Growth effects of permanently high energy prices: recent evidence for Germany

The international oil markets had to contend with considerable volatility in the past few years. The price of crude oil rose steeply until mid-2008 and then underwent a sharp correction on account of the severe global recession. However, at present, it is still relatively high compared to earlier economic slumps. This indicates that, in the past few years, energy use has not simply been subject to temporary price volatility but has instead become permanently more expensive. Net energy-importing economies are thus undergoing numerous supply and demand adjustment processes.

One particular aim of this article is to estimate the adverse effect of increases in the price of energy use on the goods and services supplied by the German business sector over the 2004-08 period. A decisive factor with regard to the longer-term consequences for growth and wealth will be firms' ability to adjust their assortment of products to changes in the structure of demand and to convert their manufacturing processes to less energy-intensive methods. Economic and wage-setting policy can play a key role in this context.

Energy prices in an environment of high demand and scarce supply

Extremely sharp rise in oil prices during last global economic upswing…

During the last business cycle, global economic activity was accompanied by an extremely strong reaction of the crude oil price. After the New Economy bubble had burst and the global economic downturn had subsequently been overcome, the spot price for a barrel of Brent crude initially fluctuated in a band between US$20 and US$30 before then jumping to over US$140 by July 2008. Cyclical tensions emerged at this price level, and the world economy rapidly descended into a sharp and synchronised slump following the escalation of the financial crisis in September 2008. Against this background, the oil price then fell by around US$100 within half a year. Since the beginning of the year, however, it has rebounded steadily, to slightly more than US$70.

… partly permanent

Despite the deep global recession – notwithstanding the fact that the OPEC nations have in the meantime made concerted supply cutbacks – international crude oil prices are currently still well above their level during the comparatively mild economic downturn at the beginning of this decade. This indicates that the real price of oil has trended upwards over the past few years. The oil price rally up until mid-2008 was fundamentally justified inasmuch as the highly energy-intensive nature of the last growth cycle caused global demand for crude oil to far outstrip supply. Moreover, it was precisely in the last stage of this rally, when the price of crude oil, which was already quoting at US$70 a barrel, once again doubled within a one-year period, where speculation is likely to have driven it to exaggerated levels. Although the growing activity of financial investors in the international commodity markets tends to increase volatility, its impact on the long-term price path is virtually nil.[1] For the question as to whether or not adjustments are necessary, the volatility in the price of oil is less important than a permanent level shift caused by economic fundamentals. This is because purchases of new consumer goods, like comprehensive investment in energy-saving technology and the modification of production processes, will pay off only if cost reductions can be achieved over a relatively long time horizon. Any such adjustments that have already been made will not be reversed even if energy costs fall because modifications entail considerable fixed costs.

Along with the limited supply of fossil fuels and rising exploration costs, the emerging market economies' rapidly growing hunger for energy, which the advanced economies' increased efforts to save energy are only partly able to offset, would indicate that the price path will be pointed upwards over the long run. The formation of futures market prices shows that this is also what market participants are expecting. During the last global economic cycle, the term structure was pointed upwards on average, which, compared to a "normal" situation where futures prices decline over the maturity spectrum, indicates a

1 For more on this see eg S Reitz and U Slopek, Nonlinear oil price dynamics: A tale of heterogeneous speculators?, forthcoming in the German Economic Review.

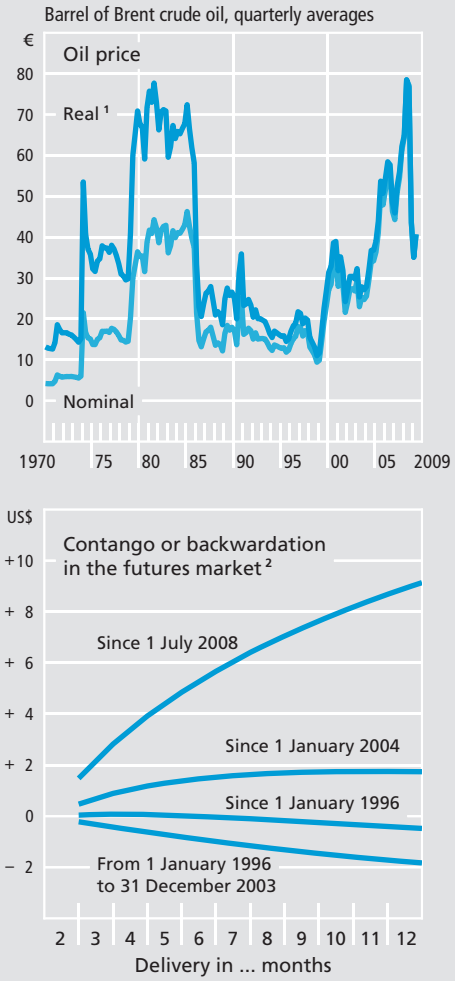
pronounced expectation of rising prices.[2] The sharp fall in spot prices in the second half of 2008 coincided with a renewed massive widening of the contango for forward delivery contracts. In the light of future expectations, the current level of oil prices can thus be assessed as low even though, in comparison with the cyclical position of the world economy, it should tend to be assessed as high.

