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Understanding Alcohol Consumption across Countries*

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Abstract

With unpublished data from the International Comparison Program that cover the consumption of three alcoholic beverages in over 150 countries, we analyse drinking patterns around the world with an index-number approach, by estimating a demand system, and by studying the interaction among beverages in generating utility. We consider a separate demand system for each income quartile and find that tastes are not too different across quartiles. Broadly speaking, the results are robust to rolling sub-samples of countries, an alternative demand model and sample selectivity issues. The differences in the cost of alcohol across countries is also investigated, as is its role in affecting the degree of price-sensitivity of consumption.

JEL codes: D12, C30

Keywords: International drinking patterns; price sensitivity of consumption of beer, wine and spirits; alcohol demand system; alcohol and utility

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Introduction

Alcohol is consumed worldwide and in many countries drinking absorbs a nontrivial part of the consumer's budget.¹ Drinking accounts for more than 10% of spending on food in roughly half of countries around the world, as shown in Table 1. There is also substantial diversity in drinking patterns across countries with the share of spending on alcohol in total consumption ranging from 1.4% to 2.2% as we move from rich to poor countries. Spending on alcohol is 13% of food expenditure in rich countries, compared to 5% in poor countries. An understanding of the economics of alcohol consumption is important for public policy, due to the costs associated with excess drinking, and the substantial government revenue that alcohol taxes generate in many countries.

To what extent can the diversity of drinking patterns be explained by cross-country differences in incomes and prices? Are tastes in different countries identical, similar or entirely different? Given that alcohol affects cognitive abilities when consumed above a certain amount, how then can the theory of the utility-maximising consumer be applied to alcohol demand? This paper sheds some light on these issues using the unpublished cross-country data from the International Comparison Program of the World Bank (hereafter, ICP, 2011).

There is a large volume of literature on the demand for alcoholic beverages. Figure 1 presents information on citations over the last three decades for four terms related to alcohol and food demand. As can be seen, while the absolute number of citations for the term "food demand" is by far the largest, its growth rate is lower than that for both "international consumption or cross-country demand" and "alcohol demand". The growth in citations is highest at 9.4% p.a. for "alcohol demand", pointing to increasing academic interest in this topic. Table 2 summarises prior studies regarding alcohol consumption around the world, separated into four broad groups. The first group refers to useful summaries of elasticities of alcohol demand. Then comes earlier studies of alcohol demand across countries. After accounting for the role of prices and incomes, by and large, these studies suggest different countries have different tastes. The studies in third group use the new database available from the Wine Economics Research Centre to study wine markets internationally. The final group refers to more recent studies addressing the role of globalisation leading to a "homogenisation" of tastes across countries.

Our study contributes to the literature in the following ways. First, this study uses 153 countries and is the first using such a large number of countries to investigate alcohol demand. Second, in a novel application, we use an index-number approach in a preliminary analysis of the price sensitivity of alcohol consumption. Proceeding more formally, we then estimate a version of the Rotterdam model for the international demand for beer, wine and spirits. With such a large number of countries, we are able to examine differences and similarities in consumption patterns and tastes at different income levels. This also enables us to analyse the

¹ The only major exception is in Islamic countries where alcohol is prohibited/avoided for religious reasons.

degree of utility interactions among the three beverages. We use three ways to establish the robustness of the basic results: (i) Rolling regressions with country sub-samples show the demand equations are reasonably stable. (ii) Estimates of an alternative demand model indicate the estimated elasticities are largely the same. (iii) Using the Heckman (1976) approach, we find sample selectivity of countries does not lead to major biases. Finally, we present information on the cost of alcohol as a whole in each country, analyse how that affects the price-sensitivity of drinking and discuss policy implications.

The rest of the paper is structured as follows. The next section provides a preliminary analysis of drinking patterns and tests of the law of demand. A demand system is applied to the cross-country data in Section 2. Section 3 examines in some detail the utility interactions between the three alcoholic beverages. Robustness checks are given in Section 4. Section 5 discusses differences in the price of alcohol, while Section 6 contains concluding comments.

1 Drinking Patterns and Price-Quantity Relationships around the World

The data we use are obtained from the ICP and consist of the annual expenditures and the corresponding prices of beer, wine and spirits for 153 countries in 2011. Table 3 provides income per capita in each country in 2011; in total, these countries cover 83% of world population and 90% of income. These countries are allocated into income quartiles. With income in the US set at 100, the mean income declines from 66.1 in the rich quartile to 5.0 in the poor quartile. This section summarises global drinking patterns and examines whether the law of demand applies to beer, wine and spirits by using two simple approaches.

We start with the budget shares. Let p_{ic} be the price of beverage i in country c and q_{ic} be the corresponding quantity consumed. Expenditure on this beverage is $p_{ic}q_{ic}$ and the expenditure of three beverages is $\sum_{i=1}^3 p_{ic}q_{ic}$. The within-alcohol budget share of beverage i is then $w_{ic} = p_{ic}q_{ic} / \sum_{i=1}^3 p_{ic}q_{ic}$. Suppose in a certain country, the within-alcohol budget shares for beer, wine and spirits are 50%, 25% and 25%, respectively. Thus, drinkers allocate half of their alcohol spending to beer, while the remaining half is equally divided between wine and spirits. With 50% of the total devoted to beer, we could say that this country is beer-intensive. It seems reasonable to use 50% as the line of demarcation to classify each of the 153 countries. Where spending is more spread out and there is no beverage absorbing 50% or more of the budget, we dub the country “diversified”. Table 3 presents the results of this classification scheme and Table 4 provides the summary statistics.

We can examine patterns in the consumption of beer, wine and spirits with a simple geometric device. Since the three shares for each country are non-negative with a unit sum, they can be plotted in a tetrahedron, as shown in Figure 2. All points located in the bottom left sub-triangle in Figure 2 correspond to a beer share of more than 50%. There is also a sub-triangle that is closest to the vertex for wine, which corresponds to the wine share of at least 50%. The

sub-triangle for spirits is similarly interpreted. In addition to these three sub-triangles, the overall triangle contains a fourth sub-triangle, the region in the “centre”. In this region, no one share is more than 50% and consumption is not dominated by any single beverage. The budget share vector for each of the 153 countries can then be plotted in the tetrahedron. The figure gives the fraction of the 153 countries in each region. Thus, 42.5% of countries are beer-intensive, 8.5% wine-intensive, 9.8% spirits intensive and 39.2% are diversified. In this sense, the most popular beverage in the world is beer. The interesting conclusion from this figure is the extent of “specialisation” in consumption as only 39.2% of countries diversify their drinking.

The law of demand (LOD) states that an increase in the price of a good results in a decrease in its consumption, suggesting negative correlation between price and consumption. We shall examine whether or not this is so for alcohol consumption. Consider the following Divisia (1925) price and volume indexes:

$$\log P_c = \sum_{i=1}^3 w_{ic} \log p_{ic} , \quad \log Q_c = \sum_{i=1}^3 w_{ic} \log q_{ic} .$$

The relative price and relative quantity of each beverage can be expressed as:

$$\log \left(\frac{p_{ic}}{P_c} \right) = \log p_{ic} - \log P_c , \quad \log \left(\frac{q_{ic}}{Q_c} \right) = \log q_{ic} - \log Q_c .$$

For each country, we can record if the relative consumption of beverage i is above or below average and similarly for its relative price. Then, we can do this for all countries and summarise the results in the form of a 2×2 contingency table. Table 5 presents such a contingency table for beer, wine, spirits individually and for the three beverages combined (referred to as the “total” in table). The entry in each cell is the number of occurrences (that is, the number of countries) and percentages are in parenthesis. The off-diagonal elements provide evidence supportive of the LOD. Thus, for beer, $12+59 = 71\%$ of all countries have a negative price-quantity relationship. For wine and spirits, in 84% and 73% of countries prices and quantities are negatively related. For all beverages, 76% of countries are in the correct cells. Thus, for the majority countries, the evidence is supportive of the LOD. This conclusion is reaffirmed by the negative values of the measure of association, ϕ , in the table.

The Divisia price and volume indexes can be viewed as weighted first-order moments of the prices and quantities. The corresponding second-order moments are

$$\Pi_c^p = \sum_{i=1}^3 w_{ic} (\log p_{ic} - \log P_c)^2 \quad \text{and} \quad \Pi_c^q = \sum_{i=1}^3 w_{ic} (\log q_{ic} - \log Q_c)^2 ,$$

which are weighted variances. There is also a weighted price-quantity covariance and correlation,

$$\Pi_c^{pq} = \sum_{i=1}^3 w_{ic} (\log p_{ic} - \log P_c)(\log q_{ic} - \log Q_c) \quad \text{and} \quad \rho_c = \frac{\Pi_c^{pq}}{\sqrt{\Pi_c^p \Pi_c^q}} .$$

Given the consumer's tendency to move away from items with higher prices towards those with lower ones, this correlation is expected to be negative according to the LOD. Figure 3 is a frequency of the correlations in the 153 countries and as can be seen, 86% are negative, with an overall mean of -0.61, again supportive of the LOD.

