

A Beer Consumption Kuznets Curve?

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Abstract

In the U.S., post World War II increases in beer consumption peaked in the early 1980s. Since then, per capita consumption has been trending downward. Evidence suggests that this apparent pattern is strongly related to economic growth (real incomes). We present a simple, neoclassical, utility-based model to examine this beer consumption – income behavioral relationship. Borrowing a bit from the 'environmental Kuznets curve' literature, we show that beer consumption increasing with income at a decreasing rate is linked to the relative income sensitivities of the marginal utility and disutility of beer consumption less the marginal utility of damage mitigation effort. We mirror this behavioral nuance with a more general Engel aggregation test.

Keywords: Beer consumption, income, Kuznets curve, Engel aggregation

JEL Classifications: D11, D31, D91

Introduction

Mounting evidence suggests that the long-run relationship between beer consumption and income has an inverse U-shape.² Because this national-income related pattern resembles Kuznets' (1955) findings for income inequality and economic growth – might we have a beer consumption Kuznets curve?³ Herein, casual empirics appear to say yes. Table 1 describes two 59-year time-series for the U.S. – beer consumption per capita and real GDP per capita. Figure 1 below shows the YX plot of the two series and a fitted trendline.

Table 1. Data descriptions, sources and descriptive statistics

Beer consumption. Apparent beer consumption for the U.S. in gallons per capita (1967-2025). Compiled by The Beer Institute and based on reporting from individual states. The numerator reflects total shipments and/or sales determined by local tax payments and/or state reports of malt beverage shipments. Population counts are from the U.S. Bureau of the Census. Mean 21.175, STD 2.084.
Gross domestic product. The nation's GDP per capita in thousands of 2017 chained dollars. U.S. Bureau of Economic Analysis, GDP per capita Series. Mean 45.195, STD 12.403.

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² See Hogarty and Elzinga (1972); Lee and Tremblay (1992); Gil and Molina (2009); Fogarty (2010); Colen and Swinnen (2016) and Kunce (2024). Cantarero-Prieto et al. (2019) provide evidence of a general alcohol consumption Kuznets curve for select OECD countries. Evidence, to date, relies on reduced-form regressions of consumption on polynomial income and various other controls.

³ Grossman and Krueger (1995) are widely cited as responsible for the now sizable 'environmental Kuznets curve' literature.

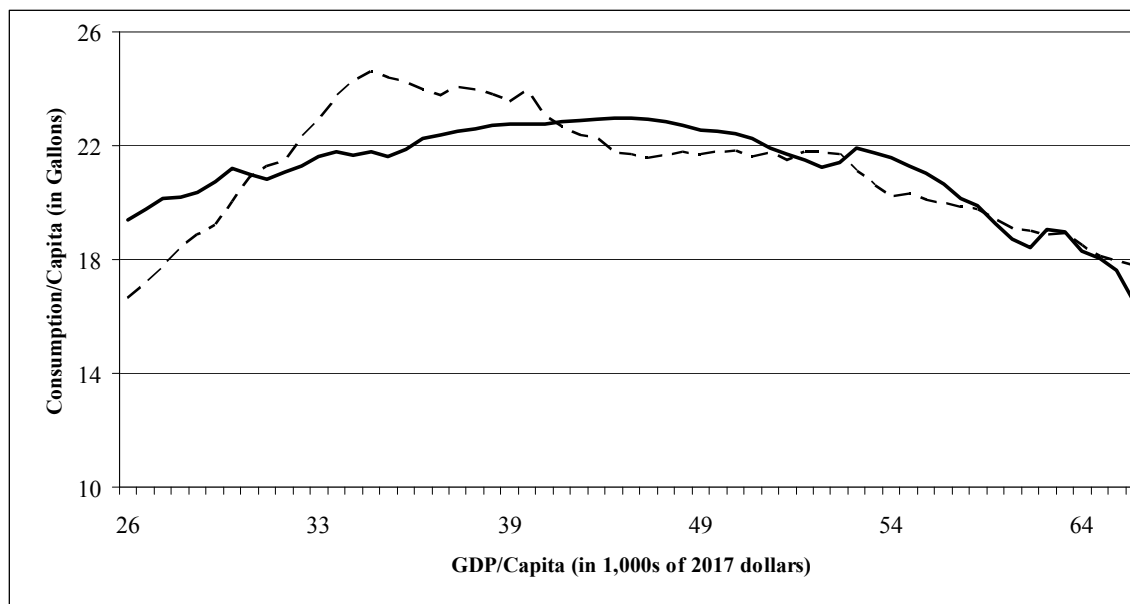


Figure 1. The relationship between U.S. beer consumption and GDP (1967-2025).
 ----- Observed ——— Fitted trendline

Regressing consumption on a constant, GDP and GDP^2 yields,

$$\begin{aligned} Consumption = & 1.179 + 1.003(GDP) - 0.012(GDP^2) \\ & (1.830) \quad (7.625) \quad \quad (-7.859) \quad R^2 = 0.76, \end{aligned} \quad (1)$$

where t-statistics are shown in parenthesis.⁴ Both naive series plots indicate concavity.