Overall bill for imported energy

Higher prices in the international crude oil markets affect enterprises and households in the net importing countries differently – depending on the volume and mix of energy consumption. In Germany's overall energy mix, petroleum currently accounts for around one-third; however, the prices of other key sources of energy in Germany, particularly natural gas, are pegged to the crude oil price. In addition, account has to be taken of changes in exchange rates because these commodities are usually denominated in US dollars on international markets.

Considering the German economy as a whole, rising energy prices initially amount to a transfer of real income to foreign countries since the vast majority of the amount of primary energy consumed domestically has to be imported. One measure of the total burden on households and enterprises is the economy's bill for imported energy, which rose by just under €40 billion per year to €85 billion between 2004 and 2008.[3] The value of net energy imports a year earlier was thus around 3½% of nominal gross domestic product (GDP). The main reason for the strong increase in expenditure on primary energy imports was the doubling of energy prices relative to the GDP deflator. What kept

Oil prices and term structure in the futures market



1 Nominal oil price deflated with the national consumer price index and normalised to the year 2008. — **2** Average against the one-month-ahead futures price in US dollars.

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2 This standard maturity pattern in the futures market for oil, called "backwardation", can be explained by motives of inventory holding as well as option theory. See eg R S Pindyck (2001), The Dynamics of Commodity Spot and Futures Markets: A Primer, Energy Journal 22, 3, pp 1-29, and R H Litzenberger and N Rabinowitz (1995), Backwardation in Oil Futures Markets: Theory and Empirical Evidence, Journal of Finance 50, 5, pp 1517-1545.

3 See also Deutsche Bundesbank, Energy bill for the German economy under increasing price pressure, Monthly Report, August 2008, pp 54-55.

the outflow of income from being even worse was that the euro appreciated against the US dollar by nearly one-fifth during the period under review. Additional relief was provided by a moderate reduction in the German economy's dependency on imported energy. Lastly, the overall energy intensity also diminished, generally reflecting greater thriftiness in the use of fuels and energy-intensive inputs. In the business sector, reasons for this trend include not only structural change but also the increased use of energy-saving technologies in the manufacturing process. Households are modifying their consumption habits inasmuch as they are reducing the use of energy-intensive durable goods – also in favour of comparable, yet more energy-efficient, products. In housing construction, for instance, new standards in heating technology and insulation are becoming established.

Supply and demand effects

Moreover, consideration must be given to the effects of interplay between the household and business sectors. The reduced leeway for expenditure caused by unavoidable spending on energy and the price-induced shifts in the structure of household demand impact on the business sector by increasing the demand for some goods and services and reducing the demand for others. The new requirements for the assortment of goods and services affect not only factors such as return on investment but can also bring about changes in the structure of the economy. In that vein, one of the causes of the crisis affecting the car industry, particularly in the United States, is that the tremendous spike in fuel prices which lasted until mid-2008 led to increased purchases of small and mid-sized cars, the manufacture of which had been regarded for a long time as relatively unprofitable. The transfer of additional income to crude oil and natural gas exporting countries associated with rising energy prices is another factor which causes changes in the demand structure; these countries reinject some of their surpluses into the international trade cycle by purchasing more consumer and capital goods. During the past global economic upswing, this recycling of petrodollars through the trade channel benefited, in particular, German exporters, who have a relative competitive advantage in the area of high-end industrial goods.

Tools of economic policy

Economic policy incentives are also important alongside market-led adjustment mechanisms. As part of the "Ecological Tax Reform" adopted by Germany's "red-green" coalition government, an additional levy was imposed on the consumption of petroleum, gas and electricity. A current example is the conversion of the car tax to an emissions-based system that incentivises the purchase of fuel-saving cars. In addition, the CO_2 Building Rehabilitation Programme of the KfW Banking Group is promoting the modernisation of the housing stock to meet the same energy standards as new buildings.

Long-term energy substitution and the role of wage policy

All in all, a permanent increase in the energy price level impacts on growth and welfare in Germany in a variety of ways. The short-term impacts are already reflected in the available data and will be analysed thoroughly for the household and business sectors in the following; in addition, however, the medium to

long-term impacts also need to be considered. Whether or not the economy will be permanently weakened by an oil price shock will depend on how the bargaining parties react to the reduction in the available real income. The availability and use of energy-saving technology and research into new possibilities for energy substitution also play a key role in this context. For all of these factors, it is of paramount importance that the business sector is able to fund investment in productive capacities and research projects and that cost pressures from other areas do not put the expected return on capital under pressure. The economy is in a much better starting position now than during the two oil price shocks of the 1970s because the last energy price surge was not followed by any significant second-round effects. Instead, apart from cyclically-induced higher labour compensation growth towards the end of the upswing, wage-setting policy has maintained moderation and remained focused on employment throughout.

