CPB Netherlands Bureau for
Economic Policy Analysis

A simulation of energy prices and corporate profits

Firms have absorbed higher energy prices by saving energy and raising output prices. We use a stress test to investigate the effects of higher energy prices on firms' profits. In our main scenario the increase in loss-making firms is limited at about 2%-points.

The biggest increases in loss-making firms are in the other non-metallic mineral products, the manufacturing of beverages and the wellness & funeral industry. In the main scenario the share of loss-making firms in these industries increases by about 4%-points.

CPB - April 2023

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High energy prices and firm profits

Firms in the Netherlands have adapted well to higher energy prices.
This stress test shows the impact on firm profitability is limited

The change:

permanent rise in energy prices, compared to 2019:

natural gas +196%

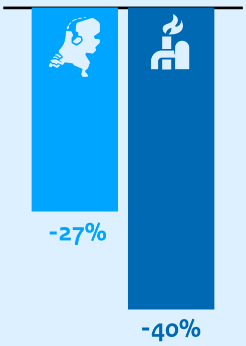
electricity +115%

The adaptation:

Saving energy

Gas use in the Netherlands fell in 2022, most clearly in the manufacturing industry

change in gas use, in % compared to 2019



This concerns the costs for goods and services bought from other firms. Among other things, wage and rental costs of the firm itself are not covered by this

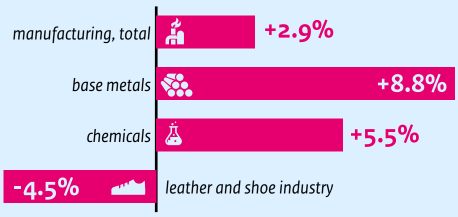
Passing on increased costs to customers

Output prices have been risen sharply...

average change in output prices, in % compared to 2019

... and in some industries more than the rise in input costs, including energy

largest change in output prices minus input costs in manufacturing, in % compared to 2019



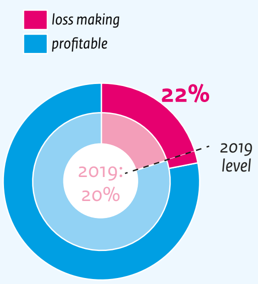
Main scenario:

This analysis shows the consequences for profitability if firms use 20% less energy and the additional energy costs are passed on to their customers, which decreases demand for their goods and services

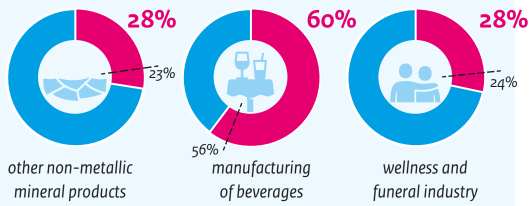
In addition, the publication contains two scenarios in which firms adjust less or not at all

The outcomes:

The number of firms that do not make a profit increases by 3,700 compared to 2019 (pre-Covid), when 1 in 5 firms made a loss



Industries in which the number of loss making firms increases the most:



Policy implications:

Rely on the adaptability of firms; generic compensation for increased energy prices is not necessary

Main messages

- Production costs increased for many firms as a result of high energy prices in 2022. Firms have adapted to this by saving energy and raising output prices.
- This simulation study shows that the number of firms that may incur losses due to high energy prices is limited. In the most likely scenario in which firms adjust energy consumption and output prices, the share of loss-making firms increases by 2 percentage points (3,700 firms with one or more employees). If firms neither reduce their energy consumption nor increase their output prices, this increases to a maximum of 4 percentage points (7,500 firms). There are, however, major differences between industries.
- Generic energy price compensation is not appropriate: a large proportion of firms can adapt without support, which maintains regular firm dynamics as much as possible. That does not alter the fact that a number of individual firms have been hit hard by the energy shock.

Summary

In this publication we examine the extent to which Dutch firms have adapted to the increased energy prices and possible consequences for their profitability. Firms have been through turbulent times: after the Covid-19 crisis, they were confronted with a sharp rise in energy prices. This puts pressure on profitability, although the extent to which this happens depends strongly on the adaptability of firms and the industry in which these firms operate.

Energy-intensive firms with higher energy costs experienced more incentives to save energy. Based on energy consumption data for industries, the air transport industry and various manufacturing industries such as the chemical industry have high energy intensity (Section 2.1). We see that natural gas consumption in manufacturing has been reduced by approximately 40% compared to 2019. By way of comparison: in total, natural gas consumption by households and firms has decreased by 27% compared to 2019. These natural gas savings may have been achieved in various ways: by reducing total energy consumption, switching to cheaper energy sources or by temporarily suspending operations.

Firms have passed on a substantial part of the increased energy costs to customers (Section 3). We observe an increase in output prices in both services and manufacturing. The largest increases in output prices have mainly taken place in energy-intensive industries, with the biggest increases in the air and water transport industries, by approximately 20 and 25% respectively (Section 3.1). However, this only covers the change in sales prices, and not the extent to which increased costs are passed on to customers. For manufacturing in particular, we see that increased costs have been passed on in output prices (Section 3.2). On average, we find that output prices have increased by 2.9 percentage points more than the prices of goods and services firms buy from other firms (cost prices), including energy. Output prices for the two most energy-intensive industries rose faster than cost prices, by 8.8 percentage points for the basic metal industry and 5.5 percentage points for the chemical industry. This points to a substantial pass-through of increased costs into output prices. These findings are supported by the responses of entrepreneurs in surveys: in 2022, they indicated a much greater desire to increase prices compared to 2019 (Section 3.3).

We use a stress test for firms to map out to what extent the profits of individual firms are affected by the higher energy costs. We simulate how the profitability of firms changes under different scenarios. The scenarios vary in the extent to which firms have the ability to adapt, which previous studies did not account for. The past two years have shown that firms can both save energy and, at least partially, pass on cost

increases. Across all of the scenarios we examine the effect of a price increase of 196% for natural gas and 115% for electricity on corporate profit, which corresponds to the price increase in 2022 compared to 2019, the year we consider to be a year of normal business operations (Section 2.2).

In our main scenario, in which we assume that firms can adapt by saving energy and passing on energy costs in full to customers, the percentage of loss-making firms rises slightly. This scenario best matches what we observed based on price and energy usage statistics and results in an increase of approximately 3,700 (2 percentage points) loss-making firms out of the 200,000 firms we examined in total (Section 4.1). Despite the full pass-through of the increased energy costs, the number of loss-making firms increases because higher output prices lead to less sales: after all, consumers will shift their demand to products that have risen less in price. For comparison, in an unlikely scenario in which firms do not adapt at all to the increased energy costs, the number of loss-making firms increases by 7,500 (4 percentage points, section 4.3).

We find large differences between industries. The three industries where the share of firms that become loss-making is the largest in the main scenario are: the other non-metallic mineral products (like manufacturing of glass), the manufacturing of beverages and the wellness & funeral industry. In these industries, the share of loss-making firms increases by approximately 5 percentage points. The increase in the share of loss-making firms is greatest in the other non-metallic mineral products industry, but the combined revenue of these loss-making firms is relatively limited, approximately 0.25 billion euros. Of the other industries in the top 10 with the largest increase in the share of loss-making firms, combined revenue is highest in the food and beverage outlets and nutrients industries, both around 2 billion euros. On the other hand, the share of loss-making firms in the trade and repair of cars and motorcycles is small, in the bottom 10, but the combined turnover of these firms is relatively larger, about 4.5 billion euros.

The consequences are similar for firms of different sizes. In the main scenario, the share of loss-making firms increases by approximately 1.9 percentage points for smaller firms, 1.4 percentage points for medium-sized firms and 1.0 percentage points for large firms.[1] It should be noted here that we assume equal adaptability of firms: the degree of energy savings, pass-through and loss of demand in the stress test do not differ by firm size. In reality, these things may depend on the size of a firm.

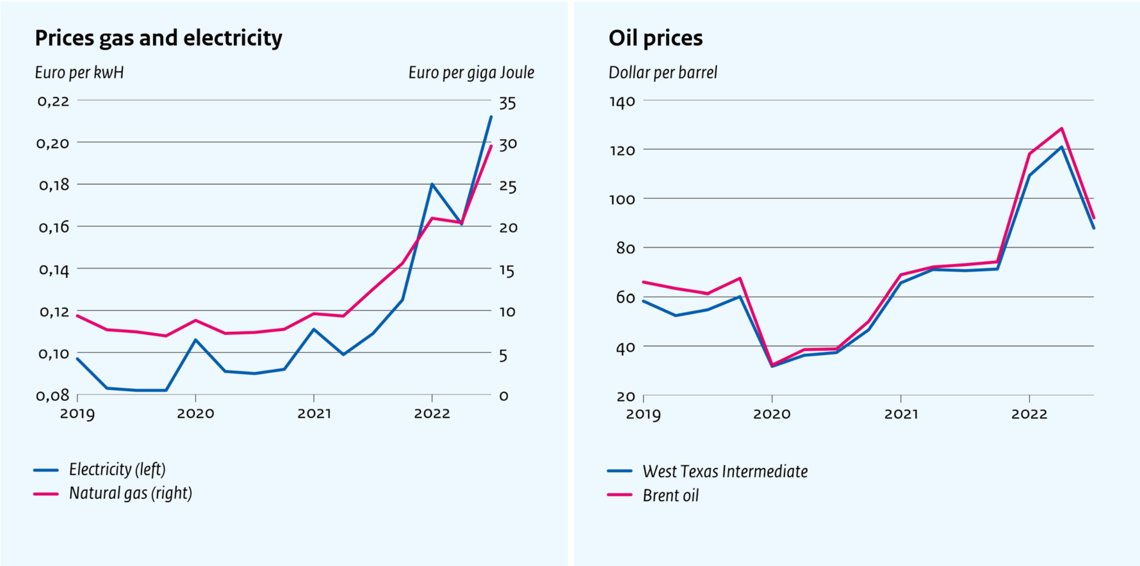
Given the findings of this study, generic energy price compensation is not appropriate for firms' energy costs. Individual firms will differ in the extent and speed with which they will be affected by the increase in energy costs. This depends, among other things, on price agreements in their purchase and sales contracts. Firms also differ in their adaptive behaviour and may lose market share if competitors adapt more quickly. But in total, the percentage of firms that may become loss-making as a result of the energy price shock is considerably lower than in previous crisis periods (see, for example, Pruijt and Brouwer, 2022). In addition, the increase in energy costs is expected to be partially permanent:[2] firms will eventually have to adapt to the new situation. Without generic support, regular firm dynamics are maintained as much as possible. Support policy is more justifiable in the case of temporary than permanent shocks.[3]

[1]We categorise firms by size based on the number of employees. Small firms are firms with up to 49 employees, medium firms have 50–249 employees, and firms with at least 250 employees are considered large.
[2] See also the CEP (2023) (link).
[3] CPB (2022). Van coronasteun naar generiek beleid: Inzichten voor een langetermijnstrategie. CPB Coronapublicatie.

1 Introduction

Energy prices rose extraordinarily sharply in 2021 and 2022. The outbreak of war in Ukraine in February 2022 led to major disruptions in energy supplies – especially natural gas – resulting in extraordinary price increases. But even before the war, energy prices had already increased due to the recovery of the world economy after the Covid-19 recession.[4] It's not just households facing high energy bills, firms have also had to deal with high natural gas and electricity prices (figure 1.1).[5] Although prices have fallen since early 2023, they remain historically high. Oil prices, on the other hand, have fallen more strongly, even in 2022, which is why we do not include oil in our analysis.

Figure 1. 1 Energy prices increased sharply in 2022



Source: Statistics Netherlands (natural gas and electricity) and Datastream (oil), calculations by CPB. These are the weighted averages of user prices for electricity and natural gas. The latest available values are for 2022Q3. The explanation of the calculation of these prices can be found in appendix 6.1.2.

In this study, we map out the possible consequences of the energy price increase on corporate profits, and how this differs between industries and firm size. There is concern that not all firms can cope with the high energy prices and that many will suffer losses as a result. The aim of this study is to analyse to what extent this is the case, and how this differs, for example, between industries or between large and small firms. Because the prices of natural gas and electricity have risen sharply, we focus our analysis on these energy sources.

Firms can absorb the increased energy costs in various ways, although the extent to which they do so will vary greatly. If costs rise, a firm can respond by adjusting production processes or raising prices. A rise in output prices may cause demand to fall. This pass-through has been visible in the past year, although the extent differs between firms and between industries. For example, firms in a highly competitive market may have lower margins to absorb cost increases and they will be more inclined to raise prices. Because higher energy prices affect all firms, this means that costs rise not only for an individual firm, but also for competitors. This allows firms to increase prices without losing sales. In addition, higher energy prices will

[4] For more background information on the rise in energy prices, see CPB (2022) December Scenarios and CPB (2023) Centraal Economisch Plan 2023, among others. .
[5] See, for example, the CPB publication (2022) Stresstest kosten van levensonderhoud (Cost of living stress test).

provide an incentive to save energy (or to switch to alternative, cheaper sources). The degree of energy savings can differ greatly between firms and between industries. That partly depends on how energy intensive firms are, as well as on the possibilities firms have to switch to other inputs. The incentive to save energy also depends on the energy contracts of firms. Firms with longer-term fixed price energy contracts will have little or no energy cost increase to deal with. Unfortunately, we do not have access to contract length data for this study.

This study details the effects of high energy prices on firms using a stress test. We vary the extent to which firms implement price and energy saving adjustments. In this study, we take annual financial figures for 2019 of all non-financial Dutch firms.[6] We use scenarios to investigate what will happen to the profit and loss account if energy costs are increased, in line with the actual energy price increase between 2019 and 2022. This allows us to analyse the increase in the share of loss-making firms by industry and by size. Because it is not possible to determine exactly per firm to what extent it can increase prices and limit energy consumption, we use a bandwidth for this. We analyse the consequences for when firms can significantly increase prices and save energy in one scenario and when firms cannot adapt at all in another. In practice, we have seen that price and energy use adjustments have taken place in most industries. We also use a third intermediate scenario where firms only partially raise output prices but don't reduce energy consumption.

Previous studies took little or no account of possible adjustments, which have been visible in the past two years. In the DNB stress test of 1 July 2022 (Pruijt and Brouwer, 2022), the share of loss-making firms per industry was also examined. However, in their analysis, firms do not adjust their energy consumption and they do not pass on the increased energy costs, not even partially, to their customers.[7] The share of loss-making firms in the DNB 'Basic' scenario rises by 3.2%. Based on an analysis of industry averages, ING (2022) finds the largest first-order effects of increased energy prices – in this case including oil prices – in the aviation and transport industries (particularly due to higher oil prices). They include second-order effects, whereby firms increase output prices for business customers thus raising their customers' costs. Based on a similar analysis, but with more energy types (including coal and nuclear energy), Strategy& (2022) finds a large decline in profit margins in the base metals, agriculture and chemicals industries in particular. Rabobank (2022) presents forecasts for added value in industries and find that manufacturing and trade in particular could come under pressure.[8] Since adjustments have indeed been visible at firms in the past two years, through energy savings and passing-on costs to customers, our research offers an important addition to the previous analyses.

