# An Ethanol Blend Wall Shift is Prone to Increase Petroleum Gasoline Demand

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***Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Corpus Christi, TX, February 5-8, 2011***

A recent article by Zhang et al. developed the economic theory underlying the current U.S. regulation restricting the percentage of ethanol fuel allowed in conventional vehicles; popularly termed the “blend wall.” Regulations required no more than 10% ethanol, *E10*, be used in fueling U.S. conventional non-flex-fueled vehicles. On October 13th, 2010, EPA partially granted Growth Energy’s waiver request to increase the blend wall from 10% to 15% on 2007 or newer vehicles. Any blends higher than 15% require a flex-fuel vehicle capable of running on higher ethanol/gasoline blends. This includes the current *E85* blend containing 85% ethanol and emerging mid-range blends, *E30* and *E40*, with 30% and 40% ethanol, respectively. As summarized by Zhang, et al., when the U.S. average ethanol blend approaches or exceeds the blend wall, further ethanol supply will be channeled into higher blends. Currently, this is predominantly *E85*. In their article, Zhang et al. derive the comparative statics associated with shifting the blend wall, $\gamma$, where $\gamma$ is the fraction of ethanol incorporated into the intermediate ethanol fuel, $E\gamma$ ($0.10 \leq \gamma \leq 0.20$). Their results, summarized in Table 1, yield the theoretical directions of price and quantity movements in response to a blend wall shift. Specifically, a positive shift in the blend wall, $\gamma$, will increase the prices of ethanol, $p_e$, and *E85*, $p_{85}$, increase the quantities of ethanol, $Q_e$, and $E\gamma$, and increase the amount of total ethanol used in blending $E\gamma$,$Q_\gamma^e$, While, the price of $E\gamma$, $p_\gamma$, and quantity of *E85* along with quantity of ethanol, $Q_{85}^e$, and petroleum gasoline, $Q_{85}^g$, used in blending E85 will respond in the opposite direction . These unambiguous results are in contrast to indeterminate results for a positive blend wall shift, $\gamma$, on petroleum gasoline used for $E\gamma$, $Q_\gamma^g$ and the total petroleum gasoline consumption, $Q_G$.

In terms of policy analysis, a major shortcoming of this comparative statics analysis is failure to determine the magnitude of the responsiveness of prices and quantities, and in the important case of total petroleum gasoline consumption, even its direction. Depending on how responsive *Eγ* is to a blend wall shift, *γ*, and the ratio of gasoline use for *E85* relative to *Eγ*, total petroleum gasoline consumption may increase or decrease with a positive shift in the blend wall.

Theoretically, the total effect of a blend wall shift on the total petroleum gasoline consumption could be explained by decomposing the effect into substitution and expansion effects. For the substitution effect, given the technological ability to substitute ethanol for petroleum gasoline in *Eγ*, an increase in the blend wall, γ, holding the level of *Eγ* constant at $E\gamma^0$, always yields a negative effect on the gasoline petroleum consumption, $\partial \mathrm{Q_G} / \partial \gamma|_{\mathrm{d}E\gamma=0} < 0$ . Thus, with no expansion effect, the total effect would correspond to the negative substitution effect. With a zero expansion effect, the relaxation of blend wall will result in more ethanol consumptions. This will then enhance energy security with less dependence on foreign petroleum gasoline consumption. However, a positive expansion effect might exist. Depending on the magnitude and direction of both the substitution and expansion effects, an anomaly occurs when the positive expansion effect offsets the negative substitution effects. A relaxation of the blend wall would then yield an increase in petroleum gasoline consumption (Zhang et al.).

As a companion article of Zhang el al., the objective of this paper is to provide the magnitudes of price and quantity responsiveness, and in particular determine the likely direction and magnitude of total petroleum gasoline consumption from a positive shift in the blend wall. Based on published elasticities and other parameter values, Monte Carlo analysis results measuring the direction and magnitude of a blend wall shift are presented. Such direction-magnitude determination is of major energy policy importance in the analysis of alternative policies to wean the US from its addiction to foreign petroleum gasoline. If the waiver does little toward such weaning, then its benefits are questionable.

