Gasoline demand is price-inelastic

Both the temporary impact of price rises and the muted response of falls soon converge towards equilibrium

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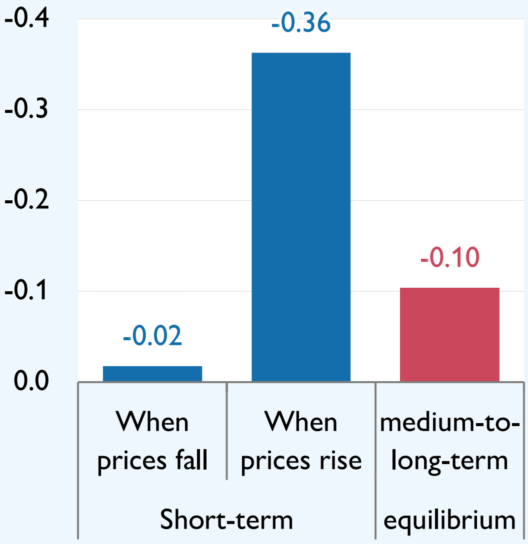
Summary

Amid persistently high gasoline prices in Japan, six ruling and opposition parties have agreed to abolish the provisional gasoline tax rate within 2025, intensifying the debate. The abolition of the provisional tax rate, which accounts for around 15% of the retail prices of regular gasoline, will have a significant impact.

The impact of price changes on demand is often examined through the price elasticity coefficient—the percentage change in demand resulting from a 1% change in the prices. Energy, possessing a strong character as a necessity, is considered inelastic with respect to price, and the absolute value of its price elasticity coefficient is small. The price elasticity of demand for gasoline, estimated based on the orthodox Koyck lag model, shows a short-term elasticity of −0.08 and a long-term elasticity of −0.10.

To escape the implicit constraint that demand in long-term is more price elastic than in short-term and considering the time-series characteristics of the target data, gasoline demand was formulated as an error correction model. The price elasticity coefficient obtained for the medium-to-long-term equilibrium state using this calculation method is −0.10, which is almost identical to the long-term elasticity coefficient derived from the orthodox calculation method. However, the short-term price elasticity coefficients differ significantly: when prices fall, the elasticity is only −0.02, whereas when prices rise, it reaches −0.36 (Figure 1). That is, even when gasoline becomes cheaper, there is scarcely any immediate upward impact in demand; conversely, price rises induce a certain degree of conservation behaviour. However, whether prices rise or fall, consumers' short-term behaviour patterns do not persist; equilibrium is restored before long.

Figure 1 | Price elasticity coefficients of demand for gasoline



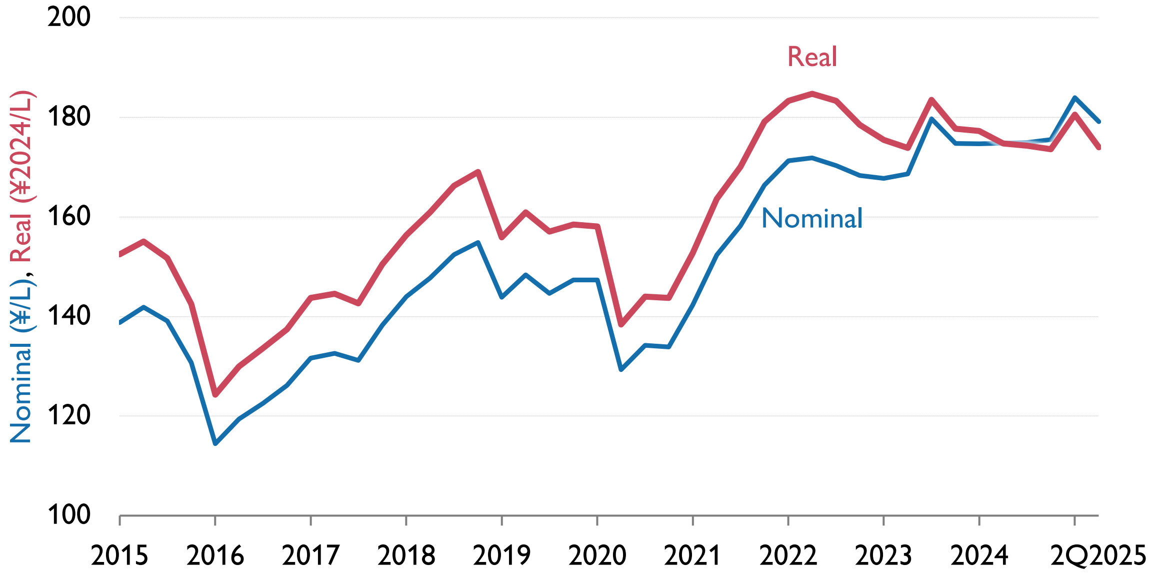
As indicated by the price elasticity coefficient in the medium-to-long-term equilibrium, demand for gasoline is considerably inelastic with respect to the price. Nevertheless, the subsidy (averaging ¥19.5/L) that has continued since 2022 is estimated to have increased gasoline demand, and consequently carbon dioxide emissions from its combustion, by 1.1%. Considering measures to offset this upward impact, the side effects of price intervention are far greater than perceived. Should the provisional tax rate of ¥25.1/L on gasoline be abolished entirely, the impact would exceed that of the subsidy. Unless we carefully consider not only immediate concerns but also the greater burdens that lie ahead, matters may well become increasingly difficult.