This publication has the following structure. We discuss the supporting analyses about the energy use of firms in section 2 and the degree of pass-through in section 3. The main results for the scenarios that we have used are presented in section 4. The appendix contains information about the data and method used (section 6.1), information about energy consumption by firms (6.2) and more information about the pass-through of high energy costs into output prices (6.3).

2 Energy consumption by industry

Firms' energy consumption depends on the industry in which the firm operates and this in turn influences the extent to which firms implement energy savings. Firms in the air transport, chemical

[6] These are taken from the NFO database and are all limited liability companies

[7] Incidentally, this was entirely defendable, since that study was published shortly after the outbreak of the war in Ukraine, and the evidence on both of these phenomena was therefore still very limited at that time.

[8] In a comparable study, CE Delft (link) looks in particular at the growth of manufacturing. They believe that manufacturing will generally grow in line with the trend in GDP, with the exception of base metals (no growth) and refining (shrinkage).

industry and basic metal industry have a high *direct* energy consumption as a percentage of total production. Total energy consumption also includes indirect energy consumption: the energy embodied in intermediate inputs. We find that the difference between direct and total energy consumption is small. Firms can limit the increase in energy costs by reducing energy consumption. In 2022, households and firms in the Netherlands consumed 22% less natural gas than in 2021. Since mid-2021, industry has been able to reduce natural gas consumption by even more: natural gas consumption fell by about 40% without reducing total production. Such large savings are not possible for all firms.

In this section we describe the energy intensity of firms per industry and the energy saving measures they have taken. We first discuss the direct energy intensity, defined as the share of direct energy costs in the value of final production. Then we discuss the total energy intensity, taking into account the use of intermediate inputs in production chains. We then turn to the extent to which firms are able to reduce their energy consumption.

2.1 Energy intensity

Instant energy intensity

The use table of Statistics Netherlands (Statistics Netherlands) provides a good source for the direct energy consumption of an industry.[9] This data includes the cost of importing energy and the margins that are added to it (such as taxes and trade margins). We use data from 2019, because energy consumption during the Covid-19 crisis is not representative of 'normal' business operations[10] and we focus on the 2-digit industry level.[11] In this section we distinguish two categories of energy: crude oil, raw natural gas & coal; and electricity & processed natural gas.[12] We take the total use of these energy products as a share of total production as a benchmark for direct energy consumption.

The air transport industry in particular has an intensive direct energy consumption. Figure 2.1 shows the direct energy consumption. For all non-energy industries, the average intensity is 2.1% of the total production value, with 1.5% crude oil, raw natural gas & coal and 0.6% electricity and processed natural gas. The top 5 energy-intensive industries are: air transport (22%), chemical industry (11%), basic metal industry (10%), water transport (9%) and fishing (9%).[13, 14] For some of these industries, such as air transport, this is mainly due to the relatively high consumption of oil.

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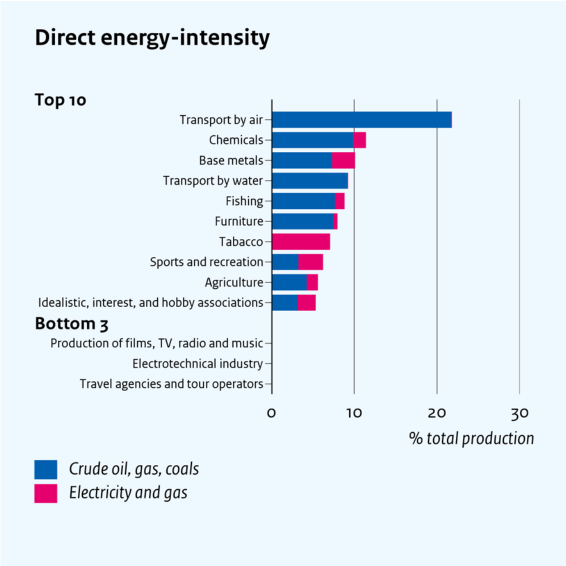
[9] For more information about the methodology to calculate energy intensity, see appendix 6.2.1.
[10] The latest available data of the usage table is 2021, which means that the mapping of the current energy intensity may be disrupted by the Covid-19 crisis.
[11] Industries can be distinguished on a more or less fine-grained level, this is called the digit level. Statistics Netherlands distinguishes 81 industries at the 2-digit level, for example the chemical industry (2-digit) falls within the manufacturing industry (1-digit).
[12] For the purposes of the analyses in this section, we cannot distinguish the price development of electricity from natural gas.
[13] This ranking does not differ much from ING (2022). They use data from Eurostat with a breakdown between oil, natural gas and electricity. They calculate the use of energy in terrajoules per 1 million euros of added value in EU27 in 2018.
[14] The European Commission has looked in particular at the production costs of energy-intensive industries, on an international scale. In addition to the costs of energy consumption, this analysis also includes costs of energy-intensive raw materials, for example. European manufacturing generally scores high on the production costs of energy-intensive industries, such as in the cement industry. European Commission. (2022). Production costs from energy-intensive industries in the EU and third countries. JRC Science for Policy Report.

Figure 2.1 Energy intensity by industry (top ten highest and three lowest)



Source: Statistics Netherlands (Statistics Netherlands), use tables 2019, calculations by CPB.

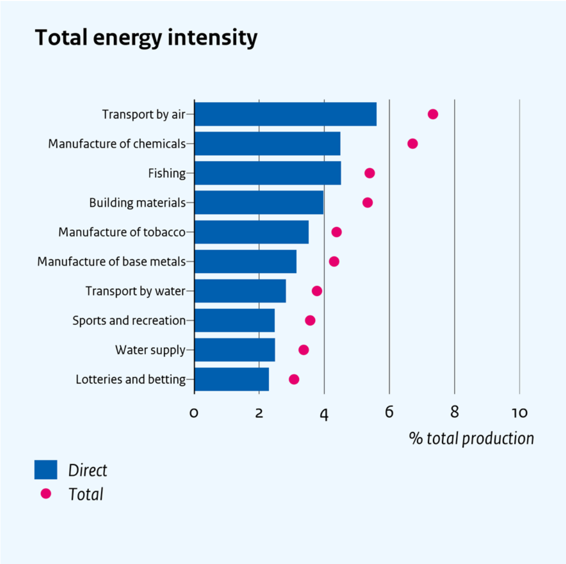
Total energy intensity

To get a better picture of the energy dependency per industry, it is useful to also take into account energy used by suppliers. An industry that consumes little energy itself can still be highly energy dependent if it needs a lot of inputs from other energy-intensive industries.[15] The total energy intensity is the sum of the direct energy intensity and the indirect intensity via intermediate inputs. For the calculation of the total energy intensity, we use the input-output tables of the relevant industries. The direct intensity calculated from this source deviates in some ways from the direct intensity based on the use table, which causes a difference in the direct intensity between figures 2.1 and 2.2.[16]

The differences between direct and total intensities are generally limited. The direct energy intensity therefore generally gives a good picture of the energy dependence of an industry. For the chemical industry, the difference between total (6.7%) and direct (4.5%) energy intensity is the largest (2.2 percentage points) because it uses many energy-intensive intermediate inputs originating from within the chemical industry itself. Figure 2.2 shows that these supply chain effects are limited for most industries. In addition, the ranking according to energy intensity is not very sensitive to the chosen measure (direct or total): the top 10 energy-intensive industries for total energy intensity are comparable to those for direct intensity. In the stress test we therefore do not include higher prices of intermediate inputs (Section 4.1).

[15] We do not take energy-intensive use of raw materials into account. This can be an important factor in the impact of increased energy costs for some firms, such as in the chemical industry with the production of fertilisers. Since we have no information about energy-intensive use of raw materials, we do not include this in the analysis.
[16] An explanation of the method can be found in appendix 6.2.1.

Figure 2.2 Energy intensities based on input-output table 2019 (% total production)



Source: Statistics Netherlands input-output tables, calculations by CPB.

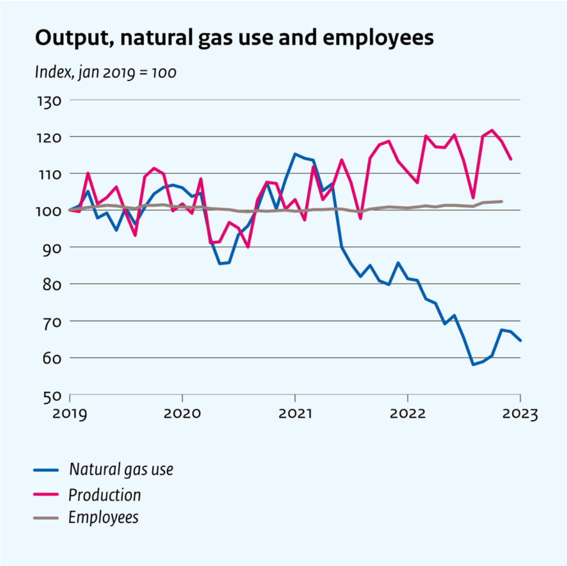
2.2 Energy saving measures

Firms can reduce their energy costs in various ways. They can produce more efficiently, switch to other cheaper energy sources or purchase intermediate inputs that were previously produced themselves. These adjustments are not free. For example, time and money may be involved in adjusting production processes, which would not have been implemented without the increased energy prices. As such, total production costs decrease less than energy costs.

Since the rapid rise in energy prices in early 2022, firms have saved energy. In 2022, households and businesses in the Netherlands consumed 22% less natural gas than in 2021 (27% less than in 2019),[17] while GDP increased by 4.5% (and 5.3% since 2019).[18] Part of this decrease was due to a warm winter, but the decrease in natural gas consumption in the Netherlands is considerably greater than in other countries in Europe.[19] The Netherlands uses relatively more natural gas than other European countries (although the dependence on Russian natural gas in the Netherlands is lower).[20] Large manufacturing users connected to the GTS system have reduced natural gas consumption by about 40% since mid-2021 whilst total manufacturing production has increased (see Figure 2.3).[21] Since mainly large consumers are connected to the GTS system, the consumption of smaller customers may deviate from this. Natural gas consumption per unit production has also fallen by approximately 20% in various manufacturing industries, which include large-scale consumers, except in the food industry (see appendix 6.2.2). Needless to say, industry averages may not be representative for all firms within an industry.

[17] Statistics Netherlands (2022). Natural gas consumption in the Netherlands in 2022 lowest in 50 years (link).
[18] Statistics Netherlands data for GDP build-up from manufacturing (link).
[19] Eurostat (2022). EU natural gas consumption down by 20.1% (link).
[20] See, for example, figure 9 of the CPB report "Analysis of international trade sanctions against Russia" (link).
[21] For the volume of production we use production statistics from Statistics Netherlands with regard to manufacturing (link). Production can be seen as the volume development of the added value at basic prices. Statistics Netherlands' natural gas consumption for manufacturing relates to all firms connected to the GTS network (network firm Gasunie Transport Service link). It therefore does not concern all firms in the industry. Employment in manufacturing is also taken from Statistics Netherlands (link).

Figure 2.3 Natural gas consumption in industry has fallen sharply, output has not



Source: Statistics Netherlands. Calculations by CPB.

International literature shows that firms generally use less energy after a price increase. Labandeira et al. (2017) show on the basis of a meta-study – a study in which the state of the literature is summarised up to that point – that firms have approximately 0.2 percentage point less energy demand for each percentage point increase in the energy price. After an increase of 196% in the natural gas price and 115% in the electricity price – in 2022 compared to 2019 – the demand for natural gas would be expected to fall by about 40% and electricity by about 20%. There are, however, four important caveats to be noted. First, Labandeira's study covers the period before the current energy crisis. The extent to which firms deal with the recent large and rapid increase in energy costs can differ greatly compared to the past, mainly due to the size of the price increase.[22] Second, the price elasticities in this study do not preclude some firms from producing less or stopping altogether. Although this does not seem to be the case for industry (see Figure 2.3), it is possible for other industries. Third, there are costs associated with reducing energy consumption, such as adapting production processes. Finally, energy demand may differ between firms and industries. It may be easier for some firms to adjust energy consumption than for others.

Our own analysis shows that firms have already taken energy-saving measures in recent years. Based on industry data on revenues and costs from 2009-2020, we find that energy costs[23] per unit of revenue move less than one-to-one with the natural gas price in almost all industries.[24] In 80% of industries, energy costs per unit of revenue increase by less than 0.8% if natural gas prices rise by 1%, the median being around 0.45%. 0.8% means that with an equal revenue and an increase in the natural gas price of 1%, an energy saving of 0.2% takes place. The results of this partial analysis can be found in appendix 6.2.3. In the past, firms therefore seemed able to implement energy-saving measures. However, there are two important caveats. Firstly, during the period studied, the changes in energy prices were much smaller than now. As a result, firms may have had fewer incentives to save energy than they do now. This means that our estimates may underestimate energy

[22] On the one hand, this can give firms more incentives to reduce energy consumption. On the other hand, it is also possible that sustainability transformation has already taken place at firms since the study was carried out. As a result, the incentive to become more sustainable may also be lower.
[23] The energy costs on which these estimates are based exclude energy used by means of transport (mainly oil) and exclude energy costs used for raw materials. See the notes to the Statistics Netherlands data used for this (link).
[24] There is a high correlation between the natural gas price and the electricity price in this period, which means that not both energy sources are included in the regression. Due in particular to the large increase in natural gas prices, this has been given the focus in the regressions.

savings. Secondly, we do not take into account long-term energy contracts of firms. This would overestimate the energy savings, because the actual energy costs are less sensitive to changes in the market price for natural gas.

Based on this information, we assume energy savings of 20% for all industries in the stress test. It is possible that firms in some industries have more or less opportunities for energy savings. However, this variation is difficult to observe for the recent period of high energy prices, so we make the same assumption for all industries. Given the savings of approximately 40% in industry since mid-2021 – see figure 2.3 – 20% seems to be a relatively conservative estimate. We use this conservative estimate for two reasons. Firstly, because not all firms can easily reduce energy consumption or because there are low energy-intensive firms, such as in the service industries, that have to less incentive to save energy than in industry. Secondly, saving energy entails costs. Consider, for example, switching production processes to other energy sources. In that case, the total costs for a firm fall less than energy costs. However, we have no insight into these costs, so we use 20% in the stress test.

3 Pass-through of high energy prices into output prices

Firms have also absorbed the higher energy prices by passing them on in output prices that have risen sharply, not only in energy-intensive industries. In particular, higher mark-ups in manufacturing seem to indicate that firms in these industries were able to pass on high energy costs to a large extent. Firms in less energy-intensive industries have also raised output prices. There are a surprising number of manufacturing industries where the increase in output prices is bigger than the increase in costs. For the two most energy-intensive industries, output prices rose more strongly than the increase in cost prices: 5.5% more for the chemical industry and 8.8% more for the base metal industry. These findings are supported by the answers of entrepreneurs in the business survey. For example, 46% of all non-financial firms in the 2023 survey indicate that the degree of pass-through is high to complete.

