this counterfactual, the aggregate output loss caused by the energy crisis can then be computed as the difference between GDP in the scenario without a crisis (unobserved scenario) and GDP in the scenario with a crisis (observed scenario). Similarly, the loss in manufacturing output should be computed as the difference between production without the energy crisis and with the energy crisis.

In this paper, we use this approach to compute the short-run output cost of the energy crisis in Germany. We take our estimate of GDP in the hypothetical no-crisis scenario from the pre-crisis forecast of the five economic research institutes that perform business cycle analysis for the German government (Joint Economic Forecast, 2022a).[13] Specifically, the business cycle analysis of these institutes conducted in the spring of 2022 provides the "best" estimate of the path of German GDP without an energy crisis given the available information at that time (conditional forecast). These estimates can then be compared with the actual GDP development to compute the economic loss due to the energy crisis. Clearly, this approach captures all direct and indirect effects on the German economy of the Russian war in Ukraine (rise in energy prices, rising uncertainty, reaction of the central bank and fiscal policy), and this should be kept in mind when interpreting the results.

Figure 5b) shows the estimates of the GDP path in the hypothetical case (Joint Economic Forecast, 2022a) as well as the actual path of GDP. From Figure 5b) we can see that the output loss in the one-year period following the Russian war in Ukraine, the period Q2-2022 until Q1-2023, amounted to 4.1 percent according to the five economic institutes.[14] This output loss is mainly driven by the fact that German growth was expected to rebound strongly in 2022 after the Covid-19 crisis, which in Germany basically lasted until the spring of 2022 when all Covid-19 restriction were finally lifted. But it should be noted that the GDP forecast of the Joint Economic Forecast (2022a) was published in spring 2022 and already takes into account some of the negative effects of rising energy prices. If anything, it is an under-estimate of GDP in a world without an energy crisis, and therefore results in an under-estimate of the output cost of the energy crisis 2022/23. For example, in December 2021 the German central bank still expected an increase of quarterly GDP in the period from Q2-2022 until Q1-2023 of more than 5 percent (Bundesbank, 2021), in which case the output loss amounts to slightly more than 5 percent. Note further that a similar analysis conducted for the manufacturing sector would yield even larger output losses since industrial production was expected to expand even

[13] These are the five Leibniz-Institutes "Deutsches Institut der Wirtschaft (DIW), "Institute for Economic Research at the University of Munich (Ifo)", „Kiel Institute for the World Economy (IfW)", "Halle-Institute for Economic Research (IWH)", and "Ruhr-Institute for Economic Research (RWI)".

[14] As common in the business cycle literature, this paper uses GDP data at a quarterly frequency to analyze the short-run movements in aggregate economy activity. The use of the quarter-to-quarter change ensures that the measure of output loss constructed here is independent of the growth path before the crisis (before the "energy shock" hit the economy). Using this approach, the one-year output cost of the energy recession is simply the area between the two GDP-time paths in Figure 6 (the sum of the differences for Q2-2022, Q3-2022, Q4-2022, and Q1-2023).

more than GDP before the crisis. Specifically, using the forecast for the manufacturing sector from Joint Economic Forecast (2022a), we find a production loss of 6 percent for industrial production in the period Q2-2022-Q1-2023.

Using the same method, we can also compute the corresponding economic losses in the Covid-19 crisis 2020 and the financial crisis 2008/09. This allows us to put the results for the energy crisis into perspective. We can further compute the one-year real wage losses in the three crises using the same method. We compute the change of quarterly real wages in the first year following the "beginning" of the crisis, and compare this change with the forecast of the quarterly real wages of the five economic research institutes.[15] The results of the analysis on output losses and wages losses are summarized in the following table: [16]

Table 2. One-year output and wage losses in Germany for three economic crises

	Output loss	Real wage loss
Energy crisis 2022/23	4.1 %	3.4 %
Covid-19 crisis 2020	2.5 %	0.8 %
Financial crisis 2008/09	5.8 %	0.4 %

Note: Output and wage losses are the difference between before-crisis forecasts and actual values of quarterly GDP and quarterly real wages one year after the beginning of crisis. Energy crisis Q2-2022 to Q1-2023, Covid-19 crisis Q1-2020 to Q4-2020 and financial crisis Q4-2008 to Q3-2009. Forecasts are taken from the consensus forecast of the five economic research institutes DIW, Ifo, IfW, IWH, and RWI.

Table 2 shows that the output loss during the energy crisis 2022 was comparable to the output loss during the Covid-19 crisis and somewhat less than the loss during the financial crisis 2009. Table 2 also shows that the loss in real wages during the energy crisis by far exceeds the corresponding losses during the Covid-19 crisis and the financial crisis. In short, the energy crisis was an economic crisis comparable to the Covid-19 and the financial crisis in terms of output losses, but the negative effect on workers' wages has been much stronger.

The result that a large energy price shock has substantial economic consequences should not come at a surprise. Simulation results based on macro models calibrated to US data suggest substantial effects of energy shocks due to endogenous mark-ups (Rotemberg and Woodford, 1996). In addition, time series evidence indicates that supply-driven energy shocks can have substantial output

[15] The forecast of real wages is computed as the difference between the forecast of nominal wages and the forecast of consumer prices inflation in fall of the year preceding the crisis. We thank the IWH for providing me we the unpublished data the respective forecasts of quarterly wages.

[16] A further comparison to the oil crisis 1973-75 might also be useful. The oil price shock that hit the German economy in 1973 led to an absolute decline in annual output only in 1975 by 0.9 percent and there was no further year with negative output growth in the 1970s. Using the same method as in table 1 (but with annual data) and the forecast of the economic research institutes taken from (IWH, 2023), we find an annual output loss of 3.4 percent in 1975.

effects (Kilian, 2008). Of course, these results do not directly speak to the energy crisis 2022, but they define a prior belief. From this point of view, it is quite surprising that the recent policy debate in Germany was dominated by one paper (Bachmann et al., 2022) that suggests very moderate output effects of energy shocks (see also section 3.1).

The above calculations assume that the forecast of the five research institutes provides relatively good estimates of output in the hypothetical scenario without a crisis. This is the case if i) past forecast haven been relatively good in "normal times" (absent a crisis shock) and ii) there has been no major additional macro shock hitting the Germany economy during 2022, respectively 2009 or 2020. The first condition is met in the sense that the forecasting error in normal times is small enough that it would not change the broad conclusion that in all three crises the output losses were of similar magnitude and that in the energy crisis the real wages were much larger than in any other pre-war crisis.[17] The following argument suggest that the second condition is also met, at least in the energy crisis 2022.

In the public debate, three shocks to the German economy have been mentioned that could have had a strong impact on GDP unrelated to the energy crisis: Global supply chain disruptions, a fall in Chinese demand or supply of intermediate goods due to lock-downs in 2022, and a labor-supply shock due to an increase in sick days. A closer look at the data reveals that neither of the three shocks is a likely candidate for such an alternative explanation. Regarding global supply chains, all available indicators point towards an easing of supply chain problems over the year 2022 in Germany. For example, the ifo-indicator of material shortage steadily improved during 2022 (Destatis, 2023). Thus, these developments improved conditions for economic growth in 2022 relative to 2021, and there were no significant surprises in 2022 regarding supply bottlenecks that could have invalidated the conditional forecasts. Regarding a possible "China shock" due to lockdowns in China, this type of economic China shock appears not to have had much of an effect on the German economy beyond the effect that was already incorporated in growth forecasts. Specifically, China remained the biggest trading partner for Germany in 2022, and exports to China, as well as imports from China, rose strongly compared to 2021, though the increase in imports was more pronounced (Matthes, 2023). Put differently, there was no large negative surprise in Chinese growth relative to the growth-assumption made in Joint Economic Forecast (2022a). Finally, the number of sick days increased in 2022 relative to 2021, and such a negative supply shock could presumably explain part of the weak growth performance in 2022. However, a look at the monthly data reveals that the increase in sick days already occurred in the first quarter of 2022 (BKK, 2023), which implies that it does not affect the

[17] There is extensive literature on the accuracy of GDP forecasts for the German economy that cannot be discussed here because of space limitations. See, for example, Müller (2021) and Döpke, Fritsche, and Müller (2019).

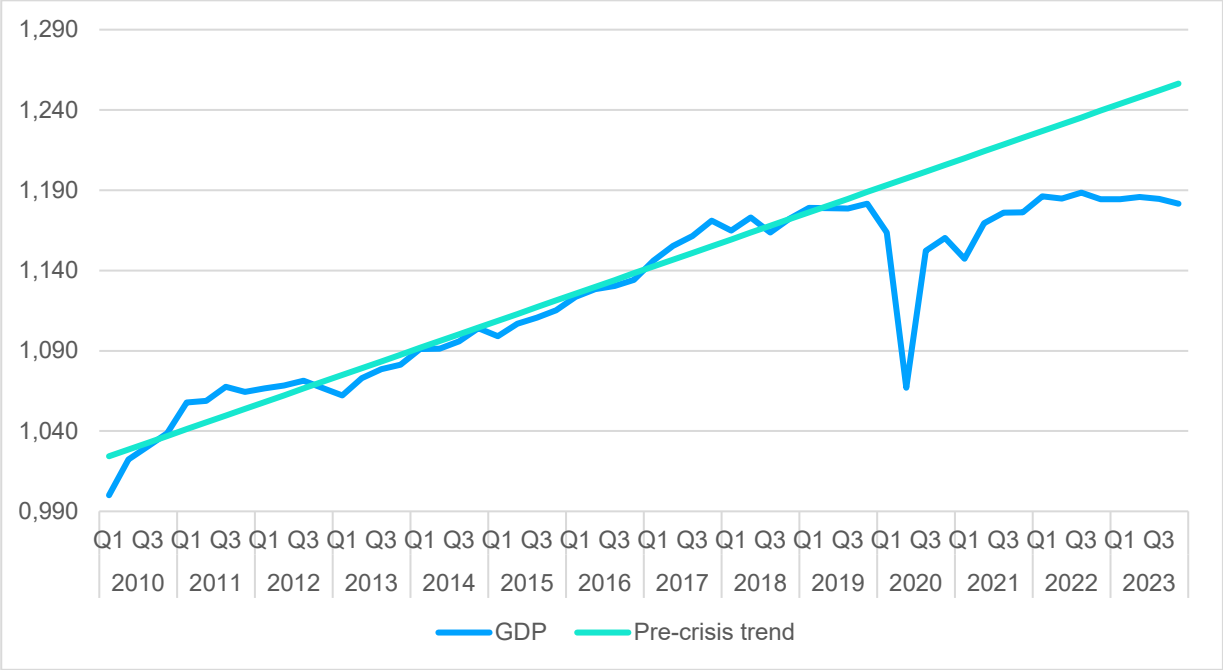
output cost of the energy crisis as computed here since the method only captures changes that occurred after Q1-2022. In addition, there was an increase in labor supply in 2022 due to the migration of almost a million people from Ukraine to Germany, which works in the opposite direction and leads to the conclusion that the output loss in Table 2 might be an underestimate of the true cost.

The tightening of monetary policy in 2022 is clearly a development that had an economic impact. However, changes in monetary policy only affect economic activity with a time lag, and it is therefore an open question how much of the monetary tightening of the European Central Bank that began in July 2022 has affected growth in 2022 substantially. Further, the tightening of monetary policy in 2022 should not be considered an independent shock unrelated to the energy crisis, but a policy reaction to rising inflation that was driven to a large extent by the dramatic increase in energy prices. In this sense, the energy crisis was the ultimate driver of these output losses caused by the tightening of monetary policy. Note further that German fiscal policy in 2022 was expansionary, which tends to dampen the negative output effects of the energy price shock. Clearly, there is room for additional research and we can disagree on the nature of the counterfactual. However, there should be no disagreement that a useful debate about the output cost of crises requires benchmarking against a counterfactual.

2.4. Signs of substantial long-run economic damage (hysteresis)

Economic crises not only reduce output in the short-run, but they can also affect production in the long-run (potential output) – the so-called hysteresis effect of recessions (Blanchard and Summers, 1987, Blanchard, Cerutti, and Summers, 2015). More precisely, the one-year output loss shown in table 2 might turn into a permanent output loss if there is no strong recovery in the years to come. These long-run output losses represent economic costs of crises that go beyond the short-run costs. The following figure suggests that the economic outlook for the German economy appears bleak, and the danger of significant long-run losses seems real. In fact, the four-year period 2019-2023 is already the longest no-growth period on record since data collection began in 1950, with the period 2001-2004 coming in second – the time when Germany was called the sick man of Europe. In addition, the economic outlook for 2024 is similarly bleak.