Why would beer consumption volume rise then fall with real incomes? The simple answer suggests that as a society's per capita income rises, more disposable funds become available to spend on non-essential goods, including alcoholic beverages. However, once incomes pass a certain level, an upper limit to the utility of more consumption volume is reached (Lee and Tremblay, 1992). Beer may reach this saturation point much earlier than wine or premium spirits due to its water volume and lower alcohol content. Moreover, while higher income societies may be drinking less adjunct lager in volume, they are drinking more pricey beer (Swinnen, 2017). Preferences seem to be shifting to perceived higher quality segments – a four-pack of premium pilsner over a suitcase of Keystone Light.⁵ Another explanation imagines that higher income societies prioritize health and wellness, causing consumption volumes to fall (Colen and Swinnen, 2016).

⁴ See Schervish (1987) for a discussion of the many defects of naive polynomial regressions. Moreover, our simplification ignores key controls (e.g. population-age demographics, substitutes, etc.).

⁵ In a related vein, a rather multi-disciplined literature is developing regarding wide-spread cannabis legalization and its ancillary effects. Recreational legalization efforts in the U.S. started in 2012. In particular, what are the effects of states' legalization on the consumption of other intoxicating substances? Without question, alcohol and marijuana are the two most commonly used intoxicants in the U.S. The focus of a large part of this literature is whether marijuana and alcohol are 'substitutes' or have a 'complementary' relationship (Kunce, 2025).

Since the 1970s, awareness of the health risks associated with drinking has increased. Government regulation of alcohol consumption and related behaviors reinforce this heightened attention (Fogarty, 2010).

What is glaringly lacking in this literature is a theoretical foundation. Herein, we develop a neoclassical, utility-based model to examine the beer consumption – income behavioral relationship. Borrowing a bit from the environmental Kuznets curve literature,⁶ we show that beer consumption increasing with income at a decreasing rate is linked to the relative income sensitivities of the valued marginal utility and disutility of beer consumption less the valued marginal utility of damage mitigation effort. Concavity of beer in income rests on the magnitude of the relative sensitivities. An Engel aggregation check reinforces the concave relationship.

Model

Envision a national economy made up of identical citizens whose goal is to maximize overall utility. Because these individuals are alike in all ways, we normalize the population to one representative resident.⁷ This representative receives utility from essential consumption, C , non-essential consumption, B , and disutility from deleterious effects, D , when consuming B . Consider B a consumption volume of beer. Utility then becomes,

$$U = U(C, B, D), \quad (2)$$

where U is quasi-concave in C , B and $-D$, continuously differentiable and increasing in C and B , but of course decreasing in D . Marginal utilities are then defined, $U_C > 0$, $U_B > 0$, and $U_D < 0$, where subscripts denote partial derivatives. Clearly D is a byproduct of consuming B and our resident can certainly mitigate these damages. We define this damage function as,

$$D = D(B, E), \quad (3)$$

where E represents mitigation efforts that can be costly to our resident. Correspondingly, damage function partials become, $D_B > 0$ and $D_E < 0$. The curvature properties of D reside in the many $\{B, E\}$ -space derivatives of the compound version of Equation (2). The resident's budget constraint is defined as,

$$I = p_C C + p_B B + p_E E \text{ or } N = I - p_C C = p_B B + p_E E, \quad (4)$$

where the far right-hand side of Equation (4) represents an expression for non-essential (discretionary) income, N . Subscripts on price terms denote goods.

⁶ See, for example, Andreoni and Levenson (2001).

⁷ Outcomes from this type of utility modeling are consistent with Pareto efficiency.