Change in consumption habits

Households' energy use…

Households currently devote, in nominal terms, slightly more than 8% of their entire consumer spending to energy use; around one-third of this spending is on individual transport and two-thirds on residential expenditure. In the second category, the lion's share, or just under three-quarters, is for space heating, followed by 12% for warm water and just under 15% for all other uses, such as lighting, cooking and the operation of electrical appliances.[4]

… also dependent on properties of consumer goods

The utility of consumption for households is usually created not by energy use itself but by heat generation and in combination with durable goods. The properties of these products are the main determinants of the price elasticity of energy demand in the various areas of application. When energy prices rise, a household can initially curtail or avoid using energy-intensive goods, provided this is consistent with the household's preferences. If, as in the case of space heating and many other durable goods, such options are limited, the alternative adjustment strategy is to change over to more energy-efficient product variants. In this context, key factors that affect the decision include not only the purchase price or costs of modification relative to the expected savings but also technological factors such as the service life of the durable good and the availability of more energy-efficient product types. Psychological aspects such as perceptions and habits can also, for certain consumer goods, push aside pure, mostly long-term oriented, profitability considerations. If a cost-benefit analysis leads to a decision against the status quo, household appliances and cars are generally purchased new. In the case of residential property, the prevailing options are converting or modernising heating technology and improving insulation.

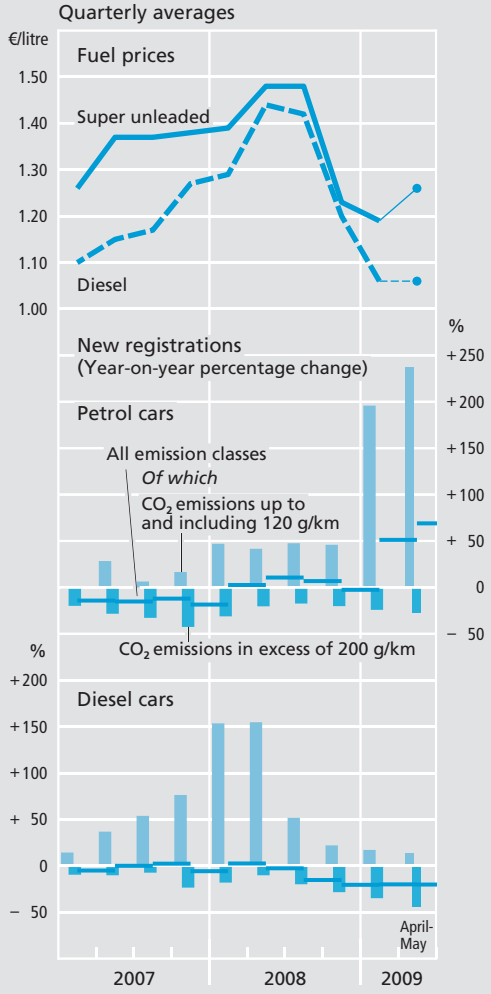
Use of low-energy-consumption products…

If energy price rises are seen as permanent, in the case of durable goods in particular it is often better to buy a new product than to

4 See also H Mayer and C Flachmann, Energieverbrauch der privaten Haushalte 1995 bis 2006, Federal Statistical Office, Wirtschaft und Statistik 12/2008, pp 1107-1115 (available in German only).

Fuel prices and new car registrations

Quarterly averages



Sources: Federal Statistical Office, Federal Motor Transport Authority and Bundesbank calculations.

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continue using the old product, because the expected cost savings will be incurred throughout the entire lifetime of the product. Not only do space heating and mobility account for the majority of private energy consumption, but heating and insulation technology and cars alike both have a relatively long service life; adjustment measures in these areas are therefore particularly profitable. Cost consciousness with respect to energy consumption, moreover, has increased because space heating, warm water and household electricity prices, along with petrol and diesel prices, have risen very sharply in the past few years. Household energy prices rose by just under 65% between 2000 and 2008, with those for fuels and lubricants going up by just over 42% during the same period.