In this section, we discuss the extent to which firms have adjusted their output prices in 2022. In 3.1, we discuss adjusting output prices and look at the relationship with a number of industry characteristics. In 3.2 we show the extent to which high energy prices are passed on, using mark-ups as a yardstick. We also show that firms have been able to maintain their profit margins. In 3.3 we discuss the answers given by entrepreneurs in surveys to provide more insight into the extent to which costs can be passed on.

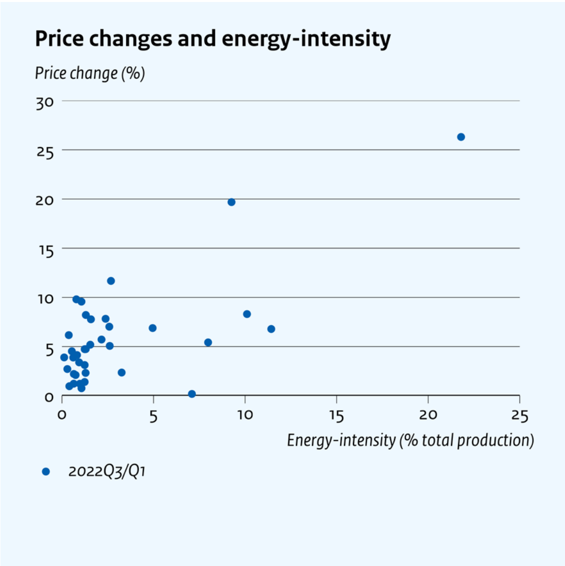
3.1 Price adjustments in 2022

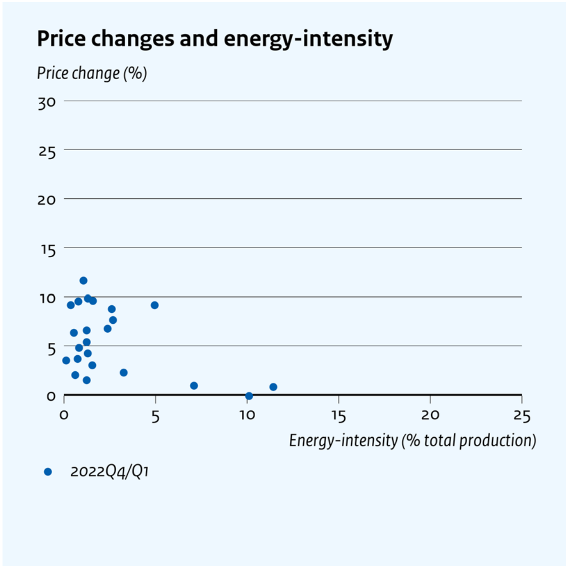
We use the price indices of Statistics Netherlands to detail realised price adjustments for 2022. We calculate price developments from March to September 2022 for 22 manufacturing industries and for 14 service industries.[25] Additionally, we do the same for March to December 2022 for the 22 manufacturing industries, since realised prices are unavailable for the service industries for this time period.

[25] We use realised producer prices from Statistics Netherlands (manufacturing, link) and services prices (services, link). We report price developments for 2-digit industries, excluding the petroleum industry.

Energy-intensive industries have increased their output prices the most. In figure 3.1 we relate the change in output prices for the third and fourth quarters of 2022 to the direct energy intensity in 2019 (as presented in section 2.1). We see that most industries have significantly increased their prices. Firms in the energy-intensive air and land transport industries increased their prices on average the most in the third quarter (26% and 20% respectively). Figure 3.2 shows that these price increases were modest in comparison in 2019, the last 'normal' year before the Covid-19 crisis. Median inflation in 2022 (Q3/Q1) was much higher (4.7%) than in 2019 (0.3%). The average price increase in the third quarter of 2022 was 5.8%: for industry 5.7% and for service industries 5.9%. There have been relatively smaller price increases in the fourth quarter (from March to December) for the manufacturing industries.

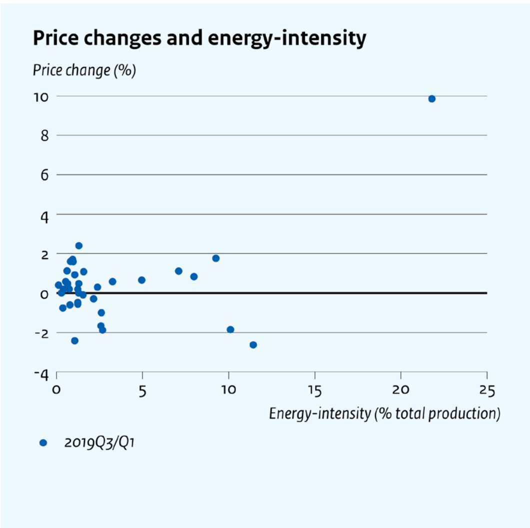
Figure 3.1 Output prices in the third quarter in 2022 have risen more for the most energy-intensive industries (left), but this relationship is not visible in the fourth quarter (right)





Source: Statistics Netherlands. CPB calculations.

Figure 3.2 Output prices in 2019 only show a limited increase

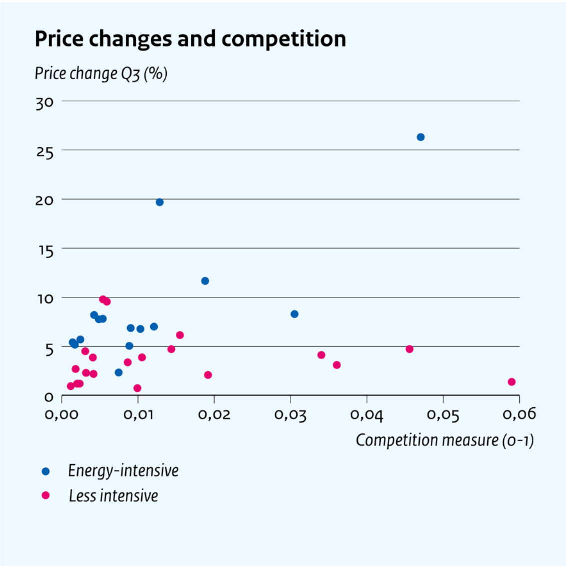


Source: Statistics Netherlands. CPB calculations.

The degree of pass-through may depend on the level of competition in an industry. In the first instance it might be thought that firms with market power can pass on cost increases to their customers. However, the reverse is also possible: these firms may pass on less of the cost increase, a phenomenon also known as the pass-through paradox.[26] Firms operating in competitive markets have low profit margins and will have to pass on higher cost to survive. Firms with a lot of market power have higher margins. For these firms, it may be optimal for profit maximisation to reduce margins and raise prices less. We measure the degree of competition using the Herfindahl–Hirschman index (HHI index). This index is between zero and one, where zero is a market with perfect competition and one is a market with only one firm (monopoly).[27]

We find no clear relationship between the price increase and the degree of competition, given the energy intensity of an industry. The relationship between price changes in Q3 2022 (Q3/Q2) and the HHI index is shown in Figure 3.3. We distinguish two groups of industries in the figure: energy-intensive industries with an intensity greater than the median value (1.3%), and less energy-intensive industries with an intensity that is less than the median value. We find that firms in the industry with the highest energy intensity and highest price increase (air transport) experience relatively little competition. In addition, we find a combination of relatively small price increases, low energy intensity and little competition for four industries.

Figure 3.3 Relationship between price changes and competition in 2022 (Q3/Q2)

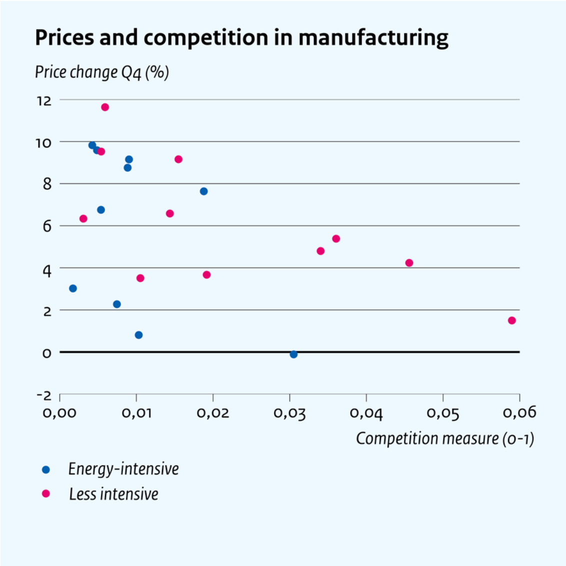


Source: Statistics Netherlands. CPB calculations.

Firms in manufacturing industries with more market concentration appear to have made smaller price increases, although the relationship is weak. The price changes in the last quarter of 2022 (quarter 4/quarter 2) are only available for manufacturing industries (see Figure 3.4). The weak negative relationship indicates that firms in a manufacturing industry with more market concentration have increased prices less, which is in line with the pass-through paradox.

[26] See the blogs (in Dutch) by Hinloopen (2022a), Een afwentelingsparadox, and Hinloopen (2022b), IPhone en brood: de rol van marktmacht bij het ontstaan van inflatie, and the publication by Genakos and Paglierom (2022). See appendix 6.3.1 for a more extensive discussion of the pass-through paradox.
[27] The HHI index is defined as the sum of the squares of the market shares of the firms in an industry (see for example the description of the HHI index by Eurostat (link). We use the share of the turnover of the firms in the NFO dataset. This index therefore does not include the market shares of non-incorporated firms and foreign exporters of final products.

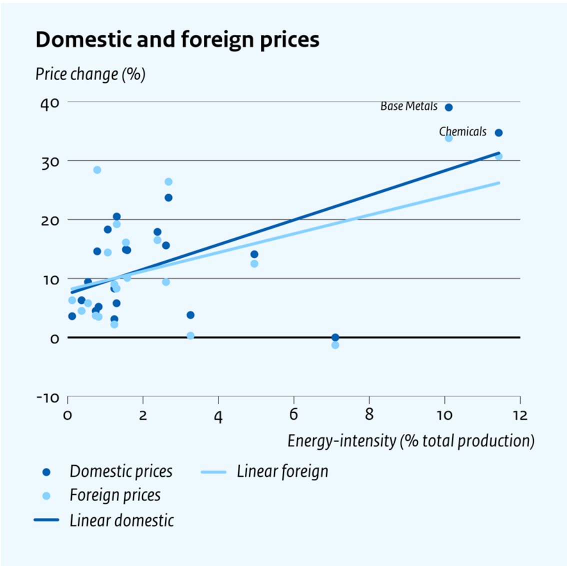
Figure 3.4 Relationship between inflation and competition for manufacturing industries in 2022 (Q4/Q2)



Source: Statistics Netherlands. Calculations CPB.

A related question is whether the degree of pass-through depends on international competition. If a firm competes with foreign firms that are affected by the same cost increase, a larger pass-through in output prices is a plausible option. But this option becomes less attractive if foreign competitors are less affected by higher energy prices. For example, energy prices have risen more in Europe than in the United States.[28] To test this relationship, we look at differences in the inflation of domestic and foreign output prices of the manufacturing industries. In figure 3.5 we present the relationship between the energy intensity (in 2019) and the year-on-year price changes in December 2022. These price changes are divided into output prices on the domestic and foreign markets for each branch of industry.

Figure 3.5 Relationship between energy intensity and inflation of domestic and foreign output prices in industry



Source: Statistics Netherlands, producer prices (link). Calculations CPB.

[28] See, for example, the prices of natural gas in the study by the IEA (2022). Natural gas prices in Europe, Asia and the United States, Jan 2020 – February 2022. (link).

Energy-intensive industries have on average increased their domestic output prices more than their prices for the foreign market. For the five most energy-intensive industries, the domestic price increase is greater than the foreign one. For the chemical industry and the basic metal industry, the difference between the price increase on the domestic and foreign markets is 4 percentage points and 5 percentage points, respectively. A possible explanation is that the product mix for domestic and foreign sales of these broad industries differs, making a comparison of sales prices less relevant. Another possible explanation is that industries that produce more comparable goods, such as the chemical industry, experience more competition on foreign markets, which means they can pass on less in their export prices. There may also be more competition on quality than price on foreign markets.

3.2 Developments in mark-ups and profit margins in industry

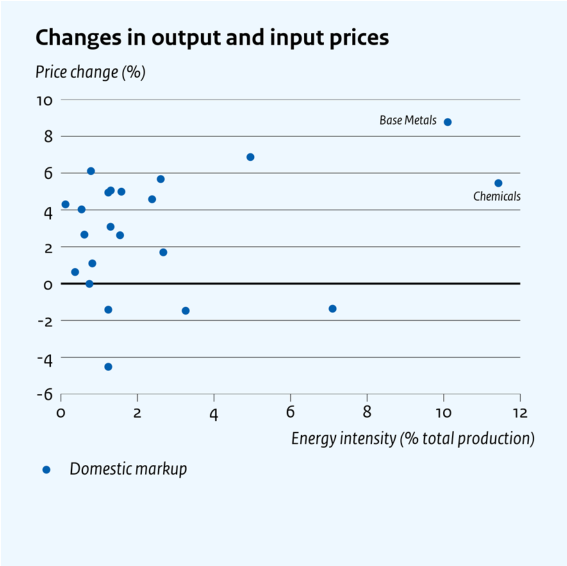
We use the change in markups as a measure of the degree of pass-through. We measure the growth rate of the mark-up as the difference between the growth rate of the sales price and the growth rate of the cost price of intermediate inputs (user prices). If firms fully pass on the cost increase in output prices, the mark-up is constant and pass-through is complete. If the mark-up falls, pass-through is not complete: output prices are not increased fully with the increase in costs. If the output price rises faster than the cost price, the mark-up rises. These developments of the mark-up are under the assumption that other factors, such as energy structure, do not change.

We present evidence for mark-ups for various manufacturing industries. Recent preliminary figures are available for output and cost prices for November 2022, although these data are only available for manufacturing industries. We interpret the price of domestic consumption as the cost price of intermediate inputs.[29] This price includes price increases from suppliers but no changes in the cost of added value. Given the limited number of observations, the results are sensitive to outliers. In addition, they are averages by industry, some firms may be able to adjust the mark-up more than others in the same industry.

We find a large pass-through of cost prices for most industries. In figure 3.6 there are surprisingly many results above zero and few below. The unweighted average of the amount passed on is 2.9 percentage points. Given the large increases in energy prices, these relatively small differences suggest a large shift by most manufacturing industries.[30] For the two most energy-intensive manufacturing industries, output prices have risen more than the increase in cost prices: 5.5% more for the chemical industry and 8.8% more for the basic metal industry. The degree of pass-through is on average lower for more concentrated and more export-oriented industries.[31]

[29] Domestic consumption of industrial products is composed of domestic sales and imports. The import prices of industrial products are available separately. The correlation with the total consumption price is 0.98. We weight the cost increase of intermediate inputs with the cost share in the value of output in 2019.
[30] Firms that could not pass on the high energy prices and therefore left the industry are therefore no longer observed in 2022. This selection effect leads to a higher pass-through measure for the remaining firms.
[31] See the figures in appendix 6.3.1.