In a stylized simplifying move, we opt to isolate the resident's problem to choices of B and E . Essential consumption C is treated as a background numeraire.⁸ From the compound version of Equation (2), we define a reduced-form of utility that encapsulates beer consumption and its potential damage, conditional on the optimal consumption of essentials. The reduced-form resident's problem becomes,

$$\text{Max}_{B,E} \tilde{U}(B, D(B, E)), \quad (5)$$

subject to the right side of Equation (4). Collapsed $\tilde{U}$ continues to be well behaved. The Lagrangian of the resident's problem is,

$$L = \tilde{U}(B, D(B, E)) + \lambda(N - p_B B - p_E E). \quad (6)$$

The first-order conditions (FOC) form the following set of simultaneous equations,

$$L_\lambda = N - p_B B - p_E E = 0, \quad (7)$$

$$L_B = (\tilde{U}_B + \tilde{U}_D D_B) - \lambda p_B = 0, \quad (8)$$

$$L_E = (\tilde{U}_D D_E) - \lambda p_E = 0. \quad (9)$$

The term, in parenthesis, in Equation (8) reflects the total marginal utility of consuming B . It captures both the direct utility and disutility of beer consumption. The term, in parenthesis, in Equation (9) denotes the marginal utility of mitigation effort. The optimal tangency condition becomes,

$$\frac{(\tilde{U}_B + \tilde{U}_D D_B)}{(\tilde{U}_D D_E)} = \frac{p_B}{p_E}. \quad (10)$$

The sufficient second-order condition (SOC) for this constrained maximum is based on the second partials of Equations (7) - (9) forming the bordered Hessian determinant,⁹

$$|\overline{H}| = \begin{vmatrix} L_{\lambda\lambda} & L_{\lambda B} & L_{\lambda E} \\ L_{B\lambda} & L_{BB} & L_{BE} \\ L_{E\lambda} & L_{EB} & L_{EE} \end{vmatrix} = \begin{vmatrix} 0 & -p_B & -p_E \\ -p_B & L_{BB} & L_{BE} \\ -p_E & L_{EB} & L_{EE} \end{vmatrix}. \quad (11)$$

A maximum requires $|\overline{H}| > 0$,

⁸ Related simplification maneuvers are discussed in Mas-Colell et al. (1995). More formal separable and quasi-linear utility representations are characterized, generally, in Allen and Rehbeck (2026).

⁹ We form the bordered Hessian using this notation to avoid drowning in an ocean of curvature and cross partials of U and D . For reasons that will become clearer below, we keep the presentation of the equivalent cross second partials L_{BE} and L_{EB} distinct. See the Appendix to this paper for expanded derivative details.

$$|\overline{H}| = (p_B p_E L_{BE} - p_B^2 L_{EE}) - (p_E^2 L_{BB} - p_B p_E L_{EB}) > 0. \quad (12)$$

With the SOC satisfied and by applying the implicit function theorem, Equations (7) - (9) yield the optimal values of the endogenous variables,

$$\lambda^* = \lambda^*(p_B, p_E, N), \quad (13)$$

$$B^* = B^*(p_B, p_E, N), \quad (14)$$

$$E^* = E^*(p_B, p_E, N). \quad (15)$$

We are interested in the curvature of B^* as N expands. We use Marshallian demands purely as a means to model consumption behavior.¹⁰ What conditions influence beer consumption to increase with income at a decreasing rate?

Evaluating Equations (7) - (9) at the optimums from Equations (13) - (15) allows the formation of this matrix system of three equations,

$$\begin{pmatrix} 0 & -p_B & -p_E \\ -p_B & L_{BB} & L_{BE} \\ -p_E & L_{EB} & L_{EE} \end{pmatrix} \begin{pmatrix} \partial \lambda^* / \partial N \\ \partial B^* / \partial N \\ \partial E^* / \partial N \end{pmatrix} = \begin{pmatrix} -1 \\ 0 \\ 0 \end{pmatrix}, \quad (16)$$

where,

$$\frac{\partial B^*}{\partial N} = \frac{(p_E L_{BE} - p_B L_{EE})}{p_B (p_E L_{BE} - p_B L_{EE}) - p_E (p_E L_{BB} - p_B L_{EB})}, \quad (17)$$

$$\frac{\partial E^*}{\partial N} = \frac{-(p_E L_{BB} - p_B L_{EB})}{p_B (p_E L_{BE} - p_B L_{EE}) - p_E (p_E L_{BB} - p_B L_{EB})}. \quad (18)$$

By the SOC, the denominator of both Equations (17) and (18) are positive. For both to be a normal goods, the numerators must be positive. As long as the marginal damage from beer consumption decreases with mitigation, $D_{BE} < 0$, the numerators of Equations (17) and (18) will tend positive.¹¹ Beer consumption and mitigation effort increase with income.

We define a useful ratio that *pits* the sensitivity of the differenced, valued FOC marginal utilities, $p_E L_B - p_B L_E$, with respect to changes in beer consumption (B) *against* changes in mitigation effort (E),

¹⁰ The comparative static $\partial \lambda^* / \partial N = (L_{BE} L_{EB} - L_{BB} L_{EE}) / |\overline{H}|$.