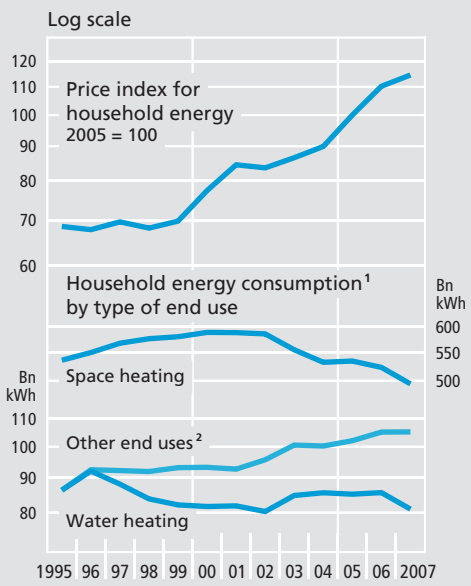
… in individual transport…

Not only profitability considerations but also the generally high sensitivity associated with fuel price movements are likely reasons why a visible demand shift has taken place in the area of individual transport. For years already, the percentage of diesel cars among privately owned cars has been on the rise. One reason is that pump prices for diesel in Germany have usually been lower than those for regular petrol. In addition, diesel engines are more efficient, which makes them an attractive option for drivers who cover a greater number of kilometres, despite the somewhat higher price tag and higher car taxes. It therefore comes as no surprise that the trend towards purchasing diesel cars is becoming more prevalent if total kilometrage is used as the benchmark as opposed to the number of vehicles owned. Whereas cars with petrol engines drove only a little over 10% fewer kilometres in 2006 than in 2000, total kilometres driven by privately owned diesel cars rose by around 75% over the same period.

The rise in fuel prices, which was particularly sharp in the period from mid-2007 to mid-2008, as well as growing environmental awareness, have apparently contributed to the recent trend of attaching greater importance to fuel consumption than to other ve-

hicular properties when purchasing new cars. This is evidenced by the fact that, since 2008, an above-average number of low-fuel-consumption cars have been registered, whereas new registrations of cars that consume a very large amount of fuel have fallen over the past two years. This trend is likely to continue since, following the adoption of new rules in early 2009, car taxes have been assessed on the basis of emission classes and are thus pegged to fuel consumption. The currently very high number of registrations in the small and compact car categories, however, is associated above all with the environmental premium being granted for the scrappage of old cars; in this segment, this has reduced the actual price paid for new car purchases the most as a percentage of the price tag.

Household energy: prices and use



1 Temperature adjusted. — **2** Includes lighting energy, mechanical energy for the operation of electrical appliances and process heat, eg for cooking.

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... and heat generation

Since peaking in 2000, household energy consumption for space heating has fallen considerably – after adjustment for temperature-related fluctuations – both in absolute terms and relative to living space. If households do not wish to go without what they regard as a comfortable room temperature in the cold months, one way to achieve savings is by fully utilising efficiency reserves in respect of temperature regulation. Moreover, rising heating bills are motivating households to place more value on the installation of energy-saving heating facilities and insulation in new buildings and on the conversion of older buildings. This type of building restoration is currently being promoted by a KfW programme through low-interest loans and, since 2007, also through direct investment grants. In the 2005-07 period, support was given to a total of 91,000 projects, thereby bringing around ¾% of total living space in existing real estate to the energy consumption level of new buildings.[5] The savings achieved through these measures are estimated to have contributed to around 7½% of the reduction in the use of space heat and warm water over the aforementioned period.

Shifts in demand structure

In the two main areas of household energy use, the considerable rises in energy prices have led to distinct shifts in the structure of demand. Since the rise in energy prices is increasingly being seen as a trend, consumption-related energy use has been the

5 See K D Clausnitzer, J Gabriel, N Diefenbach, T Loga and W Wosniok, Effekte des CO_2-Gebäudesanierungsprogramms 2007, Expert opinion commissioned by the KfW Banking Group, May 2008 (available in German only).

focus of more and more attention. Economic policy incentives in that direction have accelerated this trend. Changes in consumer habits have repercussions on the business sector because the assortment of goods and services has to be modified.

Short-term quantitative effects on the total supply of goods

Energy cost-associated reduction in output

The manufacture of goods and services generally requires energy; therefore, if this factor of production becomes more expensive, this can, in and of itself, impose an additional cost burden on many firms. Options for short-term adjustment are usually very limited because manufacturing processes are predetermined and the available plant and machinery, including their energy consumption functions, are nearly impossible to alter. Labour input can be manipulated to a limited extent by using tools to increase flexibility, such as working hours accounts, fixed-term employment contracts or temporary work; existing wage contracts, however, constrain employers' capacity to modify labour remuneration. Passing on energy price-related cost pressure to sales prices is likewise hardly viable in the short term in many sectors. Under these circumstances, profit-maximising firms are often forced to reduce energy consumption for cost reasons by curbing production. This is countervailed to a degree by a partial substitution effect inasmuch as earnings can be reinvested in energy-efficient plant and machinery within the regular capital turnover. However, this means that the combination of inputs will generally adjust only very slowly to the changes in relative input prices, thereby initially causing the negative scale effect to predominate.

Obsolescence of productive capital

Another reason for reducing the supply of goods is that high energy prices cause existing production facilities to become prematurely obsolescent – or, in economic terms, to age faster – and therefore to be shut down or at least not used as intensively as before for efficiency reasons. Capital depreciation triggered by cost pressures should be analytically distinguished from demand-driven obsolescence, which is caused by the fact that – as explained in the preceding section – durable consumer goods, but also energy-intensive capital goods, can no longer be sold on the market, or only in smaller quantities. This likewise causes production capacity to become unprofitable. Theoretically, the value of the manufacturing stock is already depreciated the moment a permanent energy price shock materialises; at the firm level, this leads to extraordinary write-downs on fixed assets. In the balance sheet, this is associated with a loss of equity if compensatory measures are not taken. Taken to its extreme, this can also cause whole firms to exit the market, thereby further shrinking the productive capital stock.