Figure 3.6 The degree of pass-through in industry, in relation to energy intensity (year-on-year in Nov. 2022)

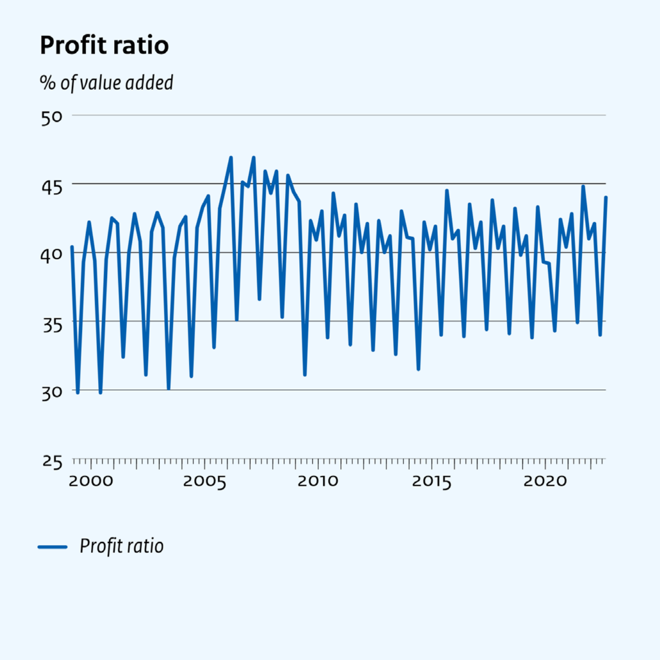


Source: Statistics Netherlands, producer prices, import and consumer prices (link). Calculations CPB.

The total profit ratio[32] **in 2022 did not differ from other years.** The remaining question is whether firms have managed to maintain their profit margins. Statistics Netherlands publishes the profit ratio, defined as gross operating surplus divided by gross value added, for all non-financial firms (figures from 2020 onwards are provisional).[33] However, this figure also includes the petroleum industry and unfortunately the 2022 profit ratios are not available by industry. Figure 3.7 shows that this ratio follows a strong quarterly pattern. As in previous years, the ratio was relatively low in the second quarter of 2022 (34%), followed by a strong recovery in the third quarter (44%). This figure suggests that the average profit margin was not particularly affected in 2022. Recent Statistics Netherlands figures show that the gross profit of non-financial firms also turned out higher in the fourth quarter of 2022.[34] The ECB also finds that profit margins in the euro area have not fallen in 2022.[35]

[32] As mentioned earlier, we use the term 'firms' when referring to non-financial firms to have.
[33] Source: Statistics Netherlands (2022). Non-financial firms again record higher profits (link).
[34] Source Statistics Netherlands (2023). Niet-financiële bedrijven boeken opnieuw meer winst.
[35] This is evident from the ECB speech of March 6, 2023, Figure 6 (link).

Figure 3.7 The profit ratio did not fall on average in 2022 (% added value)



Source: Statistics Netherlands.

3.3 Data from corporate surveys

Surveys answers from entrepreneurs provide more insight into the extent to which costs can be passed on. Entrepreneurs were asked what development of sales prices they expect in the next three months.[36] The balance, defined as the difference between the fraction of entrepreneurs expecting an increase and the fraction expecting a decrease, provides insight into the share of firms that pass on cost increases to customers. However, this data does not contain information about the size of the price change, it is only about whether firms intend to adjust prices. We briefly discuss the results of the survey in the second and fourth quarters of 2022 (all figures can be found in appendix 6.3.2).

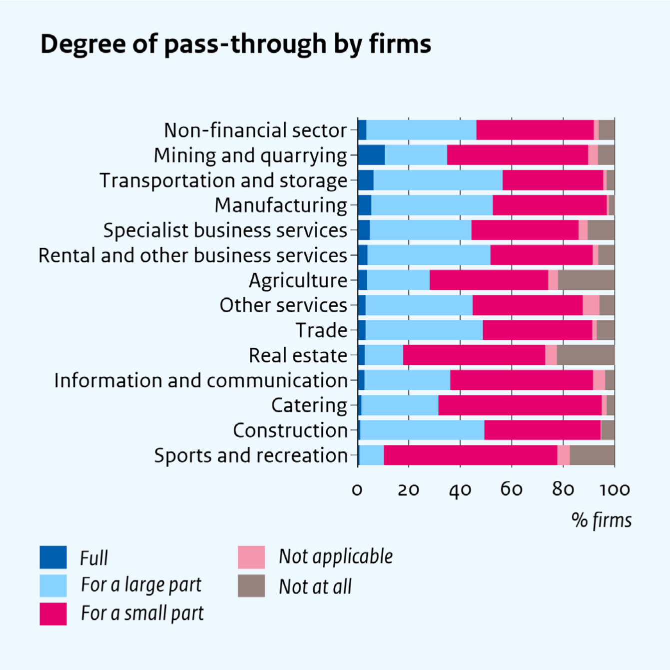
We find no evidence that more firms in energy-intensive industries in Q2 2022 planned to increase their prices in the next three months. A majority of entrepreneurs in all industries expect a price increase (the median balance is 27.7%). By comparison, in the 2019 Q2 survey, the dispersion of balances around the median (4.5%) was small. The relationship with energy intensity is weak in the second quarter of 2022. A possible explanation for this weak relationship is that many entrepreneurs had already adjusted prices in the second quarter after the unexpected sharp increase in energy prices in the first quarter. This explanation is in line with the picture from the survey of the last quarter of 2022. Firms in the most energy-intensive industries are now less likely to expect they will have to raise their prices.

In industry, a majority of entrepreneurs say that they can pass on a large portion of cost increases to their customers. In the survey of 2023 (first quarter) an additional question was asked about the extent to which cost increases are passed on,[37] although, unfortunately, the answers are only available for 1-digit industries. Figure 3.8 shows the share of entrepreneurs that have indicated that they can pass on the cost increase. Of all

[36] See Statistics Netherlands, Conjunctuurenquête Nederland, (link).
[37] Source: Statistics Netherlands (2022). "Half of the firms can hardly or not at all pass on higher costs".

non-financial firms, 46% indicate that the degree of pass-through is large to complete. The share in the manufacturing industry is 53%.

Figure 3 Entrepreneurs' answers to the question: Can you pass on cost increases to customers? (% in 2023, first quarter)



Source: Statistics Netherlands Business Survey (Conjunctuurenquête).

Firms in energy-intensive industries have indicated in the second quarter of 2022 that they expect an increase in turnover. It is noteworthy that more entrepreneurs in the energy-intensive industries in the second quarter of 2022 were more optimistic about their turnover than about their price. In addition, entrepreneurs appear to be more optimistic about an increase in total turnover than in foreign turnover, which indicates that there seemed to be particular confidence about increasing turnover on the domestic market. Firms may have been more pessimistic about foreign sales due to competition. Firms abroad may have had smaller increases in energy costs. Passing on prices is then a less attractive option when competitors are doing it less, which can lead to reduced turnover in foreign markets. In the last quarter of 2022, entrepreneurs in the most energy-intensive industries have become more pessimistic about their future turnover (the total turnover balance is strongly negative).

As 2022 progressed, more entrepreneurs replied that profitability had deteriorated. The balance shows the difference between the fraction of entrepreneurs reporting an increase and the fraction reporting a decrease in the previous three months. However, this data does not include information on the size of the profit change. The median value in the second quarter of the balance of profitability is small, which means that the two groups are the same size. Nonetheless, a large majority of entrepreneurs in the two most energy-intensive industries report that profitability improved in the previous three months. However, at the end of the year the situation deteriorated: the median balance drops to -12%.

We conclude from section 3 that the increased energy prices have largely been passed on in output prices; this conclusion therefore serves as the starting point for our stress test. Output prices have risen sharply, and not only in energy-intensive industries. Subsequently, mark-ups and profit margins do not seem to have fallen significantly in most industries. These are strong indications that a large part of the cost increase has been passed on. An important caveat here, however, is that we only have these provisional data for a limited number of industries. The degree of pass-through can vary greatly between industries. Because of this uncertainty about the extent of pass-through, we vary in our scenarios the extent to which firms are able to pass on the increased energy costs. The first scenario is more in line with practice than the third scenario, in which no transfer takes place at all.

4 The consequences of increased energy prices for corporate profitability

In a stress test, we study three different scenarios in which firms adapt to a greater or lesser extent. In every scenario we increase energy prices (natural gas at 196% and electricity at 115%) over the period 2019–2022. Our main scenario assumes that firms reduce their energy consumption by 20% and then fully pass on the resulting increase in energy costs in their output prices. These higher output prices lead to a decrease in demand. Scenario 2 assumes that firms do not implement any energy-saving measures and only pass on 50% of the cost increase to their customers without a drop in demand. Scenario 3 assumes that firms do not save energy or raise prices at all.

In our main scenario, the number of loss-making firms rises to a limited extent, by 2 percentage points. This scenario most closely reflects the adaptation observed in the previous sections. In the base year 2019, before the increase in energy costs, the share of loss-making firms was 20%. This percentage rises to 22% in the main scenario. In the second scenario, the number of loss-making firms increases by 3 percentage points. In the third scenario, the number of loss-making firms increases by 4 percentage points.

However, there are differences between industries, with the impact being greatest for some energy-intensive industries. In the other non-metallic mineral products industry, the share of loss-making firms increases from 23% to 27%. This industry includes, for example, firms in the production of glass and cement. In the beverage manufacturing industry the increase is from 56% to 60%, and in the wellness & funeral industry from 24% to 28%. On the other hand, there are also industries that are barely affected in this scenario.

The consequences are similar for firms of different sizes. For smaller firms, the share of loss-making firms increases by approximately 1.9 percentage points, for medium-sized firms by 1.4 percentage points and for large firms by 1.0 percentage points.[38] It should be noted here that we assume that firms have equal adaptability: the degree of energy savings, passing on and loss of demand do not differ per firm size in the stress test. In reality, these things may depend on the size of a firm.

4.1 General principles for all scenarios

To determine the extent to which corporate profits could be affected by the rise in energy prices, we use a stress test on firms. A stress test can be used to simulate the consequences of changing economic conditions,

[38] We categorise firms by size based on the number of employees. Small firms are firms with up to 49 employees, medium firms have 50–249 employees, and firms with at least 250 employees are considered large.

in this case energy prices, on the financial position of firms. We analyse different scenarios in which firms react differently to the energy price increase, via energy savings and the passing on of increased costs.

In the stress test, we increase energy costs in line with actual price developments for natural gas (+196%) **and electricity** (+115%) **over the period 2019–2022 and analyse how many firms become loss-making and to what extent profit margins fall.** We use data from individual firms (the 2019 key financial data of all Dutch non-financial firms).[39] Where data is not available at firm level – such as the level of energy consumption – we use data per industry. In this analysis, we do not make predictions for 2023, or an explicit retrospective of 2022, and do not look at the consequences for bankruptcies.[40] For a full description of the approach, see appendix 6.1.

We analyse three different scenarios in which firms adapt to a greater or lesser extent. In **scenario 1**, we assume that firms reduce their energy consumption by 20% and then fully pass on the resulting increase in energy costs in their output prices. This passing-on leads to a decrease in demand.[41] A more conservative estimate is given in **scenario 2**: here we assume that firms do not implement any energy-saving measures and pass on only 50% of the cost increase to their customers. There is no drop in demand in this scenario. Finally, **scenario 3 provides** insight into what happens if firms do not respond: neither by saving energy nor by raising prices. This scenario is in line with previous studies such as Pruijt and Brouwer (2022) and provides an upper limit for the number of loss-making firms under the simulated energy shock. This scenario is the least consistent with the real-world observations discussed in sections 2 and 3.

The results may be slightly biased due to some limitations of the analysis. Not all data is available at the level of individual firms, so we have to assume that these data are the same per industry (such as energy intensity) or even for all firms (such as the degree of energy savings). This results in an underestimation of the variation in profitability: in practice there are larger differences between firms and industries. In addition, we do not include all cost increases: we do not include energy types other than electricity and natural gas. We also focus only on the direct effect of the energy price increase. These limitations may lead to an underestimation of the impact on profitability, although there is reason to assume that this underestimation is relatively limited. We discuss these limitations and their effects on our analysis in more detail in the appendix (Section 6.1.3).

4.2 Scenario 1: firms save energy and pass on the full cost increase, which reduces demand

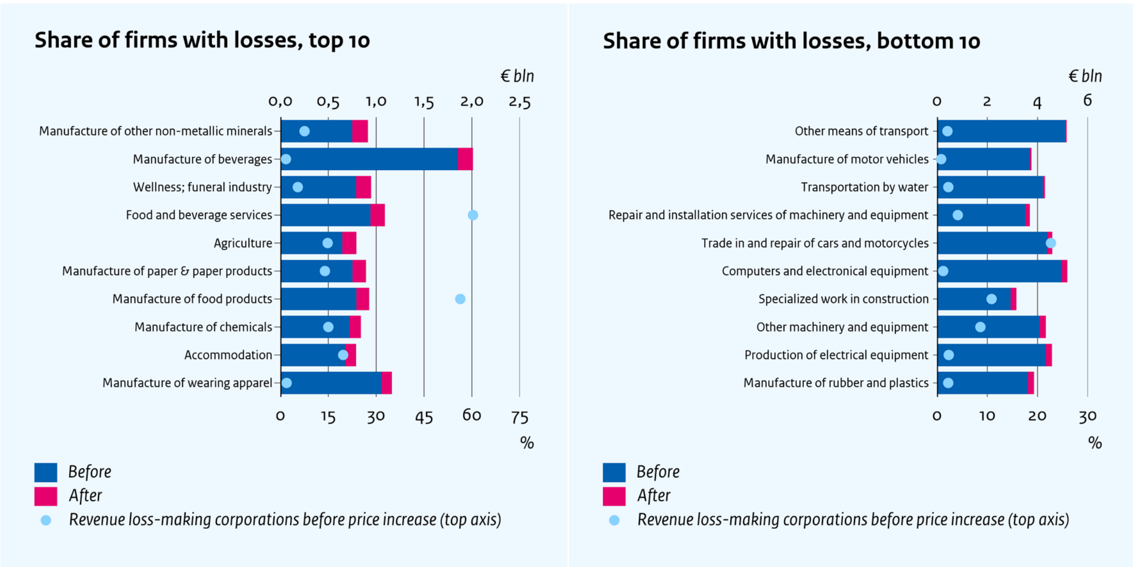
The share of loss-making firms increases by 2 percentage points in this main scenario. In 2019, the percentage of all firms in our sample that made a loss was 20%. If we increase the natural gas and electricity prices in the stress test by 196% and 115% respectively, this percentage rises to 22%.