Figure 7. Output and trend output in Germany 2010-2023



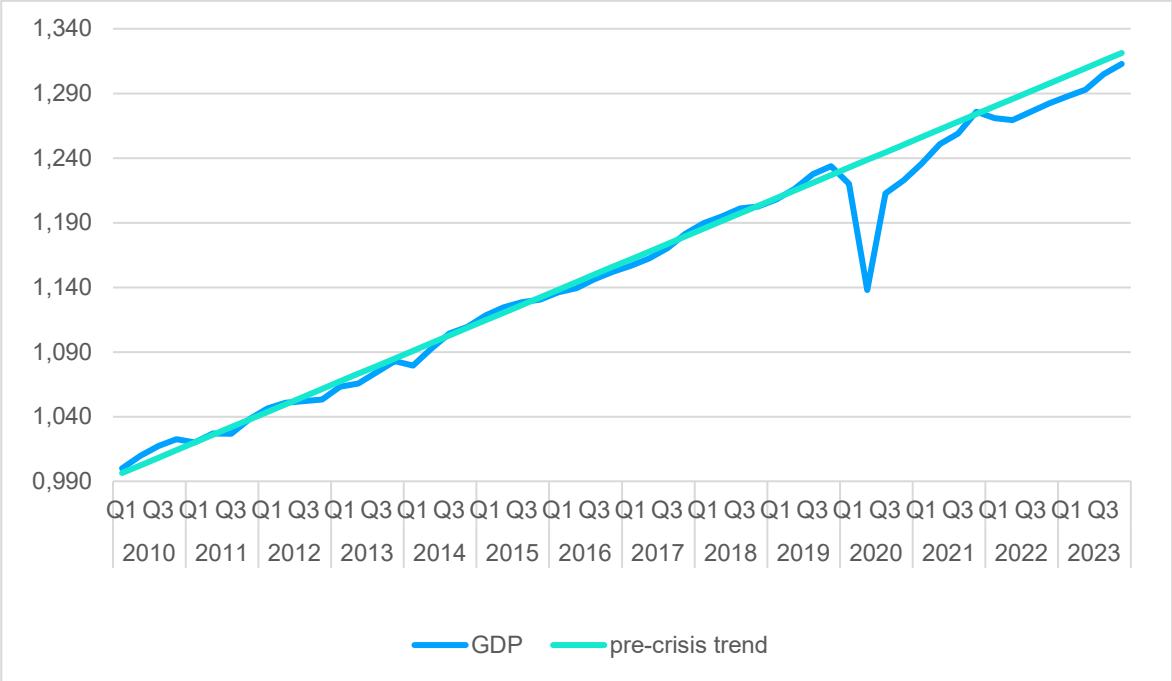
Note: Real quarterly gross domestic product on a logarithmic scale normalized to one in Q1-2010. Blue line are actual values and turquois line is the best linear pre-crisis trend 2010 – 2019.

Figure 7 shows that the German economy is struggling to recover from the twin shock – COVID-19 and energy crisis. Indeed, actual output at the end of 2023 is about 7 percent below the pre-crisis trend. If we apply the same methods to real wages, we find that real wages are 10 percent below their pre-crisis trend in 2023. In addition, the IMF (2024) reports that Germany was the only advanced economy with negative GDP growth in 2023, and that the projections for 2024 and 2025 are lower than for any comparable country. In other words, there is preliminary evidence that strong hysteresis effects have set in. Of course, to what extent crisis-induced short-run output loses become permanent heavily depends on policy choices. From this point of view the decision of the German government to start tightening fiscal policy in 2023 (Lindner, 2023a,b) and to continue on this path of fiscal restrains makes a stagnation scenario and large hysteresis effects more likely. Interestingly, the German government does not seem to have much faith in its own ability to fight the threat of long-run economic gloom: According to the latest estimates, the German government expects that most of the 7 percent difference between pre-crisis trend and actual output depicted in Figure 7 is permanently lost (BMF, 2024a; BMWK,2024).[18]

[18] Real GDP growth is projected to be 0.2 percent in 2024 and 1 percent in 2025, and the output gap is estimated to be 0.6 percent in 2024 and 0.5 percent in 2025 (BMWK, 2024; BMF, 2024a). These estimates have serious consequences for the possibility to finance an investment-focused fiscal package: If the output gap is estimated to be 7 percent instead of 0.6 percent in 2024, then the German debt brake would allow for an additional 1.3 percent of deficit-financed public spending (Krebs, 2024).

A comparison of the recent experiences of Germany and the US underscores this point. In Germany, fiscal policy during the Covid-19 crisis was moderately expansive. Further, Germany is an energy importing country that was directly hit by the energy shock in 2022, and it started to tighten fiscal policy already in 2023 in the middle of the energy crisis. In contrast, US fiscal policy was more expansionary in response to the Covid-19 shock. In 2022, he US has also been the worlds' most important oil producer (EIA, 2022) and has experienced a positive terms of trade shock from the energy crisis. In addition, the Biden administration implemented three ambitious investment programs that are growth enhancing: The Bipartisan Infrastructure Law in 2021, the Chips and Science Act in 2022, and the Inflation Reduction Act in 2022. We would therefore expect a strong recovery of the US economy following the economic downturn in 2020. The next figure confirms that this conjecture is correct. If anything, Germany would have needed an even more ambitious fiscal policy than the US to achieve a similar return to the pre-COVID-19 growth trend.

Figure 8. Output and trend output in the US 2010-2023



Note: Real quarterly gross domestic product on a logarithmic scale normalized to one in Q1-2010. Blue line are actual values and dotted line is the best linear pre-crisis trend 2010 – 2019.

There are several economic channels that can account for persistent output effects of temporary shocks. We only sketch some of the main mechanisms and leave any further analysis for future research. First, the original contribution by Blanchard and Summers (1987) emphasizes long-run effects on unemployment. Second, job loss is often associated with the loss of firm- or sector specific human capital, which explains the empirical finding that recessions often have scarring effects (Schmieder, Wachter und Heining, 2023). Third, physical capital can be destroyed during times of crisis, even

though this might also lead to a positive effect on productivity due to a "cleansing effect" (Caballero und Hammour, 1994). Fourth, private investment goes down during crises, which reduces potential output by lowering the physical capital stock and innovation activity (Benigno and Fornaro, 2018). Fifth, if temporary shocks go hand in hand with an increase in endogenous uncertainty, then this can generate persistent output effects (Straub and Ulbrich, 2023). Finally, hysteresis effects of economic crises are general features of Neo-Keynesian models of economic growth (Fazzari und Gonzales, 2023).

3. ECONOMIC AND POLITICAL CONSEQUENCES OF STABILIZATION POLICY

3.1. Short-run stabilization policy and its economic consequences

In the wake of the energy crisis 2022, the German government made several policy choices that could be summarized as short-run stabilization policy. First, it used standard fiscal policy measures like transfer payments and temporary tax cuts to provide relieve and stabilize the economy through aggregate demand management. It introduced two smaller fiscal packages in the spring of 2022 right after the beginning of the Russian war in Ukraine. Second, the German government managed energy supply by aggressively buying up natural gas in world markets and continuing to import natural gas from Russia as long as possible (also see 2.1). Third, after an extended period of back and forth, the government announced a third, much larger fiscal package (Doppel-Wumms) in the fall of 2022. A core measure were energy price controls, the so-called energy price brake, to tame inflation and to provide relieve for households and firms. It was fully implemented in January 2023, with some early payments being made in December 2022. In this section, we briefly discuss to what extent these policy choices were successful in stabilizing the economy.

We can get a sense of the effect of fiscal policy measures (including the energy price brake) by looking at the volume of extra spending and applying a fiscal multiplier. In total, the policy measures taken by the German federal government in response to the energy crisis amounted to additional fiscal spending of around 100 billion euro in 2022 and 2023: around 30 billion euro in the first two spring fiscal packages, 20 billion euro for taking majority stakes in the energy companies Sefe (formerly Gazprom Germania) and Uniper, 10 billion euro for immediate relief in December 2022, and about 35 billion euro for the energy price brake (Dullien, Rietzler, Tober, 2022; Krebs, 2024).[19] If we do not include the 20 billion euro for the rescue of Sefe and Uniper, then the German federal government increased fiscal spending by around one percent of annual GDP in each year 2022

[19] The third fiscal package („Doppel-Wumms") was announced to have a volume up to 200 billion euros, but in the end only 70 billion euro of the announced 200 billion euro was spent in 2022 and 2023 (BMF, 2024b). This is the reason why fiscal measures that rely on announced fiscal spending (Dao et al., 2023) provide a biased estimate of the actual fiscal stance of Germany in 2022 and 2023. In addition, the German government has the habit of including old programs into newly announced fiscal packages, which requires caution to avoid double counting when using „announcement data".

and 2023. If we assume a fiscal multiplier between one and two, which lies in the range of fiscal multipliers for economies in a recession with slack in aggregate demand (Coenen et al., 2012, Gechert and Pfannenberg, 2018), the German fiscal policy reduced the annual output loss of the energy crisis by one to two percent. In other words, without these fiscal measures, the short-run output loss associated with the energy crisis would not have been 4 percent (table 1), but rather 5 to 6 percent.

These simple back-of-the envelope calculations do not take into account the specificity of the various programs and the structure and state of the German economy. Thus, they should be interpreted as a very rough guide. In addition, using a simple fiscal-multiplier argument does not capture the stabilization effect of an energy price brake through its reduction in price uncertainty, which is the focus of our theoretical analysis in section 4. This effect on output of the German energy price brake via a reduction in uncertainty was probably substantial, but at this stage there is little quantitative work of this particular channel of price controls on output.[20] In addition, the delayed and sub-optimal implementation of the German energy price brake for industrial firms meant that its positive impact on the economy was smaller than it could have been (see section 4).

In contrast to (conventional) fiscal policy, there is much less work on the effectiveness of energy supply management as a macroeconomic stabilization tool in an energy crisis. As we can see from table 1, the dual-strategy of purchasing natural gas in global energy markets at any cost and continuing to import Russian gas (no immediate embargo in March 2022) was successful in reducing the size of the energy supply shock and avoiding a gas shortage.[21]

What would have happened if the energy-supply management of the German government had been less successful in reducing the size of the energy supply shock that hit the German economy? Clearly, gas tanks had filled up more slowly in the summer of 2022, prices would have stayed high for a much longer than depicted in Figure 1, and a gas shortage in the winter of 2022/23 would have been more likely. We will never know for sure what would have happened in the hypothetical worst-case "what if"-scenario, but there are several model simulations that can give us a hint of the extent of the damage. The following table shows the results of papers that have simulated the output losses that could have been caused in a worst-case scenario. These papers consider not only the short-run effect of high energy prices on output via the aggregate-demand channel, but also take the supply-side channel when manufacturing firms are forced to reduce production because of a lack of energy

[20] Pallotti et. al (2023) estimate the heterogeneous welfare effects of the recent inflation surge across households and their results also speak to this uncertainty-channel of price controls on welfare, but what we have in mind here is an effect on aggregate output through the stabilization of aggregate demand or some other general equilibrium channel.

[21] For example, Germany still imported a large amount of natural gas from Russia in the period April to September 2022, and in the case of an immediate gas embargo and the gas supply would have been reduced correspondingly - see also section 4.2.

supply into account – see Krebs (2022c) for more details on the various economic channels. All papers take into account that firms can replace natural gas by alternative energy sources, but assume that this energy substitution is limited in the short-run.[22]

Table 4. Short-run output loss in a worst-case scenario in Germany

Bachmann et al. (2022)	Bundesbank (2022a)	Joint Economic Forecast (2022a, b)	Joint Economic Forecasts (2022c)	Krebs (2022)
0.2% - 1.3%	9%	8%	10%	5% - 12%

Note: Joint Economic Forecast (2022a,b) are the difference between before-crisis forecasts and simulated worst-case scenario of quarterly GDP five quarters after beginning of energy crisis (Q2-2022 until Q2-2023). Bundesbank (2022a)[23] is the difference between before-crisis forecasts (December 2021) and simulated worst-case scenario of GDP in 2023 -- see the figure on page 36 of Bundesbank (2022a). Bachmann et al. (2022)[24] and Joint Economic Forecast (2022c) includes only supply-side effects; all others include demand-side and supply-side effects.

Table 4 shows that most papers suggest very large output losses in a worst-case scenario. Indeed, the results cluster around an output loss between 8 and 10 percent. This suggests that in a worst-case scenario, the German economy would have experienced additional output losses in the range of 4 to 6 percent compared to the output loss of 4 percent that has been observed. We can also see that the paper by Bachmann et al. (2022) stands out by predicting very small output losses even in a worst-case scenario. Indeed, the upper bound of an output loss of 1.5 percent is only reached if natural gas prices had increased more than the observed peak price of 300 euro/mwh in September 2022, and had remained at such elevated level for a long time.[25] Given that we observed an output loss of around 4

[22] Bundesbank (2022a), Joint Economic Forecast (2022a,b,c) and Krebs (2022b) model energy substitution as a switch from one Leontief function to another, and use the available evidence about the German manufacturing sector to calibrate the degree of switching. Specifically, Bundesbank (2022a) and Joint Economic Forecast (2022a,b,c) assume, based on the available evidence for German manufacturing, that firms can reduce natural gas consumption by 10 percent without any reduction of production, and Krebs (2022b) assumes that firms can save up to 20 percent of natural gas without reducing production. Bachmann et al. (2022) use a top-down approach based on a CEX production function that does not use empirical evidence – beyond a list of carefully selected examples -- regarding the gas substitution possibilities of the German manufacturing sector.

[23] Bundesbank (2022b) computes an output loss of 5 percent in 2022 relative to a baseline scenario that already takes into account output losses associated with the energy crisis. If one uses the same reference scenario, then Bundesbank (2022a) and Bundesbank (2022b) yield similar results with respect to output losses in a worst-case scenario, but the timing differs (2022 vs 2023).

[24] The output (GDP) losses of 0.2 percent and 1.3 percent are based on an analysis of what is called a "state-of-the-art model" in Bachmann et al. (2022), where the loss of 0.2 percent is the result of the simulation of a calibrated model economy and the GDP loss of 1.3 percent is computed using a sufficient-statistics approach (table 2 of Bachmann et al. 2022). The paper also conducts a simple back-of-the envelope calculation based on an aggregate production function and an ad-hoc assumption about an aggregate substitution elasticity, and these calculations yield an upper bound of 2.2 percent for the GDP loss. The output loss of 3 percent mentioned in the executive summary of Bachmann et al. (2022) and often quoted in the media is not based on any calculation. Geerolf (2022) provides an excellent discussion of the different approaches taken in Bachmann et al. (2022).