Keywords: gasoline, price elasticity coefficient, carbon dioxide emissions

Persistently high gasoline prices and mounting debate

Gasoline prices in Japan remain high (Figure 2). Whilst the real prices of regular[1] gasoline adjusted for general prices have fallen slightly compared to 2023, the nominal prices—the figures displayed at service stations—remain near record highs.

Figure 2 | Regular gasoline retail prices



Note: Real prices are deflated using the gross domestic product deflator.
Sources: Calculated from the Ministry of Economy, Trade and Industry 'Petroleum Product Price Survey' and the Cabinet Office 'National Accounts'

Under these circumstances, following the results of the 27th House of Councillors election in July 2025, six ruling and opposition parties agreed to abolish the 'provisional tax rate'[2] on gasoline taxes (gasoline tax and local gasoline tax) within 2025, intensifying discussions that had begun before the election. While the impact depends on the balance with the subsidies provided for major fuel oils, the complete abolition of the provisional tax rate, which accounts for approximately 15% of the retail prices of gasoline, would have a significant effect (Figure 3).

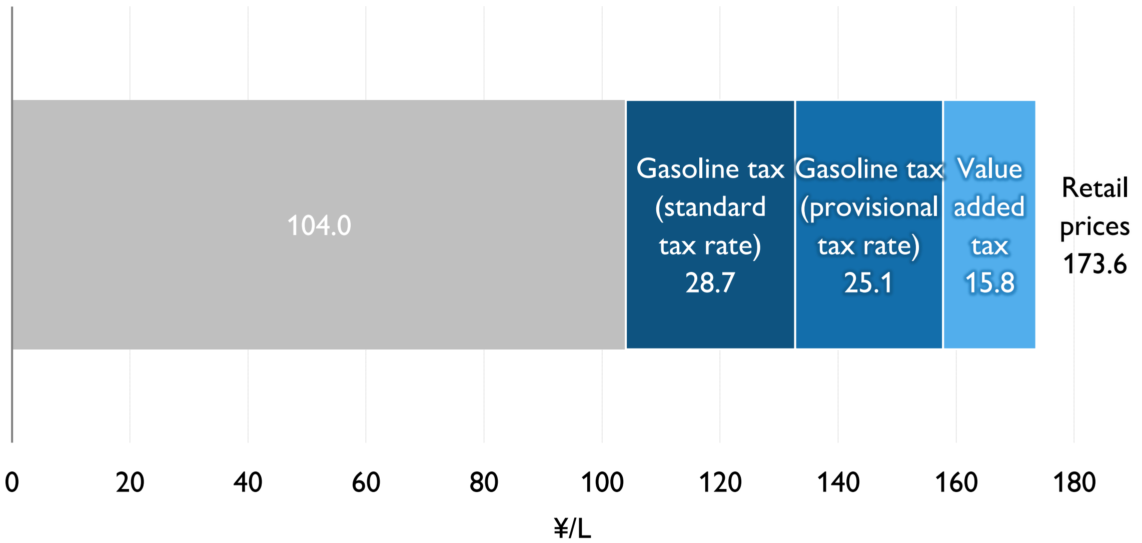
Should high gasoline prices ease, benefits for motorists—whether households or businesses—are certain to be felt. On the fiscal front, however, the challenge lies in how to compensate for the estimated ¥1 trillion reduction in tax revenue, with ruling and opposition parties divided on the issue. Furthermore, it must be noted that concerns exist that the government artificially lowering the prices through the abolition of the provisional tax rate, which has been in place for half a century, (or the subsidy) could generate undesirable announcement effects regarding climate change and resource conservation. Moreover, as a direct consequence, stimulating gasoline demand through price reductions will inevitably lead to an increase in carbon dioxide emissions associated with its combustion.