[39] This concerns the dataset 'Non-Financial Enterprises' (NFO) of Statistics Netherlands. We use the data for 2019 because we see this year as the most recent year of 'normal' business operations: key financial data for 2020 and 2021 may differ due to the consequences of the Covid-19 pandemic.
[40] If firms are loss-making in a certain year, this does not immediately mean that it will also lead to an increase in bankruptcies, for example, what happens in the longer term and a firm's financial buffers also play a role. We do not include this in our analysis. Bankruptcies were still at a historically low level in 2022, see the Statistics Netherlands data for 2022 (link).
[41] We assume a uniform elasticity of demand of -1, based on Anderson et al. (1997). This means that for every percent increase in selling price, demand falls by one percent. Because demand decreases, not only does turnover fall, but variable costs also fall. Incidentally, we do not include supply chain effects: we therefore only look at direct energy costs and not at higher costs of other inputs.

There are differences between industries; the impact is greatest in a few energy-intensive industries. Figure 4.1 (left) shows the ten industries with the largest increase in the share of loss-making firms. In the industry other non-metallic mineral products, for example, this share increases from 23% to 27%. This industry includes, for example, firms in the production of glass and cement, for which a lot of energy is used. In the beverage manufacturing industry, the share increases from 56% to 60%, and in the wellness & funeral industry, the share rises from 24% to 28%. On the other hand, there are also industries that are hardly affected in this scenario. The increase in the share of loss-making firms is limited in the three other means of transport industries; cars, trailers and semi-trailers and transport by water (see figure 4.1, right).[42]

We also detail revenue at the loss-making firms. The number of firms making a loss may give a distorted picture of the economic impact of the increase in energy costs. For example, in one industry there may be many firms that suffer losses, but these are all small firms, while in another industry there are a number of large firms suffering losses. The dots in figure 4.1 show the actual turnover in 2019 before the price increase of all firms that are loss-making. The increase in the proportion of loss-making firms is greatest in the other non-metallic mineral products industry, but the combined turnover of these loss-making firms is relatively limited, approximately 0.25 billion euros. The share of loss-making firms in the beverage manufacturing industry is also high, but their combined turnover is even smaller. Of the other industries in the top 10, the combined turnover of all loss-making firms is highest in the food and beverage services and manufacturing of food products industries, both around 2 billion euros. On the other hand, the share of loss-making firms in the trade and repair of cars and motorcycles is small, in the bottom 10, but the combined turnover of these firms is relatively larger, about 4.5 billion euros.

Figure 4.1 Share of loss-making firms after energy-saving measures, full pass-through and drop in demand (scenario 1)[43]



The consequences are comparable for firms of different sizes (measured by number of employees). The share of loss-making firms increases by approximately 1.9 percentage points for small firms, 1.4 percentage points for medium-sized firms and 1.0 percentage points for large firms. It should be noted here that we assume that firms have equal adaptability: the degree of energy savings, passing on and loss of demand do not

[42] The consumption of other energy types, in particular fuel, may be considerable in the industries mentioned, but their prices have risen considerably less than those of natural gas and electricity.
[43] The figures are arranged according to the largest and smallest changes in the share of loss-making firms.

differ per firm size in the stress test. In reality, these adjustments may depend on the size of a firm, but we have no information on this.

The differences between firm sizes within industries are much more substantial. If we split the data into the combination of firm size and industry, some industries stand out, and the ratio between large and small firms is sometimes reversed. For example, there is an increase of 10.3 percentage points for medium-sized firms in the other non-metallic mineral products industry, while the impact on small firms is only 4.6 percentage points. Table 4.1 shows a selection of some of the industries most impacted.

Table 4.1 Increase (in percentage points) in the share of loss-making firms by size, a selection of industries (scenario 1)

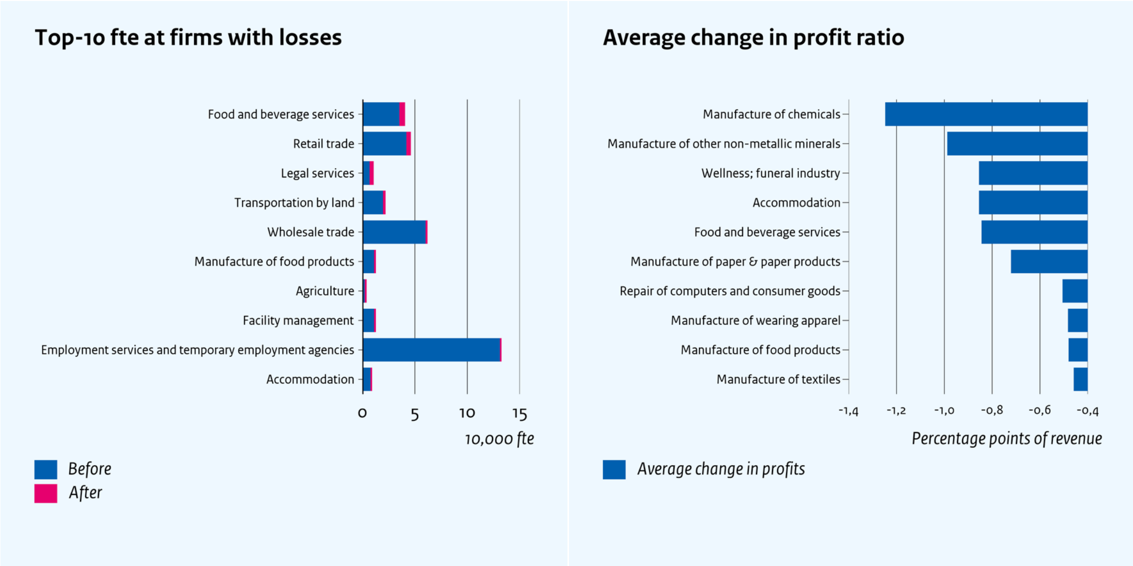
Industry	Small	Medium size	Big
Manufacture of other non-metallic mineral products	4.6	10.3	-
Agriculture, hunting and services for agriculture and hunting	4.6	5.7	-
Wellness and other services; funeral industry	4.5	8.7	-
Legal services	1.4	7.9	7.4
Food industry	3.2	3.3	6.7

Note: Sufficient observations are not available for all firm sizes for all industries. That is why these are no longer included in the category of large firms in agriculture, for example.

Employment at loss-making firms is largest in service industries. Figure 4.2 (left) shows the number of employees employed by loss-making firms, both before and after the energy price increase and firms' adjustments. We show the ten industries in which the increase in this number of employees is the largest. What is striking is that it is precisely service industries that have been hit hardest; this is because relatively many people work here. For example, in the three most affected industries, the number of employees at loss-making firms increase by approximately 14,000 compared to before the price increase. In total, the increase for all industries is approximately 37,500. With approximately 130,000 full-time jobs (FTEs) at loss-making firms, the employment services and temporary employment agencies stands out, but this is mainly a reflection of the absolute number of employees that are active here.

Energy-intensive industries are experiencing the biggest drop in profits. In figure 4.2 (right) we show the average decrease in profitability (net profit as a percentage of revenue) in an industry due to the price increase. After all, it may be the case that profits in a certain industry can, on average, fall a lot without firms making a loss. In Figure 4.2 (right), it is largely the same industries that are hit hardest as in Figure 4.1 (left): profitability fell the most in the chemical industry, at 1.2% of revenue.

Figure 4.2 Number of employees at loss-making firms and profit change by industry (scenario 1)



4.3 Scenario 2: firms pass on half of the cost increase and save no energy

If firms pass on only part of the increase in energy prices, the share of loss-making firms rises from 20% to 23%. The increase is therefore slightly larger than in scenario 1, in which this share is 22%. Particularly in energy-intensive industries, profitability is significantly reduced in this scenario. As figure 4.3 shows, the industries in which the percentage of loss-making firms increases the most are other non-metallic mineral products (from 23% to 33%), paper industry(from 23% to 32%) and chemical products (from 22% to 30%). These industries are also part of the top ten in scenario 1, but the increase in loss-making firms in scenario 2 is greater. The decrease in profitability (as a percentage of turnover) is also the greatest for these industries, with a decrease of approximately 2.5 percentage points.

In total, due to the increase in energy costs, the number of employees at loss-making firms in the top three affected industries will increase by approximately 4,000 and turnover by approximately 1 billion euros. This increase is considerably greater in the food and beverage services, with approximately 12,500 employees, while turnover at loss-making firms in the wholesale industry increased most, with 5.2 billion euros. At about 7 percentage points, the increase in the percentage of loss-making firms in the beverage manufacturing industry is less than in the aforementioned top three, but the share of loss-making firms here does reach a level of 62%. Apparently, many firms in this industry were already operating at a loss in 2019. However, the total number of employees and the total turnover at loss-making firms in this industry will grow only slightly: by 37 employees and by 12 million euros respectively.

Figure 4.3 Share of loss-making firms after partial pass-on of the increase in energy prices (scenario 2)

There are differences within industries with regard to the size of firms that become loss-making. For medium-sized firms in the other non-metallic mineral products industry, the share of loss-making firms increased by 20.5 percentage points. However, the impact is only half of that for small firms in this industry. Table 4.2 shows the increase in the share of loss-making firms by size for a selection of industries. It can be seen that in some industries the smaller firms are hit hardest, whilst in others it is the large firms.

Table 4.2 Increase (in percentage points) in the share of loss-making firms by size, a selection of industries (scenario 2)

Industry	Small	Medium size	Big
Manufacture of other non-metallic mineral products	9.9	20.5	
Manufacture of paper	9.6	6.5	
Agriculture, hunting and services for agriculture and hunting	8.6	14.8	
Accommodation provision	6.9	4.5	10.0
Food industry	6.6	7.9	10.0

Note: Sufficient observations are not available for all firm sizes for all industries. That is why these are no longer included in the category of large firms in agriculture, for example.

4.4 Scenario 3: no response from firms

If firms neither save energy nor pass on costs to customers, the percentage of loss-making firms rises from 20% to 24%. In this scenario, the impact of the energy price rise is the greatest, although a percentage of 24% is also historically not exceptional. For example, Pruijt and Brouwer (2022) report that in 2009 the percentage of loss-making firms was 34.6%. The total number of employees at loss-making firms increases in this scenario from 567 thousand to 707 thousand. The total turnover of firms that suffer a loss rises from 79 to 114 billion euros.

In this third scenario, energy-intensive industries in particular are the hardest hit again. The ten most and least affected industries are shown in Figure 4.4. The proportion of loss-making firms increases the most in the other non-metallic mineral products industry, from 23% to 44%. The share also rises sharply in chemical products (from 22% to 42%) and for the paper industry (from 23% to 42%). One explanation is that in these industries the consumption of natural gas and electricity accounts for a large part of the total costs. The effects are smallest in the motor vehicles, trailers and semi-trailers, water transport and other means of transport industries. These are industries that consume relatively little natural gas and electricity, but do consume significant quantities of oil and fuels, which we do not include in the analysis (see section 2.2.).

Figure 4.4 Share of loss-making firms after the increase in energy prices (scenario 3)

Firms of different sizes are hit roughly equally, although there are larger differences between industries compared to the other scenarios. In this scenario, we see that the increase in the share of loss-making firms is very similar between different firm sizes: small (4 percentage points), medium-sized (5 percentage points) and large (4 percentage points). When subdivided by size class and industry, there are a few groups of firms that are hit harder. For example, the share of loss-making medium-sized farms in agriculture has risen by approximately 35 percentage points. Table 4.3 shows the increase in the share of loss-making firms by size for a selection of industries.

Table 4.3 Increase (in percentage points) in the share of loss-making firms by size, a selection of industries (scenario 3)

Industry	Small	Medium size	Big
Manufacture of other non-metallic mineral products	21.0	30.8	
Manufacture of chemical products	21.0	23.6	
Manufacture of paper and paper products	15.7	30.4	
Agriculture, hunting and services for agriculture and hunting	16.9	35.2	
Food and beverage services	14.8	13.3	9.3

Note: Sufficient observations are not available for all firm sizes for all industries. That is why they are no longer included in the category of large firms in the chemical industry, for example.

The results of this scenario are largely in line with an earlier analysis by De Nederlandsche Bank. The DNB stress test of 1 July 2022 (Pruijt and Brouwer, 2022) also analyses the consequences of higher energy costs on the share of loss-making firms per industry. In their study it is assumed that firms do not adjust their energy consumption and increased energy costs are not passed on.[44] Conceptually and in terms of the approach, the 'Basic' scenario from the DNB analysis is very similar to our scenario 3, although there are some differences in terms of data and method.[45] The share of loss-making firms in the DNB scenario 'Basic' increases by 3.2% (in our scenario 3 this is 3.8%) and the number of employees at loss-making firms increases by 165 thousand (in our case: 140 thousand). The most affected industries are also similar: the top three most severely affected industries in our analysis can be found in the top five in Figure 3 of Pruijt and Brouwer (2022). However, our scenarios 1 and 2 show that the responses of firms are rather important: cost pass-through and energy savings are important ways that firms can limit the damage.

Our results for this latter scenario are also consistent with other recent literature and analyses. Based on an analysis of industry averages, ING (2022) finds the largest first-order effects of increased energy prices – in this case including oil prices – in the aviation and transport industries (particularly due to higher oil prices). This study also includes second-order effects, whereby firms raise prices for business customers, which is particularly important in the manufacture of food and beverages and manufacture of rubber and plastics industries. Based on a similar analysis, but with more energy types (including coal and nuclear energy), Strategy& (2022) finds a large decline in profit margins in the base metals, agriculture[46] and chemicals industries in particular. Rabobank (2022) presents forecasts for added value in industries and finds that industry and trade in particular could come under pressure.[47]

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[44] Actually, this was entirely defendable, since that study was published shortly after the outbreak of the war in Ukraine, and the evidence on both of these phenomena was therefore still very limited at that time.
[45] These are the two main differences in the data and method: the DNB analysis was carried out shortly after the sharp rise in energy prices, which is why energy prices have been included up to and including the first quarter of 2022. We have data available in our analysis up to and including the third quarter. In addition, the DNB analysis uses 2020 data from firms as a starting position, and we use 2019. As a result, the financial position of firms may differ.
[46] This concerns the name of the industry "crops and animal production".
[47] In a comparable study, CE Delft (link) looks in particular at the growth of the industry. They believe that the industry will generally grow in line with the trend in GDP, with the exception of base metals (no growth) and refining (shrinkage).

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6 Appendices

6.1 Data and method of the stress test

6.1.1 Firm data

The stress test uses firm-level data from Statistics Netherlands for the financial position of firms. The 'Niet-Financiële Ondernemingen' (NFO, Non-Financial Corporations) dataset forms the backbone of our data: it contains key financial data on an annual basis of all firms active in the Netherlands, with the exception of the financial sector. We therefore do not include other forms of business in our analysis: wherever 'firms' is mentioned in the stress test refers to corporations. We link the NFO data to other information about firm properties from the 'Algemene Bedrijven Register' (ABR).

We take 2019 as the starting point for the financial position of firms. Ideally, recent data are the starting point of a business stress test, but data for 2022 are not yet available. We see the year 2019 as the most recent year of normal business operations, in which the revenue and cost structure of firms resembles that of 2022. The use of data for 2020 or 2021 could give a strongly distorted picture, due to the Covid-19 pandemic.[48] However, differences between 2019 and 2022 other than the increased energy prices are not taken into account.