¹¹ See the Appendix to this paper for expanded derivative details.

$$r(\cdot) = \frac{p_E L_{BB} - p_B L_{EB}}{p_E L_{BE} - p_B L_{EE}} = \frac{\alpha(\cdot)}{\beta(\cdot)}. \quad (19)$$

The numerator of Equation (19) captures how the valued marginal utility of beer consumption bends with more beer consumed *minus* how the valued marginal utility of mitigation effort changes with more beer. The denominator describes how the valued marginal utility of beer consumption changes with more mitigation effort *minus* how the valued marginal utility of mitigation bends with more mitigation. Given that both goods are normal, the numerator of r tends negative and the denominator tends positive. The ratio, $\alpha(\cdot)/\beta(\cdot)$, presents r as a primitive, implicit function of optimal choices of B and E , exogenous prices, and disposable income.

When using r , with suitable rearrangement, Equations (17) and (18) conveniently become,

$$\frac{\partial B^*}{\partial N} = \frac{1}{p_B - p_E r}, \quad (20)$$

$$\frac{\partial E^*}{\partial N} = \frac{-r}{p_B - p_E r}. \quad (21)$$

Beer as a normal good requires, $r < p_B/p_E$, the tangency price ratio.¹² Mitigation as a normal good requires, $r < 0$. Interestingly, $\partial E^*/\partial N = -r(\partial B^*/\partial N)$. If $|r|$ is greater than 1, mitigation effort has a larger slope response to changes in income.

Given r is implicit in N , we apply the quotient-rule to Equations (20) and (21),

$$\frac{\partial^2 B^*}{\partial N^2} = \frac{p_E(\partial r / \partial N)}{(p_B - p_E r)^2} = \frac{p_E r_N}{(p_B - p_E r)^2}. \quad (22)$$

$$\frac{\partial^2 E^*}{\partial N^2} = \frac{-p_B(\partial r / \partial N)}{(p_B - p_E r)^2} = \frac{-p_B r_N}{(p_B - p_E r)^2}. \quad (23)$$

The sign of Equation (22) is determined by the sign of r_N . Beer consumption increasing with income at a decreasing rate requires $r_N < 0$. This results in mitigation effort increasing with income at an increasing rate.

Under what conditions would the ratio r decrease with income? Differentiating the far right-side of Equation (19) with respect to N yields,

¹² As $r \rightarrow p_B/p_E$, $dB/dN \rightarrow$ infinity. See the Appendix to this paper for a graphic representation of the robust region of the model.

$$r_N = \frac{\beta\alpha_N - \alpha\beta_N}{\beta^2}, \quad (24)$$

where the quotient-rule difference of the ratio interactions in the numerator, $\beta\alpha_N - \alpha\beta_N$, must be negative. The relative change, with respect to N , of the numerator and denominator of r now comes into play. There are many sign and magnitude rate of change scenarios that yield a negative numerator. Most, understandably, will be very sensitive to how income expansion is assumed to change the components p_{ELBB} , p_{BLEB} , p_{ELBE} and p_{BLEE} . In an effort to illustrate and understand plausible conditions that would lead to a negative numerator in Equation (24), we numerically simulate hypothetical changes to the derivative components of the numerator and denominator of r , as income expands. By keeping the model primitive, we avoid any functional form restrictions. Starting values and component evolution are governed by all requirements of two-good normality detailed above. As such, four mathematically relevant simulations were explored.¹³

Simulation 1 ($\alpha_N < 0$, $\beta_N > 0$, $|r| < 1$). Initial values selected for all components yield a negative $\alpha(\cdot)$, a positive $\beta(\cdot)$, and $|r|$ slightly less than one. As income rises, more beer and mitigation effort are consumed. The $\alpha(\cdot)$ component, p_{ELBB} , is assumed to trend more negative as a result. The cross-curvature force, p_{BLEB} , is assumed to trend slightly positive. This results in $\alpha(\cdot)$ trending more negative with more beer consumption. Regarding the denominator of r , $\beta(\cdot)$, the component p_{BLEE} is assumed to trend more negative with more mitigation effort. The cross-curvature force will behave as it did in the numerator, more mitigation effort reduces damage. As a result, the denominator, $\beta(\cdot)$, will trend more positive with increases in mitigation effort. To obtain the downward slope depicted in Figure 2, the rate at which $\alpha(\cdot)$ changes, proportionally, must be greater than the rate of change of the denominator.