Production structure…

Capital depreciation and market adjustment effects are virtually impossible to quantify at the macro level. The empirical assessment of the short-term supply effect of an energy price shock is therefore focused on calculating the scale and substitution effects. The decisive factor, however, is that substitution possibilities generally do exist, yet can vary from one economic sector to the next. The

extent to which it is possible to reduce the consumption of energy per unit of output produced by increasing the input of capital goods depends on the production structures in the given sector and the availability of technologies. (See also the box on pages 38 and 39.)

... and energy use in industrial and transport sectors

It is particularly those business sectors that account for a large percentage of commercial energy use which are of interest in this article. This is true of the industrial and transport sectors, which accounted for 63% and 18% of commercial energy use on average over the 1995-2007 period. The relative importance of energy as a factor of production in these sectors becomes clearer if these shares are assessed in the light of the fact that the industrial sector contributed around one-third, and transport merely 5%, to the business sector's value added over the aforementioned period.[6]

Supply effects dependent on sector-specific factors and multiplier effects

The effects on the supply of industrial goods and the services rendered by the transport sector need to be quantified separately for a variety of reasons. One is that econometric studies have shown that the elasticity of substitution between capital and energy is much higher in industry than in transport.[7] In both sectors, though, the substitutability of these factors of production is relatively inelastic, especially in the short term; with a given capital stock, this trait, in isolation, indicates a comparatively weak supply-side response to a relative change in factor prices. In addition, the effective price to be paid for using one unit of energy varies depending on the sectoral energy mix, since the individual sources of energy are subject to similar but not identical price trends, with time lags also playing a role. In the transport sector, fuels are a key intermediate factor of production, with petroleum products accounting for more than four-fifths of the energy consumed in this sector.[8] With a share of just under 30%, petroleum was still the biggest individual item in industrial energy consumption in 2007; however, this figure also includes non-energy uses, which are particularly significant in the chemicals industry.[9] Gas and electricity each accounted for around one-fourth of use, while coal and lignite (including coal products) contributed around one-sixth; the use of renewable energy made up less than 5% of overall industrial energy use. Moreover, the supply effect on other sectors of the economy can vary in intensity depending on the sector. A decline in industrial production will affect not only a number of business services providers but also the transport sector, which means an energy price surge will hit the latter directly and indirectly. Although it is also possible that a primary shock in the transport sector could have a similar impact on other

6 The business sector is defined here as encompassing manufacturing (excluding energy), retail trade, hotels and restaurants, transport, communications and "financing, renting and business services".
7 For more information, see T A Knetsch and A Molzahn, Supply-side effects of strong energy price hikes in German industry and transportation, forthcoming Discussion Paper of the Deutsche Bundesbank's Research Centre.
8 This figure even stood at around 90% up until 2005. Since then, biomass, which also includes biodiesel, is being increasingly used as fuel.
9 Just over 80% of the non-energy use in the total economy is accounted for by the manufacture of chemicals products. For more information, see eg H Mayer, Umweltökonomische Analysen im Bereich der Energie, Federal Statistical Office, EEA Online Publication, 2006 (available in German only).

A production function approach to modelling the supply effect of a permanent energy price shock

In production theory, energy is classified, depending on sector and degree of aggregation, as a factor of production and/or as output. While own production of electricity and heat is negligible in most economic sectors and energy can thus be regarded uniquely as a factor of production, energy sources are both inputs and outputs in the energy sector as well as in parts of the mining industry, depending on the degree of processing. Since heterogeneous products are usually not modelled in a macroeconomic framework, it makes sense to consider energy (understood as primary energy consumption) as an input factor only and adjust aggregate output for primary and other types of energy production. (Alternatively, one can consider only the imported part of primary energy consumption as an input factor.) This applies, in particular, to countries such as Germany which import the majority of their energy demand.

Output can be adjusted for energy components relatively simply if one looks not at the total economy, but at individual economic sectors – in this case, the industrial and transport sectors, which do not produce energy, barring any production for their own needs. Under these circumstances, the production technology can generally be construed as a function of the form $Y_t = f(K_t, L_t, E_t, A_t)$, where Y_t is output, K_t, L_t, E_t capital, labour and energy respectively and A_t technological progress.

In contrast to the standard production function, where the primary factors are capital and labour, Y_t cannot be represented here by an indicator of value added (ie GDP in a total-economy analysis), as this measurement concept, according to the national accounts, includes only costs or income incurred in connection with primary inputs, while costs relating to energy use, as well as the consumption of other intermediate inputs, are deducted from real gross output. Conceptually, the above production function is consistent with an output indicator which, in addition to value added, includes real expenditure on energy use.