After cleaning the data, we are left with a dataset of about 200,000 firms. We remove firms from the sample whose data appear to be incorrect or deviate too much from a typical firm balance sheet. For example, we remove firms whose balance sheet totals are negative or whose solvency is less than -100%. We also remove observations from firms in industries for which we have fewer than 150 observations in 2019.[49] Our final dataset contains approximately 200,000 firms, spread over 55 industries (on a 2- *digit* SBI level).[50] Table 6.1 shows the number of firms that we include in our stress test per industry.

Table 6.1 Observations by industry

SBI	Description	observations
a	**Agriculture, forestry and fishing**	
1	Agriculture, hunting and services for agriculture and hunting	1312
C	**Manufacturing**	
10	Manufacturing of food products	1329
11	Manufacture of beverages	169
13	Manufacture of textiles	317
14	Manufacture of clothing	183
16	Primary woodworking and manufacture of articles of wood, cork, reed and wickerwork (excluding furniture)	688
17	Manufacture of paper, cardboard and paper and cardboard products	190

[48] As a robustness analysis, we also performed the stress test on preliminary data for 2020 and 2021. Although the percentages for loss-making firms differ slightly, the changes per industry remain largely unchanged.
[49] We do this to ensure that there are sufficient firms left for the scenarios that they are representative of an industry. When in appendix 6.1.4. after switching to the PS data, we no longer apply this restriction, because we work with a much smaller number of observations there.
[50] Statistics Netherlands distinguishes a total of 81 industries at SBI-2 digit level. However, there are enough observations – after our sample choices – for our analysis for only 55 of these.

18	Printing, reproduction of recorded media	842
20	Manufacture of chemical products	405
22	Manufacture of rubber and plastic products	658
23	Manufacture of other non-metallic mineral products	488
25	Manufacture of metal products (not machinery and equipment)	3317
26	Manufacture of computers, electronic and optical equipment	632
27	Manufacture of electrical equipment	499
28	Manufacture of other machines and equipment	1667
29	Manufacture of cars, trailers and semi-trailers	298
30	Manufacture of other means of transport	419
31	Manufacture of furniture	907
32	Manufacture of other goods	999
33	Repair and installation of machines and equipment	1741
D	**Production, distribution and trading of electricity, natural gas, steam and cooled air**	
35	Production, distribution and trading of electricity, natural gas, steam and cooled air	548
E	**Water extraction and distribution; waste and waste water management and remediation**	
38	waste collection and treatment; preparation for recycling	421
39	Remediation and other waste management	196
F	**Construction industry**	
41	General civil and utility construction and project development	8037
42	Earthworks, hydraulic engineering and road construction (no earthmoving)	1187
43	Specialized construction work	9838
G	**Wholesale and retail trade; repair of cars**	
45	Trade in and repair of cars, motorcycles and trailers	6042
46	Wholesale and brokerage (not in cars and motorcycles)	28995
47	Retail (not in cars)	12509
H	**Transport and storage**	
49	Land transport	3724
50	Transport by water	987
52	Storage and transport services	2508
53	Mail and couriers	380
i	**Accommodation, meals and drinks**	
55	Accommodation provision	1589
56	Food and beverage outlets	6131
J	**Information and communication**	
58	Publishers	931
59	production and distribution of motion pictures and television programs; making and publishing sound recordings	1265
61	Telecommunications	347
62	Information technology service activities	13826
63	Information service activities	1421
m	**Consultancy, research and other specialist business services**	
69	Legal services, accountancy, tax advice and administration	12702

70	Holdings (not financial), group services within own group and management consultancy	34586
71	Architects, engineers and technical design and consultancy; inspection and control	9004
72	Research and development work	1148
73	Advertising and market research	3888
74	Industrial design and styling, photography, translation and other consultancy	3071
75	Veterinary services	298
N	**Rental of movable property and other business services**	
77	Rental and lease of cars, consumer goods, machines and other movable goods	2153
78	Job placement, employment agencies and personnel management	5820
79	Travel brokerage, travel organization, tourist information and reservation agencies	741
80	Security and Investigation	631
81	Facility management, cleaning and landscaping	2173
82	Other business services	1465
S	**Other services**	
95	Repair of computers and consumer goods	297
96	Wellness and other services; funeral industry	911
Source: Statistics Netherlands SBI codes (link).		

6.1.2 Data on energy prices and energy consumption

We calculate changes in natural gas and electricity prices by taking a weighted average of the price for commercial end users. Energy prices for commercial consumers are reported by Statistics Netherlands in six tariff brackets for electricity and four brackets for natural gas, with prices in higher consumption brackets generally lower (large consumers pay proportionally less).[51] For this reason, we weight these different prices according to consumption in order to arrive at a total price increase per energy type. We take the transaction prices exclusive of VAT, but including all other taxes. We then weight the six and four prices with the amount of consumption in each bracket to arrive at an average price of natural natural gas and electricity for each year or quarter.[52, 53] Finally, we compare the annual average of these prices over 2019 with the average prices over the first three quarters of 2022 to arrive at the average price increases of natural gas (+196%) and electricity (+115%) that form the starting point in the stress test.

To estimate energy consumption per firm in 2019, we use Statistics Netherlands data at the industry level. For the starting position of firms, it is necessary to have an estimate of the energy consumption per firm in 2019. However, energy costs are not reported separately in the NFO; these fall within the collective category 'cost of turnover'. As such, we estimate the energy consumption of firms in 2019 on the basis of Statistics Netherlands industry statistics.[54] We do this by multiplying the industry-average energy intensity (costs for energy consumption as a percentage of revenue) by the revenue of each firm.

Because some industries use relatively more natural gas or electricity than others, the percentage increase in energy costs differs between industries. Energy consumption per firm – as an estimate described

[51]For energy prices we use the Statistics Netherlands-Statline table 'Natural gas and electricity, average prices of end users' (link).

[52]These brackets for the prices of natural gas and electricity are not fully in line with those for the consumption of both energy carriers. For this we make a weighted average of the price based on the final consumption. For example for natural gas this means: $Price\ user\ bracket\ 1 = Price\ tariff\ 1$, and $Price\ user\ bracket\ 2 = ((1.000.000 - 284.333) * \ Price\ tariff\ 2 + (284.333 - 170.000) * price\ tariff\ 1)/(1.000.000 - 170.000)$

[53]Source: Statistics Netherlands Natural gas consumption by firms (link) and Electricity consumption by firms (link).

[54]This concerns the series 'Costs of energy consumption' from the Statistics Netherlands-Statline table 'Manufacturing; labor and financial data, by industry, SBI 2008' (link).

above – consists partly of natural gas and partly of electricity. We do not know what this energy mix is for each firm, but based on Statistics Netherlands data we do know what the average energy mix is for each industry.[55] That is why we calculate the percentage of natural gas and electricity per industry and then assume that every firm in the industry has this energy mix. We then weight the price increases of natural gas and electricity with these percentages to arrive at a percentage by which the energy costs per firm rise. For example, in the stress test a firm operating in an industry that only uses natural gas faces an energy cost increase of 196%, while this is 115% for a firm in an industry that uses only electricity.

6.1.3 Method and assumptions in profit calculation

In the stress test, we calculate the profit of individual firms after increasing energy costs. We use the equation below to calculate profitability, where index *i* refers to the individual firm, while index *s* refers to the industry in which firm *i* operates. In principle, profit is equal to a firm's revenue minus costs. We look at the profit before tax; all other costs are therefore included in this. The starting point is that energy costs are increased by a percentage g_s as described above. We then calculate the new profit after accounting for this cost shock.

$$
\begin{aligned}
Profit(d)_{is} &= f_s(revenue_i) - c_s(costs_i) \\
&= \big((1+p_s)*(1+q_s)\big)*revenue_i - (1+g_s)*(1+h)*(1+\ e_e*q_s)*energy\_costs_i - \\
&\quad (1+e_l*q_s)*wages_i - (1+e_o*q_s)*other\_costs_i
\end{aligned}
$$

Here, the various symbols are defined as follows; more explanation follows in the subsequent paragraphs:

- d: pass-through of energy costs increases;
- i: index for the firm;
- s: index for the industry;
- $f_s(.)$, $c_s(.)$: functional form for revenue and total costs, respectively;
- p_s: relative price change; if the price increases by, for example, 10% this equals 0,1;
- q_s: relative change of output (the number of products sold); if output decreases by, for example, 10% this equals -0,1;
- g_s: relative increase of energy costs;
- h: energy savings;
- e_e, e_l en e_o: elasticity of costs with respect to output; this concerns the energy cost-, the wage-, and other cost-elasticity, respectively;
- δ: price elasticity of demand.

Energy savings

Firms can implement energy saving measures and thus reduce energy costs. We assume that this decrease in energy costs has no adverse effect on output. This decrease in energy costs is represented by parameter h. We determine the degree of energy savings based on insights from energy consumption in industry, our own estimates and the study of Labandeira et al. (2017). We have shown in section 2.2 that the industry has reduced natural gas consumption by approximately 40%. In a meta-study, Labandeira et al. (2017) find short-term elasticities between energy prices and the demand for energy of approximately -0.2 (see also table 6.2). This means that firms demand about 0.2 percentage point less energy for every percentage point increase in the energy price. The price increase of 196% for natural gas and 115% for electricity thus results in a decrease in demand of approximately 40% and 20% respectively. In the long term, these elasticities are higher, between -0.5 and -0.6, because firms have more time to adjust the energy mix. However, there are also costs associated with changing the energy mix, such as adjusting production processes. In addition, industries can differ

[55] This follows from the Statistics Netherlands table 'Business energy consumption by tax bracket, 2019' (link).

greatly in the extent to which energy saving measures can be implemented. For these reasons, we use a relatively conservative estimate (see also section 2.2), and assume that firms are able to save 20% of their energy costs in the first scenario, as described in section 4.1. It follows that h equals -0,2.

Table 6.2 Elasticity between energy prices and energy demand, Labandeira et al (2017)

	Short-term	Long-term
Energy as a whole	-0.149	-0.572
Electricity	-0.201	-0.513
Natural gas	-0.184	-0.568

Pass-through and demand response

Firms can also pass on the higher energy costs to customers; we use three different scenarios for the extent to which firms do so. The first scenario is based on the assumption that firms fully pass on the increased energy costs to customers ($d = 1$). In this case, firms increase their output price by just enough – given an unchanged output – to make up for their increased energy costs. In the second scenario, we assume that firms pass on half of the increased energy costs to customers, in which case $d = 0{,}5$. In the last scenario, we assume that firms are unable to respond to the increased energy prices. In this case it is not possible to pass on the increased energy costs to customers (i.e. $d = 0$). Altogether, the relative price change p_s depends on the increase of energy costs $[(1 + g_s) * energy\_costs_i]$, after any energy savings (h), and the extent of pass-through d. This translates into:

$$p = d * [(1 + g_s) * (1 + h) - 1] * energy\_costs_i / revenue_i$$

In response to the price change in the full pass-through scenario, we also assume that demand can change by q_s. In response to the higher output price, customers may decrease their demand for the applicable goods and services. We only take this demand response into account in the full pass-through scenario. In the scenario where 50% of energy costs are passed on, we assume that no demand adjustment takes place, so as to disentangle the effect of pass-through. Because of the response of demand, in the full pass-through scenario the revenue is affected by two factors: the price change p_s and the output change q_s. Since the demand response in the current environment is highly uncertain, we base this parameter on the literature, see Anderson et al. (1997). We use two possible values for the demand elasticity δ: -1 and -0.5. The relative change of output q_s therefore equals: $q_s = \delta * p_s$. An elasticity of -1 means that the decrease in demand fully compensates for the price increase, so that revenue will be (approximately) unchanged. Conversely, with an elasticity of -0.5, the fall in demand will compensate for half of the price change. In the scenarios without full pass-through we abstract from this demand response, i.e. in those scenarios $\delta = 0$.

Energy consumption also depends on firms' output. If firms are faced with a lower demand, output will fall and therefore so will energy costs. Since a lower output requires less energy, the energy costs will decrease. By how much energy costs will decrease in response to the output drop, depends on the elasticity of energy costs with respect to output, denoted by e_e. We determine this elasticity based on the assumption of Vogt and Van der Wiel (2020), in which an elasticity of 0.8 is used for the change in variable costs (excluding wage costs).

Wages and other costs

Wage expenses and other costs also depend on the change in output. As soon as firms are confronted with a drop in output, the costs for wages (employing fewer people) and other costs also fall. For the elasticity between output and wages, we rely on the parameter of Vogt and Van der Wiel (2020). We set this to 0.2. We also use their elasticity between output and other costs of 0.8 of Vogt and Van der Wiel (2020).[56] The difference between these elasticity derives from the fact that a relatively large share of wage expenses are fixed costs; hence the output elasticity of wage expenses is lower than that of other costs.

Table 6.3 Overview of parameters and elasticities in the stress test

Cost	Parameter	Value
Elasticity of energy costs and other costs with respect to output	e_e and e_o	0.8
Elasticity of wage expenses with respect to output	e_l	0.2
Increase of energy costs	g_s	
Energy savings	h_s	-0.2
Revenue		
Pass-through: response of output prices to increases of energy costs	p_s	0, 0.5, or 1
Elasticity of demand: response of output to increases of output prices	q_s	-1 or -0.5

Our method has a number of limitations that may bias the results. Firstly, we have no information about the energy contracts of individual firms, so we have to assume average price increases per industry. Secondly, we do not know the energy mix (the share of natural gas and electricity) per firm; we therefore assume that the energy mix within industries is the same for all firms. Third, the assumption of uniform price adjustments, energy savings and demand elasticities may not do justice to the extent to which individual firms do this. These three data limitations do not necessarily lead to an overall overestimation or underestimation of the share of loss-making firms, but they do mean that heterogeneity between firms is less pronounced. Fourth, we do not take into account the use of other energy types such as oil and fuels. However, the prices of these energy types have risen much less than those of natural gas and electricity. Fifth, we keep the prices of all other (non-energy) inputs constant. However, this means that any supply chain effects – one firm raises prices for other firms because of increased energy costs – are not taken into account. These last two limitations lead to a small underestimation of the impact (see section 2.1 for a discussion of the importance of supply chain effects).

We do not take into account the Energy Cost Allowance (TEK). From November 2022, small and medium-sized enterprises (SMEs) have been able to use a government compensation scheme to support energy costs.[57] This compensation reduces a firm's final costs, and therefore also has an impact on the adjustments made by firms, such as passing costs on in output prices. We do not include this scheme in our analysis, so we overestimate the increase in energy costs in the stress test for firms that use this scheme. Due to the implementation date being in the recent past, no information is available yet on which firms are using the scheme.