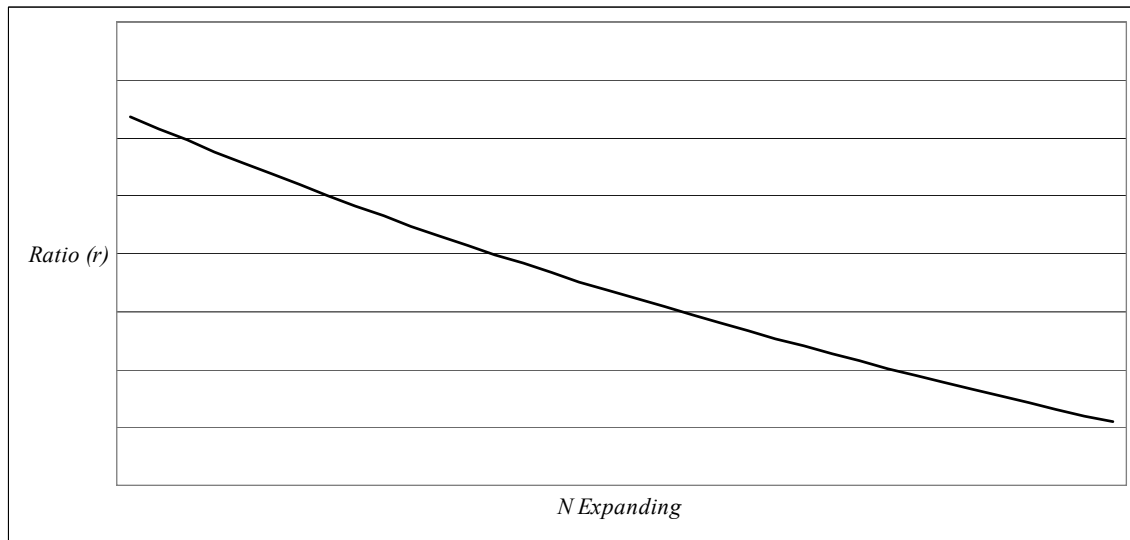


Figure 2. Graphic depiction of r changing with N .

¹³ The simulation involving $\alpha_N > 0$, $\beta_N > 0$ is degenerate.

Simulation 2 ($\alpha_N < 0$, $\beta_N > 0$, $|r| > 1$). This scenario mimics all assumptions of Simulation 1 except initial values were selected to yield $|r|$ slightly above one. Differences in the simulated results are subtle (mainly involving shifts along the vertical axis), the depiction in Figure 2 captures the general response.

Simulation 3 ($\alpha_N < 0$, $\beta_N < 0$, $|r| > 1$). Initial values selected for all components yield a negative $\alpha(\cdot)$, a positive $\beta(\cdot)$, and $|r|$ slightly greater than one. The numerator $\alpha(\cdot)$, again, trends more negative with more beer consumption. In this scenario, the denominator, $\beta(\cdot)$, now decreases with more mitigation effort. The component $p_B L_{EE}$ is assumed to trend less negative with more mitigation effort. The cross-curvature force still increases, only slightly. To obtain the downward slope depicted in Figure 2, the rate at which $\alpha(\cdot)$ changes must be greater than the rate of change of the denominator.

Simulation 4 ($\alpha_N > 0$, $\beta_N < 0$, $|r| > 1$). Initial values selected for all components yield a negative $\alpha(\cdot)$, a positive $\beta(\cdot)$, and $|r|$ slightly greater than one. In this scenario, the denominator, $\beta(\cdot)$, continues to decrease with more mitigation effort. The numerator $\alpha(\cdot)$, now, trends less negative with more beer consumption. The component, $p_E L_{BB}$, is assumed to gradually trend less negative. The cross-curvature force, $p_B L_{EB}$, is assumed to trend slightly positive. Again, to obtain the downward slope depicted in Figure 2, the rate at which $\alpha(\cdot)$ changes must be greater than the rate of change of $\beta(\cdot)$. This last simulation was very sensitive to the component rates of change modeled. Understandably so, we are compressing a whole geometry of curvature and saturation into this one ratio.

The common thread for all simulations,

$$\beta \alpha_N - \alpha \beta_N < 0 \Rightarrow \frac{\alpha_N}{\alpha} > \frac{\beta_N}{\beta} \Rightarrow r_N < 0, \quad (25)$$

contends that the rate at which $\alpha(\cdot)$ changes, proportionally, has to be greater than the rate of change for $\beta(\cdot)$.¹⁴ Moreover, keeping r in a robust region avoids unstable simulated results.¹⁵ What this translates to is income-driven changes in beer consumption must effect curvature more than income-driven changes in mitigation effort, at the margins. As damage from beer consumption accelerates and mitigation's effectiveness responds more slowly, the sensitivity ratio r will fall with income. The optimal consumption mix tilts to more mitigation effort.