The direct supply effect in the industrial and transport sectors is derived using a production structure which, in several respects, is more precise than the general form.[1] In order to reproduce central features of the neoclassical growth model (eg the existence of a steady-state equilibrium), the production function exhibits constant returns to scale and labour-augmenting technological progress. Furthermore, the production structure is assumed to be nested in the sense that, at a downstream stage, labour is combined with an intermediate product X_t which, at the upstream production stage, results from the combination of capital and energy. Its formula is

$$Y_t = g\left(X_t, A_t L_t\right)$$

1 Details of the theoretical model approach, econometric estimates and empirical results can be found in T A Knetsch and A Molzahn, Supply-side effects of strong energy price hikes in German industry and transportation, forthcoming Discussion Paper of the Deutsche Bundesbank's Research Centre.

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While, at the end product stage, no other assumptions have to be made regarding the functional form of the production technology, the volume and composition of the intermediate product (or capital-energy bundle) are determined using a so-called CES function with the following specification.

$$X_t = D\Big[(1-b)K_t^{-\rho} + bE_t^{-\rho}\Big]^{-\frac{1}{\rho}}$$

The substitutability between capital and energy is described using (partial) elasticity of substitution $\sigma = (1+\rho)^{-1}$. The production function is also characterised by the distribution parameter b and the scale factor D.

In the event of an unforeseen energy price shock which affects both the cost structure and cost-earnings relationship, the ability of firms to react is generally a function of time. Since it is assumed that firms cannot change the prices of the intermediate and final product, nominal wages are settled and physical capital stock is predetermined, the only adjustment strategy available to enterprises in the short term is to reduce their demand for energy. At the upstream stage, profit-maximising firms combine the factors in such a way as to use less energy per installed capital good, which in turn implies that, on the basis of the given stock of fixed assets, the volume of intermediate goods produced falls. Excluding the possibility of labour hoarding, there is a corresponding drop in demand for labour at the downstream stage, as the real wage is fixed by construction.

Based on the percentage rise in energy prices, the short-term volume effect on the supply of goods, including the impact of the resulting reduction in employment, can be approximated using the energy price elasticity ε of the end product, which takes the following form in this model.

$$\varepsilon = -\frac{b}{1+\rho}\left[\left(\frac{P_t^E}{Db}\right)^{\left(-\frac{\rho}{1+\rho}\right)} - b\right]^{-1}$$

It is interesting to note that the elasticity depends not only on production technology, but also, with the exception of the Cobb-Douglas production function ($\rho = 0$), on the real energy price level P_t^E, ie on the energy price relative to the price of the intermediate good. For plausible parameter values, it is *ceteris paribus* – in absolute terms – smaller, the more difficult it is to substitute capital for energy. By contrast, absolute elasticity increases in line with the weight of energy in the production process.

It should be noted in general that the results presented here are not based on the concept of a steady-state equilibrium, in which all factors of production have completely adjusted to the new price relationships.

Energy mix, by sector

Percentage shares

Item	1995	2000	2005	2007
Enterprises [1, 2]				
Petroleum	47.2	46.4	45.3	43.4
Gas	20.1	21.2	20.4	20.1
Coal and coal products	12.2	11.1	9.2	10.1
Renewable energy	0.2	0.4	3.1	4.6
Electricity and other sources of energy	20.3	21.0	22.0	21.8
Of which				
Manufacturing				
Petroleum	32.0	30.8	29.8	28.1
Gas	26.6	28.0	27.4	27.2
Coal and coal products	18.2	17.0	14.1	15.7
Renewable energy	0.3	0.4	3.2	3.7
Electricity and other sources of energy	23.0	23.7	25.4	25.3
Transport				
Petroleum	91.1	91.2	88.0	83.8
Gas	1.6	1.7	1.5	1.6
Coal and coal products	0.2	0.1	0.0	0.0
Renewable energy	0.1	0.6	4.0	8.6
Electricity and other sources of energy	7.0	6.5	6.5	6.1
Memo item				
Primary energy consumption of the economy [3]				
Petroleum	39.9	38.2	35.7	33.6
Natural gas, associated gas	19.6	20.7	22.3	22.3
Hard coal and lignite	26.6	24.8	23.5	25.7
Hydropower and wind energy	0.6	0.9	1.2	1.5
Nuclear energy	11.8	12.9	12.3	11.0
Other sources of energy [4]	1.6	2.6	4.9	5.9

1 Source: Federal Statistical Office. — **2** Excluding mining of energy sources and energy supply. — **3** Source: Working Group on Energy Balances. — **4** Including foreign trade balance for electricity.

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sectors of the economy, this is quite difficult to prove empirically.[10]

Effective energy price increase in the industrial and transport sectors

The starting point for assessing the short-term effect on the supply of goods in the economy is the effective energy price increase, estimated to have been 64% in the industrial sector and 75% in the transport sector over the 2004-08 period. Whereas, among industrial firms, the increase in the price of this factor of production during this period is quite comparable with the oil price shocks in the 1970s, carriers shouldered a considerably heavier cost burden over the period under review. Apart from the fact that the pronounced wage moderation of the past had made it possible to offset at least some of the additional energy costs internally, the extent and the length of the increases indicate that there may have been lagged and partial price pass-through, for which the empirical study adjusts.