6.1.4 Other results

The consequences for industries with loss-making firms, as presented in section 4.1, remain roughly the same with a smaller response to demand. This is an adjustment of the elasticity of demand from -1 to -0.5 in scenario 1, which means that customers respond less to a price increase. In this case, the share of loss-making

[56]Bighelli et al. (2022) also have these parameters for individual industries. Although they vary by industry, they are not far from the elasticities we apply here. Future research can use these parameters for individual industries.
[57]See the announcement about the introduction of the TEK compensation at the national government of October 14, 2022 (link).

firms increases from 20% to 22%. The increase in the share of loss-making firms is particularly large for the manufacturing of beverages, other non-metallic mineral products and postal services (see figure 6.1). The ordering of industries differs mainly because the adjustment of other costs depends on customer demand: with a lower elasticity of demand, the other costs also fall less sharply. Once again, the effects are smallest in the other means of transport, production of motor vehicles, and transportation by water industries.[58]

Figure 6.1 Share of loss-making firms after energy-saving measures, full pass-on and drop in demand (scenario 1, with demand elasticity -0.5)

The order of industries changes slightly if we use more detailed firm information on energy costs. The Production Statistics (PS) of Statistics Netherlands has more detailed energy costs data for a subset of firms. Using this data, if firms can save and pass on energy costs (scenario 1), the increase in the proportion of loss-making firms is particularly large in the legal services, agriculture and wellness & funeral industries (see figure 6.2). For these industries, the impact of the demand for goods and services is greater than if we estimate this with the Statline data, as presented in section 4.1. The smallest effects can be observed in the postal services, security and investigation, waste management, wearing apparel manufacturing, civil engineering, and production of motor vehicles industries.

[58] The order of the bottom ten industries changes slightly compared to Figure 4.1. This is mainly due to the assumption regarding the elasticity of demand for the other costs related to sales.

Figure 6.2 Share of loss-making firms based on PS data after energy-saving measures, full pass-on and drop in demand (scenario 1, PS data, elasticity -1)

The order of industries that are hit hardest shifts more in the scenario where firms cannot make adjustments once we use data from the PS. The results are shown in figure 6.3. In this scenario, we see that the share of loss-making firms increases sharply in the industries of agriculture (from 15% to 42%), manufacturing of food products (from 17% to 41%) and food and beverage outlets (from 20% to 42%). For the available firms in these industries, energy costs represent a large part of the total costs. The smallest effects can be observed in the postal services, information technology services and telecommunications industries.

Figure 6.3 Share of loss-making firms based on PS data, only increase in energy prices (scenario 3)

6.2 Energy consumption

6.2.1 Energy intensity

We calculate energy intensity using input-output tables. The input-output table gives the value of all domestic supplies by industry *i* to industry *j* (Z_{ij}). We express Z_{ij} as a fraction of the value of total output x_j: $a_{ij} = \frac{z_{ij}}{x_j}$. The first round change in demand for intermediate inputs after a change in total output equals $A\Delta x$ in matrix notation. The resulting change in output leads to an additional demand equal to $A[A\Delta x] = A^2\Delta x$. The final change in demand, and thus output in all industries, is now calculated as:

$$[A + A^2 + A^3 \ldots]\Delta x = [(I - A)^{-1}]\Delta x = (L - I)\Delta x$$

We calculate the direct energy intensity as a_{ij} and the total energy intensity as i_{ij}. This is after an increase in the total output of industry *j* by 1 euro. We identify four energy-supplying industries (i's): petroleum and natural gas extraction, other mineral extraction, petroleum industry, and energy firms. We next report the energy intensities for the non-energy industries (j). The results of this can be found in section 3.1.

Energy intensities calculated from input-output tables are underestimates. Unlike the usage table, this value does not include the import of intermediate inputs and margins (tax and trade margins). As a result, energy-intensive inputs obtained from abroad are not included in the industry-specific energy intensities.

6.2.2 Energy saving measures (substitution)

This appendix shows that the price elasticity and the substitution elasticity are the same for certain production functions. In the main text, we used the price elasticity of energy demand from Labandeira et al (2017) as a measure of the energy-saving, or substitution, possibilities in production. There is more information available in the international literature on price elasticities than on substitution elasticities. We show below that under certain conditions the price elasticity of the demand for energy is equal to the elasticity of substitution between energy and the other factors of production. For this we use the work of Bachmann et al (2022) for a production function with energy as input.

Output, *Y*, is produced by combining energy, *E*, and all other factors of production (such as labour and capital), *X*, into the following CES production function

$$Y = \left(\alpha^{\frac{1}{\sigma}} E^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{\frac{1}{\sigma}} X^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}},$$

where α determines the importance of energy in production and σ is the elasticity of substitution between energy and the other factors of production. To show that the elasticity of substitution is equal to the price elasticity of energy demand, we need to derive factor demands, which are derived from a cost minimisation problem.

$$min P_E E + P_X X$$

where P_E is the price of energy and P_X is the price of other factors depending on producing a given amount of output, Y*:

$$Y^* = \left(\alpha^{\frac{1}{\sigma}} E^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{\frac{1}{\sigma}} X^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}.$$

The *Lagrangian* for this function is

$$L = P_E E + P_X X - \lambda[\left(\alpha^{\frac{1}{\sigma}} E^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{\frac{1}{\sigma}} X^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} - \mathrm{Y}].$$

The *first order condition* for energy is

$$0 = P_E - \lambda\alpha^{\frac{1}{\sigma}} E^{-\frac{1}{\sigma}} \left(\alpha^{\frac{1}{\sigma}} E^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{\frac{1}{\sigma}} X^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}},$$

and for the other factors of production

$$0 = P_X - \lambda(1-\alpha)^{\frac{1}{\sigma}} X^{-\frac{1}{\sigma}} \left(\alpha^{\frac{1}{\sigma}} E^{\frac{\sigma-1}{\sigma}} + (1-\alpha)^{\frac{1}{\sigma}} X^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}.$$

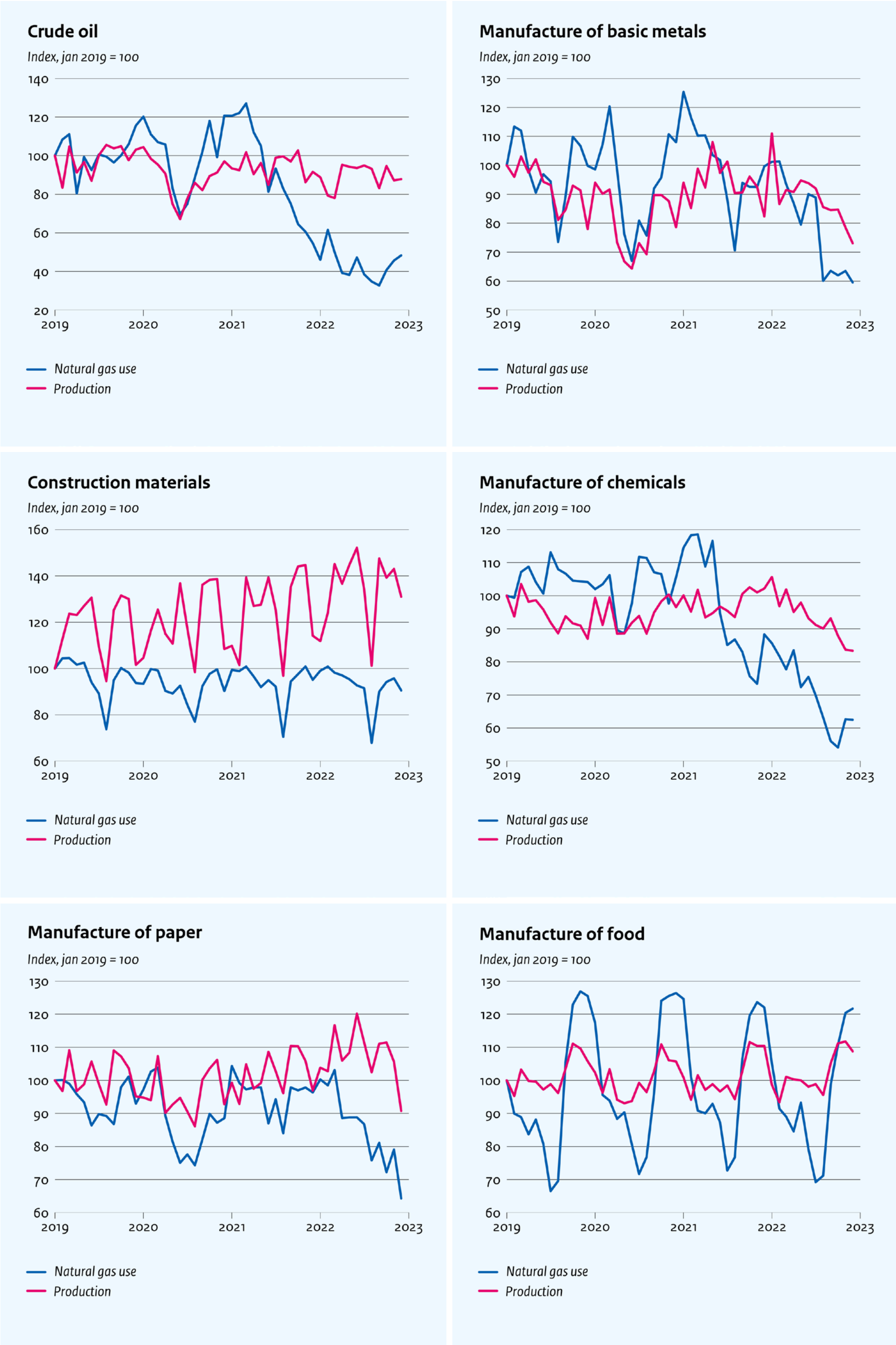
Combining these two conditions and eliminating common terms, the demand for energy arises in relation to the other factors of production:

$$\frac{E}{X} = \frac{\alpha}{1-\alpha}\left(\frac{P_E}{P_X}\right)^{-\sigma}.$$

Keeping the price and quantity of the other factors constant, σ is both the price elasticity of energy demand and the substitution elasticity between energy and the other production factors in the production function. Therefore, we use price elasticity estimates as a measure of the substitution opportunities that firms can exploit.

A sharp decrease in natural gas consumption is visible for various manufacturing industries, with the exception of manufacturing of food products. Figure 6.4 shows natural gas consumption and volume of production for six manufacturing industries. With the exception of **manufacturing of food products**, we see that natural gas consumption has fallen by between 15% and 50% in five of the six industries. The largest decrease in natural gas consumption can be seen in the petroleum industry, with approximately 50% less natural gas consumption compared to 2019. In food, there is a strong cyclical pattern in natural gas consumption, and this has not decreased compared to previous years.

Figure 6.4 Natural gas consumption for manufacturing industries



Source: Statistics Netherlands, calculations by CPB.

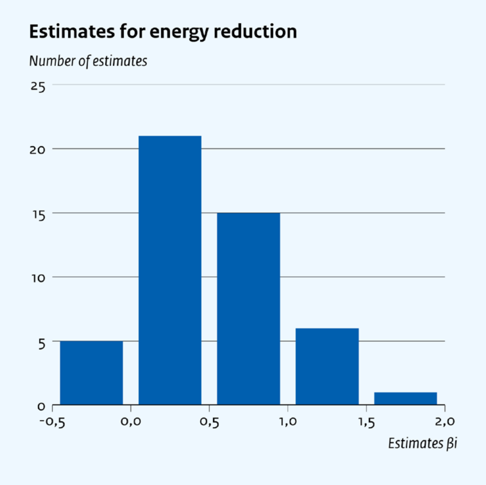
6.2.3 Historical data on energy savings

A regression analysis based on historical data provides insights into how much energy savings, or substitution, firms can achieve. We do this by estimating a regression equation between natural gas prices and energy costs from 2009-2020 for different industries (at SBI-2 digit level). Due to the high correlation between natural gas and electricity prices and the limited number of observations, we only look at the relationship between natural gas prices and energy costs. We calculate energy costs as a percentage of revenue, based on annual industry data from Statistics Netherlands,[59] and use natural gas prices for non-households from Eurostat.[60] It is important to note that due to data availability there are only 11 observations per industry, so the estimates can be surrounded by a lot of uncertainty. This gives the following regression that we estimate for total energy costs as a percentage of revenue for industry *i*:

$$\Delta \frac{Energy\_costs_{it}}{Revenue_{it}} = \beta_i \Delta Pgas_t + \epsilon_{it}$$

In the majority of industries, energy costs per unit of revenue increase by less than 0.8% if natural gas prices rise by 1%. The parameter β_i from the above equation gives an indication of the degree of energy savings for industry *i*. By way of illustration, a value of 0.5 indicates that only half of the increase in the natural gas price results in higher energy costs. If energy costs increase in line with the increase in natural gas prices, no energy savings will take place ($\beta = 1$). When energy costs rise less than energy prices, we see this as an indication of possible energy saving by firms ($\beta < 1$). The average value is 0.46 and 80% of the industries have a value less than 0.8 (figure 6.5). This is indicative that in the past firms were able to ensure that the price increase of natural gas did not immediately lead to the same increase in energy costs.

Figure 6.5 Estimates of the parameter βi for energy saving measures



Source: Statistics Netherlands, CPB calculations.

There are important caveats to the regression analysis. First, the number of observations is limited and the recent period of large increases in energy prices is missing. As a result, the estimated relationship can be surrounded by a lot of uncertainty and does not contain information about the current possibilities for energy savings. Secondly, it is possible that firm revenue has changed significantly during the sample period. This also influences our dependent variable, energy costs as a percentage of revenue, so that the impact of natural gas prices does not only affect energy costs. Finally, there are major differences within industries.

[59]The energy costs on which these estimates are based exclude energy costs used by means of transport (especially oil) and exclude energy costs used for raw materials. See the notes to the Statistics Netherlands data used for this (link). We use the same industries as in the stress test as much as possible. The Statistics Netherlands source for this regression analysis has no data for industries 1 and 70, and is not complete for industries 14, 75, 79, 82 and 96. A total of 48 industries are available for these estimates (see Table 6.1 for the industry names).
[60]Source: Eurostat, Natural gas prices for non-household consumers (link).

6.3 Pass-through to output prices

6.3.1 The pass-through paradox

The pass-through paradox describes the relationship between market power and the passing on of increased energy prices to customers.[61] According to the pass-through paradox, firms with a lot of market power pass on less to customers than firms with little market power. In this appendix we explain the economic reasoning.

The standard price rule follows from (static) profit maximisation:

$$P = m\ MK,$$

where the optimal price P is a mark-up, m, over marginal cost, MK. The mark-up is higher if there is less competition and if demand is less price-elastic.

The pass-through paradox can be explained using two stylised cases. In a market with perfect competition, many identical firms are active. In this case, the markup is equal to 1. This means that each firm achieves the minimum required return on capital and cannot reduce the margin further. Every firm will fully pass on a cost increase, because otherwise they will make a loss. A monopoly is the other extreme market form. Of all market forms, a monopolist opts for the highest mark-up and therefore also for the highest price. This firm operates on the most price-elastic part of the demand. A further price increase will cost the most revenue, because the firm will lose customers at higher prices. When costs rise, a monopolist will pass on less to customers in order to keep profits as high as possible. According to this argument, the degree of pass-through is higher in more competitive markets.