Engel aggregation

With the stylized utility maximization problem above, we found that our resident's beer consumption increased with disposable income at a decreasing rate when the downside of over-consumption overwhelms the effectiveness of damage mitigation. We can mirror

¹⁴ In the simulations, the center term of Equation (25) was modeled as, $1 + ((\alpha_T - \alpha_0)/\alpha_0) > 1 + ((\beta_T - \beta_0)/\beta_0)$ or equivalently, $\alpha_T/\alpha_0 > \beta_T/\beta_0$, where T denotes the terminal simulated value and 0 denotes the initial value.

¹⁵ See Figure A1 in the Appendix to this paper.

this curvature result using the more general Engel aggregation identity. Substituting the Marshallian demands into Equation (4), then differentiating with respect to I yields,

$$1 = p_C \left(\frac{\partial C^*}{\partial I} \right) + p_B \left(\frac{\partial B^*}{\partial I} \right) + p_E \left(\frac{\partial E^*}{\partial I} \right). \quad (26)$$

With a bit of apposite algebra Equation (26) becomes,

$$\begin{aligned} 1 &= \frac{p_C C^*}{I} \left(\frac{I}{C^*} \frac{\partial C^*}{\partial I} \right) + \frac{p_B B^*}{I} \left(\frac{I}{B^*} \frac{\partial B^*}{\partial I} \right) + \frac{p_E E^*}{I} \left(\frac{I}{E^*} \frac{\partial E^*}{\partial I} \right), \\ &= s_C \varepsilon_C + s_B \varepsilon_B + s_E \varepsilon_E, \end{aligned} \quad (27)$$

where s identifies the share of income spent on a particular good and ε denotes the good's income elasticity. All terms are evaluated at the optimum so we will drop the * superscript from this point on. If a good's income elasticity is positive, it is considered normal. Nothing in Equation (27) prohibits beer, or any other good, from being normal. Now we need to find how the income elasticities change with income. Differentiating the lower expression of Equation (27) with respect to income yields,

$$0 = s_C \frac{\partial \varepsilon_C}{\partial I} + \varepsilon_C \frac{\partial s_C}{\partial I} + s_B \frac{\partial \varepsilon_B}{\partial I} + \varepsilon_B \frac{\partial s_B}{\partial I} + s_E \frac{\partial \varepsilon_E}{\partial I} + \varepsilon_E \frac{\partial s_E}{\partial I}, \quad (28)$$

where indexing and grouping becomes helpful,

$$0 = \sum_i s_i \frac{\partial \varepsilon_i}{\partial I} + \sum_i \frac{\partial s_i}{\partial I} \varepsilon_i, \quad (29)$$

given $i = C, B, E$. We are interested in isolating the sign of $\partial \varepsilon_B / \partial I$ in the first summation term in Equation (29). Starting with beer's budget share, $\partial s_B / \partial I$ becomes, using the quotient-rule,

$$\frac{\partial s_B}{\partial I} = \frac{p_B}{I^2} \left(I \frac{\partial B}{\partial I} - B \right) = \frac{p_B}{I^2} (\varepsilon_B B - B) = \frac{s_B}{I} (\varepsilon_B - 1), \quad (30)$$

or more generally,

$$\frac{\partial s_i}{\partial I} = \frac{s_i}{I} (\varepsilon_i - 1). \quad (31)$$

Substituting Equation (31) into (29) gives,

$$\sum_i s_i \frac{\partial \varepsilon_i}{\partial I} = \frac{1}{I} \left(1 - \sum_i s_i \varepsilon_i^2 \right), \quad (32)$$

given that $\sum_i s_i \varepsilon_i = 1$. Let's focus on the right-side of Equation (32). If Equation (2) is homothetic, so that consumption shares are constant and all income elasticities are unity, the right-side of Equation (32) vanishes and $\partial \varepsilon_i / \partial I = 0$. For nonhomothetic utility, where consumption shares and income elasticities do vary with income, $\sum_i s_i \varepsilon_i^2 > 1$ yielding the right-side of Equation (32) less than zero. This relationship stems from the strict convexity of ε_i^2 . The convex combination $\sum_i s_i \varepsilon_i^2$ must be greater than $\left(\sum_i s_i \varepsilon_i = 1 \right)^2$ when the ε_i are not all equal using Jensen's inequality (Deaton and Muellbauer, 1980).