[25] See Figure 7 in SVR (2022) for a computation of the output losses based on the sufficient statistics for different price changes and degrees of replacing Russian gas imports with alternative imports. For a situation in which about half of the

percent with less of a price increase (table 1), a crucial model implication is rejected by the data. Put differently, the empirical evidence suggests that the model used in Bachmann et al. (2022) is not suitable for a comprehensive analysis of the short-run economic consequences of a large energy shock. This model rejection is unsurprising given that a number of crucial modelling assumptions are unrealistic, respectively not in line with the evidence -- see Geerolf (2022) for an excellent account of the main shortcomings of the analysis.

Table 4 only lists the results of papers that take into account possible supply-side effects during an energy crisis. There are many papers that mainly focus on the demand-side effects, but do not consider the output losses due to large supply-side effects and therefore find smaller output losses. See, for example, Krebs (2022c) and SVR (2022) for a survey of the many policy papers on this issue, which were mainly written in the spring of 2022. Clearly, these papers miss an important economic channel that is at play in case of an energy shortage, and putting too much weight on their results can be very misleading. For example, almost all economics papers written before the financial crisis predicted that shocks to the financial sector would have moderate output effects, but this results turned out to be a poor guide for policy making with disastrous consequences. This shows the danger of simply counting the number of economics papers that produced a certain result without a proper discussion of the underlying economic assumptions.

There is an important policy lesson to be drawn from table 4: Sudden disruptions in energy supply can have large economic costs. In this sense the short-run energy management of the German government in 2022 was a success despite the output and real wages losses (see previous section) since it prevented an energy shortage and the associated economic meltdown that would have caused a short-run output loss of 8 to 10 percent and a hike in inflation even larger than what has been observed. Of course, the energy crisis still caused a short-run output loss of around 4 percent (table 2) and is causing long-run damage to the German economy (Figure 7), and these losses could have been avoided if Germany had already pursued a strategy of sufficient energy storage before the war in Ukraine. Thus, Germany and Europe had to learn the hard way an old lesson, namely that in emergencies market forces can never generate the stability of energy and food supply that the government can provide with an adequate storage policy (Weber, 2021b).

The results in table 4 seem to contradict our claim that the German government should have introduced an energy price brake that would have given manufacturing companies an incentive to produce more, but would have also led to more energy consumption by these companies. However,

Russian gas imports are replaced by alternative imports, the (permanent) gas price increase associated with the output loss of 1.5 percent is about 350 euro/mwh.

this seeming contradiction can be resolved by looking at the timing and the numbers, which we present in more detail in section 4.2. The analysis shows that energy-price controls with a positive incentive effect for manufacturing companies in Germany would have led to a relatively small increase in energy use spread out over time, which would have given sufficient time to replace the small amount of "missing" gas with alternatives. This result underscores that one of the main functions of price controls is to buy time for supply adjustments when they are hampered for reasons like wars (Galbraith, 1980). Note that matters are very different with respect to the no-embargo decision: A decision of the German government to impose an immediate embargo in April 2022 would have reduced energy supply abruptly by a large amount just at a time when it was needed the most, implying an immediate and substantial increase in the ex-ante probability of a gas shortage in the winter 2022/23 (see section 4.2) and corresponding market turbulences.

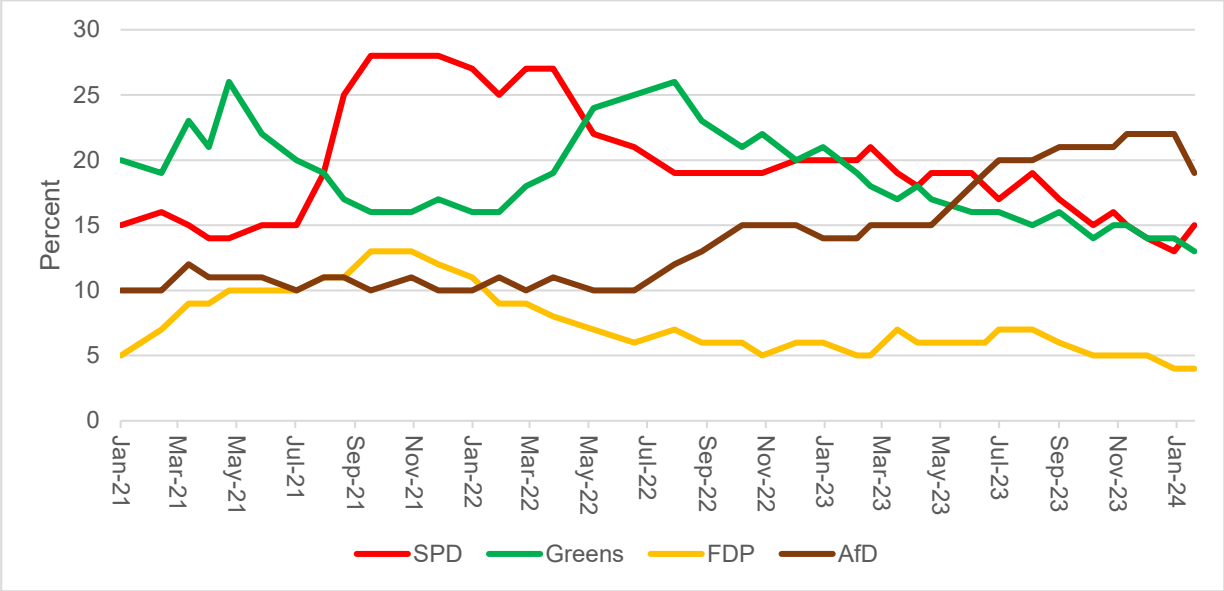
3.2. The political consequences of delaying the use of price controls

The economic consequences of the energy shock have been immense, but the political consequences are just as worrying. Consistent with the literature that links economic insecurity/uncertainty to the rise of populists' parties, we show that the approval rates for the far-right Alternative for Germany (AfD) strongly correlate with two policy decisions of the German government that increased economic uncertainty, respectively did not sufficiently reduce a large rise in economic uncertainty. The following figure shows the time development of the approval rating of the far-right AfD and the three governing parties, the SPD (Social Democratic Party), the Green Party (Gruene/Buendnis90), and the FDP (Free Democratic Party).

Figure 9 provides support for the hypothesis that the rise of far-right parties in Europe is tightly linked with increases in economic insecurity combined with a failure of government to provide an adequate policy response due to fiscal restraints.[26] Specifically, there are two episodes in which the AfD's approval rating went up strongly, the period July to October 2022 and the period May 2023 to July 2023, and these two periods coincided with two events in which the German government failed to react decisively to rising economic turmoil.

[26] See, for example, Fetzer (2019) and Gabriel, Klein, and Pessoa (2023). See also Gold (2022) and Rodrik (2020) for surveys, and Scheiring et al (2024) for a meta-analysis. Our argument is also in line with surveys that show that AfD voters have been much more concerned about indicators of economic insecurity (rising prices, general economic future, own economic future) than voters of other parties (Hövermann, 2023).

Figure 9. Public support for AfD (brown line) and for the Three-Parties of the Coalition Government



Note. Results of surveys conducted by the social science institute „Forschungsgruppe Wahlen". Survey results are used by the public television channel ZDF in their so-called „Politbarometer". Question asked: "Which party would you vote for if there were an election next Sunday".

First, by June 2022 the market price of natural gas had risen tenfold (see figure 1) and electricity prices had dramatically increased as well, but the German government hesitated to introduce energy price controls that could provide some sense of security to households and companies.[27] Instead they opted for one-off cash transfers and tax breaks which did compensate a substantial share of the financial burden for the majority of households depending on wage incomes, less so for those on social benefits and retirees (Dullien et al., 2022). But such one-off financial compensation, unlike a price intervention, did not ensure against the enormous uncertainty caused by rapidly increasing energy costs. The risk of unprecedented price volatility continued to be borne by households. By the summer of 2022, many families in Germany realized that energy costs could eat up a large fraction of their income during the upcoming heating season. Instead of protecting households against energy cost shocks, the German government even contemplated introducing an additional levy on the price of gas (Gasumlage) consistent with the advice of German mainstream economists (Bachmann et al., 2022).

Towards the end of the summer 2022, discontent with the government's policy on the price front was rising, but no solution was in sight. The main political stumbling block to the introduction of energy price controls at that time was the neoliberal government party, FDP, and their finance minister, Christian Lindner, who objected to such an intervention on grounds of economic principle

[27] In addition, for a long time the German government blocked any European agreement on price caps for natural gas purchases, but it was mainly the lack of decisive national policy that helped the AfD gain support.

– the government distortion of price signals is always a bad policy – and because fiscal and monetary policy were supposed to be the only tools to fight inflation. Indeed, on September 3th, 2022, the German government still proposed a (third) fiscal package that did not contain a cap on energy prices (BMF 2022a). After mounting public pressure, the German government backtracked and finally announced on September 29, 2022, a large fiscal package with an energy price brake (Doppel-Wumms), which was turned into law in December 2022 (Bundesregierung, 2022). This was a 180 degree turnaround from the gas price levy policy that was the focus of the public debate in the summer: The government now pledged to protect all households and citizens against the price shock. Approval ratings for the AfD stopped climbing in October 2022, while the SPD could gain somewhat.

There was a second surge in AfD approval in the period May 2023 to July 2023 that is closely linked to the attempt of the German government to push through its ambitious climate agenda while at the same time tightening fiscal policy with a return to the debt brake. The German government could have used the exemption rule to the debt brake in 2023, as it had done in the years before, but it made the political decision, pushed through by a neoliberal finance minister, Christian Lindner, not to do so. [28] Of course, applying the exemption rule would have required a recognition of the enduring economic emergency that followed from the energy shock. But prominent German economists insisted that there was "not even a recession" (Moll, Schularick, and Zachmann, 2023), let alone an economic emergency that would warrant exceptional fiscal measures. This played into the hands of fiscal conservatives and provided the argument for a "normalization" of fiscal policy (Feld, Schmidt, and Wieland, 2022; Lindner, 2023a,b) – in this sense market fundamentalism legitimized fiscal fundamentalism. In other words, if presumably there is no crisis because market forces worked their magic, then there is also no reason to use expansionary fiscal policy to fight the economic consequences of a crisis.

The result of this policy stance was that while the minister for economic affairs and climate action, Robert Habeck, started his campaign to make the building sector climate neutral by removing oil- and gas-based heating systems in spring 2023, the finance minister, Christian Lindner, refused to provide additional funding to support those private households who faced huge financial costs of making their homes climate neutral. In other words, it was the demand for fiscal restraint in a time of economic turmoil that was feeding popular discontent helping the far-right party AfD. Needless to

[28]The German government used the exemption clause to the balanced-budget rule (the so-called German debt brake) in the COVID-19 years 2020 and 2021 to launch large-scale fiscal packages, but its fiscal response to the energy crisis was much more timid: The exemption rule was used in 2022 to launch what became a moderate fiscal package (see section 3.1) and for 2023 no exemption rule was used (until the ruling of the constitutional court in November 2023). In other words, even though the German debt brake is a constraint on German fiscal policy that needs reforming in the coming years, it was not the main reason for the relatively timid fiscal response to the energy crisis that resulted in fiscal tightening in 2023 (Krebs, 2024).

say, the policy advice given by German mainstream economists at that time was of little help since they mainly suggested to increase the carbon price (Edenhofer, 2022, Grimm, 2022b), which would make heating with oil and natural gas even more costly.

Figure 9 also shows that the decline of the Social Democratic Party (SPD) in the approval rating is the mirror image of the rise of the AfD. This does not come as a surprise since Chancellor Olaf Scholz is a member of the SPD and any perceived failure of him to act decisively in a crisis situation leads to a plunge in his party‘s approval rating. Figure 9 also shows that the Green party experienced a substantial, but short-lived rise in popularity in 2022. This rise and fall was mainly driven by the somewhat bellicose, moral stance of some Green ministers and prominent Green politicians on the war in Ukraine, which initially was highly popular in Germany, but lost its appeal when the realities of the war in Ukraine and the economic consequences for Germany became clear. Finally, we can see from Figure 9 that the FDP steadily lost support until the approval rating hit around 4 to 5 percent, which is close to their voter base. This is a regular pattern whenever the FDP governs: Any political party that is based on the principles of market fundamentalism will fail miserably when called to govern since its political platform is an economic fairy-tale that bears no resemblance to reality.[29]

We stress that we do not claim that economic factors alone can explain the rise of far-right parties in Europe. Clearly, both economic factors and „cultural“ (and social) factors are important determinants, and the two factors often interact. In addition, the public discontent caused by the failure of the government to deal with economic insecurity adequately can strengthen the support for any party that manage to provide a platform for the voter dissatisfaction caused by economic insecurity (not necessarily a right-wing party). Indeed, developments during the two months of December 2023 and January 2024 are a case in point. After the ruling of the constitutional court in November 2023, which declared the fiscal plan of the German government to be unconstitutional (i.e. not in line with the constitutionally enshrined debt brake), there was an intensive public debate about further spending cuts and large resistance against these cuts. And while the approval rate for the AfD further increased in December 2023, they took a nose dive in January 2024. The AfD’s recent loss in public support can be explained by two events that both happened in January 2024. First, Germany witnessed a very public discussion of the racist political agenda of the AfD and its proximity to neo-Nazi groups, which resulted in a large number of public protests against the AfD with millions of participants nationwide.

[29] Neoliberal parties often try to compensate for this lack of governing skills by creating a distraction. In the case of the FDP in 2022 and 2023, this meant permanent attacks on the Greens (their coalition partner), on low-income families, and on people with an immigration background. In the end, this strategy implied that many statements made by prominent FDP politicians were indistinguishable from statements made by right-wing AfD politicians.