A number of deviations from the stylised cases may go against the pass-through paradox. **First, a market contains firms that are *heterogeneous* and affected by different marginal cost increases.** Firms do not use the same production technologies, so energy intensities can vary within the same industry. In addition, there are also different options for saving expensive energy by switching to less expensive energy or using other inputs, or absorbing this increase with financial buffers. These factors also influence the degree of pass-through to customers, and may differ within the same industry.

Secondly, the degree of pass-through depends on the type of energy contract. Firms that have entered into a contract with fixed energy prices will not or will suffer later from a cost increase, in contrast to firms with a contract with variable prices.[62] A counterargument follows from the principle of the *opportunity cost*. When determining the output price, it is not the purchase price that is relevant, but the proceeds from an alternative use of the input.[63]

Third, the pass-through paradox relies on static optimisation, with little regard for *dynamic* considerations. If an entrepreneur expects the increase in energy prices to be temporary, customers may be lost if the output price increases. For this entrepreneur, it may be a better strategy to opt for a small price

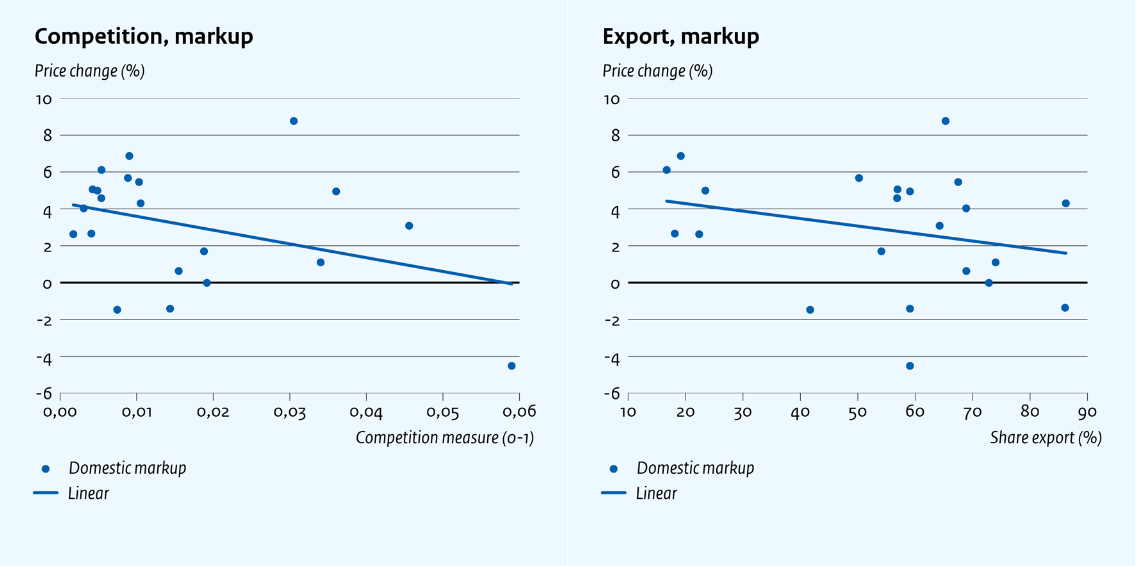
[61] See Hinloopen's (2022a) blogs (in Dutch), Een afwentelingsparadox. (link) and Hinloopen (2022b), iPhones en brood: de rol van marktmacht bij het ontstaan van inflatie. (link), and Genakos and Paglierom (2022, link).
[62] ABN-AMRO (2022) studies the growth of advances paid to energy suppliers by small SMEs in eight industries. They conclude that the average growth of energy payments is largely the same across industries, but that the spread between firms has increased, often as a result of different energy contracts. ABN AMRO (2022). Small business energy payments are on the rise (link).
[63] For example, anecdotes are known of firms in greenhouse horticulture with a permanent contract for which it was more profitable to reduce their production and to sell their natural gas to other users, see for example the article in the Financieel Dagblad (2022, in Dutch) “De glastuinbouwer kan beter energie verkopen dan tomaten” (link).

increase and a reduction in the profit margin. Or a firm can use this period strategically to increase its market share at the expense of other firms. These dynamic, longer-term considerations are not included in the pass-through paradox.

Finally, the impact of international competition is not taken into account. If a firm competes with foreign firms that are affected by the same cost increase, a larger pass-through into output prices is a plausible option. But this option becomes less attractive if foreign competitors are less affected by rising energy prices. For example, energy prices have risen more in Europe than in the United States.[64]

We find that the degree of pass-through is lower on average for more concentrated and more export-oriented industries. The relationship with the degree of concentration, measured by the HH index in 2019, in Figure 6.6 (left) is negative. Pass-through is therefore highest in smarkets with more competition. However, the relationship is sensitive to outliers. There is also a negative correlation with the exports of the industrial branches (figure 6.6, right). This figure illustrates whether the degree of transfer is different for industries that export more and are therefore more confronted with competition on foreign markets. For manufacturing industries that mainly produce tradable goods – with a larger share of exports in 2019 – we find a negative correlation.

Figure 6.6 Relationship between the degree of pass-through in industry and competition (left) and exports (right)



Source: Statistics Netherlands. Calculations by CPB.

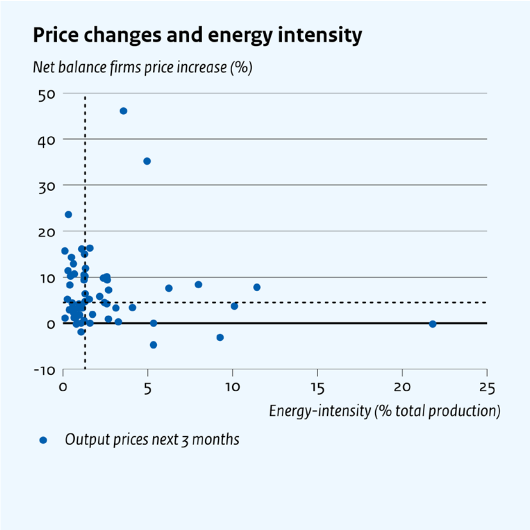
6.3.2 Business survey

Entrepreneurs' answers about expected developments in prices, revenue and profits are informative for how firms plan to respond. Below are figures that support section 3.3. Figure 6.7 shows that in the second quarter of 2019, the balance of firms that have indicated that they will raise prices in the next three months is small. Figure 6.8 shows that this balance was significantly higher in the second and fourth quarters of 2022. Entrepreneurs seemed to have been surprisingly positive about turnover in 2022, both in the second quarter (Figure 6.9, left) and the fourth (Figure 6.9, right). In addition, entrepreneurs appear to be more optimistic about an increase in total revenue than in foreign revenue, which indicates that there seemed to be

[64]See, for example, the prices of natural gas in the study by the IEA (2022). Natural natural gas prices in Europe, Asia and the United States, Jan 2020 – February 2022. (link).

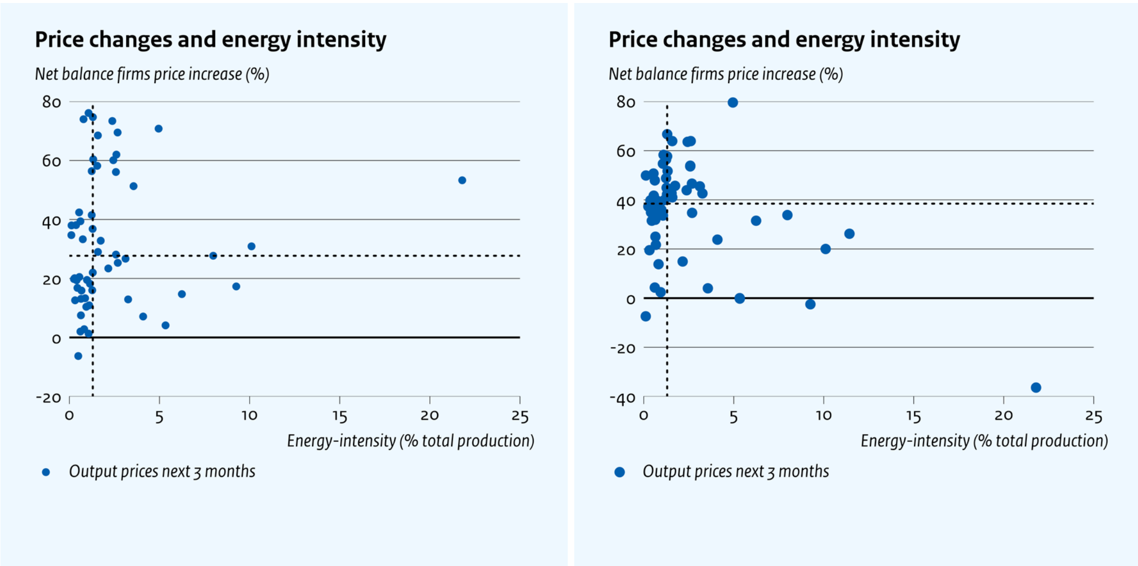
confidence in rising revenue in the domestic market in particular (figure 6.10). In the course of 2022, more entrepreneurs replied that profitability had deteriorated (figure 6.11) in the past three months.

Figure 6.7 Relationship between energy intensity and expected price changes over the next three months in 2019Q2



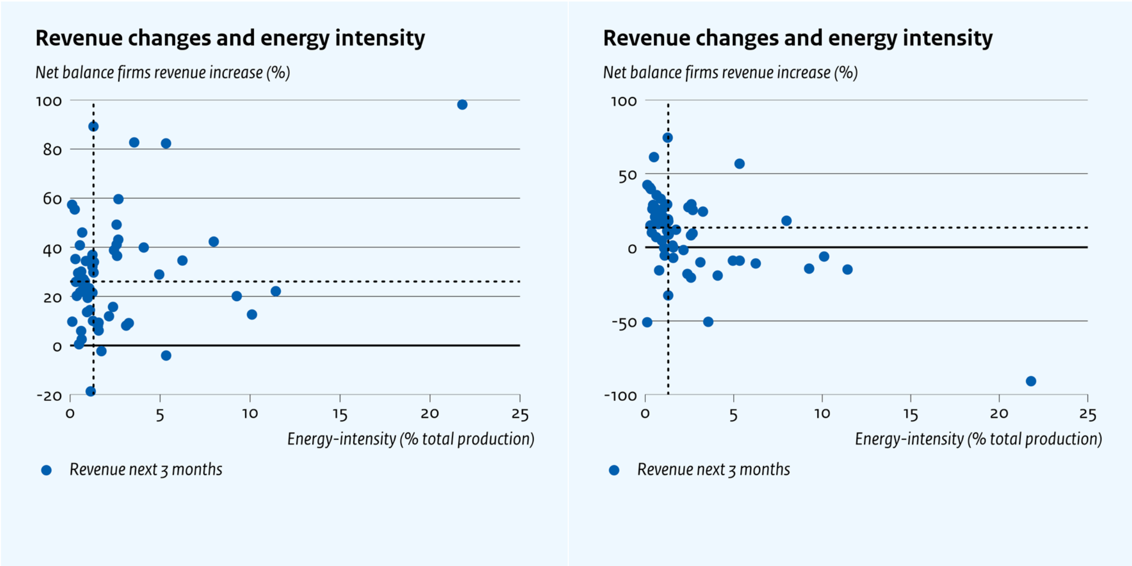
Source: Statistics Netherlands, calculations by CPB.

Figure 6.8 Relationship between energy intensity and expected price changes over the next three months in 2022Q2 (left) and 2022Q4 (right)



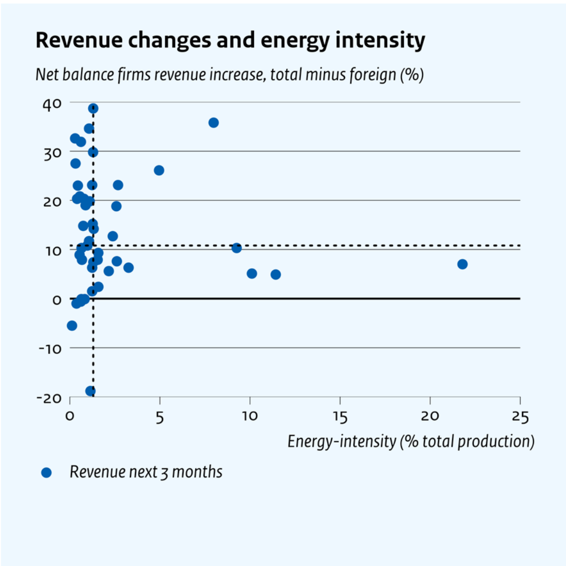
Source: Statistics Netherlands, calculations by CPB.

Figure 6.9 Relationship between energy intensity and expected revenue in the next three months in 2022Q2 (left) and 2022Q4 (right)



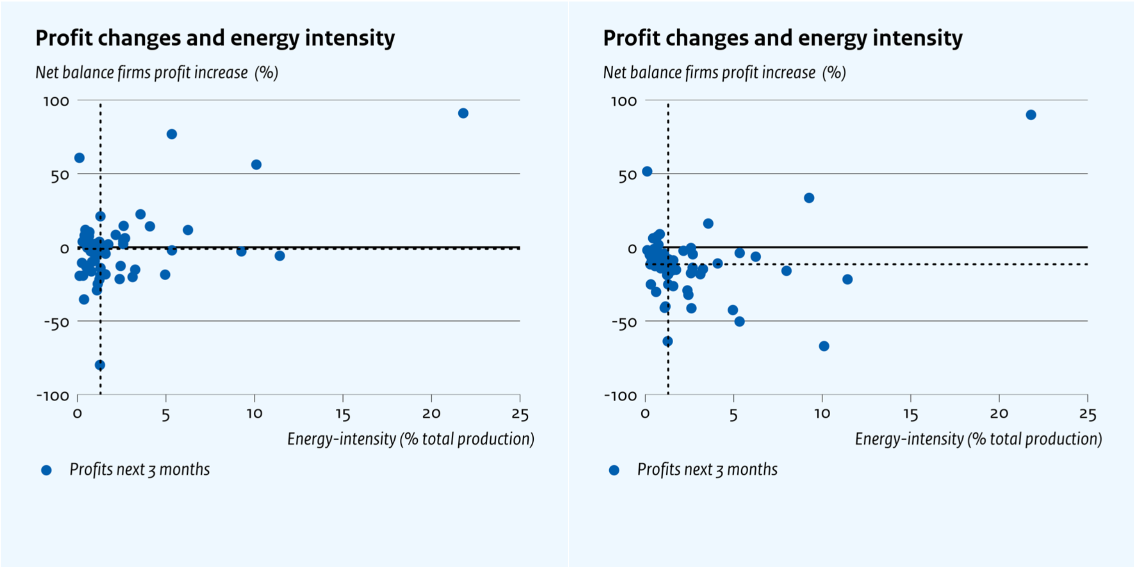
Source: Statistics Netherlands, calculations by CPB.

Figure 6.10 Relationship between total revenue minus foreign revenue over the next three months in 2022Q2 and energy intensity



Source: Statistics Netherlands, calculations by CPB.

Figure 6.11 Relationship between energy intensity and profitability over the past three months in 2022Q2 (left) and 2022Q4 (right)



Source: Statistics Netherlands, calculations by CPB.