**Ethanol Industry Perspective**

The ethanol industry advocates an increase in the ethanol blend level for all conventional vehicles. They state this increase is necessary to avoid two major problems created by the current blend wall. First, the blend wall restricts the ability to achieve the 36 billion gallons of renewable fuels set in the 2007 Energy Bill under the Renewable Fuel Standard (RFS). Second, by holding down ethanol prices, the blend wall stymies ethanol industry's growth. The RFS program not only provides a foundation for the industry but promises long-term stability. However, the 10% regulatory cap on the amount of ethanol that can be blended into gasoline places the RFS at risk (Nuembery). The ethanol industry believes their future success depends on the EPA approving the waiver shifting the blend wall. In evaluating the effects of the waiver the ethanol industry realizes the importance of sound science and data (Dinneen).

As addressed below, this science should not only include the physical science of vehicle engine fuel-blend compatibility, but also the social science of fuel market effects. A major rational in support for a waiver to shift the blend wall is increased energy security through using less foreign petroleum gasoline. However, this rational is presented with little or no underlying economic analysis. Providing such analysis reveals a positive shift in the blend wall will have the opposite effect and likely increase instead of decrease the U.S. dependence on petroleum gasoline. The shift will lead to an increase in the price of E85 and lower the price of $E\gamma$. The lower price of $E\gamma$ creates an expansion effect in the consumption of $E\gamma$ which increases the use of petroleum gasoline. Employing published elasticities, results indicate this expansion effect completely offsets the substitution of ethanol for petroleum gasoline as the blend wall shifts. Contrary to blend wall waiver proponents, this results in total consumption of petroleum gasoline increasing.

**Parameter Values**

The magnitudes of the comparative statics for a change in the blend wall, γ, may be determined by appealing to published elasticities, quantities and historical fuel prices (Table 2). Data on per unit prices and quantities for ethanol, petroleum gasoline, and E85 are based on weekly observations from August 1998 to July 2008 published by Ethanol and Biofuels News. The mean values, minimum and maximum ranges of ethanol and E85 prices are net of the $0.45 federal tax credit. The price of blended gasoline was calculated as the weighted average of ethanol and petroleum gasoline. Associated 2009 U.S consumption of petroleum gasoline and ethanol are 126.80 billion gallons and 10.95 billion gallons, respectively (EIA). In terms of E10 and E85, the American Coalition for Ethanol estimates 99% of ethanol fuel is used in blending E10 with the remaining 1% for E85 (Kolrba). Data on total quantity of ethanol are from 'Fuel Ethanol Review' on the website of EIA (http://www.eia.doe.gov/emeu/aer/renew.html) and are measured in gallons.

Estimates of parameter elasticities are from published articles with the own ethanol demand $\varepsilon^{D}_{e,p_e}$ and supply elasticities $\varepsilon^{S}_{e,p_e}$, along with the cross elasticity for gasoline,$\varepsilon^{D}_{e,p_\gamma}$, from Luchansky and Monks' empirical ethanol supply and demand model. However, no cross elasticity estimates for the E85 price response on ethanol, $\varepsilon^{D}_{e,p_{85}}$ are available. As a measure of this responsiveness, the own E85 price elasticity of demand,$\varepsilon^{D}_{E85,p_{85}}$, estimated by Anderson was employed. With E85 consisting of 85% ethanol, this should serve as a reasonable surrogate for the cross elasticity. Finally, based on an extensive literature review, Parry and Small's demand elasticity for gasoline was employed for the own blended fuel demand elasticity.