Expanding Equation (32) for our model variables, in light of the nonhomothetic case,

$$s_C \frac{\partial \varepsilon_C}{\partial I} + s_B \frac{\partial \varepsilon_B}{\partial I} + s_E \frac{\partial \varepsilon_E}{\partial I} < 0. \quad (33)$$

Recall that C is essential consumption and the choice of E is tied to the consumption of B . Essential consumption takes up the lion's share of the resident's budget and the positive income elasticity of this large bundle of goods, arguably, will not swing wildly with income expansion. We would expect $s_C(\partial \varepsilon_C / \partial I)$ to be positive but sufficiently small. Mitigation efforts are not necessarily driving curvature. Consumption of E is reactionary and we would expect this budget share to be small and its elasticity positive with perhaps modest income-driven increases. Given this plausible overall setting, the positive beer elasticity must decline with income, $s_B(\partial \varepsilon_B / \partial I) < 0$.

Concluding remarks

A few caveats. We treat the ratio r as if income changes directly shift all marginal effects. This may suffice conceptually, but by doing so we presume a very particular way income maps into utility and preferences. Second, the idea that mitigation effort increases, comparatively, with income is certainly intuitive, but not guaranteed. Wealthy societies may care more about health outcomes – or they may not. Lastly, our maximization model simplifications certainly limit the myriad of substitution effects. Increases in income, arguably, may reset the mix of the entire consumption set. Modeling maneuvers for the sake of tractability are not without limitations. At any rate, the model's core logic – as incomes rise, damage from more beer consumption overwhelms the effectiveness of increased mitigation, therefore $r_N < 0$ and $\partial^2 B^* / \partial N^2 < 0$, is coherent. The caveats simply address whether these forces are systematic enough to show up in real data.

Regarding a productive empirical direction, tracing whether rising real incomes reshape beer and/or mitigation (health) margins seems warranted. Estimates of the direction and size of relative marginal utility shifts appears more useful than simply regressing consumption on income and income-squared. Income related estimates involving substitution patterns, health preferences, and demographic driven lifestyle modifications would be significant additions to the extant literature. If future empirical work can pin down these income effects, a beer Kuznets curve may turn out to be more than just a theoretical or empirical curiosity.

References

- Allen, R. and Rehbeck, J. (2026). Satisficing, aggregation, and quasilinear utility. *Quantitative Economics*, 17(2), 431-460.
- Andreoni, J. and Levinson, A. (2001). The simple analytics of the environmental Kuznets curve. *Journal of Public Economics*, 80, 269-286.
- Beer Institute, (2026). <https://www.beerinstitute.org>
- Cantarero-Prieto, D., Pascual-Saez, M. and Diego, M.G. (2019). Examining an alcohol consumption Kuznets curve for developed countries. *Applied Economics Letters*, 26(17), 1463-1466.
- Colen, L. and Swinnen, J. (2016). Economic growth, globalization and beer consumption. *Journal of Agricultural Economics*, 67(1), 186-207.
- Deaton, A. and Muellbauer, J. (1980). *Economics and Consumer Behavior*. Cambridge University Press.
- Fogarty, J. (2010). The demand for beer, wine and spirits: A survey of the literature. *Journal of Economic Surveys*, 24(3), 428-478.
- Gil, A. and Molina, J. (2009). Alcohol demand among young people in Spain: An addictive QAIDS. *Empirical Economics*, 36, 515-530.
- Grossman, G.M. and Krueger, A. (1995). Economic growth and the environment. *Quarterly Journal of Economics*, 110(2), 353-377.
- Hogarty, T. and Elzinga, K. (1972). The demand for beer. *Review of Economics and Statistics*, 54(2), 195-198.
- Kunce, M. (2024). Beer income elasticities in the U.S.: An autometric, cross-sectionally dependent, dynamic panel approach. *Journal of Beer Economics*, 2(1), 37-57.
- Kunce, M. (2025). Legal cannabis affects on U.S. state-level beer consumption: A principal-components dynamic panel approach. *Journal of Beer Economics*, 3(1), 15-29.

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review*, 45(1), 1-28.

Lee, B. and Tremblay, V. (1992). Advertising and the U.S. market demand for beer. *Applied Economics*, 24(1), 69-76.

Mas-Colell, A., Whinston, M.D. and Green, J.R. (1995). *Microeconomic Theory*. Oxford University Press.

Schervish, M.J. (1987). Polynomial regression: A review. *The American Statistician*, 41(3), 190–195.

Swinnen, J. (2017). Beer consumption and trade in an era of economic growth and globalization. *Choices*, 32(3), 1-6.

Appendix

Lagrangian partial derivative details.