To what extent, then, do changes in gasoline prices affect the demand?

[1] The same shall apply hereinafter.

[2] The amount increased from the standard tax rate stipulated by the Gasoline Tax Act and the Local Gasoline Tax Act under the Special Taxation Measures Act: ¥25.1/L (¥24.3/L for Gasoline Tax, ¥0.8/L for Local Gasoline Tax)

Figure 3 | Cost structure of retail gasoline prices [July 2025]



Sources: Calculated from the Ministry of Economy, Trade and Industry 'Petroleum Product Price Survey'

Under orthodox valuation method, a 1% change in gasoline prices leads to a 0.1% change in demand over the long term

The impact of price changes on demand is often examined through the price elasticity coefficient—the percentage change in demand quantity in response to a 1% change in the prices. For necessities, it is difficult to curb demand sufficiently to offset or substantially mitigate the impact of increased payments resulting from the price rises. Consequently, necessities typically exhibit a low absolute value for price elasticity coefficient (being inelastic), meaning consumers perceive a significant burden from price increases. Furthermore, energy sources such as gasoline generally possess strong characteristics of necessities and are therefore considered inelastic to the prices—hence they are also regarded as excellent targets for taxation.

The orthodox method for calculating (constant) price elasticity efficient involves regression analysis using the natural logarithm of demand quantity as the dependent variable, alongside the natural logarithm of price, the natural logarithm of the dependent variable from the previous period (the Koyck lag), and other relevant indicators as independent variables. That is,

$$\ln Demand = \beta_0 + \beta_p \ln Price + \cdots + \beta_1 \ln Demand_{-1} + Error$$

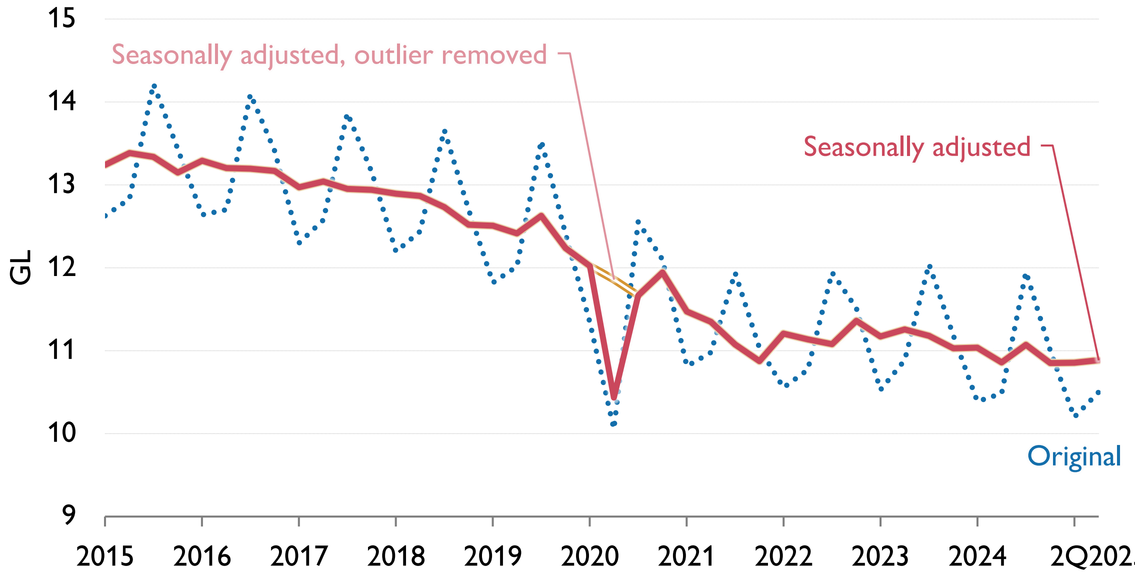
where the price elasticity coefficients are obtained from actual data. Specifically, β_p is the short-term price elasticity, representing the degree of impact on demand during the period when the prices changed. $\beta_p / (1-\beta_1)$ is the long-term price elasticity, representing the ultimate degree of impact on demand if the changed prices were to be maintained[3].