It is to be emphasised that the above tests are of a preliminary, or informal, nature only. In the subsequent section, we examine the microeconomics of drinking behaviour more formally with a demand system that permits econometric testing of the implications of utility-maximisation theory.

2 A Demand System

This section applies a demand system to the alcohol data to obtain the price and income elasticities for the three beverages. The Rotterdam model (Barten, 1964, Theil, 1965) is a leading demand system that is designed for time-series data in terms of changes over time. An important feature of this model is its consistency with any conventional utility function, rather than a specific algebraic form. However, some modification is clearly necessary before this model can be applied to cross-country data, rather than time-series data. We shall use a modified levels version of the Rotterdam model due to Barten (1989). For beverage i in country c this takes the form:

$$(1) \quad w_{ic} (\log q_{ic} - \log Q_c) = \beta_i \log Q_c + \sum_{j=1}^3 \pi_{ij} \log p_{jc} + \varepsilon_{ic}.$$

The left-hand side of the above equation is $w_{ic} (\log q_{ic} - \log Q_c)$. This is consumption of beverage i , $\log q_{ic}$, relative to total alcohol, $\log Q_c$, weighted by its budget share, w_{ic} . This variable is explained by real total consumption of alcohol (or the total "volume") and the prices of the three beverages. As total consumption of alcohol is held constant by the variable $\log Q_c$ on the right, it can be seen that equation (1) for $i = 1, 2, 3$ is a conditional demand system. The coefficient of $\log Q_c$, β_i , can be termed the volume coefficient. The π_{ij} 's are known as Slutsky coefficients and refer to the price substitution effects. The term ε_{ic} is a zero-mean disturbance with a constant covariance matrix. By dividing both sides of equation (1) by w_{ic} and rearranging, it can be seen that $1 + \beta_i / w_{ic}$ is the volume elasticity of demand for i (to be referred to as the income elasticity, for short), and π_{ij} / w_{ic} is the $(i, j)^{\text{th}}$ price elasticity, the elasticity of demand for i with respect to the price of j on account of the substitution effect.

The Slutsky coefficients are subject to two constraints: (i) Homogeneity, $\sum_{j=1}^3 \pi_{ij} = 0, i = 1, 2, 3$, so that an equi-proportional change in prices has no effect on consumption; (ii) Symmetry, $\pi_{ij} = \pi_{ji}, i, j = 1, 2, 3$, so that, for example, the effect on wine consumption of a \$1-increase in the price of a bottle of beer is the same as the effect on beer consumption of

a \$1-increase in the price of a bottle of wine. Equation (1) for $i = 1, 2, 3$ is an allocation model as $\sum_{i=1}^3 w_{ic} (\log q_{ic} - \log Q_c) = 0$, so that in order to keep the total unchanged, additional consumption of one beverage must be offset by reduced consumption of the other two combined.

As shown in the Appendix, preliminary estimates of the model indicate that the residuals from the i^{th} equation, $\hat{\varepsilon}_{ic}, c = 1, \dots, 153$, tend to be positive in those countries that are intensive in beverage i . Thus, we divide the $153 - 60 = 93$ countries that are intensive in any one of the beverages into 3 groups, denoted by $\mathbf{S}_1, \mathbf{S}_2, \mathbf{S}_3$, and express the disturbance term in equation (1) as $\varepsilon_{ic} = \sum_{j=1}^3 \alpha_{ij} I_c(c \in \mathbf{S}_j) + \eta_{ic}$, where $I_c(c \in \mathbf{S}_j)$ is an indicator function equal to 1 when c is a beverage- j -intensive country, 0 otherwise, and η_{ic} is a zero-mean, iid disturbance term. Equation (1) then becomes

$$(2) \quad w_{ic} (\log q_{ic} - \log Q_c) = \sum_{j=1}^3 \alpha_{ij} I_c(c \in \mathbf{S}_j) + \beta_i \log Q_c + \sum_{j=1}^3 \pi_{ij} \log p_{jc} + \eta_{ic}.$$

We estimate equation (2) for beer, wine and spirits as a seemingly unrelated regression with homogeneity and symmetry imposed.² The estimates for all countries are contained in the left-hand part of panel A of Table 6. Consider the estimates of the intercepts and Slutsky coefficients (both $\times 100$) reproduced below:

Equation	Intercepts	Slutsky coefficients
Beer	$\begin{bmatrix} 23 & -13 & -15 \end{bmatrix}$	$\begin{bmatrix} -22 & 9 & 13 \end{bmatrix}$
Wine	$\begin{bmatrix} -9 & 20 & -7 \end{bmatrix}$	$\begin{bmatrix} 9 & -18 & 9 \end{bmatrix}$
Spirits	$\begin{bmatrix} -13 & -7 & 23 \end{bmatrix}$	$\begin{bmatrix} 13 & 9 & -22 \end{bmatrix}$

Intriguingly, the above 3×3 matrix of intercepts is not far from symmetric, and with the signs changed, is approximately equal to the Slutsky coefficient matrix (on the right). This pattern can be seen from panel A in Figure 4 that plots the nine estimated intercepts against the corresponding Slutsky coefficients. The points are closely scattered around the straight line with a slope of -45° line, suggesting an inverse proportionality relationship of the form $\alpha_{ij} = \kappa \pi_{ij}, \kappa \approx -1$. This link between the price effects and the intercepts means that, for example, if beverages i and j are good substitutes (so their π_{ij} is a large positive value), the intercept in equation i for beverage- j -intensive countries is a large negative value. Simply put, when i and j are closely related alternatives, the higher consumption of j (the intensive beverage) comes at the expense of lower consumption of beverage i , other factors remaining unchanged. Moreover, this relationship holds for all pairs of beverages. Among the three independent off-

² As it is an allocation model, one equation is redundant and dropped in estimation. Tests show that the homogeneity and symmetry constraints are not rejected. See Table A1 in the Appendix for details.

diagonal Slutsky coefficients, the largest is for the pair {beer, spirits}; the intercept for this pair is also the largest in absolute value.

The proportionality constraint is enforced in the right-hand part of panel A of Table 6 and a comparison with the unconstrained estimates on the left reveals that the estimates are roughly unchanged, while the standard errors fall. As the likelihood ratio test statistic of this constraint, 3.64, is insignificant, proportionality is not rejected, as expected. Similar results apply to each income quartile, as can be seen from the other panels of Table 6 and Figure 4. In summary, proportionality seems to be useful in estimating the demands. In what follows, we shall accordingly use the restricted estimates contained on the right of Table 6.

Several other comments can be made about the estimates on the right of Table 6. First, for each income group, all the intercepts and Slutsky coefficients are significant, pointing to the important role of prices in determining alcohol consumption. Second, in each case, the estimate of the proportionality coefficient κ is also significant and close to -1, which is consistent with the -45° lines of Figure 4. Third, none of the volume coefficients β_i is significant, so the corresponding income elasticities, $1 + \beta_i/w_{ic}$, are not significantly different from 1, which is surprising. Fourth, in every case, each of the three off-diagonal Slutsky coefficients is positive, which means the beverages are pairwise substitutes, as expected. Fifth, the restricted coefficients do not differ substantially across the income distribution. The implied price elasticities of Table 7 for the rich seem somewhat different to those for the other quartiles, but the differences are unlikely to be significant. Thus, controlling for the influences of beverage intensity, income and prices, we can say that tastes appear not to be too different across countries, at least across the income quartiles.

3 Utility Interactions

When the three beverages as a group are separable from all other goods, we can consider utility from the group by itself, to be denoted by $u(q_1, q_2, q_3)$. The marginal utility of beverage i is $\partial u / \partial q_i < 0$, which declines with additional consumption of the beverage, $\partial^2 u / (\partial q_i)^2 < 0$. When the consumption of some other beverage increases, this marginal utility changes by $\partial^2 u / \partial q_i \partial q_j$ for $i \neq j$. When this cross derivative is negative, additional consumption of beverage j causes the i^{th} marginal utility to fall, just like the case of additional consumption of i itself. Thus, we could say i and j are “similar” in generating utility and so are substitutes for one another. When $\partial^2 u / \partial q_i \partial q_j > 0$, beverage i and j are “different” and could be described as complements. Finally, when i and j are independent, $\partial^2 u / \partial q_i \partial q_j = 0$. It is to be noted that this concept of substitutability/complementarity based on the utility function is different to that of Slutsky, which is based on the sign of the “substitution effect” $\partial q_i / \partial p_i$, with real income held

constant. The demand equations we have estimated can be used to provide some guidance on the utility interactions as measured by $\partial^2 u / \partial q_i \partial q_j$.