**Benchmark Results**

Employing benchmark values of prices, quantities and elasticities in calculating the comparative statics in Table 1 provide the direction and magnitude given a blend wall shift. All the results presented in Table 3 yield the theoretical comparative statics expected signs in Table 1, and present a monotone trend with respect to shifting the blend wall. For all the elasticities, the responsiveness of prices and quantities tend toward zero as the blend wall shifts upward. The initial blend wall shift away from E10 has a greater absolute impact on the elasticities compare with higher ethanol blends. As the prices of ethanol and E85 and quantities of Eγ, ethanol, and gasoline increase in response to a blend wall shift, their responsiveness to the blend wall declines. In contrast, the responsiveness to blend wall shifts of the price of Eγ and quantities of gasoline and ethanol used in E85 rise, in absolute value, as their levels increase. As indicated in Table 3, the responsiveness of gasoline and ethanol used in E85 although negative are close to zero. However, the quantity of E85 is the most responsive to a blend-wall shift. As the blend wall shifts, E85 declines. This apparent contradiction is caused by the very low percentage of the total gasoline and ethanol production funneling into the E85 market. The U.S. E85 market is currently limited, with a small number of retailers and flex-fuel vehicles. Besides the elastic responsive of E85 to a blend-wall shift, the quantity of ethanol used in Eγ is also elastic. This positive elastic response is very favorable to the ethanol industry, especially when coupled with the positive price response. All the other responses are inelastic indicating a more modest response. Of particular interest are the price of Eγ and quantities of Eγ, gasoline used in Eγ, and total gasoline consumption. As the blend wall shifts, the price of Eγ declines with a corresponding increase in the consumption of Eγ, gasoline used in Eγ, and total gasoline consumption. The conclusion is a positive shift in the blend wall will likely increase total gasoline consumption and lead to greater energy insecurity. Only if the blend wall increases to the point of allowing E21 does the substitution effect counter the expansion effect, so total gasoline consumption does not increase with a blend wall shift.

**Parameter Simulations**

The wide ranges of parameter values in Table 2 imply that the benchmark results may have associated relatively large variances. Monte Carlo simulation is then used for investigating the comparative statics elasticities. For this simulation, 1000 random draws of parameter elasticities in Table 2 were generated employing kernel smoothing or two-sided power probability distributions over respective ranges of parameters. In particular, for the ethanol, petroleum gasoline, blended gasoline, E85 prices, and quantity of ethanol, the probability distributions were estimated by kernel smoothing. With only the benchmark value and end-point ranges available for the elasticities, two-sided power distribution were employed to capture the asymmetric properties of the parameter ranges relative to the benchmarks. These random draws were generated for each blend wall (E10, E12, E15, E20). Repeated random draws yield varying distribution moments. By randomly drawing 1000 parameter elasticities in Table 2 100 times results in a clustering of moments allowing the calculation of the distribution's moments.

The Savitzky-Golay Smoothing filter is also employed to mitigate possible effects from some unobservable noise. This noise may occur from interactions among the parameters. Independence of parameters is assumed, while this independence may not be strictly satisfied. As an example, the price of ethanol, $p_e$, and its own price elasticity of demand, $\varepsilon^D_{e,p_e}$, tend to influence and interact with each other. Characteristics of time-series data employed may also cause noise from unobservable information.

The objective is to derive reliable estimates by mitigating the noise resulting in improved estimates of distribution moments. With these filtering techniques, the standard deviations of the distribution are reported in Table 3. Not surprisingly the deviations are relatively large. The wide range of parameter values in Table 2 account for this result. This is particularly true for the own E85 price elasticity of demand. With improved estimates of these parameters, the standard deviations in Table 3 would significantly decline.

**Sensitivity analysis**

The wide ranges of parameter values in Table 2, which lead to large standard deviations in Table 3, suggest investigating the effect of the parameter elasticities on the comparative static elasticities. Regressing the mean of the 100 randomly generated vectors for each comparative statics elasticity on the mean of 100 generated vectors for each parameter elasticity, provides the influence each parameter has on the comparative statics results. Table 4 lists the influence of parameter elasticities on the blend wall comparative statics elasticities at a blend wall of E10.