This chapter shall follow this approach. We used domestic gasoline sales (Ministry of Economy, Trade and Industry 'Resource and Energy Statistics') as demand volume, and realised retail gasoline prices (Ministry of Economy, Trade and Industry 'Petroleum Product Price Survey') deflated by the gross domestic product (GDP) deflator (Cabinet Office 'National Accounts') as the price. Furthermore, other independent variables included the average of real GDP (Cabinet Office 'National Accounts') for the current and previous periods, and a time trend adopted as a proxy variable for the effects of trend changes such as regulatory fuel efficiency improvements, demographic shifts, and the progression of car-free lifestyles. The frequency was set to quarterly due to data constraints and seasonally adjusted series were used

[3] $|\beta_1|$ must be less than 1.

for gasoline demand, GDP, and GDP deflator[4] (Figure 4). The target period was approximately 10 years, from the first quarter of 2015 (1Q2015) to the current 2Q2025.

Figure 4 | Domestic gasoline sales



Source: Calculated from the Ministry of Economy, Trade and Industry 'Resource and Energy Statistics'

The estimated equation is as follows, with the *t*-value in brackets:

$$\ln \mathit{Gasoline\ demand} = -4.112 + 1.334 \times \ln\left((\mathit{Real\ GDP} + \mathit{Real\ GDP}_{-1})/2\right)$$
(−1.83) (5.24)
$$-0.08116 \times \ln \mathit{Real\ retail\ gasoline\ price} - 0.005062 \times \mathit{Time\ trend}$$
(−2.76) (−5.88)
$$+0.2209 \times \ln \mathit{Gasoline\ demand}_{-1}. \qquad \text{(Equation 1)}$$
(1.70)

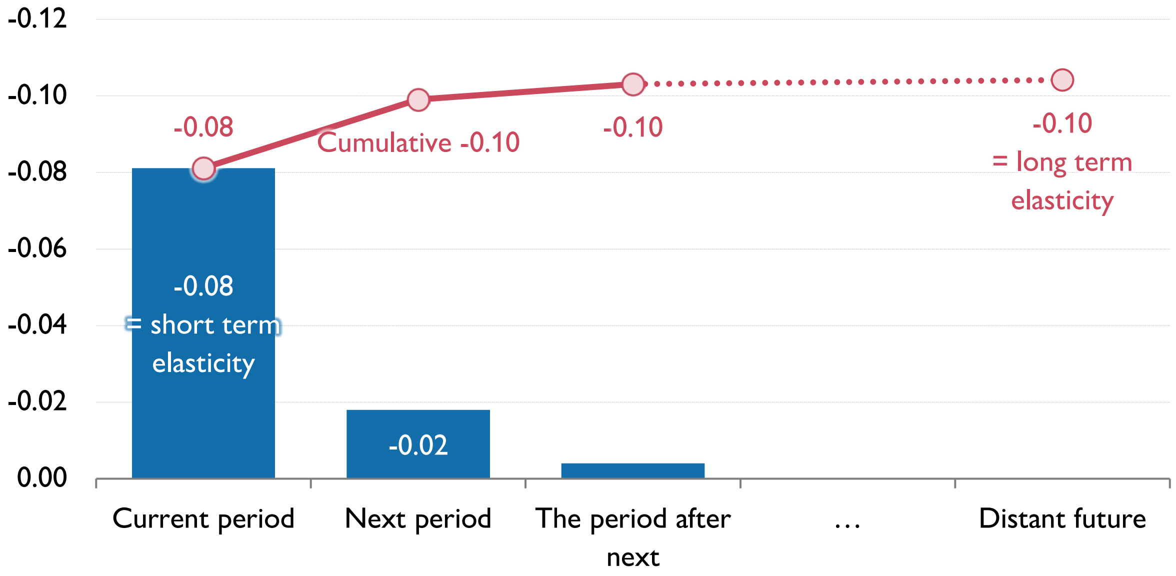
$R^2 = 0.982$, 1Q2015–2Q2025

The resulting price elasticity coefficients of demand for gasoline are −0.08 for the short term and −0.10[5] for the long term (Figure 5). That is, a 10% reduction in real retail gasoline prices increases gasoline demand by 0.8% in the current period and by 1.0% in the distant future—though it approaches that level considerably in the following period.

[4] During the second quarter of 2020 (2Q2020), as part of measures to prevent the spread of COVID-19, strong encouragement was given to curb people's movement, specifically to refrain from non-essential and non-urgent outings. Economic and social activities faced extremely severe constraints, and the resulting sharp decline in passenger transport significantly depressed gasoline demand in particular. Whilst it would have been possible to handle such a 2Q2020 period using a dummy variable in regression analysis—effectively excluding the data from estimation—, the approach adopted was to correct for the outlier, considering the analysis using residuals described later. Specifically, the effect of the additive outlier (AO2020.2) detected during the seasonal adjustment process using the US Census Bureau's X-13ARIMA-SEATS Seasonal Adjustment Program was removed from the seasonally adjusted series. This measure was applied to gasoline demand, real GDP and nominal GDP.