Houthakker (1960) showed that the total substitution effect of a change in the price of good j on the consumption of good i can be divided into specific and general effects, with the former addressing the utility interactions between i and j . For the beverages group, this distinction can be expressed as:

$$(3) \quad \pi_{ij} = v_{ij} - \phi \eta \theta_i \theta_j.$$

Here, π_{ij} is the $(i, j)^{\text{th}}$ Slutsky coefficient, as before, which represents the total substitution effect. The first term on the right-hand side of equation (3) is the specific effect, defined as $v_{ij} = (\lambda/M) p_i p_j u^{ij}$, where $\lambda > 0$ is the marginal utility of alcohol expenditure (M), p_i is the price of good i and u^{ij} is the $(i, j)^{\text{th}}$ element of the inverse of the 3×3 Hessian matrix of the utility function, $[\partial^2 u / \partial q_i \partial q_j]^{-1}$. If $\mathbf{P}$ is a diagonal matrix with the three prices on the diagonal, the 3×3 matrix of the v_{ij} can be expressed as $[v_{ij}] = (\lambda/M) \mathbf{P} [u^{ij}] \mathbf{P}$. The inverse is $[v_{ij}]^{-1} = (M/\lambda) \mathbf{P}^{-1} [u_{ij}] \mathbf{P}^{-1}$, where $u_{ij} = \partial^2 u / \partial q_i \partial q_j$. Accordingly, the $(i, j)^{\text{th}}$ element of $[v_{ij}]^{-1}$ is $v^{ij} = k \cdot \partial^2 u / \partial (p_i q_i) \partial (p_j q_j)$, where $k = M/\lambda > 0$. In words, this element is proportional to the $(i, j)^{\text{th}}$ element of the Hessian matrix of the utility function in expenditure terms, $[\partial^2 u / \partial (p_i q_i) \partial (p_j q_j)]$. Thus, given numerical values of the matrix $[v_{ij}]$, its inverse provides useful information about the utility interactions of the beverages.

The second term on the right-hand of equation (3) is $\phi \eta \theta_i \theta_j$. Here, η is the income elasticity of alcohol as a whole. The term ϕ is the income elasticity of the marginal utility of income (known as the “income flexibility”), while θ_i is the marginal share of beverage i . Thus, given values of π_{ij} , η , ϕ and θ_i , we can obtain the corresponding v_{ij} as $\pi_{ij} + \phi \eta \theta_i \theta_j$. For further details, see Liu (2018).

The estimates of π_{ij} are from the right side of panel A of Table 6. The marginal share implied by model (2) is $\theta_i = \beta_i + w_i$, which is evaluated with the estimate of β_i and the mean of budget share w_i . Additionally, on the basis of prior estimates summarised in Clements and Zhao (2009, pp. 228-29), the income flexibility ϕ is assumed to be -0.6. We also set $\eta = 1$, a value close to the estimate of Clements and Johnson (1983). Using these values, the estimates of v_{ij} and the inverse are contained in the following table. The three off-diagonal elements in the inverse matrix are negative, suggesting that the marginal utility of each beverage decreases with additional consumption of each of the others, and so the beverages are substitutes in this sense.

Among the three off-diagonal elements, the largest is -0.91, referring to the impact of additional spirits expenditure in depressing the marginal utility of expenditure on wine. Then comes the effect of spirits on beer, followed by wine on beer. These reflect intuitively plausible linkages between the three beverages and raise interesting possibilities for producers (should spirits producers target beer drinkers in their advertising?), as well as taxation policies (such as the revenue leakages from the typically higher taxes on spirits into typically lower-taxed wine).

Beverage	Matrix $[v_{ij}] \times 10$			Matrix $[v_{ij}]^{-1}$		
	Beer	Wine	Spirits	Beer	Wine	Spirits
Beer	-3.53 (0.16)	0.23 (0.06)	0.46 (0.13)	-2.94	-0.44	-0.60
Wine		-2.15 (0.09)	0.44 (0.07)		-4.89	-0.91
Spirits			-2.57 (0.15)			-4.16

Note: As the 3×3 matrix $[v_{ij}]$ is symmetric, the lower triangle is equal to the upper triangle. Standard errors are in parentheses.

4 Robustness Checks

In this section, we consider three checks on the robustness of the results from the demand equations. Our first check is on the stability of the parameter estimates by using rolling regressions with sub-samples of countries. With countries ranked by income per capita and a rolling window of 110 countries, we have $153 - 110 = 43$ sets of estimates. The solid lines in Figure 5 represent the point estimates, with dark and light grey areas representing the one- and two-standard errors bands, respectively. These fancharts show that the price coefficients are quite stable. The wine volume coefficient decreases and that of spirits increases, but these coefficients are not significantly different from zero, as in Table 6. The conclusion is that the estimates are tolerably stable.

Our second robust check relates to the functional form of the demand model. Rather than the modified Rotterdam, we now use the Almost Ideal Demand (AID) model (Deaton and Muellbauer, 1980). Using the same approach as before for the intercepts, the i^{th} equation of this model is

$$(4) \quad w_{ic} = \sum_{j=1}^3 \alpha_{ij} I_c(c \in S_j) + \beta_i \log Q_c + \sum_{j=1}^3 \gamma_{ij} \log p_{jc} + \mu_{ic},$$

where the notation is as before. This model has the same variables on the right-hand side as the Rotterdam, but the left-hand side is now the budget share of beverage i in country c . Table 8 contains the price elasticities implied by the SUR estimates of equation (4) for $i = 1, 2, 3$. Comparing these back to their Rotterdam counterparts of Table 7, we see that the own-price elasticity of wine for all countries is -1.04 from the AID model, while this elasticity is -0.72 according to Rotterdam. Only the rich quartile has similar elasticities (-0.66 for Rotterdam and -0.64 for AID); the other three quartiles are quite different. That this is the only noticeable

difference among the 45 price elasticities of Table 8 indicates we have some degree of confidence that the functional form of the demand model is not particularly problematic. But due to the “similarity” of the two models, it should be acknowledged this conclusion is based on evidence that is somewhat limited.

Countries are included in our sample on the basis of whether or not they consume alcohol. But in this context, “whether or not” is not as straightforward as it sounds as it involves the choice of some cut-off value for consumption. Does this sample-selection procedure bias our results? Our third check addresses the effects of sample selectivity. Clements et al. (2018) use Heckman’s (1976) approach to control for selectivity in the estimation of alcohol demand equations with the 2005 ICP data. We use the same approach with our data (from the 2011 round of the ICP) and the estimates of the demand equations that control for selectivity are presented in Table 9. These estimates are generally consistent with the results of panel A of Table 6.

5 Where is Alcohol Expensive, Where Cheap and Does it Matter?

Our analysis of alcohol demand has implications for alcohol prevention policies and programs. A large literature establishes that public policy that raises prices, such as higher taxation, to be a simple and effective tool to address the alcohol-related harm (Cook and Durrance, 2013; Wagenaar et al., 2009). The reduction of drinking resulting from higher taxation is large compared to other policies such as legal age limits, advertising bans, import quotas, etc. Selvanathan and Selvanathan (2005, Chap. 11) provide information on alcohol restriction policies in 45 European countries. They give qualitative information on licencing arrangements, sales restrictions, advertising limitations and drink-driving laws; there is also quantitative information on taxation in 22 countries. Ideally, we would like data on the impact on prices of such policies for all 153 countries in our sample. But as this is lacking, we shall adopt the approach of analysing prices directly as it is likely that in the majority of countries high (or low) prices reflect the presence (or absence) of stringent policies. Accordingly, this section considers alcohol prices across countries, followed by an analysis of the effects of alcohol prices on the price-sensitivity of drinking.

Table 10 presents the 153 countries ranked in terms of alcohol prices relative to the general price level in each country. The quartile means reported in the last row of each panel reveal that alcohol is generally cheaper in rich countries, and substantially so. Countries with the cheapest alcohol include Australia, the United States, Russia, Japan and the Europeans. Figure 6 is a visualisation of the relationship between prices and income. From the four bars on the far right, for countries with expensive alcohol, it can be seen that poor countries account for about 40% of the total. On the other hand, from the bars on the far left, where alcohol is cheapest, rich countries dominate. Figure 7 plots prices against income, and the slope of the regression line is negative and significant in all cases. The small elasticities here can be reconciled with the large price differences by recognising that the income differences across countries are huge.