As indicated in Table 4, relative to the other parameters, the own elasticity of ethanol supply, $\varepsilon^{S}_{e,p_e}$, has the largest influence on all the comparative statics elasticities. The only exceptions are the ethanol and gasoline E85 elasticities( $\varepsilon_{Q^{e}_{85},\gamma}$ and $\varepsilon_{Q^{g}_{85},\gamma}$), the E85 price and total quantity of ethanol where the influence for all the parameters is small or essentially zero. The estimate for own elasticity of ethanol supply,$\varepsilon^{S}_{e,p_e}$, listed in Table 2 is very inelastic and its range is very narrow relative the other elasticities. This narrow range for $\varepsilon^{S}_{e,p_e}$ relative to the other comparative statics elasticities results in a small change in $\varepsilon^{S}_{e,p_e}$ having a relative large impact on the comparative statics elasticities.

From Table 4, as own elasticity of ethanol supply, $\varepsilon^{S}_{e,p_e}$, becomes more elastic, it drives down the elasticity of Eγ price with respect to the blend wall, γ, $\varepsilon_{p_\gamma \gamma}$, making it more elastic. The greater response of Eγ price to the blend wall will yield higher consumption of petroleum gasoline. This higher consumption of petroleum gasoline is reflected in the positive response of petroleum gasoline elasticities, $\varepsilon_{Q^g_\gamma,\gamma}$ and $\varepsilon_{Q_G,\gamma}$to an increase in $\varepsilon^{S}_{e,p_e}$.

The cross price elasticity of ethanol demand to the Eγ price, $\varepsilon^{D}_{e,p_\gamma}$, and the own Eγ elasticity of demand, $\varepsilon^{D}_{E\gamma,p_\gamma}$, also influence the comparative statics elasticities $\varepsilon_{p_\gamma \gamma}$, $\varepsilon_{E\gamma,\gamma}$, $\varepsilon_{Q^e_\gamma,\gamma}$, $\varepsilon_{Q^g_\gamma,\gamma}$ and $\varepsilon_{Q_G,\gamma}$. As $\varepsilon^{D}_{e,p_\gamma}$ and $\varepsilon^{D}_{E\gamma,p_\gamma}$ become less responsive to the price of Eγ, $p_\gamma$, (more inelastic) $\varepsilon_{Q^g_\gamma,\gamma}$ becomes less response to a blend-wall shift.

In summary, the prices of ethanol and Eγ through their influences on ethanol supply and demand along with the demand for Eγ, are exerting the major influences on the elasticity of total petroleum gasoline to a blend-wall shift. As ethanol supply becomes more responsive to its own price and ethanol demand along with Eγ demand are more responsive to the price of Eγ, the more responsive petroleum gasoline is to a blend-wall shift. These results may be directly related to the substitution and expansion effects of total petroleum gasoline to a change in the blend wall. The expansion effect is strengthened relative to the substitution effect as ethanol supply becomes more responsive to its own price and ethanol demand along with Eγ demand are more responsive to the price of Eγ.

**Conclusions**

Consistent with the comparative statistics results of Zhang et.al, the results at this analysis indicate that relaxing the EPA’s regulation on a maximum10% ethanol blend for conventional gasoline, the blend wall, will likely increase the prices for ethanol and E85 and lower the price for Eγ. These price effects are caused by a higher demand for ethanol and increased supply of Eγ and a lower supply of E85. A positive shift in the blend wall drives a larger price wedge between Eγ and E85. This reduces the demand for E85 and potentially retards the shift toward flex-fuel vehicles. Results indicate total petroleum gasoline consumption will positively respond to an increase of the blend wall, indicating the positive expansion effect offsets a negative substitute effect. Although a relaxation of blend wall reduces the quantity of E85 and associated petroleum gasoline, effects on petroleum gasoline are quite small. E85 only accounting for a relatively small market share explains this result. The results reinforce the comparative statics analysis that allowing higher ethanol fuel blends to be available for all vehicles potentially has the adverse spillover effect of reducing the demand for flex-fuel vehicles.

The empirical results support the anomaly of the blend-wall waiver increasing petroleum fuel consumption. A relaxation of the blend wall is prone to increase rather than decrease total petroleum gasoline demand. Rather than enhancing the security of the energy sector, relaxation of the blend wall might exacerbate the risk of energy insecurity by failing to reduce the dependence of foreign petroleum. In addition, it is likely to retard adoption of flex-fuel vehicles.