[5] $= -0.08116 \div (1 - 0.2209)$

Figure 5 | Price elasticity coefficients of demand for gasoline estimated using orthodox calculation method



Note: Estimated using a model incorporating the Koyck lag as an independent variable

Price effects—delving into the relationship between short-term and long-term

Is the long term always more elastic than the short term?

The short-term price elasticity of demand for gasoline being merely −0.08 may strike supply-side stakeholders as an underestimate. One factor contributing to this discrepancy with perceived reality could be whether the focus is on nationwide demand or on one's own sales volume, which is also influenced by competition with rival outlets and companies.

However, simultaneously, one may also cite the potential for bias stemming from the formulation in regression analysis. Employing a Koyck lag model, a type of distributed lag model, implicitly assumes that the cumulative impact of prices increases over time as the sum of a geometric series, as depicted in Figure 5[6]. However, in reality, this pattern may be a reasonable approximation in some cases, but not in others. Therefore, this chapter will estimate short-term price elasticity independently of their medium-to-long-term counterparts.

The simplest method for this purpose is to adopt not only price in the current period but also lagged prices as independent variables, whilst omitting the Koyck lag. The estimation results when adopting the previous period's real retail gasoline prices are as follows[7]:

[6] Assume that the coefficient β_1 of the Koyck lag term is positive.

[7] By not using a distributed lag model, multicollinearity and insufficient degrees of freedom may exert a non-negligible influence in some cases. Fortunately, however, the variance inflation factor (VIF) in Equation 2, at a maximum of 6.3, suggests multicollinearity but does not appear to be severe.

$$\ln \textit{Gasoline demand} = \underset{(-2.35)}{-5.396} \underset{(9.68)}{+1.685} \times \ln\left((\textit{Real GDP} + \textit{Real GDP}_{-1})/2\right)$$
$$\underset{(-3.69)}{-0.1507} \times \ln \textit{Real retail gasoline price}$$
$$\underset{(1.52)}{+0.05373} \times \ln \textit{Real retail gasoline price}_{-1}$$
$$\underset{(-26.9)}{-0.006500} \times \textit{Time trend}. \qquad \text{(Equation 2)}$$
$R^2 = 0.981$, 1Q2015–2Q2025

In this case, while the short-term price elasticity is −0.15, the long-term price elasticity is −0.10[8], being less elastic than the short term due to a rebound effect occurring in the subsequent period. When prices rise, consumers may react excessively, causing demand to initially fall; however, demand subsequently recovers as consumers gradually adapt—though, of course, it does not return to its original level. The combination of short-term and long-term price elasticities described above can be interpreted as representing this pattern of demand.

More accurate estimates—error correction model

Although not previously mentioned, the natural logarithms of gasoline demand, real GDP and real gasoline retail prices each represent first-order integrated processes. Simultaneously, they are estimated to be in a cointegration relationship[9]. Consequently, Equation 3 linking them can be interpreted as representing a medium-to-long-term equilibrium relationship. The coefficient for real gasoline retail price indicates that the price elasticity in the equilibrium state—that is, over the medium to long term—is −0.10. This value is almost identical to the long-term price elasticity derived from the Koyck lag model in the previous chapter.