Second, in January 2024 a new, populist party on the left entered the public arena (BSW), which is spearheaded by a charismatic politician (Sarah Wagenknecht) and immediately attracted the support of many people that feel disenfranchised.[30]

4. ENERGY PRICE CONTROLS

4.1. Energy price controls and energy supply management

As discussed in chapter 2, the German government used a three-layered strategy to alleviate the pain of the crisis and stabilize the economy: Conventional fiscal policy, energy price controls (energy price brake), and energy supply management (the purchase and storage of natural gas). In this section, we take a first step towards a simplified representation of the government decision problem and disregard conventional fiscal policy. This leaves us with two types of government policy: energy price controls and energy supply management.

To illustrate the main economic tradeoff involved, we consider a simplified description of the energy crisis, which corresponds to the formal model we analyze in the appendix. Time is divided into two periods: The first phase (year 2022) lasts from March to December 2022 and the second phase (year 2023) lasts from January to December 2023. The German government can use three policy instruments that affect the supply and price of natural gas German households and companies face: i) Buy natural gas in world markets, ii) continue to buy natural gas from Russia (delayed/no embargo), and iii) introduce price controls. Clearly, the first two are policy instruments that are part of a strategy of energy supply management. Price controls come in two flavors. A price cap for energy users in Germany (price control of type I) and -- together with EU countries -- an agreement not to buy natural gas in world markets at prices higher than a predetermined threshold (price controls of type II). Note that the first type of price control only changes the price the end users of natural gas pay in Germany (retail price), but not the price in world markets or the price paid for imports to Germany if we neglect possible general-equilibrium (feedback) effects. In this case the government creates a wedge between market prices and user prices and pays the difference. In contrast, the second type of price control is a buyers' cartel that reduces the price paid in world markets and for imported natural gas.

[30] In the survey of Politibaromter released on February 23, 2024, the BSW had an approval rate of 5 percent. Further, public support of BSW is very strong in East Germany, where three state elections are scheduled in 2024 and there is a real danger that the AfD will be the party with the largest number of votes in at least one of the three states elections.

The following table summarizes the main policy instruments available to European governments, respectively the German government, and their consequences for energy supply and prices neglecting possible general-equilibrium (feedback) effects.

Table 5. Policy instruments and their effects on supply and prices in the short-run

	World supply	German supply	Supplier price	User price
Price control I	no effect	no effect	no effect	decrease
Price control II	no effect	decrease/no effect	decrease	decrease
Gas purchase	no effect	increase	increase	increase
Gas embargo	decrease	decrease	increase	increase

Note: Price control I is a cap on retail prices for households and companies, where the government pays energy companies the difference between the market price and the retail price. Price control II is a price cap on the government purchase of natural gas in world markets. Gas purchase is the purchase of (liquefied) natural gas by the government in world markets. Gas embargo is an embargo on the imports of (pipeline) natural gas from Russia.

Table 5 assumes that the world supply of natural gas was fixed (perfectly inelastic) in the short run, which implies that price controls would not affect the worldwide production and supply of gas. A highly inelastic short-run supply function is in line with the description of the natural gas market in 2022 by many market experts (IEA, 2022; Neuhoff, 2022).

The table also assumes that an immediate gas embargo would have destroyed world supply in the short-run. This is plausible since pipeline gas that Germany/Europe imported from Russia could not easily be liquefied because of a lack of conversion and transportation facilities, which means that the immediate response to an immediate gas embargo in spring 2022 would have been a reduction of gas production in Russia (including burning of some gas). Of course, in the medium-run the Russian capacity to convert natural gas into its liquefied state can be ramped up and after the initial drop of worldwide gas supply, part of the initial drop would be reversed (though at higher production costs).

Price controls of type II can lead to a decrease in the effective gas supply in Germany because EU countries are not the only buyers in the world market for liquefied natural gas (LNG). Indeed, the reason why the German government initially resisted the introduction of an EU gas price cap in the summer of 2022 was that it was afraid that other countries, mainly in Asia, would buy up more of the world supply and the EU would be left with less to purchase. However, some researches acquainted

with the market for LNG argued that any price cap higher than 50 euro/MWh would have only negligible effects on the amount available to EU countries since at this price Asian demand would be dropping out (Fabra, Neuhoff, and Berghof, 2022). Clearly, there was a threshold price in 2022 at which non-European gas demand would go to zero, but there was some uncertainty regarding the exact value. By late fall the German government felt more comfortable with the supply situation in Germany/Europe and decided to give up its blockade, so that in December of 2022 a European price cap at 180 euro/MWh could be announced (European Council, 2022).

Table 5 hints at the complexity of the economic decision problem many European governments were facing in 2022. For understanding the efficiency of price controls in an environment with endogenous price uncertainty, this complexity is not necessarily useful and we therefore reduce the description to its essentials. Specifically, the two-period model of an economy we analyze in the Appendix disregards the supply management decision of the government and does not distinguish between price controls of type I and type II (the first two rows in table 5) – in the model there is no wedge between buyer's and seller's price. With this in mind, we now discuss the effect of energy price controls in such a simplified world.

4.2. Energy price controls and its economic consequences

There are various versions of price controls that have been used in the past that differ with respect to their main characteristics and their effect on the economy. In this paper, we define energy price controls as any direct change of the price system of a market economy by the government in order to achieve the following goals:[31]

i) Reduce inflation

ii) Reduce the effect of rising energy costs on households and firms

iii) Reduce price uncertainty (economic insecurity) for households and firms

iv) Buy time for energy-supply management

There are at least five economic channels through which energy prices controls can affect the economy. First, energy price controls reduce measured inflation and therefore the response of monetary policy in a high inflation environment. Second, energy price controls increase disposable income for households thereby strengthening aggregate demand and stabilizing the economy. This macroeconomic stabilization effect can also be achieved with transfer payments, but price controls are a simple means to condition the transfer payments on household-type and future price movements that deals with the issue of inequality. Specifically, energy price controls ensure that those households most exposed to energy price risk receive the most, and that income support increases automatically with

[31] Dao et al. (2023) use the term "unconventional fiscal policy" and define it as „set of fiscal measures, possibly expansionary, motivated by the desire to mute the effects of the increase in energy prices and to lower inflation".

rising energy prices. Third, price controls reduce price uncertainty, which provides economic security for households and increases the incentive of firms to invest (stabilization of business investment in a crisis situation).[32] Fourth, energy price controls dampen the rise in energy costs for firms and therefore provide an incentive to continue production – a macroeconomic stabilization effect that works via a "supply-side" channel. Of course, this also increases first-period energy use and therefore might reduce the availability of gas in the second period (intertemporal trade-off), unless, however, the government manages to increase gas supply in the second period at very little cost. In this sense price controls buy time for government procurement efforts to correct the shortfall of supply. Fifth, households also have an incentive to use more energy than they would without the price controls, though this effect can be alleviated with non-linear pricing schemes that avoid some of the inequities of rationing by price explosions.

Proponents of energy price controls have referred to one or more of these five economic channels to rationalize their support. Blanchard (2022) suggests that the reduction in the inflation rate could "make the job of monetary policy easier" (first channel). Dullien and Weber (2022a,b), Krugman (2022), and Stiglitz (2022) all argue that energy price controls provide income support to private households that dampens the rise in economic inequality and insecurity caused by rising energy prices (second and third channel). To prevent the "overuse" of energy by households (fifth channel), Dullien and Weber (2022a,b) and Stiglitz (2022) propose to use non-linear pricing schemes. Specifically, Dullien and Weber (2022a,b) suggest to allocate a fixed allowance of price-capped gas to every household to protect basic needs from the price shock, while the market prices operate for all energy consumption beyond that. Stiglitz (2022) proposes to use a fraction of past energy consumption of an individual households to determine the energy allowance for which the price is capped, and also suggests using a multi-layered scheme (more than one price cap).

Opponents of energy price controls usually argue that the control of prices by the government will lead to the misallocation of resources that could harm economic growth or have some other negative economic consequences (Chicago Booth, 2022).[33] In the case of the energy price controls that were introduced in Germany and Europe, this "misallocation-effect" presumably refers to the result that an energy price cap would give an incentive to households and firms to use "too much" energy (fourth and fifth channel). In other words, the incentive effect of price controls is always bad

[32] In neoclassical economics with risk-neutral firms, the negative link between uncertainty and investment is usually rationalized by assuming non-convex adjustment costs.

[33] A price cap on fossil energy like natural gas also reduces the incentive to invest in climate-friendly technologies and could therefore slow down the transition to a climate-neutral economy. However, one needs to keep in mind that the market price for natural gas in Europe increased more than tenfold in the summer 2022 relative to its value at the beginning of 2021 (Figure 1), and the policy debate was never about eliminating this hike completely. Instead, most policy proposals discussed price caps levels much higher than the pre-crisis level. For example, the German energy price brake put the price cap on natural gas at a level more than three times higher than the pre-crisis market price.

in terms of output or at least welfare, and – if possible – it should always be avoided. According to this view, price controls are in a certain sense always third-best. The first-best policy is to have enough energy stored so that an energy crisis cannot occur. If the energy crisis occurs and we are in a second-best world, then the government should use lump-sum transfer payments that possibly condition on household types and economic circumstances. Price controls are only useful in a third-best world, in which we have a crisis situation and the implementation of sufficiently heterogeneous lump-sum transfer payments is impossible for practical reasons.

In this paper, we question this conventional wisdom on price controls. Specifically, we argue that the incentive-effect of price controls can lead to a re-allocation of resources that is socially beneficial – especially when complemented with government supply management that minimizes the likelihood of future shortfalls. We formalize our ideas in the Appendix using a simple two-period production model with an energy sector. The economic intuition for our result can be seen by considering the intertemporal tradeoff German/European society was facing in 2022 (first period). On the one hand, the impact of rising and highly uncertain energy prices on production in the first period (2022) should be reduced. On the other hand, the likelihood of a natural gas shortage in the second period (winter/spring 2023) should also be kept as low as possible. In other words, society faces an intertemporal decision problem in the first period with uncertain second-period outcome. Price controls in the first period increase energy use and production in the first period, but also reduce gas storage and therefore increase the likelihood of a gas shortage in the second period, unless they are complemented with suitable government procurement efforts. To insist that any policy intervention in the first period should never have any incentive effect amounts to saying that the market resolves this tradeoff optimally. However, we show this reasoning to be incorrect if there is endogenous uncertainty about-second period prices, which can lead energy prices in both period to be higher than socially beneficial (social welfare maximizing). In this sense energy markets overreact and lead to a sub-optimal decline in production.

To see how energy price controls can lead to a better allocation of resources, consider the German energy price brake. Our discussion in section 4.3 below shows that it was designed in a way so that it would not provide any incentives for firms to produce more than they would without an energy price brake. In other words, the German energy price brake had no incentive-effect for firms (fourth channel of price controls). In contrast, we argue that an energy price brake that had given manufacturing companies an incentive to produce in 2022 would have reduced the observed short-run output loss (table 2) and everybody would have been better off. More generally, if the German government had introduced a better designed energy price brake earlier, it would have reduced uncertainty and stabilized production in 2022, and the short-run output losses would have been perhaps

only 2 percent instead of the observed 4 percent (table 2).[34] Further, the output gap between actual output and pre-crisis trend at the end of 2023 would be substantially smaller than the observed 7 percent (Figure 7). Indeed, if the German government had early on introduced a properly designed energy price brake and had implemented an additional, deficit-financed "green" investment-package in 2023 (Green New Deal),[35] we could have expected a robust recovery starting in 2024 and a closing of the gap between pre-crisis trend and actual output by 2026.

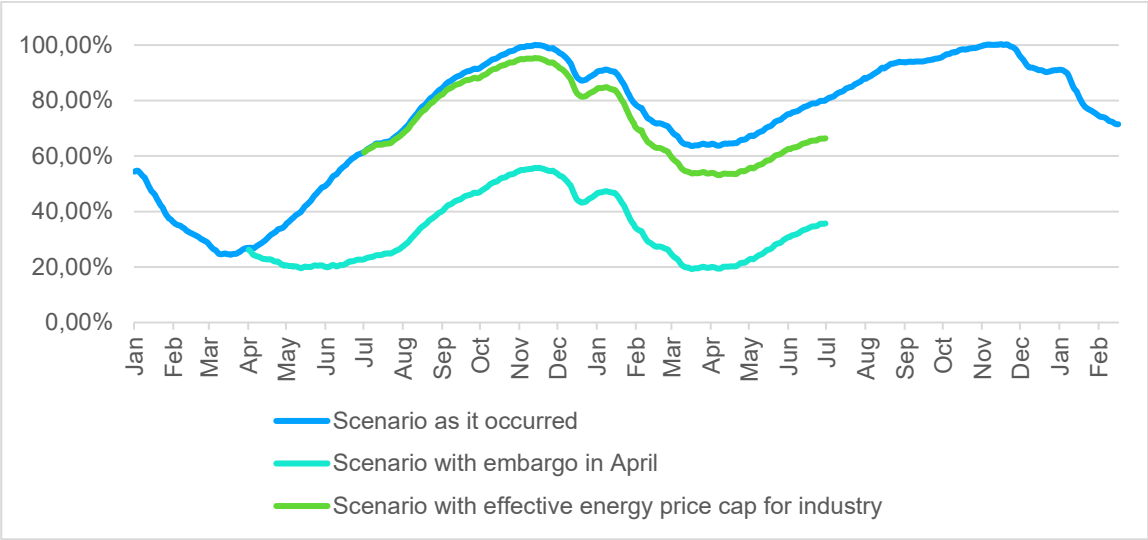
In this positive-scenario, manufacturing companies would have used more energy than they actually did in 2022, which has a certain economic cost that has to be taken into account. This cost is, however, small compared to the gain that would have come from the early implementation of a well-designed energy price brake. Specifically, suppose the German government would have followed our proposal and introduced an energy price brake with an incentive effect for manufacturing companies in July 2022 along with its forceful procurement efforts. Suppose further that in this hypothetical scenario, manufacturing companies would have reduced their use of natural gas only by 7 percent in 2022 relative to 2021, instead of the 17 percent reduction that has been observed (table 1). In other words, energy price controls would have given manufacturing companies an incentive to use 10 percent more natural gas than they would have used without the price controls -- this amount to an additional annual use of 33 terawatt-hour gas. The following figure depicts what would have happened to natural gas storage in Germany if, beginning in July 22, for one year each month 33/12 = 2.75 terawatt-hour more gas would have been used (keeping everything else equal).