With these results as a foundation, relaxation of the blend wall might not be a sustainable choice for the energy sector. Announced by EPA, E15 could only be used in few vehicles in certain model years. For a wider application for E15, certain equipments including fuel pumps should be installed or replaced in order to meet the emission standard. Therefore, a long-run strategy might be to retain the current blend-wall restrictions on conventional non-flex fuel vehicles and thus reduce any comparative advantage conventional vehicles have over flex-fuel vehicles. This would provide increased incentives for motorists to drive flex-fuel vehicles and open the fuel-ethanol sector to the total vehicle fuel market without any restrictions (Zhang et. al).

In terms of policy direction, policies which foster increased demand for E85 would foster greater demand for ethanol and less petroleum gasoline.  Specifically, policies should be directed toward discouraging the driving of conventional vehicles and providing incentives for increased availability and consumer willingness to use alternative fuels. For a continued viable renewable fuels sector, the ethanol industry should direct their efforts toward policies which discourage conventional fueled vehicles and encourage alternative fuels.

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**Table 1. Comparative Statics Results, Zhang, et al.**

| Elasticity Response to a Shift in the Blend Wall, $\gamma$ | Equation[a] |
|---|---|
| Ethanol price, $p_e$ | $\varepsilon_{p_e,\gamma} = \varepsilon^D_{e,p_\gamma}\frac{1}{\gamma}\frac{1}{0.85}\frac{p_g}{p_\gamma}/A > 0$ |
| Conventional blend, Eγ, price, $p_\gamma$ | $\varepsilon_{p_\gamma,\gamma} = \frac{p_e p_g}{\gamma p_\gamma}\left[\left(\left(\varepsilon^S_{e,p_e} - \varepsilon^D_{e,p_e}\right)\frac{1}{0.85}\frac{1}{p_e} - \varepsilon^D_{e,p_{85}}\frac{1}{p_{85}}\right)\right]/A < 0$ |
| E85 price, $p_{85}$ | $\varepsilon_{p_{85},\gamma} = \varepsilon^D_{e,p_\gamma}\frac{p_e}{p_\gamma p_{85}}\frac{p_g}{\gamma}/A > 0$ |
| Conventional blend, Eγ | $\varepsilon_{E\gamma,\gamma} = \frac{\epsilon_{p_\gamma,\gamma}}{\epsilon^D_{p_\gamma,E\gamma}} > 0$ |
| E85 | $\varepsilon_{E85,\gamma} = \frac{\epsilon_{p_{85},\gamma}}{\epsilon^D_{p_{85},E85}} < 0$ |
| Market quantity of ethanol, $Q_e$ | $\epsilon_{Q_e,\gamma} = \varepsilon^S_{e,p_e}\varepsilon_{p_e,\gamma} > 0$ |
| Quantity of ethanol used in Eγ, $Q^e_\gamma$ | $\varepsilon_{Q^e_\gamma,\gamma} = \frac{\gamma E\gamma}{Q^e_\gamma}\left(1 + \varepsilon_{E\gamma,\gamma}\right) > 0$ |
| Quantity of gasoline used in Eγ, $Q^g_\gamma$ | $\varepsilon^g_{Q_\gamma,\gamma} = \frac{\gamma E\gamma}{Q^g_\gamma}\left(\varepsilon_{E\gamma,\gamma}\frac{1-\gamma}{\gamma} - 1\right) > 0$, if $\varepsilon_{E\gamma,\gamma} > \frac{\gamma}{1-\gamma}$ |
| Quantity of ethanol used in E85, $Q^e_{85}$ | $\varepsilon_{Q^e_{85},\gamma} = \frac{0.85E85}{Q^e_{85}}\varepsilon_{E85,\gamma} < 0$ |
| Quantity of gasoline used in E85, $Q^g_{85}$ | $\varepsilon_{Q^g_{85},\gamma} = \frac{0.15E85}{Q^g_{85}}\varepsilon_{E85,\gamma} < 0$ |
| Total gasoline consumption, $Q_G$ | $\varepsilon_{Q_G,\gamma} = -\frac{Q^e_\gamma}{Q_G} + \varepsilon_{E\gamma,\gamma}\frac{Q^g_\gamma}{Q_G} + \varepsilon_{E85,\gamma}\frac{Q^g_{85}}{Q_G} > 0$, if $\varepsilon_{E\gamma,\gamma} > \frac{\gamma}{1-\gamma} - \frac{Q^g_{85}}{Q^g_\gamma}\varepsilon_{E85,\gamma}$ |