Panel A of Table 11 again shows that for all countries, prices are negatively correlated with income. For each quartile, the correlations between prices and consumption are negative, consistent with the law of demand. Finally, income and consumption is mostly positively correlated, consistent with what is reported by the World Health Organization (WHO, 2018).³

Next, to approach some policy implications of our research we re-estimate model (2) for each quartile of the prices with the constraints of homogeneity, symmetry and the proportionality coefficient κ , and the results are contained in Table 12. Table 13 gives the corresponding price elasticities and shows that for countries with cheapest alcohol (panel E), the own-price elasticity of beer, -0.71, is much higher than those for countries in other alcohol quartiles, which are in the range of -0.39 to -0.46. The own-price elasticity of spirits follows a similar pattern. The price sensitivity of wine, on the other hand, is not too different across quartiles. These results suggest that taxation of alcohol is likely to be more effective in reducing consumption in rich countries than in others. Given that countries currently without minimum legal-age requirements for drinking tend to be the low- and lower-middle-income ones (WHO, 2018), the introduction of these restrictions could be more appropriate for these countries.

6 Concluding Comments

To sum up, in this paper we analysed alcohol (beer, wine and spirits) demand in over 100 countries in several ways. First, we found a distinct tendency for countries to concentrate their spending on alcohol on one of the three beverages, rather than to spread it more evenly over the three. Second, in preliminary tests, we found a tendency for consumption to move away from beverages with above-average prices, towards cheaper one, which provided some support for the law of demand. Third, we estimated demand systems for each income quartile and found the elasticities not too different across the income distribution. Fourth, an investigation of the utility interactions revealed wine and spirits to be reasonably close to one another, while beer and spirits are more distant. Fifth, rolling sub-samples of countries, a different functional form of the demand equations and allowing for the potential for selectivity bias suggest the results to be fairly robust. Finally, we analysed patterns in the differences in the cost of alcohol across countries and their impact on the price sensitivity of drinking, and discussed policy implications.

³ “The economic wealth of countries is associated with higher alcohol consumption and higher prevalence of current drinkers across all WHO regions.” (WHO, 2018).

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Table 1 Alcohol and Food Consumption across the Global Income Distribution

Variable	Country income quartile			
	Rich	Third	Second	Poor
Alcohol share (%)	1.4	2.4	2.3	2.2
Food share (%)	11.4	21.0	31.1	45.8
Alcohol/Food (%)	12.5	11.4	8.2	4.9
Income (US=100)	66.6	34.3	19.3	5.5

Note: The 153 countries included in the ICP (2011) data are ranked by total consumption per capita (at PPP exchange rates). Income quartiles refer to this total consumption ranking. The alcohol share refers to its share in total consumption expenditure; and similarly for food. The food excludes alcohol. The index of income in the last row is total consumption per capita with US = 100.

Table 2 Global Alcohol Consumption: Prior Studies

Issues	Author(s)	Comments
Meta Studies of Demand for Beer, Wine and Spirits	Gallet (2007), Fogarty (2010), Nelson (2013a, 2013b) and Nelson (2014)	Analytical summary of prior estimates of demand elasticities for beer, wine and spirits
Drinking Patterns Internationally: Early Studies	Clements and E. A. Selvanathan (1987), E. A. Selvanathan (1991), Clements, Yang, and Zheng (1997), S. Selvanathan (2006) and S. Selvanathan & E. A. Selvanathan (2007)	Tastes seem to differ across countries as judged by demand equations
New Database and Analysis	Anderson, Nelgen and Pinilla (2018), Anderson and Pinilla (2018)	Extensive global wine database, 1860 to 2016. Case studies of wine production, consumption and trade for numerous countries
Cross-country Similarities	Smith and Solgaard (2000), Eriksson, Bentzen and Smith (2001), Aizenman and Brooks (2008), Nelson (2010), Colen and Swinnen (2016), Holmes and Anderson (2017), Mills (2018), Anderson, Meloni and Swinnen (2018)	Globalisation seems to lead to homogenisation of consumption patterns, especially for beer and wine. Some important differences across countries still remain

Table 3 Income Per Capita in 153 Countries in 2011

Income quartile								
	Rich		Third		Second		Poor	
	(1)		(2)		(3)		(4)	
Constituent Countries	1. Bermuda	106.7 D	40. Portugal	45.7 W	79. Georgia	25.2 D	118. Kyrgyzstan	10.1 S
	2. Cayman Islands	105.5 D	41. Qatar	45.7 B	80. Romania	24.5 S	119. China	10.0 S
	3. United States	100.0 D	42. Bahamas	45.8 B	81. Colombia	24.9 B	120. Angola	8.6 B
	4. Hong Kong	98.6 W	43. Slovenia	44.6 D	82. St. Lucia	25.2 D	121. Bhutan	9.0 D
	5. Luxembourg	97.0 D	44. St. Kitts	43.8 D	83. El Salvador	24.6 B	122. India	8.7 S
	6. United Arab E.	86.0 W	45. Croatia	38.2 D	84. Armenia	22.9 S	123. São Tomé	7.5 D
	7. Switzerland	83.5 W	46. Slovakia	37.6 D	85. Serbia	22.8 D	124. Tajikistan	7.2 S
	8. Taiwan	83.2 B	47. Bonaire	38.4 B	86. Brazil	22.3 B	125. Myanmar	6.7 D
	9. Singapore	78.5 B	48. Czech Rep	37.5 D	87. Peru	22.5 B	126. Ghana	7.2 D
	10. Austria	70.3 D	49. Montserrat	37.0 B	88. Thailand	21.9 B	127. Cambodia	6.2 D
	11. Macao	67.4 B	50. Poland	36.8 D	89. Macedonia	21.6 B	128. Cameroon	5.9 B
	12. Curaçao	66.6 B	51. Turkey	36.5 B	90. Jamaica	21.6 B	129. Nigeria	5.9 D
	13. Australia	66.4 D	52. Uruguay	35.0 D	91. Azerbaijan	21.3 D	130. Nepal	4.7 W
	14. Cyprus	65.9 D	53. Chile	34.7 D	92. Bos. Herz.	20.8 B	131. Côte d'Ivoire	5.4 B
	15. Norway	66.2 D	54. Seychelles	29.9 D	93. South Africa	21.2 B	132. Senegal	5.0 D
	16. Germany	63.4 D	55. Lithuania	33.6 D	94. Sri Lanka	19.3 S	133. Lesotho	5.3 B
	17. Sint Maarten	62.8 B	56. Hungary	34.2 D	95. Turks Caicos	20.8 B	134. Kenya	5.2 B
	18. Canada	62.3 D	57. Anti. Barb.	34.4 D	96. Ecuador	19.9 B	135. Djibouti	5.3 B
	19. Aruba	60.6 B	58. Oman	34.0 W	97. Ukraine	19.2 D	136. Haiti	4.6 D
	20. UK	59.9 D	59. Trin. Toba.	33.5 B	98. E. Guinea	19.2 B	137. Sierra Leone	4.5 D
	21. France	58.3 W	60. Mauritius	31.7 D	99. Albania	17.9 W	138. Zambia	3.8 B
	22. Sweden	58.1 D	61. Montenegro	32.0 B	100. Tunisia	18.7 B	139. Congo, Rep.	4.5 B
	23. Finland	57.7 D	62. Russia	31.5 D	101. Namibia	18.2 B	140. Gambia	4.1 D
	24. Iceland	57.6 B	63. Latvia	31.1 S	102. Mongolia	17.7 S	141. Chad	3.9 B
	25. Greece	56.3 D	64. Panama	30.4 S	103. Guatemala	16.1 B	142. Togo	4.0 S
	26. Belgium	56.1 W	65. Kazakhstan	30.1 D	104. Swaziland	15.4 B	143. Benin	3.5 D
	27. Japan	57.0 D	66. Grenada	30.5 D	105. Gabon	15.8 B	144. Madagascar	3.2 B
	28. Italy	55.3 W	67. Dominican	29.6 B	106. Philippines	13.9 D	145. Malawi	2.9 B
	29. Anguilla	54.9 S	68. Estonia	29.8 S	107. Botswana	15.1 B	146. Liberia	2.9 B
	30. Malta	53.4 D	69. Venezuela	28.7 B	108. Paraguay	14.0 B	147. Zimbabwe	2.4 B
	31. Denmark	53.3 W	70. Malaysia	28.6 B	109. Suriname	13.5 B	148. Guinea	2.5 W
	32. Netherlands	52.5 D	71. Bulgaria	27.6 D	110. Fiji	13.9 B	149. Guinea-Bissau	2.4 W
	33. New Zealand	52.9 D	72. Belarus	27.5 D	111. Moldova	13.7 D	150. Mozambique	2.1 B
	34. Spain	51.7 D	73. Belize	27.8 B	112. Nicaragua	12.9 B	151. Burkina Faso	2.1 B
	35. Bahrain	51.7 S	74. Mexico	26.2 B	113. Cape Verde	12.5 B	152. C. African	2.1 B
	36. Ireland	50.8 D	75. Virgin Is.	27.2 B	114. Morocco	12.5 B	153. Congo, D. R.	1.3 D
	37. Korea, Rep.	51.1 S	76. Dominica	26.2 D	115. Bolivia	12.1 D		
	38. Barbados	49.8 B	77. St. Vincent	25.5 B	116. Honduras	11.2 B		
	39. Israel	47.8 D	78. Costa Rica	24.8 B	117. Vietnam	10.4 B		
Mean Income	66.1		33.4		18.4		5.0	
Share of the 153 countries in the world		Population: 83%			Income: 90%			