Estimation of the overall supply effect

Assuming a given capital stock, ie excluding obsolescence, but with labour fully adjusted to a new quantity of output, model estimates show that the industrial sector could have reduced its supply of goods by a total of 3¾% between 2004 and 2008 owing to the additional cost burden imposed by that part of the energy price increase which is deemed permanent. Although at 2% the direct supply effect was much lower in the transport sector, it must also be noted for this sector that the aforementioned reduction in the supply

10 The multiplier effects are estimated using the impulse responses of a vector autoregression which models the value added of the three economic sectors under review using quarterly rates of change.

of industrial goods is associated with a reduction in the volume of transport services of around 2¼%. In the rest of the business sector, the reduced supply of industrial goods led to a loss in value added of around 1¼%. Taking these effects together, the strong rises in energy prices over the 2004-08 period dampened the growth of the overall economy's supply of goods by an estimated 1¼% throughout the period under review or by an average of ¼% per year.

Imputed reaction of labour demand

The calculations rest on the assumption of complete adjustment of labour input to the reduction in output caused by higher energy prices.[11] This is justifiable because it is the isolated effect of higher energy prices on the supply of goods which is at the centre of interest here. Therefore, impacts emanating from a weaker or lagged reaction of labour which cushion the negative impact on firms' labour demand over the short term through real wage reductions are neglected. However, one must not overlook the fact that it is especially these responses by labour market agents which help determine the overall adjustment record from the point of view of macroeconomic stability. If, for instance, the relevant adjustments in real wages meant that it was not necessary to reduce labour demand, the energy price rises would have had a much softer output effect.

Interpretation of the supply effect in a cyclical context

When interpreting the model results, two things should be borne in mind. First, the calculations are fraught with a great deal of estimation uncertainty. Second, the outcome is merely a computational quantity which influences the supply side of the economy under the conditions of average capacity utilisation; however, it is not necessarily reflected in the actual level of economic activity. The energy price increases in the previous years occurred during a phase of pronounced global economic expansion which promoted demand for German goods and services and led to perceptible economic growth in Germany.

The discovery of a dampening effect on the supply in the economy is therefore more likely to be consistent with the observation that firms sought to cover the brisk demand to a greater extent through primarily temporary measures to boost production. One indicator

Cumulative supply effects of the permanent energy price shock, 2004-08

Sector	Supply effect	Direct	Indirect	Sectoral contribution to overall effect in percentage points
	Percentage of value added			
Industrial	– 3.8	– 3.8	–	– 0.8
Transport	– 4.3	– 2.0	– 2.3	– 0.1
Rest of business sector	– 1.1	–	– 1.1	– 0.4
	Percentage of GDP			
Total economy	– 1¼	.	.	.

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11 The OECD, for instance, used a model framework without adjusting labour to estimate the oil price effects on productive potential. See OECD (2008), Economic Outlook 83, Chapter 3, pp 209-230.

is that capacity utilisation in the industrial sector stood at an extraordinarily high level for around two years up until mid-2008 and that the backlog of orders ballooned. Another fact is that, during the boom years, firms were very active in taking advantage of the new flexibility in the use of labour input and of the option to lease machinery, vehicles and other equipment, which indicates that they were hesitant to some degree about adjusting their own production capacity to past demand. Compared to the hypothetical scenario without supply-side effects, actual total capacity utilisation was therefore higher owing to the dynamic growth of the world economy.

Longer-term growth effects and the role of economic and wage-setting policy

Longer-term adjustment strategies…

The negative supply effects explained above do not necessarily have to be permanent. One of the keys to answering the question of whether an economy can sustain a permanent increase in the price of energy consumption over the longer term without sacrificing potential output growth is the ability to adapt the product range to changes in the demand structure; the other lies in possibilities of providing sustained cost relief. This can be accomplished by changing over to energy sources that are better priced over the long term. In addition, either technology can be used to enhance efficiency or energy consumption can be substituted by other factors of production, thereby reducing the energy intensity. In the 1970s and 1980s, the industrial sector succeeded in reducing the absolute use of energy despite a distinct increase in the productive capital stock. Since the mid-1990s – as was the case in the transport sector from 1970 throughout the observation period – there has been no perceptible reduction in the amount of energy used per unit of capital. In turn, though, the industrial and transport sectors' energy mix has improved over the past ten years. There was a moderate reduction in the use of fossil fuels such as crude oil, natural gas and coal, whereas the percentage share accounted for by renewable sources of energy after 1995 made a small, but no longer negligible, contribution.