[a] $A = \left(\varepsilon^D_{e,p_e} - \varepsilon^S_{e,p_e}\right)\frac{1}{\gamma}\frac{1}{0.85} + \varepsilon^D_{e,p_{85}}\frac{1}{\gamma}\frac{p_e}{p_{85}} + \varepsilon^D_{e,p_\gamma}\frac{1}{0.85}\frac{p_e}{p_\gamma} < 0$, and $p_g$ is price of petroleum gasoline.

$\varepsilon^D_{e,p_e}$ and $\varepsilon^S_{e,p_e}$ are the own price elasticity of ethanol demand and supply, respectively.

$\varepsilon^D_{e,p_\gamma}$ and $\varepsilon^D_{e,p_{85}}$ are the elasticity of ethanol demand with respect to the price of Eγ and E85, respectively.

$\epsilon^D_{p_\gamma,E\gamma}$ and $\epsilon^D_{p_{85},E85}$ are the price flexibilities of Eγ and E85 with respect to their quantities.

**Table 2. Parameter Values**

| Parameter | Description | Source | Benchmark Value | Range |
|---|---|---|---|---|
| $p_e$ | Per unit price of ethanol (dollars per gallon) | Ethanol and Biofuels News | 1.64 | 0.97 - 3.78 |
| $p_g$ | Per unit price of petroleum gasoline (dollars per gallon) | Ethanol and Biofuels News | 1.21 | 0.29 - 3.40 |
| $p_{85}$ | Per unit price of E85 (dollars per gallon) | Ethanol and Biofuels News | 1.73 | 1.04 - 3.09 |
| $Q_e$ | Total quantity of ethanol (million gallons) | U.S. Energy Information Administration | 285 | 99 - 800 |
| $\varepsilon^D_{e,p_e}$ | Own ethanol price elasticity of demand | Luchansky and Monks | −2.26 | −2.92 - −1.61 |
| $\varepsilon^S_{e,p_e}$ | Own ethanol price elasticity of supply | Luchansky and Monks | 0.24 | 0.22 - 0.26 |
| $\varepsilon^D_{e,p_\gamma}$ | Ethanol demand elasticity with respect to gasoline price | Luchansky and Monks | −2.13 | −3.06 - −2.08 |
| $\varepsilon^D_{E85,p_{85}}$ | Own E85 price elasticity of demand | Anderson | −13.00 | −20.00 - −6.00 |
| $\varepsilon^D_{E\gamma,p_\gamma}$ | Eγ demand elasticity with respect to gasoline price | Parry and Small | −0.55 | −0.90 - 0.30 |