From Equations (8) and (9) in the text:

$$L_B = (\tilde{U}_B(B, D(B, E)) + \tilde{U}_D(B, D(B, E)) \cdot D_B(B, E)) - \lambda p_B = 0, \quad (A1)$$

$$L_E = (\tilde{U}_D(B, D(B, E)) \cdot D_E(B, E)) - \lambda p_E = 0, \quad (A2)$$

$$L_{BE} = \tilde{U}_{BD} D_E + \tilde{U}_D D_{BE} + D_B \tilde{U}_{DD} D_E, \quad (A3)$$

$$L_{EB} = \tilde{U}_D D_{EB} + D_E \tilde{U}_{DB} + D_E \tilde{U}_{DD} D_B, \quad (A4)$$

$$L_{BB} = \tilde{U}_{BB} + 2\tilde{U}_{BD} D_B + \tilde{U}_D D_{BB} + \tilde{U}_{DD} D_B^2, \quad (A5)$$

$$L_{EE} = \tilde{U}_D D_{EE} + \tilde{U}_{DD} D_E^2. \quad (A6)$$

Presuming standard curvature assumptions for U and D (see Table A1 below), L_{BB} tends negative, L_{EE} tends negative and $L_{BE} = L_{EB}$ tends positive if $D_{BE} < 0$. A positive D_{BE} cross-partial would indicate that the marginal damage from beer consumption increases with more mitigation effort. Given the presumed signs for the second derivatives of the Lagrangian, the bordered Hessian determinant,

$$|\overline{H}| = p_B(p_E L_{BE\uparrow} - p_B L_{EE\uparrow}) - p_E(p_E L_{BB\uparrow} - p_B L_{EB\uparrow}) > 0, \quad (A7)$$

clearly tends positive.

Table A1. Standard curvature assumptions

Utility Partial	
$U_B > 0$	Marginal utility of beer is positive
$U_{BB} < 0$	Marginal utility of beer diminishes
$U_D < 0$	Marginal utility of damage is negative
U_{DD} weakly < 0	More and more damage weakly decreases U_D
$U_{BD} = U_{DB}$ weakly < 0	More damage decreases the marginal utility of beer
Damage Partial	
$D_B > 0$	Damage is increasing in beer consumption
D_{BB} weakly > 0	Marginal damage weakly increases with more beer
$D_E < 0$	Mitigation effort decreases damage
D_{EE} weakly > 0	Marginal effort weakly increases with mitigation effort
$D_{BE} = D_{EB}$ weakly < 0	Marginal damage decreases with mitigation effort

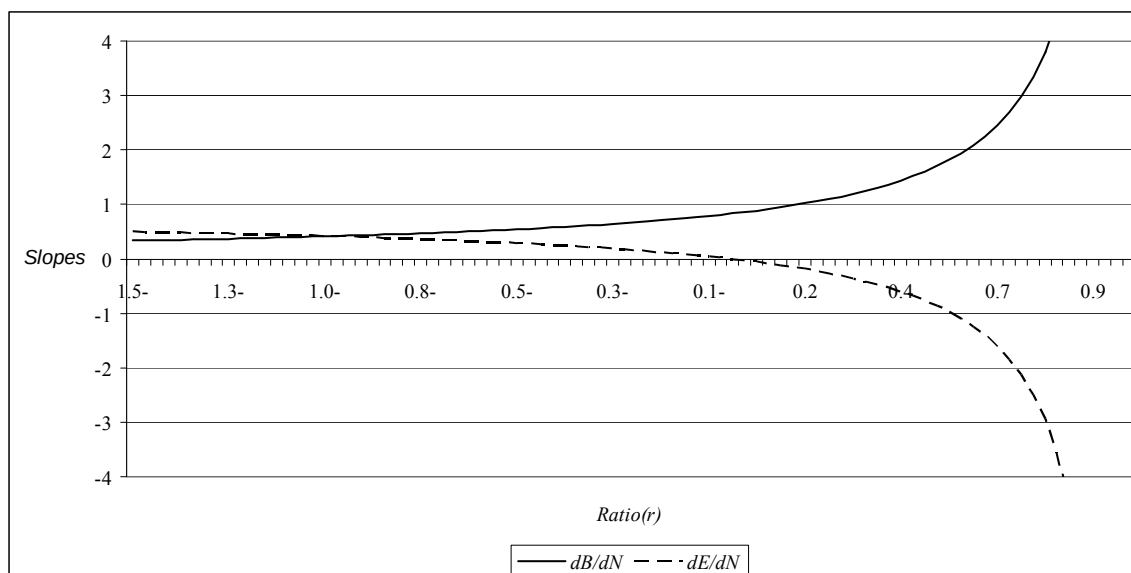


Figure A1. The range of r , prices assumed equal.

Modeling becomes unstable as initial values of r tend more positive.