Figure 10 clearly shows that the effect on gas storage and gas availability of our recommended version of energy price controls for industrial companies would have been small. Specifically, the ex-ante probability of a gas-shortage in the winter of 2022/23 would have barely changed and the "missing" gas could have easily been purchased when markets had calmed down in the summer and fall of 2023. In other words, the early introduction of a well-designed energy-price brake would have strengthened production, stabilized the economy with a negligible effect on energy supply in the short-run, giving the government sufficient time to replace compensate for the addition energy use in an orderly manner.

[34] Dao et al. (2023) confirm that the price dampening effects of energy price controls (unconventional fiscal policy) had positive effects on output.

[35] Some economists recommended such a shift in fiscal policy in 2023 (Krebs, 2023b, Tooze, 2023, Weber, 2023), but any move in this direction was derailed by self-imposed fiscal constraints. Krebs (2023b) develops the main elements of a public investment plan that goes well beyond the current fiscal plans of the German government. If implemented, the fiscal package would permanently increase public spending on education, infrastructure, housing and climate transformation of industry by about 2 percent of GDP (Green New Deal).

Figure 10. Gas storage level in Germany in three different scenarios



Source: Bundesnetzagentur (2023) and own calculations.[36]

Figure 10 also shows that the situation would have been very different if the German government had imposed an immediate import embargo on Russian gas effective April 2022, as many German economists recommended in spring 2022 (Bachmann et al., 202;, Bayer et al., 2022b).[37] In this case, the ex-ante probability of a gas shortage would have been high throughout 2022 since gas tanks would only have filled up towards the end of the year. In addition, a substantial amount of the natural gas Germany imported from Russia was exported to bordering European countries (transit), and these countries would have experienced a sudden drop in gas supply as well. Clearly, this would have meant much more turmoil in energy markets than the turbulences that were observed, and market prices would have stayed high for a much longer than depicted in Figure 1 implying much higher output losses than the ones that have been observed.

There is an additional reason why a sudden embargo-induced stop of Russian gas imports in April 2022 would have created economic and political turmoil: The German federal agency responsible for energy security (Bundesnetzagentur) most likely would have been forced to declare a natural emergency by the fall of 2022, which implies that it had started to ration the supply of natural gas for

[36] Gas storage levels in the case of an immediate embargo effective April 1, 2022, are computed using gas import data from the German Federal Network Agency (Bundesnetzagentur) for the transition points (pipelines) „Nordstream 1“ and „Waidhaus“. The calculation takes into account that gas exports would have decreased as well in case of an embargo, and assumes that the export reduction would have mimicked the observed reduction in exports in the relevant time period (as a fraction of imports). This assumption implies that about half of the embargo-induced reduction in German gas imports is passed on to neighboring European countries by reducing exports.

[37] Figure 10 also underscores that it is an inconsistent position to claim that i) an immediate embargo on Russian gas imports in April 2022 would have had „managable“ effects and ii) gas price caps with an incentive effect would be inacceptable because of their effect on gas availability in the winter 2022/23.

manufacturing companies in the summer or fall of 2022.[38] In other words, a worst-case scenario with a gas shortage in the winter 2022/2023 might have been avoided in case of an immediate embargo on Russian gas imports ex post, but there would have been a government-imposed rationing for the industrial sector and additional market turbulences that would have had very similar effects on economic insecurity and output as a gas shortage. Note that the reason that the Federal Network Agency (Bundesnetzagentur) most likely would have been forced to intervene in this way is simple: They are charged with the task of securing energy security for protected costumers (private households, hospitals, critical infrastructure, BMWK, 2023), and this goal would not have been consistent with a storage level of 50 terawatt-hour or less in September 2022 – the ex-ante likelihood of a gas shortage in the winter 2022/23 in some regions of Germany would have been too high.[39]

4.3. The German energy price brake and market fundamentalism

After months of hesitation, the German government finally announced the introduction of energy price controls for end users (type I in table 5), the so-called energy price brake, on September 29th, 2022 (Bundesregierung, 2022). The design of the energy price brake was delegated to a commission of experts. In this section, we describe the main features of the German energy price brake and give an account of the policy debate surrounding its introduction.

Even though the explicit request of the German government was to design a price dampening measure, most economists on the commission fiercely opposed anything that would amount to a non-linear pricing scheme as proposed by Dullien and Weber (2022a,b) and Stiglitz (2022) – see the discussion in section 4.2. In other words, despite some prominent endorsements of price controls (Blanchard, 2022, Krugman, 2022, and Stiglitz, 2022), many economists, including the majority of economists charged with designing the German energy price brakes, objected to using price controls as a matter of principle. We consider this knee-jerk rejection to price controls to be an example of market fundamentalism, which rules out the possibility of endogenous uncertainty and expectation driven market inefficiencies by assumption.

In the end, the proposal of the commission, which was largely adopted by the German government, was a compromise of the opposing views (Expert Commission, 2022). For households and commercial users, the commission's proposal had the non-linear pricing feature as proposed by

[38] There are three alert levels the Bundesnetzagentur can declare (BMWK, 2023). The second level (Alarmstufe) was declared in June 2022, but only the third, emergency level (Notlage) allows the rationing of the gas supply to ensure energy security for protected costumers. The emergency level was never declared by the German government during the energy crisis.

[39] Any attempt of the German government to change this rule in the summer of 2022 to make industrial users have priority over private households would have been political suicide and would have resulted in a rise in AfD approval rates much stronger than the observed increase. Indeed, some employer organizations were contemplating starting a campaign for such a rule change and started a few public „test balloons" in 2022, but very quickly decided to stay away from such a step after observing the extremely negative reaction in the media.

Dullien and Weber (2022a,b) at its core. Specifically, for households and smaller firms with non-industrial gas usage the subsidized price applied to 80 percent of past natural gas consumption, which for most households amounts to a larger protected volume than what Dullien and Weber (2022a,b) had initially proposed. On the other hand, the subsidy to implement the gas price cap was paid as a rebate on gas bills conditionals on past energy used. This approach was the only feasible procedure given the constraints in billing systems of German gas companies, but also the preferred option of economists who were primarily concerned with preserving price signals. Note, however, that the German energy price brake still has a non-linear feature since gas bills were not allowed to be negative and the rebate can only be defined with reference to the price-capped volume and the price cap. One should further keep in mind that the German energy price brake is not a simple lump-sum scheme in the sense that rebates depend on future price movements to always guarantee the price cap for the protected volume (Weber, Beckmann, Thie, 2023).[40]

The German gas price brake for households addressed the goals of energy price controls we use as part of the definition in section 4.1. First, it lowered (measured) inflation as confirmed by the Bundesbank and the Federal Statistical Bureau (Destatis). Second, it protected the purchasing power against gas price increases for the price-capped allowance. Third, it eliminated price uncertainty for the largest part of consumption. The difference between a more traditional non-linear pricing scheme and the design of the German gas price brake lies in greater price incentives (at least for those who follow the details of the scheme). But given that a substantial part of consumption is relatively price-inelastic in the short run for most households, the economy-wide impact is likely to be limited for this consumer group. This, however, is different for firms (see below).

Clearly, most people in Germany did not notice the difference between price controls with and without incentive-effects for households, and the German government did not include this nuance in its public communication.[41] However, market fundamentalists cared very deeply about the issue, and this by itself is very telling. For example, several economic members of the commission always insisted that the German energy price brake was really nothing else but lump-sum transfer payments (Bayer et al., 2022b, Grimm, 2022). In addition, prominent German economists publicly lectured anybody -- including Chancellor Olaf Scholz -- who might not share this interpretation of the German

[40] The government's and media communication also for the most did not include the difference between a simple non-linear pricing scheme and the rebate. Preserving marginal price incentives up to the point where the bill turns zero might have created some additional savings incentive for households that followed that technical nuance of the gas price brake and had the technology at hand to monitor their gas consumption in real time, which is not the case for the majority of tenants. But it also creates a perverse incentive for households that anticipate being able to save more than 20% of past gas consumption, for example because they have a second home, to switch to a more expensive gas contract in order to increase the rebate.

[41] Of course, companies (large energy users) do understand the difference and adjust their production decision accordingly -- see the discussion below.

energy price brake (Bachmann, 2022, Moll, 2022). In this moment of extreme economic insecurity for many households, a joint communication strategy on how the price brakes protect people's essential energy needs between the expert commission and the government would have been crucial. This episode is an example of the troubling tendency of mainstream economists to elevate economic principles above democracy. After all, the expert commission was asked by a democratically elected government to design an energy price brake, not to design transfer payments.

The fiercest battle in the expert commission and public debate was over the design of the energy price brake for industrial users of natural gas. We argued that energy price controls should be designed so that they give firms an incentive to continue producing (Krebs, 2022a,b Weber 2022), which – as we show in this paper – is an optimal policy in a world in which energy markets overreact due to endogenous price uncertainty. In contrast, most German economists strongly opposed anything that would go beyond lump-sum transfer payments (Bayer et al., 2022a; Grimm, 2022a), which in the case of industrial users would have meant large cash transfers independently of their production decision. More concretely, market fundamentalists proposed a so-called "hibernation premium" (Spiegel, 2022) that would have the German government write cheques to internationally operating companies like BASF even if they put production at German plants on hold because of exploding energy prices. This scheme was explicitly meant to be applied indiscriminately across all sectors without any consideration for systemically important inputs and products, including for example pharmaceuticals, critical chemicals and basic materials where Germany is a key provider for Europe and the world in many of these production line.

The hibernation scheme favored by market fundamentalists was seen as politically not palatable, but there was also no consensus for a simple subsidy scheme that would give manufacturing companies an incentive to continue producing. The outcome was therefore an unsatisfying compromise that did not correct the initial design flaw, but added another layer of complexity to prevent the worst. Specifically, industrial firms were allowed to sell the price-capped gas on the market at market prices (the "government cheque" turned speculative asset), but unions with the support of the industry association (BDI) added the condition that beneficiaries had to pledge to maintain a certain employment level in Germany to be eligible for the scheme. This clause was meant to correct the incentives to stop producing that the original scheme sought to achieve in the first place. The EU state-aid rules ultimately imposed additional restrictions that drastically reduced the amount of cash transfers an individual company could receive. Conditionalities such as commitments to work towards implementing environmental standards were added that would have been crucial for a full-fledged industrial gas price cap. In the end, the benefits of the program to most companies were too small to make it worthwhile the application. The outcome was a very low take-up rate and a tiny volume of program

funding: The gas price brake paid out less than one billion euro (0.025 percent of GDP) to industrial companies, but more than 13 billion euro to private households and small businesses in 2022 and 2023 (Ifo, 2023, BMF, 2024a), where initially it was estimated for the two budgets to be of a similar magnitude.

Ultimately, Germany implemented an effective gas price brake for households and non-industrial businesses, but it failed to protect the industrial core with properly designed energy price controls. A repeat of the gas price brake debate occurred in 2023 around a power price cap for industrial users meant to help support the electrification of energy-intensive industries, but the Finance minister, Christian Lindner, blocked the introduction of this policy (Tagesspiegel, 2023) and the German government finally decided not to implement it. Needless to say, German mainstream economists supported Christian Linder's blockade based on the argument that such a price cap would distort prices signals (Beirat-BMF; Fratzscher, 2023; Fuest, 2023). By the end of 2023 the production of the energy intensive industry in Germany had decreased by more than 20% compared to 2021, a sharper decline than the one during the COVID-19 recession. While the US is experiencing an unprecedented expansion of the manufacturing industry, Germany's industrial output in 2023 was down by more than 5 percent compared to 2021. This might well be the exodus and erosion of parts of Germany's industrial base. Of course, market fundamentalists might not be worried about these developments since they see in them the "inevitable" structural change that manifests itself in a shift to a service economy, which they consider "normal" for advanced economies.

The opposition of many economists to government interventions that change market prices is not new and echoed in the minimum-wage debate: Even though empirical research has convincingly shown that the perfect-market paradigm does not provide a good account of real-world labor markets (Cengiz et al., 2019, Dustmann et al., 2022, Manning, 2021), almost every raise in the minimum wage is accompanied by strong warnings by some economists that this would lead to higher unemployment. More generally, most economists are very comfortable with government interventions that provide transfer payments or correct externalities, but the idea that the government could intervene to reduce endogenous price uncertainty (price controls in a crisis) or rebalance power relationships (minimum wage laws) will always remain highly controversial for the majority of economists.