… influenced by technological progress and investment climate

The increased use of hydropower, wind energy and solar energy, as well as biomass, exemplify the fact that new types of energy extraction can find their place in the commercial energy mix. Further research into renewable sources of energy, as well as the development of resource-saving capital goods, are necessary conditions for providing firms with new technologies as alternatives to the status quo. However, for a changeover to actually occur, not only must the investment be profitable in and of itself, but sufficient funding must also be available. Also, it must be noted that the energy balance of a production facility is rarely seen in isolation but is instead important as a sub-element in the overall context of a decision as to whether or not to invest. Since replacement purchases and capacity expansion are usually associated with implementing higher technological standards, a generally favourable investment climate is key to the rapid proliferation of these standards and thus to the quick reduction of commercial energy consumption.

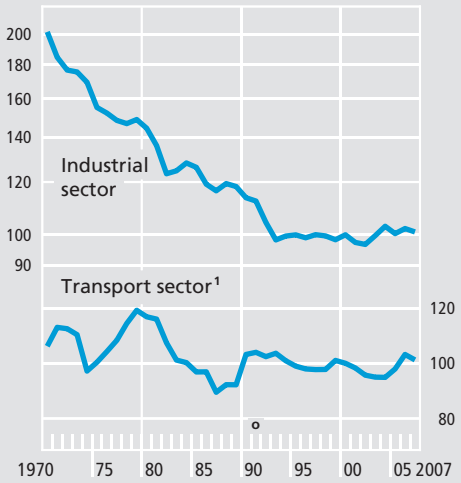
Key role played by wage policy

In this context, wage-setting policy assumes a key role for several reasons. What must be avoided is a situation in which increased costs of living lead to compensation in terms of wages, even if consumer prices go up in the wake of higher energy prices. However, even stable real labour costs mean a shift in the distribution of income among the primary factors of production if energy costs increase. This is not the only issue that needs to be taken into consideration when setting employment-oriented wage policy. In addition, although the increased use of capital to save energy can reduce the energy intensity, and thus the real income losses caused by the terms of trade, this diversion of capital usually detracts from the possibility of otherwise improving labour productivity. A similar effect ensues if an energy price shock virtually devalues part of the existing physical capital stock, thereby causing it to exit the production process prematurely.

Experience from the 1970s and 1980s shows that wage-setting policy which does not take due account of these factors not only creates second-round effects on inflation and harbours the risk of an expectation-driven wage-price spiral but also entails adverse output effects on top of the primary growth losses through the energy price rise. At the time, high wage growth, through sharply rising unit wage costs, had imposed an additional severe cost burden on firms which subsequently resulted in reduced capital formation, flatter medium-term growth and higher unemployment.[12] In the 2004-08 period, by contrast, the underlying trend towards wage moderation that had taken hold in the mid-

Energy intensity* in the industrial and transport sectors

2000 = 100, log scale



* Energy use as a percentage of real gross fixed assets, which also contain assets used by this sector in the form of operating leases. — 1 Including communication. — o From 1991, data for Germany as a whole, chain-linked with west German data.

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1990s continued, despite the considerable increase in consumer energy prices. German firms' sales prices for industrial goods and transport services remained virtually unchanged, thereby strengthening their relative position in an increasingly globalised market. Moreover, there was enough scope at this stage to grow returns on non-financial capital, causing Germany to become increasingly attractive as a production location.[13]

Task of monetary policy

In an environment of higher energy prices, monetary policy needs to ensure that the adjustment processes and any potential internal

12 See Deutsche Bundesbank, Factor prices, employment and capital stock in Germany: results of a simulation study, Monthly Report, July 2001, pp 49-61.
13 See Deutsche Bundesbank, Investment activity in Germany under the influence of technological change and competition among production locations, Monthly Report, January 2007, pp 17-30.

conflict over income distribution do not dampen the outlook for longer-term price developments. In this context, it is key that inflation expectations remain firmly anchored. Monetary policy, however, must also give due consideration to negative supply effects in the real economy, as they reduce the scope for unfettered economic growth. Experience from the 1970s shows that, at least in this regard, there is undoubtedly the danger of an overly optimistic view of potential output.[14]

Better economic starting position than in 1970s

Owing to the generally favourable price climate and the basic wage trend, there is currently a very good chance that the German economy will weather the rise in energy prices without protracted damage to potential output growth. The welfare losses would then be initially confined to the transfer of real income and the capital depreciation effect that is directly associated with the relative factor price shock in the form of higher prices for imported energy.

In a global view, it is also significant that this phenomenon represents a broadly based income distribution effect that is virtually worldwide. Should German exporters succeed, as in the past, in acquiring a larger-than-average share in the generally large demand for high-end capital and consumer goods among energy commodity exporters, the negative implications for the economy's income level in Germany would be confined to a reasonable extent. Another positive factor is that, in Germany, not only is there a broad range of new environmental technologies on offer, but these have already become quite advanced in terms of practical use. In this area, the German economy is likewise internationally very competitive.

14 For more information see A Beyer, V Gaspar, C Gerberding and O Issing, Opting out of the great inflation: German monetary policy after the breakdown of Bretton Woods, Deutsche Bundesbank Research Centre, Discussion Paper 12/2009.