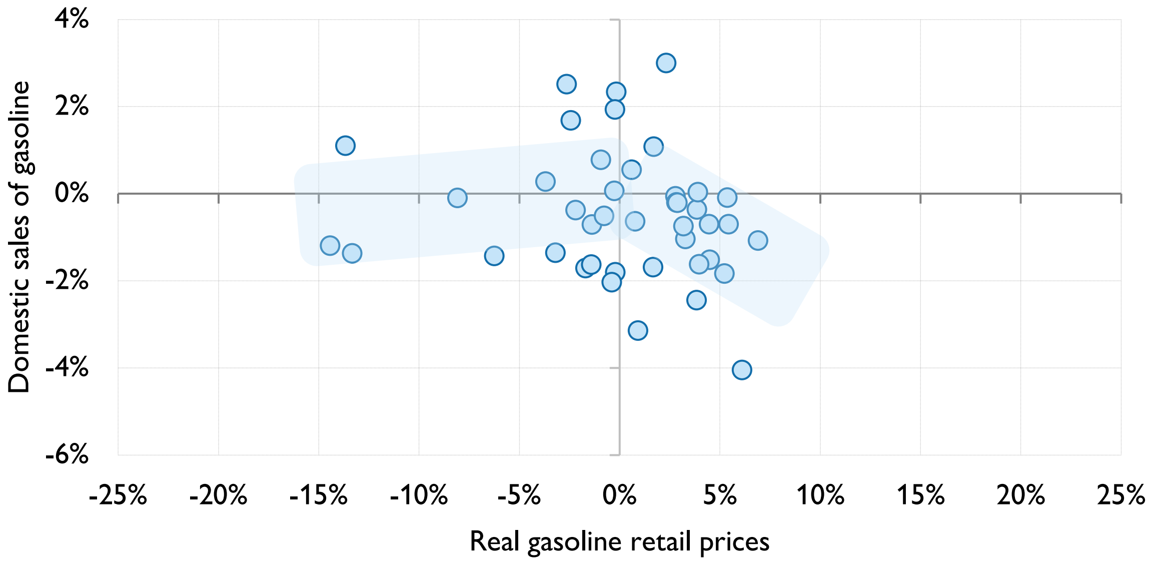
$$\ln \textit{Gasoline demand} = \underset{(-1.97)}{-4.499} \underset{(9.43)}{+1.653} \times \ln\left((\textit{Real GDP} + \textit{Real GDP}_{-1})/2\right)$$
$$\underset{(-3.86)}{-0.1037} \times \ln \textit{Real gasoline retail price}$$
$$\underset{(-26.5)}{-0.006466} \times \textit{Time trend}. \qquad \text{(Equation 3)}$$
$R^2 = 0.980$, 1Q2015–2Q2025

If gasoline demand, real GDP and real gasoline retail prices are cointegrated, then their short-term relationship can be appropriately expressed using an error correction model comprising the respective differences in the previous period (Δ) and the previous period's residuals from Equation 3 as the error correction term. Moreover, as suggested by Figure 6, which plots the previous-period change in real gasoline retail prices and demand for gasoline in a straightforward manner, consumers' short-term behaviour patterns may differ when the prices rise and fall. Taking these factors into account, the formulation was adjusted, and regression analysis was performed.

8 = −0.1507 + 0.05373

9 By the Augmented Dickey-Fuller (ADF) test for each series and the residuals of Equation 3.

Figure 6 | Real gasoline prices and demand for gasoline



Note: Quarter-on-quarter, logarithmic change rates

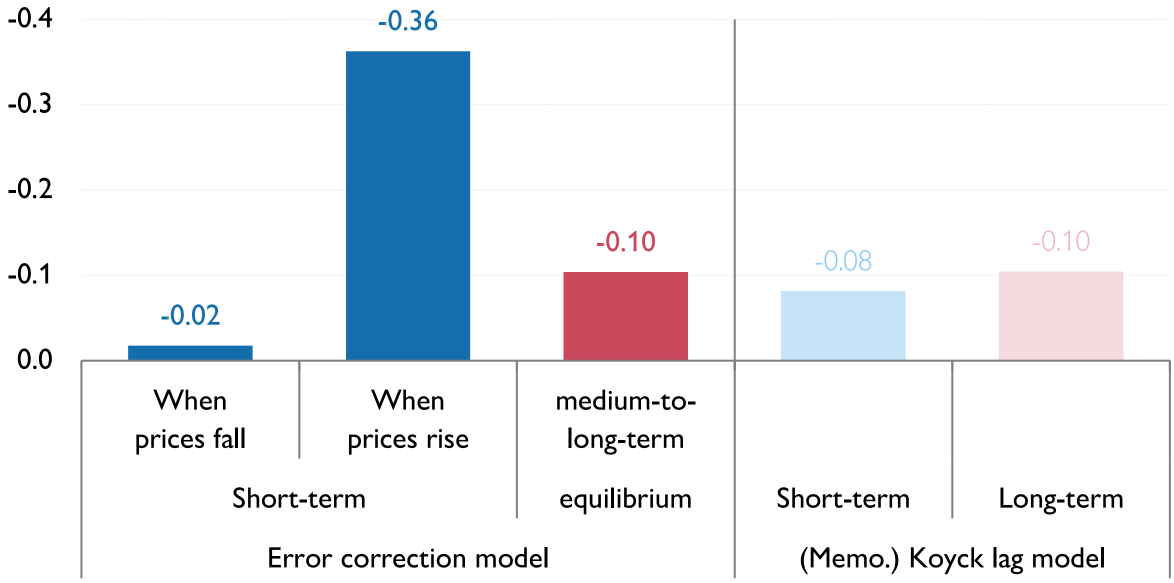
$$
\begin{aligned}
\Delta \ln \mathit{Gasoline\ demand} = {} & 1.157 \times \Delta \ln \left((\mathit{Real\ GDP} + \mathit{Real\ GDP}_{-1})/2 \right) \\
& (3.42) \\
& -0.01757 \times \Delta \ln \mathit{Real\ gasoline\ retail\ price} \\
& (-0.42) \\
& -0.3450 \times \mathit{Price\ rise\ dummy} \times \Delta \ln \mathit{Real\ gasoline\ retail\ price} \\
& (-5.07) \\
& -0.9124 \times \mathit{Error\ correction\ term}. \qquad \text{(Equation 4)} \\
& (-6.39)
\end{aligned}
$$