4.4. Beyond market fundamentalism: Endogenous uncertainty and animal spirits

We have seen that the majority view among economists ruled out endogenous price uncertainty and the inefficiency of energy markets by assumption. In this section, we discuss one important strand of the mainstream literature that speaks to the Keynesian idea that the self-fulfilling expectations (animal spirits) of market participants could generate endogenous price uncertainty leading to inefficiencies in the real sector of the economy. The work we have in mind is the so-called sunspot literature that

was developed as a reaction to the rational-expectation revolution in macroeconomics (Cherrier and Saïdi, 2018). The formal model we develop in the Appendix is a simple application of the general ideas of the sunspot-theory to the case of an energy crisis.

The seminal contributions in the sunspot literature are Azariadis (1981), Cass (1989) and Cass and Shell (1983), who show that signal variables unrelated to fundamentals (i.e. sunsport variables) could generate endogenous price movements/uncertainty that have real, negative consequences. Put differently, standard economic theory is consistent with the idea that sunspot-driven expectations generate endogenous movements in market prices and inefficient consumption or production choices. The sunspot variable serves as a coordination device for expectations, but only a few market participants have to observe it as long as everybody uses price movements to update their expectations. In market economies with sunspot equilibria, it is socially optimal to eliminate the movements in real economic activity that are driven by sunspots (self-fulfilling expectations).

The analysis in Cass (1989) is based on a two-period (finite horizon) economy and Azariadis (1981) and Cass and Shell (1983) use an infinite-horizon economy with overlapping generations (infinitely many time periods and households). A large body of theoretical work following these original contributions showed that sunspot equilibria are the rule, not the exception. For example, Cass (1992) and Siconolfi (1991) use methods from differential topology to show that for finite-horizon economies indeterminacy and inefficiency hold for a generic set of economies and are in this sense "the rule" -- see also the discussion in the Apendix. Chiappori, Geoffard, and Guesnerie (1992) summarize the corresponding results for infinite-horizon economies (no final period).[42] Woodfood (1990) argues that learning would lead to a convergence to sunspot equilibria and Krebs (1997) uses concepts from statistical physics to show that sunspot equilibria are in a well-specified sense the most likely outcome. In addition to the theoretical work, there is an extensive literature that explores the quantitative implications of indeterminacy and sunspot variables in various macroeconomic models (Farmer, 1999, 2019).

The sunspot approach provides a view of the global energy crisis and price controls that differs substantially from the perspective of market fundamentalists. According to market fundamentalists, the economic consequences of the energy price shock depicted in Figure 1 can be fully explained by the exogenous energy supply shock that accompanied the Russian war in Ukraine. In addition, they assume that the market price signal associated with the energy supply shock should not be "distorted" by any government intervention, which means that the price increase shown in Figure 1 should be

[42] Note also that sunspot-driven (sentiment-driven) fluctuations can occur in "standard" unique-equilibrium, rational-expectations, macroeconomic models (Angeletos and La'O, 2013).

passed on to production firms one-for-one. In other words, it is never desirable to reduce the energy price increase and dampen the effect on the real economy using price controls.

In contrast to market fundamentalists, the sunspot approach has little trust in the efficiency of market signals during a crisis. According the sunspot approach, the energy price increase depicted in Figure 1 is partly driven by endogenous uncertainty about future energy and goods prices. In this sense energy markets overreact to the energy supply shock associated with the Russian war in Ukraine. It is therefore socially optimal to use price controls to dampen price movements and to change market price signals. In terms of the simple two-period economy we model, the government should use energy price controls to provide incentives to produce more in the first period even if it means to reduce the availability of gas in the second period absent effective government supply management. The incentive effect of energy price controls is desirable since the market does not resolve the intertemporal tradeoff optimally. In the Appendix, we show more formally that this claim is true in a standard two-period production model with an energy sector and nominal price uncertainty that has real consequences.

In sum, the sunspot approach provides a theoretical framework for understanding why the incentive effect of energy price controls could be socially useful. In particular, it provides the theoretical foundation for the argument that the German energy price brake should have been designed in a way that gives firms an incentive not to shut down production (Krebs, 2022a,b, Weber, 2022). However, the theory does not provide clear guidance as to when and by how much an energy price hike should be dampened by price controls. Policy making becomes the art of finding the right balance in an uncertain and often chaotic world and non-linear pricing can help navigate this challenge. Clearly, more research is needed on the conditions that are conducive to the emergence of endogenous price uncertainty. In this sense, we consider our paper a first step in a broader research agenda that studies endogenous uncertainty in times of economic crises.

The rational-expectation approach to macroeconomics without endogenous price uncertainty (self-fulling expectations) is the dominating paradigm in applied macroeconomic research, even though there is, of course, a lot of theoretical work in the "mainstream" literature that speaks to the Keynesian idea of expectations-driven fluctuations -- see our references in this paper for a small sample of this rich literature. The ad-hoc narrowing of the intellectual horizon in certain parts of economics has had a profound impact on policy making in the last 40 years. Indeed, we vividly recall the blank faces we encountered when we suggested that it might not be efficient to pass the full energy price increase depicted in Figure 1 along to manufacturing firms. We also recall policy debates in which it was simply assumed that the efficiency of the market outcome is ensured as long as we can draw demand- and supply functions. Clearly, this type of market fundamentalism is an internally consistent view of

the world, but we would argue that there are at least three reasons why the sunspot-approach provides a more convincing theory of real market economies.

The first argument in support of the endogenous-uncertainty approach is a theoretical one: There are many more sunspot equilibria than there are equilibria without endogenous uncertainty. More precisely, for the typical economy, there are a continuum of inefficient sunspot equilibria, but only finitely-many efficient non-sunspot equilibria (Cass, 1992; Siconolfi, 1991). This means that the most likely market outcome is the equilibrium with a maximal amount of endogenous uncertainty (the maximum-entropy equilibrium) as long as we do not rule out any type of endogenous uncertainty by assumption (Krebs, 1997). In other words, market fundamentalists have a very limited view of the world (degenerate prior beliefs) that does not even consider the possibility of endogenous uncertainty and self-fulfilling expectations despite their theoretical likelihood.

The second argument is an empirical one. Work by Robert Shiller (1989, 2015) and many other researchers has found that financial market prices often exhibit excess volatility. For example, stock prices move more than what could be rationalized by future dividend movements. The endogenous-uncertainty approach can explain this empirical result – the so-called asset price bubbles are the sunspot-equilibria of a corresponding asset pricing model. However, there is also a fundamental explanation for the movement in stock prices that cannot be explained by movements in dividends: Movements in the discount rate with which future payoffs are discounted. Indeed, standard consumption-based asset pricing models can explain a number of so-called "empirical puzzles" once we allow for uninsurable idiosyncratic risk that correlates with aggregate risk in an empirically plausible way (Constantinides, 2002). If we go one step further and allow for the possibility of personal disasters, then consumption-based asset pricing models place few restrictions on observed asset prices, payoffs, and individual income/consumption even with "standard" preferences (Krebs, 2004). Thus, any empirical result like the excess-volatility finding can in principle be rationalized in terms of changes in the discount rate of the marginal investor, but some economists might question the plausibility of such an explanation.

The third argument is that rational policy maker would act in a crisis situation with large swings in critically important prices as though there is endogenous uncertainty, even if she is uncertain about the extent to which market price movements are driven by endogenous uncertainty. This is an implication of a simple cost-benefit analysis, as this paper shows. Specifically, if policy makers assume that there is no endogenous uncertainty even though market prices are driven by self-fulfilling expectations (type I error), they might implement price controls too late or not at all, and this policy mistake will have large economic and political costs. If, in contrast, policy makers assume there is endogenous uncertainty even though there is none, they might introduce "unnecessary" price controls

that lead to a misallocation of resources (type II error), but the economic costs of this policy mistake are often small and the political costs are nil.

5. CONCLUDING REMARKS

In this paper, we have provided evidence that the global energy crisis had severe economic and political consequences in Germany -- it was indeed a crisis. We have shown that despite its empirical failings, market fundamentalism has been at the core of the policy recommendations given by most economists. We have argued that the economists' fear of price controls is not warranted once we take into account that endogenous price uncertainty often emerges in times of crises. We have further shown that the sunspot approach provides a theoretical foundation for our claim that price controls in an energy crisis are socially useful. We conclude this paper with two comments on economic theories of market inefficiency that are complementary to the sunspot-approach.

First, the sunspot-literature can be viewed as a special case of a more general approach to the economics of incomplete markets. Specifically, indeterminacy and inefficiency of the market outcome is a common result in general equilibrium models in which insurance markets against signal variables or fundamental shocks are incomplete.[43] Stiglitz (1982) was the first to show that in general stock price movements lead to (constrained) inefficient investment decisions when insurance market are incomplete, and Geanakoplos and Polemarchakis (1986) generalize the analysis and make more precise the meaning of the phrase "in general". Geanakoplos and Mas-Colell (1989) show that in general there many (inefficient) market outcomes when financial contracts are denominated in terms of a numeraire (money). See Magill and Quinzii (1996) for an authoritative treatment of the (finite-horizon) incomplete-market literature. Overall, the results in this literature mainly point in one direction: Economic theory provides no foundation for the claim of market fundamentalists that in the real world markets always work efficiently.

Second, there is an extensive literature on private and public information in general-equilibrium models. This literature has often focused on the issue of informational efficiency of (financial) market prices, which is distinct from the question of allocational (Pareto) efficiency. Grossmann and Stiglitz (1980) and Radner (1979) are seminal contributions in this area. Further, it has been known for a long time that public information (news) can destroy allocational efficiency (Hirshleifer, 1971). There is also a game-theoretic approach that provides a theoretical foundation for the Keynesian idea

[43] This is obvious for the two-period model used in Cass (1989,1992), but perhaps less evident for the infinite-horizon economy of Azariadis (1981) and Cass and Shell (1983). For the infinite-horizon case, notice that efficiency would hold in an overlapping generations model of Cass and Shell (1983) if all households faced an Arrow-Debreu budget constraint (complete markets) with finite value of feasible consumption bundles, but this finite-value property is violated in a sunspot equilibrium (i.e. such finite-value Arrow-Debreu prices do not exist).

that financial markets are more like a beauty contest generating self-fulfilling expectations (Morris and Shin, 2002). All this work assumes a certain degree of individual rationality and starts from preferences and technologies to derive the decision rules of individual actors. In contrast, Shiller (2015) goes a step further and moves to behavioral macroeconomics to provide a theory of irrational exuberance and market inefficiency.

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Appendix

A1. Market economy without uncertainty

Time lasts for two periods, $t = 1, 2$. There is one domestic country (Germany) or domestic bloc of countries (the EU) that produces a perishable consumption good (output) using only one input factor, energy. Let $y_t = f(x_t)$ stand for the amount of output produced in period t if energy use in that period is x_t. We assume that the production function f is a continuously differentiable, strictly increasing, and strictly concave function. For example, it could be a Cobb-Douglas function: $f(x) = x^\alpha$ with $0 < \alpha < 1$.

Output is sold in competitive goods markets at price $p_1 = 1$ in period 1 and price p_2 in period 2. Thus, we normalize the first-period goods price to one, and prices of energy and second-period goods are therefore to be interpreted as relative prices. The domestic country has no endowment of energy and can buy energy in competitive markets in each period at price q. Preferences of households of the domestic country are time-additive with logarithmic one-period utility function over current consumption. Domestic households are identical (representative household) and own the firms producing output they are all capitalists. The representative domestic household solves the following utility maximization problem:

$$\max_{c_1, c_2} \{\ln c_1 + \beta \ln c_2\} \tag{1}$$

$$subject\ to\ :\ c_1 + p_2 c_2 = g_1(q) + g_2(q, p_2)$$

where c_1 and c_2 denote consumption in the first and second period, g_1 and g_2 denote the profit of domestic firms in the first and second period (see below), and β is the pure discount factor. Note that the budget constraint says that the value of total consumption purchases must be equal to the value of total (profit) income. Note also that second-period prices are known with certainty in period 1 – at the time of decision making.

There is a representative domestic firm that is owned by domestic households. In each period $t = 1, 2$, the representative domestic firms chooses the energy input according to:

$$\max_{x_1} \{f(x_1) - qx_1\} \tag{2}$$
$$\max_{x_2} \{p_2 f(x_2) - qx_2\}$$

The profit function g entering into the household decision problem (1) is the profit that is obtained when x solves (2), that is, g is the value function associated with the maximization problem (2).

There is a foreign country (Norway, Russia) that has a total/initial endowment of energy of $\bar{x}$. This country can store energy at no cost (move energy across periods costlessly). There is a representative household in the foreign country with preferences identical to the preferences of domestic households. The foreign household solves the following maximization problem:

$$\max_{\tilde{c}_1,\tilde{c}_2,\tilde{x}_1} \{\ln \tilde{c}_1 + \beta \ln \tilde{c}_2\} \tag{3}$$
$$\textit{subject to} \ : \ \tilde{c}_1 + p_2\tilde{c}_2 = q\tilde{x}_1 + q\left(\bar{x} - \tilde{x}_1\right) \ .$$

where $\tilde{c}_1$ and $\tilde{c}_2$ denote first-period and second-period consumption of foreign households, $\tilde{x}_1$ is the energy supplied to the market in period 1, and $\bar{x} - \tilde{x}_1$ is the amount of energy supplied in period 2, which is equal to the amount of energy stored in the first period.

Market clearing reads:

$$\begin{aligned} c_1 + \tilde{c}_1 &= f(x_1) \\ c_2 + \tilde{c}_2 &= f(x_2) \\ x_1 &= \tilde{x}_1 \\ x_2 &= \bar{x} - \tilde{x}_1 \end{aligned} \tag{4}$$

The first two equations in (4) represent goods market clearing and the last two equations are the energy market clearing conditions.