**Table 3. Benchmark Values and Simulated Standard Deviations for Comparative Statics**

| Elasticity Response to a Shift in the Blend Wall | Elasticity | Blend Wall[a] | | | |
|---|---|---|---|---|---|
| | | E10 | E12 | E15 | E20 |
| Ethanol price | $\varepsilon_{p_e,\gamma}$ | 0.619 | 0.609 | 0.594 | 0.571 |
| | | (0.545) | (0.335) | (0.226) | (0.261) |
| Eγ price | $\varepsilon_{p_\gamma,\gamma}$ | -0.624 | -0.614 | -0.599 | -0.576 |
| | | (20.124) | (13.638) | (10.845) | (8.278) |
| E85 price | $\varepsilon_{p_{85},\gamma}$ | 0.498 | 0.490 | 0.478 | 0.460 |
| | | (0.480) | (0.343) | (0.236) | (0.216) |
| Eγ | $\varepsilon_{E\gamma,\gamma}$ | 0.343 | 0.338 | 0.329 | 0.317 |
| | | (12.484) | (8.633) | (6.445) | (5.006) |
| E85 | $\varepsilon_{E85,\gamma}$ | -6.478 | -6.371 | -6.217 | -5.976 |
| | | (6.624) | (4.931) | (3.152) | (3.195) |
| Market quantity of ethanol Eγ | $\epsilon_{Q_e,\gamma}$ | 0.149 | 0.146 | 0.143 | 0.137 |
| | | (0.131) | (0.081) | (0.054) | (0.052) |
| Quantity of ethanol used in | $\varepsilon_{Q_\gamma^e,\gamma}$ | 1.343 | 1.337 | 1.329 | 1.317 |
| | | (12.510) | (8.653) | (6.454) | (5.018) |
| Quantity of gasoline used in Eγ | $\varepsilon^g_{Q_\gamma,\gamma}$ | 0.232 | 0.201 | 0.153 | 0.067 |
| | | (12.483) | (8.632) | (6.445) | (5.005) |
| Quantity of ethanol used in E85 | $\varepsilon_{Q_{85}^e,\gamma}$ | -0.000 | -0.000 | -0.000 | -0.000 |
| | | (0.000) | (0.000) | (0.000) | (0.000) |
| Quantity of gasoline used in E85 | $\varepsilon_{Q_{85}^g,\gamma}$ | -0.000 | -0.000 | -0.000 | -0.000 |
| | | (0.000) | (0.000) | (0.000) | (0.000) |
| Total gasoline consumption | $\varepsilon_{Q_G,\gamma}$ | 0.231 | 0.200 | 0.151 | 0.064 |
| | | (9.578) | (7.371) | (6.159) | (4.725) |

[a]Simulated standard deviations in the parentheses.

**Table 4. Influence of Parameter Elasticities on the Blend Wall Comparative Statics Elasticities at a Blend Wall of E10**

| Comparative Statics Elasticities[a] | Parameter Elasticities | | | | |
|---|---|---|---|---|---|
| | $\varepsilon^{D}_{e,p_e}$ | $\varepsilon^{S}_{e,p_e}$ | $\varepsilon^{D}_{e,p_\gamma}$ | $\varepsilon^{D}_{E85,p_{85}}$ | $\varepsilon^{D}_{E\gamma,p_\gamma}$ |
| $\varepsilon_{p_e,\gamma}$ | 0.007 | -0.032 | -0.002 | 0.002 | -0.001 |
| $\varepsilon_{p_\gamma,\gamma}$ | -0.097 | -10.423 | 0.349 | -0.048 | 1.943 |
| $\varepsilon_{p_{85},\gamma}$ | 0.002 | 0.002 | -0.001 | 0.000 | 0.007 |
| $\varepsilon_{E\gamma,\gamma}$ | 0.072 | 6.346 | -0.482 | 0.032 | -1.256 |
| $\varepsilon_{E85,\gamma}$ | -0.032 | -0.398 | 0.021 | 0.005 | -0.140 |
| $\epsilon_{Q_e,\gamma}$ | 0.002 | 0.000 | -0.001 | 0.000 | 0.000 |
| $\varepsilon_{Q^e_\gamma,\gamma}$ | 0.072 | 6.346 | -0.482 | 0.032 | -1.256 |
| $\varepsilon_{Q^g_{85},\gamma}$ | 0.072 | 6.346 | -0.482 | 0.032 | -1.256 |
| $\varepsilon_{Q^e_{85},\gamma}$ | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 |
| $\varepsilon_{Q^g_{85},\gamma}$ | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 |
| $\varepsilon_{Q_G,\gamma}$ | 0.072 | 6.346 | -0.482 | 0.032 | -1.256 |

[a] Comparative statics elasticites defined Table 1.