$R^2 = 0.637$, 2Q2015–2Q2025

Equation 4 shows that the short-term price elasticity of demand for gasoline is only −0.02 when the prices fall, whereas it reaches −0.36[10] when the prices rise (Figure 7). Even when gasoline becomes cheaper, there is scarcely any immediate upward impact in demand, whereas price rises induce a certain degree of saving behaviour. However, in either case, these short-term behavioural patterns do not persist; demand eventually settles into the equilibrium state represented by Equation 3. The time taken to converge is not particularly long, as the coefficient of the error correction term is −0.91, which is quite close to −1.

[10] = −0.01757 + −0.3450

Figure 7 | Price elasticity coefficients of demand for gasoline



For reference, although the Koyck lag model estimated that price elasticity coefficients could differ when gasoline prices fall and rise, there was little difference between the two situations.

Can the side effects of the gasoline subsidy be ignored?

The subsidy scheme for gasoline and other fuel oils, established as a 'temporary, emergency measure to mitigate sudden price shocks and prevent soaring fuel oil prices from becoming a burden on the economic recovery from COVID-19', was launched in January 2022. Subsequently, the scheme has undergone multiple extensions and structural modifications, with the subsidy payments now continuing for over three and a half years. Much has been said about the significant fiscal burden this entails[11]. In contrast, quantitative discussion regarding the upward impact on gasoline demand resulting from price suppression via the subsidy has been scarce[12]. Therefore, this section evaluates the subsidy's impact using the price elasticity of demand for gasoline obtained in the previous chapter.

From 1Q2022 to 2Q2025, the average retail price of gasoline was ¥174.0/L, with subsidies amounting to ¥19.5/L. This indicates that the subsidy suppressed retail prices of gasoline by 10.1%[13]. Furthermore, the GDP deflator decreased by 0.2%[14], resulting in an estimated 9.9% suppression of real gasoline prices. In a medium-to-long-term equilibrium state, a 1% reduction in real gasoline prices boost demand by around 0.1%. Consequently, the subsidy is estimated to have increased gasoline demand, and consequently carbon dioxide emissions from its combustion, by 1.1%.

An increase in carbon dioxide emissions of just over 1% might be considered a negligible side effect. However, in a situation where reductions in carbon dioxide emissions through desirable measures such as the introduction of energy efficient technologies and the utilisation of low-carbon energy sources are not progressing as intended, it is hardly something to be welcomed.

Moreover, even seemingly minor upward impact upon first glance cannot be dismissed as insignificant when considering measures to offset them. In Japan, improving vehicle fuel efficiency is positioned as a key means to reduce carbon

[11] The cumulative budget for support measures concerning fuel oil prices amounts to ¥8.1719 trillion (https://nenryo-teigakuhikisage.go.jp/assets/pdf/support_measures.pdf, accessed on 2 September 2025).

[12] Increased demand is generally considered favourable for many goods and services, but this is not typically the case for fossil fuels.

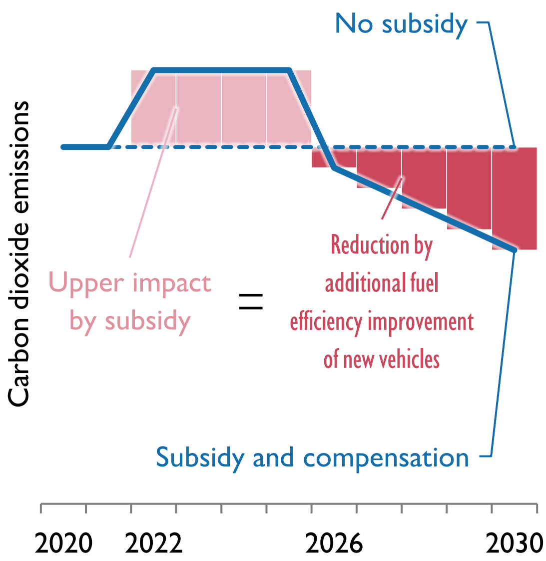
[13] The subsidy is assumed to be fully reflected in the retail prices.