A competitive equilibrium of the market economy without uncertainty is defined in the standard manner. Specifically, an equilibrium is a set of prices, (q, p_2) and an allocation, $(c_1, c_2, \tilde{c}_1, \tilde{c}_2, x_1, x_2, \tilde{x}_1)$ so that the consumption choice (c_1, c_2) solves the utility maximization problem (1), the production choice (x_1, x_2) solves the profit maximization problem (2), the choice $(\tilde{c}_1, \tilde{c}_2, \tilde{x}_1)$ solves the utility maximization problem (9), and the four market clearing conditions (4) are satisfied. It is straightforward to show the following result:

Proposition 1. The following is a competitive equilibrium of the market economy without

uncertainty. First-period energy use, x_1, is the unique solution to

$$\frac{f'(x_1)}{f'(\bar{x}-x_1)} = \beta \frac{f(x_1)}{f(\bar{x}-x_1)} \tag{5}$$

and prices are given by

$$\begin{aligned} q &= f'(x_1) \\ p_2 &= \frac{f'(x_1)}{f'(\bar{x}-x_1)} \, . \end{aligned}$$

The consumption allocation is given by:

$$\begin{aligned} \tilde{c}_1 &= \frac{q\bar{x}}{1+\beta} \\ \tilde{c}_2 &= \frac{\beta q\bar{x}}{(1+\beta)p_2} \\ c_1 &= f(x_1) - \frac{q\bar{x}}{1+\beta} \\ c_2 &= f(\bar{x}-x_1) - \frac{\beta q\bar{x}}{(1+\beta)p_2} \end{aligned}$$

Proof: Straightforward algebra using first-order conditions.

Note that condition (5) states that the marginal rate of transformation between first-period and second-period energy use is equal to the (inter-temporal) marginal rate of substitution. In our setting, the marginal rate of substitution is equal to β times the ratio of first-period and second-period consumption, which in turn is equal to the ratio of first-period to second-period output. In the case of a Cobb-Douglas production function, $f(x) = x^\alpha$, equation (5) can be solved yielding $x_1 = \frac{\bar{x}}{1+\beta}$.

The model can be used to study the effect of changes in energy supply on production and consumption in a market economy. To this end, we would change the energy supply, $\bar{x}$, and use the model to trace out the effect on energy prices, q, and the equilibrium quantities of production, y, and consumption, c. In this way, we could use the simple two-period model with certainty to trace out the economic consequences of an unanticipated energy-supply shock (full surprise of all market participants). It follows immediately from proposition 1 that a reduction in energy supply, $\bar{x}$, increases the energy price, q, and reduces first-period energy use, x_1, and production, $f(x_1)$.

A2. Comments and Extensions

We have normalized the goods price in period 1 to 1. We could have allowed the first-period price p_1 to be different from 1, but this would not affect the equilibrium allocation in the model with certainty. In other words, the classical dichotomy holds and a simple nominal re-evaluation (doubling of all prices) has no real effects.

We assume that energy prices are the same in both periods: $q_1 = q_2 = q$. This is the only arbitrage-free price in an economy with perfect storage and no uncertainty. Put differently, if $q_1 \neq q_2$, then the household maximization problem (3) either would have no solution or always a corner solution if we impose non-negativity constraints on energy trade.

We have written the budget constraints of household (1) and (3) as one constraint for trading in periods 1 and 2 (Arrow-Debreu budget constraint). We can rewrite these budget constraints as sequential budget constraints (Arrow budget constraint). In this case, households can save and borrow in a competitive credit market. For example, for domestic households the budget constraint (1) is equivalent to

$$\begin{aligned} c_1 &= g_1(q) - m \\ p_2 c_2 &= g_2(q, p_2) + m \end{aligned} \tag{6}$$

where m is the amount of money saved by domestic households in the first period. This also clarifies that the nominal interest rate in this economy is 0 and the real interest rate is equal to the negative of the inflation rate, $1 - p_2$.[1]

Our definition of market equilibrium (supply equals demand) has a build-in condition of expectational equilibrium (expectations of agents are not refuted by observable variables), which amounts to the assumption of perfect foresight in an economy without uncertainty.[2] Specifically, when household and firms make their consumption and production choices in

[1] An often-used alternative approach is to normalize the price of the consumption good to one in all periods, and to replace the second constraint in (6) by the equation $c_2 = g_2(q) + (1 + r)m$, where r is the real interest rate.

[2] It is common in the rational-expectations literature to view this assumption as an extension of the rationality assumption to area of expectation formation, but some economists have been uncomfortable with this interpretation and preferred the equilibrium interpretation used here (Phelps, 1990).

period 1, they have to form expectations about second-period prices. The correct, though somewhat pedantic way to define an equilibrium is therefore to distinguish between expected second-period prices and equilibrium prices, and to add as an equilibrium condition that the two coincide.

We follow the general-equilibrium literature and assume competitive markets, that is, we assume price taking behavior. One implication of this assumption is that the theory is silent about the way prices are set by firms. In section A4, we briefly discuss how the emergence of endogenous uncertainty in general equilibrium models with price taking can be linked to the literature on price setting in oligopolistic markets.

We use a very basic model of the economy that is sufficient to discuss the emergence endogenous uncertainty and the optimality of price controls. To make our argument as transparent as possible, we have intentionally left out several features that are not central for an understanding of the main economic mechanisms that gives rise to the optimality of price controls, but seem central for a full understanding of the impact on the European economy of the global energy crisis. Specifically, at least three extensions of our basic model would be necessary to provide an analysis of the energy crisis in Germany that is in line with all the aspects discussed in chapter 2.

First, we focus on energy as an essential input factor, and use a model without the production factors capital and labor. One way to interpret this simplifying assumption is that capital stock is fixed and labor and energy enter in a Leontief way (no short-run substitution between the two factors) into a neoclassical production function that takes capital and an energy-labor composite as inputs. In this case, the profit of domestic firms that accrues to domestic households is the return to capital and part of the energy cost paid by the domestic firm (see equation (2)) is wage payments. An extension of the basic model with physical capital and labor would allow us to distinguish between capital income and labor income, and to analyze the conflict between capitalists and workers.

Second, we assume that the supply of energy, $\bar{x}$, is fixed and certain. Clearly, a central concern in 2022 was that there could be a gas shortage in the winter 2022/23, which in the end did not occur – see the discussion in chapter 2. In other words, a central feature of the crisis situation in 2022 (the first period) was uncertainty about the supply in 2023 (the

second period). To capture this idea, we would use a model with fundamental uncertainty in which the second-period energy is a random variable and households and firms have to make decisions in the first period not knowing the realization of second-period energy supply.

Third, we emphasized in chapter 2 that the energy supply management was an essential component of the policy response of the German government. In contrast, the basic model makes no distinction between domestic households and the domestic government. We have intentionally made this simplifying assumption to focus on the policy instrument of price controls, and to show as clearly as possible that price controls with incentive effects (unconventional fiscal policy) are socially optimal when there is endogenous price uncertainty. Clearly, the more successful the government manages energy supply (first policy dimension), the less likely it becomes that energy markets display endogenous uncertainty, and therefore the less the government has to rely on prices controls (second policy dimension).

A3. Efficiency of market equilibrium without uncertainty

Consider the following social planner problem

$$\max_{c_1,c_2,\tilde{c}_1,\tilde{c}_2,x_1,x_2} \{\mu [\ln c_1 + \beta \ln c_2] + (1-\mu) [\ln \tilde{c}_1 + \beta \ln \tilde{c}_2]\} \tag{7}$$

$$\begin{aligned} \textit{subject to} : \; c_1 + \tilde{c}_1 &= f(x_1) \\ c_2 + \tilde{c}_2 &= f(x_2) \\ x_1 + x_2 &= \bar{x} \end{aligned}$$

where μ is the weight the social planner puts on the utility/welfare of the domestic country. It is straightforward to show the following result:

Proposition 2. The following allocation ist the solution to the social planner problem (7). First-period energy use is the solution to

$$\frac{f'(x_1)}{f'(\bar{x}-x_1)} = \beta \frac{f(x_1)}{f(\bar{x}-x_1)}$$

and consumption is given by:

$$c_1 = \mu f(x_1) \tag{8}$$

$$
\begin{aligned}
\tilde{c}_1 &= (1-\mu)f(x_1) \\
c_2 &= \mu f(\bar{x}-x_1) \\
\tilde{c}_2 &= (1-\mu)f(\bar{x}-x_1)
\end{aligned}
$$

Proof: Straightforward algebra using first-order conditions.

A comparison of propositions 1 and 2 shows that the market equilibrium allocation coincides with the solution to the social planner problem if μ is given by

$$
\mu = \frac{f'(x_1)\bar{x}}{(1+\beta)f(x_1)} \tag{9}
$$

This result holds because equation (5) determines first-period energy use, x_1, in both the market equilibrium and the solution to the social planner problem. Clearly, the solution the social planner problem is Pareto efficient. Thus, the market equilibrium allocation is Pareto efficient. In other words, the market works perfectly. This ist the First Welfare Theorem (Invisible Hand Theorem):

Corollary 1. In the economy without endogenous prices uncertainty the First Welfare (Invisible Hand) Theorem holds: The market equilibrium allocation (5) is Pareto efficient.

Note that proposition 2 implies that the market outcome is always optimal in the sense that, for given energy endowments, technology and preferences, we cannot make both domestic and foreign households better off. In addition, the response of the market economy to an energy shock is optimal there is no way of increasing the present value of output by government intervention. This is a direct implication of the fact that the market equilibrium is production efficient and therefore the efficiency condition (5) holds.

A4. Market economy with endogenous uncertainty (sunspots)

We now introduce uncertainty into the basic model. Specifically, assume that households and firms expect second-period energy and goods prices to be uncertain, that is, they can take on $s = 1, \ldots, S$ possible values, which we denote $q_2(s)$ and $p_2(s)$. In other words, second-period prices have become random variables. The uncertainty does not affect economic fundamentals, that is, the one-period utility function, u, the production function, f, and the endowment (supply) of energy, $\bar{x}$, are independent of the realization s. We allow households

to have heterogenous expectations in the sense that they assess the likelihood of occurrence of state s differently. Denote the probabilistic expectations of domestic households by π and the probabilistic expectations of foreign households by $\tilde{\pi}$ with $\sum_s \pi(s) = \sum_s \tilde{\pi}(s) = 1$.

We assume that preferences over uncertain consumption allow for an expected utility representation. Hence, the utility maximization problem of domestic households reads

$$\max_{c_1, c_2(.)} \left\{ \ln c_1 + \beta \sum_s \ln c_2(s)\pi(s) \right\} \tag{10}$$
$$\textit{subject to } \forall s \ : \ c_1 + p_2(s)c_2(s) = g_1(q_1) + g_2(q_2(s), p_2(s))$$

Domestic firms now solve

$$\max_{x_1} \{f(x_1) - q_1 x_1\} \tag{11}$$
$$\forall\, s \ : \ \max_{x_2(s)} \{p_2(s) f(x_2(s)) - q_2(s) x_2(s)\}$$

and the households of the foreign country face the following decision problem:

$$\max_{\tilde{c}_1, \tilde{c}_2(.), \tilde{x}_1} \left\{ \ln \tilde{c}_1 + \sum_s \beta \ln \tilde{c}_2(s)\tilde{\pi}(s) \right\} \tag{12}$$
$$\textit{subject to } \forall\, s \ : \ \tilde{c}_1 + p_2(s)\tilde{c}_2(s) = q_1 \tilde{x}_1 + q_2(s)\left(\bar{x} - \tilde{x}_1\right) \ .$$

The market clearing conditions now read:

$$\begin{aligned} c_1 + \tilde{c}_1 &= f(x_1) \\ \forall\, s \ : \ c_2(s) + \tilde{c}_2(s) &= f(x_2(s)) \\ x_1 &= \tilde{x}_1 \\ \forall\, s \ : \ x_2(s) &= \bar{x} - \tilde{x}_1 \end{aligned} \tag{13}$$

The definition of a market equilibrium is, mutatis mutandis, as above. Clearly, we can infer from the market clearing conditions that second-period equilibrium consumption can vary with the realization s, but second period equilibrium energy use and production cannot. However, the presence of price uncertainty still affects the level of energy use and production in both periods – see proposition 3 below.

The variable s is known as a sunspot variable and the related uncertainty is often called extrinsic uncertainty (Cass and Shell, 1983). The price uncertainty generated by the sunspot

variable is, if it occurs in equilibrium (see below), endogenous uncertainty in the sense that it is not a direct market reaction to uncertainty about economic fundamentals. In contrast, if the realization of s affected energy supply, $\bar{x} = \bar{x}(s)$, or the production technology, $y = f(x, s)$, or the one-period utility function, $u = u(c, s)$, we would speak of fundamental uncertainty.[3]

Note that the sunspot literature has usually imposed the additional restriction that households entertain common probabilistic expectations, $\pi = \tilde{\pi}$. In other words, households not only agree that there is second-period price uncertainty with various possible scenarios, but they also agree on the likelihood with which the various possible scenarios occur. Our assumption of heterogenous beliefs simplifies the proof and also seems much more in line with the empirical evidence. Note that one can always trace back heterogeneity of expectations to the heterogeneity of information, but in this case it would be private information about the sunspot variable.[4]

The budget constraint in (9) and (11) holds sequentially (for every realization s) and there are no insurance markets against sunspot-risk – in this sense markets are incomplete. Further, the market clearing condition (12) has to hold for each s – it is macro uncertainty. In terms of interpreting the German energy crisis, this means that we only observed one of many possible states of the world in 2023. This, in a nutshell, is the problem of empirical macro that relies on time series (aggregate panel) data to study economic crises. In general, only a few data point are available, and the number of relevant observations can only be increased by making the highly questionable assumption that there is little variation of the economic structure (institutions) across countries that could affect the individual response

[3]Of course, an information variable (news) that does not directly affect fundamentals, but is correlated with fundamentals, is the intermediate case often analyzed in the literature on information economics – see also the concluding remarks in this paper. Needless to say, there is often an observational equivalence: What some observers might interpret as the outcome of news about fundamentals, others might interpret as the outcome of the mixture of fundamental uncertainty and endogenous (sunspot) uncertainty.