Note: Countries are ranked in terms of per capita income. Income is defined as total consumption, which is the sum of per capita volumes from 108 commodities in ICP spreadsheet provided by the World Bank. (The first of 108 commodities is rice, with commodity number 110111, while the last is other services nec, 1112711.) That is, income in country c is $\sum_{i=1}^{108} p_{ic}q_{ic}/p_{ic}$, where $p_{ic}q_{ic}$ is per capita expenditure on commodity i and p_{ic} is the PPP price for country c . Income in the US is set at 100. The letter B, W, S, or D next to income corresponds to a country being Beer-intensive, Wine-intensive, Spirits-intensive or Diversified, respectively; see text for details.

Source: ICP (2011).

Table 4 Budget Shares for Four Country Groups

Beverage	Beer intensive		Wine intensive		Spirits intensive		Diversified		All countries	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Beer	67.1	12.0	25.5	10.6	23.0	12.9	36.5	8.5	47.2	20.6
Wine	13.8	9.0	59.9	4.7	16.3	10.0	30.8	10.1	24.6	16.2
Spirits	19.2	9.9	14.6	10.3	60.8	7.1	32.7	9.4	28.2	15.9
No. of countries	65		13		15		60		153	

Note: Budget shares are averages over countries and in percentage terms. “Std” refers to standard deviation.

Table 5 The Covariation of Quantities and Prices

Quantity relative		Price relative to average		Quantity relative		Price relative to average	
to average	Above	Below	Total	to average	Above	Below	Total
A. <u>Beer</u>				B. <u>Wine</u>			
Above	25 (16)	91 (59)	116 (76)	Above	8 (5)	32 (21)	40 (26)
Below	18 (12)	19 (12)	37 (24)	Below	96 (63)	17 (11)	113 (74)
Total	43 (28)	110 (72)	153 (100)	Total	104 (68)	49 (32)	153 (100)
Measure of association	$\phi = -0.26$			Measure of association	$\phi = -0.61$		
C. <u>Spirits</u>				D. <u>Total</u>			
Above	12 (8)	28 (18)	40 (26)	Above	45 (10)	151 (33)	196 (43)
Below	84 (55)	29 (19)	113 (74)	Below	198 (43)	65 (14)	263 (57)
Total	96 (63)	57 (37)	153 (100)	Total	243 (53)	216 (47)	459 (100)
Measure of association	$\phi = -0.40$			Measure of association	$\phi = -0.52$		

Notes:

1. The first entry in each cell is the number of countries, while the figure in parenthesis is the percentage of the 153 countries.
2. The measure of association ϕ lies in the range $[-1, 1]$. If the 2×2 contingency table is denoted by $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$, then $\phi = (ad - bc) / \sqrt{(a+b)(a+c)(c+d)(b+d)}$. When quantities and prices are independent, then $a = c$ and $b = d$, $ad = bc$ and $\phi = 0$. The statistic to test $H_0: \phi = 0$ is $C \cdot \hat{\phi}^2 \square \chi^2$, where C is the number of countries and $\hat{\phi}$ is the estimated value. For beer, $\hat{\phi} = -0.26$ and the statistic is $153 \times (-0.26)^2 = 10.19$, which is greater than the critical value of $\chi^2(1) = 3.84$. The null is thus rejected. The same conclusion holds for the other three panels.

Table 6 Alcohol Demand Equations, Countries Classified by Income

Beverage	Beverage-intensity intercepts			Volume	Slutsky coefficients			Beverage-intensity intercepts			Volume	Slutsky coefficients		
	Beer	Wine	Spirits	β_i	π_{i1}	π_{i2}	π_{i3}	Beer	Wine	Spirits	β_i	π_{i1}	π_{i2}	π_{i3}
Unrestricted Intercepts								Restricted Intercepts						
A. All Countries														
Beer	22.90(1.35)	-13.34(2.27)	-15.28(2.25)	0.34(0.24)	-21.84(1.85)	9.15(1.21)	12.69(1.53)	23.50(1.08)	-10.02(0.72)	-13.48(0.97)	0.18(0.22)	-21.84(1.57)	9.31(0.59)	12.53(1.34)
Wine	-9.44(1.39)	20.10(2.28)	-7.41(2.24)	0.03(0.24)		-18.31(1.37)	9.17(1.15)		19.16(1.19)	-9.14(0.85)	0.16(0.19)		-17.81(0.91)	8.50(0.72)
Spirits	-13.46(1.29)	-6.75(2.19)	22.69(2.12)	-0.37(0.24)			-21.86(1.76)	$\kappa = -1.08(0.07)$		22.63(1.04)	-0.34(0.21)			-21.03(1.53)
B. Rich Quartile														
Beer	18.88(3.57)	-14.43(3.20)	-17.27(4.78)	0.18(0.40)	-27.72(4.71)	11.70(2.95)	16.02(3.61)	21.78(3.31)	-8.96(2.79)	-12.82(1.89)	-0.19(0.48)	-26.81(5.09)	11.03(3.20)	15.78(3.62)
Wine	-9.55(3.51)	19.54(3.04)	-10.56(4.60)	0.47(0.38)		-22.25(3.02)	10.55(2.30)		18.65(3.31)	-9.69(1.63)	0.40(0.33)		-22.95(3.20)	11.92(1.56)
Spirits	-9.33(2.86)	-5.11(2.57)	27.83(3.82)	-0.64(0.36)			-26.57(3.73)	$\kappa = -0.81(0.13)$		22.51(2.12)	-0.21(0.33)			-27.70(4.08)
C. Third Quartile														
Beer	22.11(2.23)	-22.60(4.28)	-9.59(3.85)	0.56(0.33)	-23.69(3.39)	9.49(2.47)	14.20(2.40)	21.96(2.54)	-9.86(1.07)	-12.10(2.48)	0.52(0.33)	-23.88(3.48)	10.72(1.92)	13.15(2.62)
Wine	-7.31(2.48)	25.21(4.50)	-0.01(3.95)	-0.71(0.34)		-15.78(2.79)	6.28(2.16)		14.09(1.76)	-4.221(1.52)	-0.25(0.32)		-15.32(2.07)	4.60(1.39)
Spirits	-14.81(2.39)	-2.62(4.68)	9.60(4.11)	0.15(0.36)			-20.48(2.78)	$\kappa = -0.92(0.17)$		16.32(3.10)	-0.26(0.31)			-17.75(2.76)
D. Second Quartile														
Beer	22.95(3.00)	-18.96(8.05)	-19.52(4.80)	0.43(0.72)	-23.29(3.53)	8.02(2.34)	15.27(2.79)	25.41(3.12)	-9.60(1.69)	-15.82(2.41)	-0.05(0.79)	-21.16(3.70)	7.99(1.29)	13.17(2.97)
Wine	-9.38(2.92)	20.72(7.95)	-4.27(4.55)	-0.50(0.71)		-10.40(2.57)	2.38(2.04)		13.90(2.24)	-4.30(2.12)	-0.34(0.58)		-11.58(2.05)	3.58(1.15)
Spirits	-13.57(2.59)	-1.76(7.17)	23.80(4.16)	0.07(0.63)			-17.65(3.09)	$\kappa = -1.20(0.17)$		20.12(2.02)	0.39(0.61)			-16.75(3.26)
E. Poor Quartile														
Beer	24.22(2.96)	-2.27(4.47)	-15.29(3.75)	0.37(1.07)	-17.02(3.09)	8.23(1.93)	8.79(2.87)	22.08(2.92)	-8.29(2.09)	-13.79(2.46)	0.55(1.36)	-21.77(4.06)	8.18(1.79)	13.59(3.57)
Wine	-8.10(2.42)	15.96(3.61)	-6.79(3.05)	-1.17(0.90)		-20.91(2.09)	12.68(2.18)		19.00(3.09)	-10.71(2.11)	-1.22(1.18)		-18.73(2.12)	10.55(1.74)
Spirits	-16.12(2.75)	-13.68(4.08)	22.08(3.44)	0.80(1.00)			-21.48(3.73)	$\kappa = -1.01(0.14)$		24.49(2.47)	0.67(1.10)			-24.15(3.89)

Note: This table presents the estimates of demand model (2) for $i = 1, 2, 3$ (corresponding to beer, wine and spirits). As $\pi_{ij} = \pi_{ji}$, $i, j = 1, 2, 3$, only the upper triangle of the 3×3 matrix of Slutsky coefficients are presented. κ is the proportionality coefficient linking the intercepts with the Slutsky coefficients. Except for κ , all entries are $\times 100$. Standard errors are in parentheses.