[14] The impact of changes in gasoline prices on the prices of other goods and services is disregarded.

dioxide emissions from automobiles. Let us therefore consider offsetting the upward impact in carbon dioxide emissions caused by the subsidy through additional improvements in new vehicle fuel efficiency. Suppose the subsidy causes a 1.1% increase in carbon dioxide emissions over four years (2022–2025). Furthermore, suppose this cumulative increase is offset by 2030, in line with the earliest target under the Paris Agreement[15]. To achieve this, the fuel efficiency of new vehicles sold over the subsequent five years from 2026 would be further improved[16].

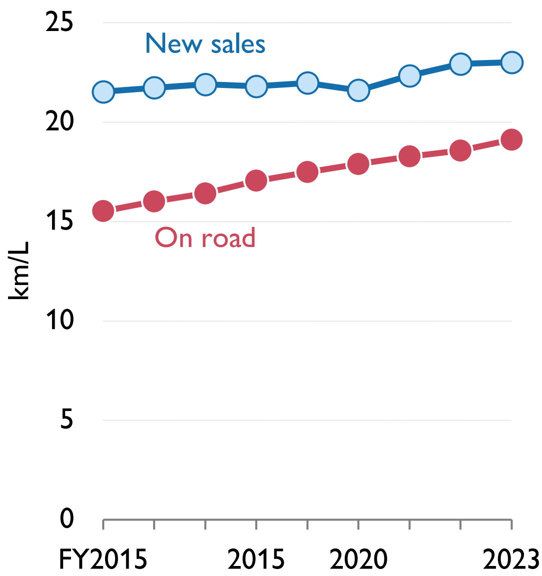
For the sake of simplification, each series determining gasoline demand (carbon dioxide emissions) is assumed to be in a steady state, excluding the impact of the subsidy and additional improvements in new car fuel efficiency (Figure 8). Assuming that vehicles aged between one and five years each account for 6% of the total fleet[17], the required additional improvement rate for new car fuel efficiency would reach 5.1%[18, 19]. In reality, gasoline demand (carbon dioxide emissions) exhibits a trend of gradual decline (Figure 4) due to factors such as regulatory improvements in vehicle fuel efficiency (Figure 9). To achieve the specified reduction target amidst a shrinking base, the required additional improvements in new vehicle fuel efficiency would need to be even greater than the value indicated above.

Figure 8 | Illustration of carbon dioxide emissions reduction through additional improvements in new vehicle fuel efficiency



Note: Additional improvements to new vehicle fuel efficiency shall be implemented such that the cumulative increase in carbon dioxide emissions attributable to the subsidy is offset by the cumulative reduction achieved through these improvements.

Figure 9 | Fuel efficiency of gasoline-fuelled passenger cars



Source: The Institute of Energy Economics, Japan 'EDMC Handbook of Japan's & World Energy & Economic Statistics'

[15] The Nationally Determined Contributions (NDCs) under the Paris Agreement set reduction targets for greenhouse gas emissions by the FY2030. However, in terms of climate change mitigation, cumulative emissions are more significant than emissions in any specific year.

[16] Measures to improve vehicle fuel efficiency (catalogue values) are difficult to implement for vehicles sold in the past. The possibility of implementing measures lies with newly sold vehicles. The available approaches are enhancing the performance of individual models and increasing the sales ratio of fuel-efficient vehicles. It should be noted that actual model changes for vehicles require a considerable amount of time.

[17] Based on passenger cars (Japan Automobile Manufacturers Association 'The Japanese Automobile Industry').

[18] $= (4 \times 1.1\%) \div (5 \times (5 + 1) \div 2 \times 6 - 4 \times 1.1\%)$

[19] On the other hand, if this can be achieved, from 2031 onwards, the cumulative reduction in carbon dioxide emissions from the additional improvements in new vehicle fuel efficiency will yield a surplus exceeding the cumulative upward impact from the subsidy.

Gasoline demand is inelastic with respect to price, but…

Given gasoline's status as an essential goods, its demand is considerably inelastic to price. Nevertheless, the subsidy exerts a far greater influence than commonly perceived. Should the provisional tax rate of ¥25.1/L be abolished entirely, the resulting impact would surpass that of the subsidy (averaging ¥19.5/L). Unless we carefully consider not only immediate concerns but also the greater burdens that lie ahead, matters may well become increasingly difficult.

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