[4]In private-information economies, agents can learn from market prices, and a rational-expectations theory of heterogeneous beliefs is only internally consistent if equilibrium prices do not fully reveal all private information (Grossman and Stiglitz, 1980, Radner, 1979). Note also that in a probabilistic choice situation the distinction between preferences and beliefs/expecations is blurred (probabilities are part of preferences) and the line between the two is in reality never as clear cut as a narrow objectivist' interpretation of the theory might suggest.

to a common shock.

Proposition 3. Consider any market economy and the corresponding certainty equilibrium with first-period energy price and energy use denote by q^* and x_1^*, respectively. There exist a market equilibrium with endogenous price uncertainty (sunspot equilibria) close to the market equilibrium with certainty. In the sunspot-equilibrium, second- period energy prices, $q_2(s)$, and second-period goods prices, $p_2(s)$, depend in a non-trivial way on the sunspot variable s, and the first-period energy price, q_1, and first-period energy use satisfy

$$\begin{aligned} q_1 &> q^* \\ x_1 &< x_1^* \end{aligned} \tag{14}$$

Further, the allocation in the market equilibrium with endogenous uncertainty is Pareto inefficient, that is, endogenous uncertainty is harmful.

Proof: We prove the existence of a non-trivial sunspot equilibrium by construction. We first collect the equations defining an equilibrium. First-period consumption of domestic households is the solution to the consumption Euler equation

$$\frac{1}{c_1} = \beta \sum_s \frac{\pi(s)}{g_1(q_1) + g_2(q_2(s), p_2(s)) - c_1} \tag{15}$$

where second-period consumption, $c_2(s)$, has been substituted out using the budget constraint. First-period consumption of foreign households is given by

$$\tilde{c}_1 = \frac{q_1 \bar{x}}{1+\beta}\,, \tag{16}$$

which is independent of uncertain second-period prices. In addition, a necessary condition for the utility maximization problem of foreign households is that energy prices have to satisfy the no-arbitrage condition

$$q_1 = \beta \sum_s \frac{\tilde{c}_1 q_2(s)}{q_1 x_1 + q_2(s)(\bar{x} - x_1) - \tilde{c}_1} \tilde{\pi}(s) \tag{17}$$

where the pricing kernel in (18) is simply the inter-temporal marginal rate of substitution of foreign households with $p_2(s)\tilde{c}_2(s)$ replaced by $q_1 x_1 + q_2(s)(\bar{x} - x_1) - \tilde{c}_1$ using the budget constraint. Finally, first-period market clearing has to hold. Second-period market clearing then holds by Walras' law.

We confine attention to prices and energy use satisfying

$$\begin{aligned} f'(x_1) &= q_1 \\ \forall\, s: \quad q_2(s) &= (1+\phi(s))q_1 \\ \forall\, s: \quad p_2(s) &= \frac{q_2(s)}{f'(\bar{x}-x_1)}\,, \end{aligned} \tag{18}$$

where ϕ a function (random variable) that represent second-period price risk. For simplicity, we assume that there are two only states, $s = 1, 2$, with realizations $\phi(1) = -\phi(2) = \bar{\phi} > 0$. The first and third equation in (15) are the first-order equations of the firm, and the second equation is our way of parameterizing endogenous price uncertainty.

Consider the equilibrium under certainty defined in Proposition 1 and denote the corresponding first-period energy use and first-period energy price by x_1^* and q_1^*, respectively. We use the first equation in (15) to define a function $q_1 = q_1(x_1)$ around the point (x_1^*, q_1^*). Using second-period prices as defined by (15) and (17) to substitute out first-period consumption of foreign households, we find that any solution to the following system of three equations defines a sunspot-equilibrium:

$$\begin{aligned} \frac{1}{c_1} &= \beta \sum_s \frac{\pi(s)}{f(x_1) - f'(x_1)x_1 + (1+\phi(s))q_1(x_1)\left[f(\bar{x}-x_1)/f'(\bar{x}-x_1) + x_1 - \bar{x}\right] - c_1} \\ 1 &= \beta \sum_s \frac{\bar{x}(1+\phi(s))\tilde{\pi}(s)}{(1+\beta)\left[x_1 + (1+\phi(s))(\bar{x}-x_1)\right] - \bar{x}} \\ f(x_1) &= c_1 + \frac{q_1(x_1)\bar{x}}{1+\beta} \end{aligned} \tag{19}$$

The first equation in (19) is the consumption Euler equation of domestic households, the second equation is the no-arbitrage condition that follows from the utility maximization of foreign households who can shift energy across periods, and the last equation expresses first-period market clearing. If there is no uncertainty, then the no-arbitrage equation is automatically satisfied and the two remaining equation determine the values of x_1 and c_1.

The last equation in (19) defines a strictly increasing, continuously differentiable function $c_1 = c_1(x_1)$ with domain an open set around the point x_1^* (implicit function theorem). Consider a small decrease in energy use from x_1^* to $x_1 = x_1^* - \Delta$ with $\Delta > 0$. It suffices to show that there are real numbers $\tilde{\pi}_1 = \tilde{\pi}(1)$, $\pi_1 = \pi(1)$, and $\bar{\phi}$ so that the first two equations

are satisfied if c_1 is given by the function $c_1(x_1)$. The existence of a $\bar{\phi}$ so that the first equation in (19) is satisfied follows if we choose $\pi(1) = \pi(2) = 0.5$ (mean-preserving spread) and notice that i) the function $c_1 = c_1(x_1)$ is strictly increasing, ii) the right-hand-side of the equation is a convex function of ϕ, and iii) all functions are continuously differentiable (mean value theorem of analysis). Finally, to prove the existence of a $\tilde{\pi}_1$ so that the second equation in (18) is satisfied, consider the equation

$$1 = \frac{\beta\bar{x}(1+\phi)}{(1+\beta)\left[x_1 + (1+\phi)(\bar{x} - x_1)\right] - \bar{x}} \tag{20}$$

where ϕ is a real number. The equation holds at $\phi = 0$. In addition, the right-hand side of (20) is a strictly monotone, continuously differentiable function of ϕ for $x_1 \neq \frac{\bar{x}}{1+\beta}$, which holds for some $x_1 = x_1^* - \Delta$.[5] Thus, there is $\tilde{\pi}_1$ with $0 < \tilde{\pi}_1 < 1$ so that the second equation in (19) holds (mean value theorem of analysis). This completes the proof of the existence of a sunspot equilibrium. The Pareto inefficiency of the sunspot equilibrium follows from a simple argument by contradiction.

Remark 1. Note that in the market equilibrium with endogenous uncertainty, the energy price is too high and production is too low in the first period. In other words, the condition (5) expressing production efficiency is not satisfied and the market does not resolve the intertemporal trade-off society is facing optimally. This is one reason for the Pareto inefficiency of the market outcome. The intuition for this result is simple: Uncertainty about second-period prices makes second-period consumption uncertain, which leads risk-averse households to reduce energy use and production in the first period there is too much energy saving and therefore too little production (precautionary saving).[6] In addition, the uncertainty about second-period prices and consumption decreases the expected utility of risk-averse households. This is a second reason why the market outcome is Pareto inefficient.

Remark 2. In the basic model we consider, the emergence of endogenous uncertainty requires uncertainty about second-period energy prices to go hand in hand with uncertainty

[5]Note that for the case of a Cobb-Douglas production function, we have $x_1^* = \frac{\bar{x}}{1+\beta}$ and therefore $x_1 \neq \frac{\bar{x}}{1+\beta}$ for all $\Delta \neq 0$.

[6]Precautionary saving is related to risk version, but a distinct concept that requires the convexity of marginal utility that holds in our model. Kimball (1990) suggest to use the term prudence for the result that agents prepare or forearm in the face of uncertainty.

about second-period goods prices since profit maximization requires:

$$p_2(s) = \frac{q_2(s)}{f'(\bar{x} - x_1)} \tag{21}$$

This proportionality of energy price uncertainty and good price uncertainty only holds because of our assumption that supply is fixed and time ends after the second period (finite time horizon). In general, such a tight connection between the two prices does not hold, but it is generally the case that endogenous energy price uncertainty and endogenous goods price uncertainty coexist. One interpretation is that the endogenous uncertainty originates in energy markets and is passed on to goods markets generating uncertainty about goods prices (inflation uncertainty) since energy prices determine the cost of production (cost-push inflation). In this case, the causality runs from energy markets (financial markets) to the real sector of the economy. However, in general equilibrium models all prices are determined simultaneously, and in this sense the model is also consistent with the reversed interpretation: The price uncertainty originates in the real sector and then energy markets follow.

Remark 3. The sunspot-equilibrium we construct is Pareto inefficient (all households can be made better off) because there is too little energy use and production in the first period: $x_1 < x_1^*$. The sunspot equilibrium is also production inefficient in the sense that the present discounted value of output could be increased, but endogenous uncertainty only decreases output in the first period (and increases output in the second period). This is a direct implication of our assumption that the economy only lasts for two periods and the total energy endowment is fixed. If we assume an open time horizon (no final period), then the sunspot equilibrium we construct would reduce production in every period. The assumption of an open ended economy is one way to formalize our idea that additional use of energy for production during the peak of the crisis has large benefits, but little cost since energy is relatively abundant in the future (after the peak of the crisis) – energy price controls buy time.

Remark 4. The proof only shows that there exists a sunspot equilibrium, but in general there are many more sunspot equilibria. More precisely, if we consider the standard general-equilibrium framework with financial assets and a typical economy (open and dense set of endowments), then there exists a continuum of sunspot-equilibria, but only a finite number of non-sunspot equilibria (Cass, 1992, Siconolfi, 1991). The (few) non-sunspot equilibria

are Pareto efficient, but the (many) sunspot equilibria are Pareto inefficient. The idea in most of this literature is to apply the implicit function theorem to the system of equilibrium equations – in our case equations system (19). The application of the implicit function theorem requires, however, that a certain regularity condition holds, which is usually shown to hold for a typical economy (open and dense set) by employing some version of Morse-Sard Theorem of Different Topology – see Balasko (2016) for a concise treatment of the subject. In this paper, we do not provide a characterization of the set of sunspot-equilibria for the model with production and energy inputs. Note that we do not rule out the existence of sunspot equilibria in which $x_1 > x_1^*$.

Remark 5. In this paper, we follow the general-equilibrium tradition and assumes price taking behavior (perfect competition). This means that the theory is silent about the way prices are set and therefore remains somewhat of a black box regarding the price-setting dynamics in response to an energy shock. An extension of our analysis to a model with price setting in oligopolistic markets along the lines of Rotemberg and Woodford (1992) seems a promising topic for future research. For example, Rotemberg and Woodford (1996) argue that implicit collusion among firms in oligopolistic markets lead to increasing mark-ups in response to a rise in energy prices, and they show this feature is important to explain the joint response of output and real wages to oil price shocks in the US.[7] In addition, Weber and Wasner (2023) argue that the COVID-19 inflation period in the US was dominated by a sellers' inflation in which firms used their market power to hike prices and provide evidence that firms in systemically significant upstream sectors implicitly coordinate to protect profit margin, which leads to rising mark-ups. Connecting this empirical research to the theory of endogenous price uncertainty seems a promising topic for future research.[8]

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[7]Clearly, indeterminacy is the rule in repeated games (Folk Theorem), and the emergence of endogenous uncertainty can be views as movement along different equilibria indexed by the sunspot variable. Specifically, Rotemberg and Woodford (1992,1996) obtain determinacy of the theory by focusing on symmetric perfect equilibria of the oligopoly game and additionally imposing the assumption that firms within an industry coordinate on the industry-best equilibrium – maximal collusion within an industry. It seems natural to link the indeterminacy of equilibrium in the current model to different degrees of collusion that depend on the realization of the sunspot variable (the coordination device).

[8]Wang and Werning (2022) incorporate a model of dynamic oligopolistic competition along the lines of Rotemberg and Woodford (1992) into the New-Keynesian framework and analyze the transition of monetary policy. They confine attention to Markov equilibria with prices as the only state variable.

A5. Price controls

The next result about optimal government policy is a direct implication of proposition 3.

Corollary 2. Price controls are socially optimal. Specifically, if the government introduces a price cap on energy prices, $q \leq q*$, then the only equilibrium is the efficient market equilibrium without endogenous price uncertainty.

The price cap imposed by the government coordinates the expectations of market participants in a beneficial way – price controls remove the possibility of harmful uncertainty and corresponding energy price hikes. Note that in equilibrium the government does not need to make any transfer payments. The government's role ist to set rules that allow all member of society to coordinate their individual actions in a way that benefits everybody.[9] Note also another way to eliminate equilibria with endogenous uncertainty is to introduce a cap on goods prices. In the simple model, both instruments – energy price cap and goods price cap – work equally well. However, in practice it is useful to go to the source of the problem, which in the case of an energy crisis means to impose an energy price cap. Of course, in the model the government could also use quantity constraints on trading to ensure that the only market outcome is the no-sunspot equilibrium, but in practice this would be much more difficult to implement.

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[9]It could be that without redistribution it is not a Pareto improvement. This ist the case if the foreign country (Norway, US) benefits more from the increase in energy prices caused by endogenous uncertainty than it loses due to the increase in consumption uncertainty.

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