**Table 7 Price Elasticities of Demand,
Modified Rotterdam Model**

Beverage	Beer	Wine	Spirits
A. All Countries			
Beer	-0.46	0.20	0.27
Wine	0.38	-0.72	0.35
Spirits	0.44	0.30	-0.75
B. Rich Quartile			
Beer	-0.73	0.30	0.43
Wine	0.32	-0.66	0.34
Spirits	0.55	0.42	-0.97
C. Third Quartile			
Beer	-0.51	0.23	0.28
Wine	0.47	-0.66	0.20
Spirits	0.43	0.15	-0.59
D. Second Quartile			
Beer	-0.37	0.14	0.23
Wine	0.47	-0.68	0.21
Spirits	0.50	0.14	-0.64
E. Poor Quartile			
Beer	-0.44	0.17	0.28
Wine	0.35	-0.80	0.45
Spirits	0.49	0.38	-0.88

Note: The $(i, j)^{\text{th}}$ price elasticity is π_{ij}/w_{ic} , where the π_{ij} 's are from the right-hand part of Table 6. The elasticities are evaluated at means.

Table 8 Price Elasticities, AID Model

Beverage	Beer	Wine	Spirits
A. All Countries			
Beer	-0.57	0.28	0.30
Wine	0.53	-1.04	0.51
Spirits	0.50	0.44	-0.94
B. Rich Quartile			
Beer	-0.71	0.32	0.40
Wine	0.34	-0.64	0.31
Spirits	0.52	0.38	-0.89
C. Third Quartile			
Beer	-0.74	0.45	0.29
Wine	0.91	-1.34	0.44
Spirits	0.45	0.33	-0.78
D. Second Quartile			
Beer	-0.43	0.19	0.24
Wine	0.63	-1.15	0.52
Spirits	0.51	0.34	-0.85
E. Poor Quartile			
Beer	-0.54	0.22	0.33
Wine	0.45	-1.13	0.68
Spirits	0.58	0.58	-1.16

Note: The $(i, j)^{\text{th}}$ price elasticity is $(\gamma_{ij} - w_i\delta_{ij} + w_iw_j + \beta_i\beta_j\log Q)/w_{ic}$, where δ_{ij} is the Kronecker delta. The elasticities are evaluated at means.

**Table 9 Alcohol Demand Equations,
Sample-Selection Controlled**

Beverage	Beverage-intensity intercepts			Volume	Slutsky coefficients			Inverse
	Beer	Wine	Spirits	β_i	π_{i1}	π_{i2}	π_{i3}	Mills ratio
Beer	20.96(1.66)	-15.61(2.72)	-14.62(2.66)	0.49(0.27)	-18.46(2.12)	7.50(1.34)	10.96(1.72)	3.78(2.37)
Wine	-6.77(1.52)	23.24(2.45)	-5.96(2.37)	-0.13(0.24)		-17.15(1.41)	9.65(1.21)	-6.22(2.13)
Spirits	-14.19(1.48)	-7.64(2.45)	20.59(2.35)	-0.37(0.25)			-20.62(1.93)	2.44(2.13)

Note: This table presents the SUR estimates of model (2) for $i = 1, 2, 3$ with the addition of the inverse Mills ratio (IMR). This ratio is from estimates of a first-stage probit model that explains the probability of a country consuming alcohol in terms of the median age (from UN-WHO) and the shares of Muslims and Christians in the population (from Maoz and Henderson, 2013). Combining the ICP data and demographic data gives a sample size of 161 countries. For the probit model, cut-off expenditure of alcohol that determines whether or not a country consumes alcohol is \$0.1 per capita; 136 countries out of the 161 are above the cut-off.

Table 10 Prices of Alcoholic Beverages in 153 Countries in 2011

Fourth Quartile, Dearest Alcohol					Third Quartile				
Country (1)	Relative Price of				Country (6)	Relative Price of			
	Alcohol (2)	Beer (3)	Wine (4)	Spirits (5)		Alcohol (7)	Beer (8)	Wine (9)	Spirits (10)
1. India	1.64	0.76	2.16	1.54	40. Taiwan	0.54	0.28	1.18	0.57
2. Sri Lanka	1.52	0.55	1.90	1.46	41. Nigeria	0.53	0.30	1.09	0.37
3. Nepal	1.35	0.93	1.67	1.14	42. St. Vincent	0.51	0.60	0.94	0.20
4. Bahrain	1.33	1.13	1.60	1.31	43. Mauritius	0.51	0.10	0.36	0.84
5. Bhutan	1.16	0.55	2.28	0.93	44. Barbados	0.51	0.37	0.95	0.62
6. Belize	1.12	1.05	1.83	1.47	45. St. Lucia	0.51	0.46	0.87	0.48
7. Gambia	1.09	0.85	1.42	0.89	46. Uruguay	0.50	0.40	0.72	0.33
8. Oman	1.03	0.57	1.25	0.74	47. Colombia	0.49	0.30	0.91	0.84
9. Myanmar	0.99	0.80	2.07	0.59	48. Dominica	0.49	0.45	0.78	0.39
10. China	0.97	-0.06	1.66	1.21	49. Chad	0.48	0.40	0.57	0.57
11. Djibouti	0.97	1.00	0.83	0.96	50. Cape Verde	0.47	0.40	0.48	0.59
12. Sierra Leone	0.96	0.76	1.09	0.95	51. Qatar	0.46	0.28	0.78	0.49
13. Seychelles	0.95	0.96	0.91	0.97	52. El Salvador	0.46	0.34	1.10	0.70
14. Guinea	0.95	0.43	1.13	1.06	53. Nicaragua	0.44	0.43	1.49	0.34
15. United Arab E.	0.90	0.68	1.09	0.63	54. Mozambique	0.43	0.38	0.56	0.38
16. Liberia	0.89	0.75	1.14	1.05	55. Montserrat	0.43	0.51	0.79	0.11
17. Guinea-Bissau	0.86	0.54	1.05	0.85	56. Côte d'Ivoire	0.42	0.33	0.54	0.62
18. Morocco	0.85	0.83	0.85	1.01	57. Georgia	0.41	0.30	0.51	0.33
19. Malaysia	0.85	0.71	1.54	0.93	58. Dominican	0.41	0.45	1.08	0.25
20. Singapore	0.84	0.54	1.52	0.95	59. Turks Caicos	0.40	0.38	0.60	0.25
21. Mongolia	0.79	0.42	1.66	1.00	60. Venezuela	0.39	0.36	0.93	0.32
22. Turkey	0.75	0.65	0.83	1.07	61. St. Kitts	0.39	0.47	0.83	0.12
23. Senegal	0.70	0.53	0.69	1.11	62. Madagascar	0.38	0.21	0.94	0.60
24. Guatemala	0.68	0.75	0.84	0.29	63. Iceland	0.38	0.43	0.05	0.77
25. Cambodia	0.67	0.50	1.68	0.71	64. São Tomé	0.37	0.09	0.53	0.54
26. Bolivia	0.65	0.61	0.69	0.66	65. Grenada	0.37	0.34	0.78	0.06
27. Tunisia	0.62	0.41	0.75	1.44	66. Costa Rica	0.37	0.18	1.24	0.43
28. Ghana	0.62	0.49	0.69	0.65	67. Togo	0.37	0.27	0.44	0.44
29. Cayman Islands	0.61	0.30	1.00	0.50	68. Anti. Barb.	0.36	0.46	0.42	0.01
30. Kenya	0.61	0.59	0.99	0.75	69. Benin	0.35	0.24	0.66	0.24
31. Thailand	0.59	0.40	1.74	0.75	70. Curaçao	0.35	0.37	0.60	0.19
32. Aruba	0.57	0.59	0.55	0.54	71. Peru	0.33	0.12	1.19	0.78
33. Hong Kong	0.57	-0.09	0.96	0.39	72. Botswana	0.33	0.32	0.29	0.50
34. Philippines	0.57	0.50	1.24	0.44	73. Suriname	0.32	0.36	0.66	0.19
35. Korea, Rep.	0.56	0.08	0.65	0.82	74. Haiti	0.31	-0.48	1.01	0.39
36. Zambia	0.55	0.54	1.23	0.26	75. Norway	0.31	0.46	-0.12	0.65
37. Fiji	0.55	0.26	1.26	1.30	76. Jamaica	0.31	0.26	0.92	0.14
38. Congo, D. R.	0.54	0.26	0.83	0.74	77. Latvia	0.30	-0.14	-0.02	0.61
39. Trin. Toba.	0.54	0.37	1.55	0.75	78. Paraguay	0.30	0.26	0.47	0.04
Average	0.84	0.58	1.25	0.89	Average	0.41	0.31	0.72	0.42

(continued next page)

Table 10 Prices of Alcohol in 153 Countries in 2011 (continued)

	Second Quartile					First Quartile, cheapest alcohol				
	Country (1)	Relative Price of				Country (6)	Relative Price of			
		Alcohol (2)	Beer (3)	Wine (4)	Spirits (5)		Alcohol (7)	Beer (8)	Wine (9)	Spirits (10)
Constituent Countries	79. Vietnam	0.30	-0.26	1.59	0.63	118. Australia	0.01	0.20	-0.46	0.39
	80. Malawi	0.26	0.30	0.47	0.15	119. Macedonia	0.00	-0.01	-0.41	0.53
	81. Macao	0.24	-0.10	0.93	0.11	120. Czech Rep	0.00	-0.28	-0.05	0.39
	82. Cameroon	0.23	0.22	0.44	0.59	121. United States	0.00	0.00	0.00	0.00
	83. Swaziland	0.23	0.19	0.27	0.40	122. Sint Maarten	0.00	-0.11	0.99	-0.24
	84. Lesotho	0.22	0.20	0.28	0.50	123. Russia	-0.02	-0.04	0.00	-0.01
	85. Bahamas	0.22	0.47	0.04	-0.31	124. Azerbaijan	-0.02	0.01	0.00	-0.05
	86. Ecuador	0.22	0.05	1.42	0.47	125. Belarus	-0.03	0.03	-0.01	-0.08
	87. Honduras	0.21	0.20	1.06	0.05	126. Mexico	-0.03	-0.20	0.25	0.33
	88. Romania	0.21	-0.28	-0.29	0.56	127. Bulgaria	-0.03	-0.13	-0.31	0.39
	89. South Africa	0.19	0.14	0.50	0.04	128. Armenia	-0.05	-0.06	0.06	-0.08
	90. Poland	0.18	-0.16	0.40	0.49	129. Chile	-0.05	0.00	-0.25	0.22
	91. Congo, Rep.	0.17	0.09	0.53	0.47	130. Ukraine	-0.06	-0.28	0.23	-0.11
	92. Burkina Faso	0.17	0.10	0.44	0.31	131. Japan	-0.07	0.24	-0.19	-0.27
	93. Greece	0.17	-0.13	-0.01	0.46	132. Sweden	-0.07	-0.11	-0.29	0.50
	94. Namibia	0.16	0.13	0.43	0.30	133. UK	-0.08	-0.05	-0.27	0.19
	95. Bonaire	0.16	0.02	0.55	0.17	134. Hungary	-0.10	-0.17	-0.47	0.52
	96. Panama	0.15	-0.12	1.02	0.39	135. Bermuda	-0.11	-0.37	0.13	-0.16
	97. Israel	0.13	0.16	-0.26	0.43	136. Angola	-0.13	-0.29	0.54	-0.11
	98. Zimbabwe	0.13	0.04	0.41	0.21	137. Brazil	-0.14	-0.22	0.43	-0.21
	99. C. African	0.12	0.19	0.76	-0.05	138. Albania	-0.15	-0.13	-0.18	0.33
	100. Estonia	0.11	-0.22	-0.21	0.41	139. Moldova	-0.15	-0.09	-0.12	-0.29
	101. Croatia	0.10	0.04	-0.03	0.31	140. Kyrgyzstan	-0.21	0.29	0.31	-0.50
	102. E. Guinea	0.10	-0.14	0.78	0.17	141. Slovenia	-0.24	-0.24	-0.41	0.21
	103. Montenegro	0.09	-0.04	0.09	0.49	142. Virgin Is.	-0.32	-0.47	0.37	-0.54
	104. Ireland	0.08	0.09	-0.15	0.36	143. Spain	-0.39	-0.38	-0.66	0.01
	105. Tajikistan	0.08	0.07	0.30	-0.03	144. Portugal	-0.41	-0.41	-0.46	0.14
	106. Serbia	0.07	-0.21	0.02	0.58	145. Italy	-0.42	-0.28	-0.53	-0.10
	107. Canada	0.07	0.12	-0.17	0.25	146. Austria	-0.42	-0.54	-0.47	-0.05
	108. Anguilla	0.07	0.28	0.68	-0.13	147. Denmark	-0.43	-0.24	-0.64	0.00
	109. Kazakhstan	0.06	0.08	-0.03	0.10	148. Netherlands	-0.46	-0.49	-0.65	0.03
	110. Finland	0.06	0.20	-0.36	0.39	149. Germany	-0.51	-0.61	-0.72	-0.03
	111. New Zealand	0.04	0.19	-0.23	0.31	150. Belgium	-0.52	-0.36	-0.67	-0.06
	112. Slovakia	0.03	-0.37	-0.27	0.53	151. France	-0.52	-0.50	-0.80	0.00
	113. Gabon	0.03	-0.14	0.34	0.27	152. Luxembourg	-0.53	-0.44	-0.82	-0.29
	114. Malta	0.02	0.09	-0.27	0.38	153. Switzerland	-0.63	-0.43	-0.82	-0.15
	115. Cyprus	0.02	0.10	-0.16	0.06					
	116. Lithuania	0.02	-0.36	-0.11	0.48					
	117. Bos. Herz.	0.01	-0.05	-0.05	0.49					
	Average	0.13	0.03	0.29	0.30	Average	-0.20	-0.20	-0.21	0.02

Note: There are 108 goods in the ICP consumption basket; let them be ordered such that beer, wine and spirits are the first three. Then, the relative alcohol price in country c is $\log P_{Ac} - \log P_c$, where $\log P_{Ac} = \sum_{i=1}^3 w_{ic} \log p_{ic}$ is the alcohol price index and $\log P_c = \sum_{i=1}^{108} w_{ic} \log p_{ic}$ is the cost-of-living index. The relative prices of beer, wine and spirits are $\log p_{ic} - \log P_c$ for $i = 1, 2, 3$.

Table 11 Correlations of Prices, Income and Consumption

Variable		Relative price of				Income	Consumption of	
		Alcohol	Beer	Wine	Spirits		Beer	Wine
A. All countries								
Relative price of	Beer	0.85						
	Wine	0.85	0.68					
	Spirits	0.80	0.58	0.58				
Income		-0.37	-0.32	-0.40	-0.28			
Consumption of	Beer	-0.67	-0.59	-0.57	-0.45	0.58		
	Wine	-0.69	-0.60	-0.83	-0.48	0.65	0.70	
	Spirits	-0.56	-0.48	-0.52	-0.52	0.68	0.74	0.72
B. Q4 Rich countries								
Relative price of	Beer	0.89						
	Wine	0.89	0.70					
	Spirits	0.84	0.76	0.59				
Income		0.11	-0.08	0.23	-0.14			
Consumption of	Beer	-0.63	-0.58	-0.57	-0.50	0.13		
	Wine	-0.81	-0.66	-0.88	-0.54	0.06	0.76	
	Spirits	-0.61	-0.42	-0.60	-0.53	-0.02	0.74	0.68
C. Q3 countries								
Relative price of	Beer	0.90						
	Wine	0.83	0.77					
	Spirits	0.67	0.42	0.43				
Income		-0.19	-0.13	-0.32	-0.11			
Consumption of	Beer	-0.64	-0.56	-0.57	-0.29	-0.03		
	Wine	-0.68	-0.60	-0.90	-0.38	0.26	0.67	
	Spirits	-0.56	-0.50	-0.58	-0.48	-0.05	0.83	0.73
D. Q2 countries								
Relative price of	Beer	0.80						
	Wine	0.71	0.51					
	Spirits	0.74	0.45	0.50				
Income		-0.15	-0.25	-0.22	-0.03			
Consumption of	Beer	-0.60	-0.51	-0.25	-0.30	0.21		
	Wine	-0.57	-0.59	-0.76	-0.41	0.32	0.25	
	Spirits	-0.27	-0.30	-0.16	-0.39	0.41	0.43	0.41
E. Q1 Poor countries								
Relative price of	Beer	0.73						
	Wine	0.83	0.49					
	Spirits	0.89	0.56	0.63				
Income		0.13	-0.01	0.29	0.05			
Consumption of	Beer	-0.60	-0.48	-0.41	-0.46	0.08		
	Wine	-0.38	-0.29	-0.43	-0.30	0.23	0.43	
	Spirits	-0.35	-0.31	-0.06	-0.53	0.39	0.27	0.25

Note: See note to Table 10.

Table 12 Alcohol Demand Equations, Countries Classified by Alcohol Prices

Beverage-intensity intercepts			Volume	Slutsky coefficients		
Beer	Wine	Spirits	β_i	π_{i1}	π_{i2}	π_{i3}
A. All countries						
23.50(1.08)	-10.02(0.72)	-13.48(0.97)	0.18(0.22)	-21.84(1.57)	9.31(0.59)	12.53(1.34)
	19.16(1.19)	-9.14(0.85)	0.16(0.19)		-17.81(0.91)	8.50(0.72)
$\kappa = -1.08(0.07)$		22.63(1.04)	-0.34(0.21)			-21.03(1.53)
B. Fourth Quartile, Dearest Alcohol						
20.79(3.20)	-6.78(1.93)	-14.01(2.82)	1.70(1.60)	-17.75(3.76)	5.78(1.59)	11.96(3.27)
	16.84(2.72)	-10.06(1.83)	-1.06(1.07)		-14.38(2.01)	8.59(1.39)
$\kappa = -1.17(0.16)$		24.07(2.25)	-0.64(1.05)			-20.55(3.31)
C. Third Quartile						
19.21(2.19)	-8.48(2.23)	-10.73(2.83)	0.25(0.47)	-23.07(3.48)	10.18(3.27)	12.89(3.16)
	15.05(3.27)	-6.57(2.57)	0.02(0.68)		-18.08(3.46)	7.90(2.30)
$\kappa = -0.83(0.18)$		17.30(4.55)	-0.27(0.70)			-20.79(4.02)
D. Second Quartile						
23.83(2.46)	-10.59(1.49)	-13.25(1.95)	0.62(0.52)	-24.70(5.57)	10.97(1.92)	13.73(4.01)
	15.30(2.84)	-4.71(2.08)	-0.17(0.55)		-15.85(2.13)	4.88(1.68)
$\kappa = -0.96(0.22)$		17.96(1.54)	-0.45(0.41)			-18.61(3.42)
E. First Quartile, Cheapest alcohol						
27.41(5.37)	-12.44(2.09)	-14.97(4.03)	-0.14(0.30)	-27.40(4.96)	12.44(2.86)	14.96(3.06)
	22.21(3.81)	-9.77(2.56)	0.22(0.34)		-22.20(4.05)	9.77(2.10)
$\kappa = -1.00(0.29)$		24.74(5.46)	-0.08(0.31)			-24.73(3.61)

Note: This table presents the estimates of demand model (2); for details, see Table 6. Countries in each quartile are listed in Table 10.

**Table 13 Price Elasticities of Demand, Modified Rotterdam Model,
Countries Classified by Alcohol Prices**

Beverage	Beer	Wine	Spirits
A. All Countries			
Beer	-0.46	0.20	0.27
Wine	0.38	-0.72	0.35
Spirits	0.44	0.30	-0.75
B. Fourth Quartile, Dearest Alcohol			
Beer	-0.39	0.13	0.27
Wine	0.24	-0.60	0.36
Spirits	0.39	0.28	-0.66
C. Third Quartile			
Beer	-0.45	0.20	0.25
Wine	0.52	-0.91	0.40
Spirits	0.45	0.27	-0.72
D. Second Quartile			
Beer	-0.46	0.21	0.26
Wine	0.55	-0.80	0.25
Spirits	0.51	0.18	-0.70
E. First Quartile, Cheapest Alcohol			
Beer	-0.71	0.32	0.39
Wine	0.35	-0.62	0.27
Spirits	0.58	0.38	-0.96

Note: The (i,j)th price elasticity is π_{ij}/w_{ic} , where π_{ij} 's are the Slutsky coefficients from Table 12. The elasticities are evaluated at means.

Figure 1 Citations Patterns for Food and Alcohol

Note: This figure gives the results of keyword searches conducted in September 2017 using Google Scholar (<https://scholar.google.com.au/>). Search terms are listed on the horizontal axis. The height of each column represents the number of articles published in the prescribed time period containing the keywords in question, measured against the left-hand axis. The right-hand axis gives the annual growth rate in the number of citations, calculated as $100 \times \frac{\log(\text{ratio of articles})}{N}$, where N is the number of decades, in our case, $N=3$.

Figure 2 The Drinking Tetrahedron **Figure 3 Price-Quantity Correlation Coefficients**

Figure 4 Intercepts and Slutsky coefficients

Figure 5 Fancharts of Rolling Estimates

Note: The rolling regressions use a 110-country window. The identity number of the last country in each window is given on the horizontal axis (countries are ordered by income per capita). The solid line represents the estimate of the parameter from model (2) and its mean over all rolling windows is given by the dashed horizontal line. The dark grey and light grey areas below and above the solid line represent the one- and two- standard error bands.

Figure 6 Alcohol Prices and Income

Figure 7 Scatter Plots of Prices against Income

Note: For a given country, $\log P_A/P = \log P_A - \log P = \sum_{i=1}^3 w_i \log p_i - \sum_{i=1}^{108} w_i \log p_i$ is the relative price of alcohol, i.e., the difference between the index of the cost of alcohol and the cost-of-living index. The relative prices of beer, wine and spirits are $\log(p_i/P) = \log p_i - \log P$ for $i = 1, 2, 3$. Income ($\log Q$) is total consumption per capita. For more detail, see notes to Tables 3 and 10.

For Information of Reviewers Only

Appendix

Figure A1 presents the residuals from the unrestricted demand equation (1) for three beverages. Panel A of the figure plots, for each beverage, the residuals with countries ordered in terms of decreasing income per capita; there seems to be no obvious pattern. However, when countries are split according to their drinking intensities, a pattern does emerge. Panel B of the figure shows substantial positive means of the residuals for the beverage in those countries intensive in that beverage – beer in the beer-intensive countries, wine in wine-intensive and spirits in spirits-intensive. Additionally, the remaining countries with diversified drinking patterns have a mean close to zero.

There are two hypotheses about the price coefficients π_{ij} . One is homogeneity, the absence of money illusion, which takes the form $\sum_{j=1}^3 \pi_{ij} = 0$. This can be tested for each equation and jointly for all three equations. The results are presented in panel A of Table A1 and as can be seen, homogeneity is not rejected. The second hypothesis is Slutsky symmetry, symmetry of the substitution effects of a price change, which is in the form $\pi_{ij} = \pi_{ji}$. This involves coefficients of different equations and can only be tested jointly. The test statistic is in panel B of Table A1 and again, the hypothesis is not rejected.

Table A1 Tests of Homogeneity and Symmetry

Beverage	Test statistic	Critical value (5% level)	Decision
(1)	(2)	(3)	(4)
A. Homogeneity			
		F(0.95,1,153)	
Beer	0.48	3.91	Do not reject
Wine	1.79	3.91	Do not reject
Spirits	0.45	3.91	Do not reject
		$\chi^2(0.95,2)$	
System	1.79	5.99	Do not reject
B. Symmetry			
		$\chi^2(0.95,1)$	
System	0.02	3.84	Do not reject

Notes:

1. In panel A, the homogeneity hypothesis takes the form $H_0 : \sum_{j=1}^3 \pi_{ij} = 0$; $H_A : \sum_{j=1}^3 \pi_{ij} \neq 0$, $i = 1, 2, 3$. In panel B, the symmetry hypothesis, given homogeneity, takes the form $H_0 : \pi_{12} = \pi_{21}$; $H_A : \pi_{12} \neq \pi_{21}$.
2. Three beverage-intensity intercepts are included in each demand equation.

Figure A1 Residuals from Unrestricted Demand Equations

$$\hat{\varepsilon}_{ic} = w_{ic} (\log q_{ic} - \log Q_c) - \hat{\beta}_i \log Q_c - \sum_{j=1}^3 \hat{\pi}_{ij} \log p_{jc}$$

Notes:

1. Each plot has 153 data points, one for each country.
2. Countries in panel A are ranked according to their per capita income, as described in Table 3.
3. In panel B countries are grouped according to the predominant beverage consumed, as discussed in Section 1. There are 65 beer-intensive countries, 13 wine-intensive countries, 15 spirits-intensive countries and the remaining 60 have diversified drinking patterns. Within each group in panel B, countries are listed in order of decreasing income. The horizontal lines for each group in this panel represent the means of the residuals.