Assessing Patterns of Alcohol Taxes Produced by Various Types of Excise Tax Methods—A Simulation Study

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Abstract

Aim: To examine patterns of tax burdens produced by specific, ad valorem, and various types of combination taxations.

Method: One hundred unique hypothetical alcoholic beverages were mathematically simulated based on the amount of ethanol and perceived-qualities contained. Second, beverages were assigned values of various costs and tax rates, and third, patterns of tax burden were assessed per unit of ethanol produced by each type of tax method.

Result: Different tax methods produced different tax burdens per unit of ethanol for different alcoholic beverages. The tax burden produced by the ad valorem tax resulted in a lower tax burden for low perceived-quality alcoholic beverages. The specific tax method showed the same tax burden for both low and high perceived-quality alcoholic beverages. However, high perceived-quality beverages benefited from a lower tax burden per beverage price. Lastly, the combination tax method resulted in a lower tax burden for medium perceived-quality alcoholic beverages.

Conclusion: Under the oligopoly market, ad valorem taxation encourages consumption of low perceived-quality beverages; specific taxation encourages consumption of high perceived-quality beverages; and combination tax methods encourage consumption of medium perceived-quality beverages.

INTRODUCTION

Recent systematic reviews and meta-analyses found that increasing alcohol excise taxes is an effective way to reduce alcohol consumption both in high-income countries (HIC) (Wagenaar et al., 2009, 2010; Elder et al., 2010) and low- and middle-income countries (LMIC) (Sornpaisarn et al., 2013). Taxation is recommended as an effective policy intervention in the World Health Organization’s (WHO) Global Strategy to Reduce the Harmful use of Alcohol, endorsed by the 63rd World Health Assembly in May 2010 (WHO, 2010a). Furthermore, it is one of three ‘best buy’ interventions to prevent and control the alcohol attributable non-communicable disease (NCD) burden in the Global NCD Action Plan adopted by the General Assembly at a meeting on the Prevention and Control of Non-communicable Diseases in April 2011 in Moscow, and also at the First Global Ministerial Conference on Healthy Lifestyles and
Non-communicable Disease Control in September 2011 in New York (WHO, 2012; for a comparison of cost-effectiveness of different alcohol policy methods see Chisholm et al., 2006).

Apart from taxation, pricing control measures include minimum pricing and the restriction of price-based promotion (i.e. discounting restriction) (Babor et al., 2010). These measures have shown to be effective in reducing alcohol consumption and related health harms by an empirical study conducted in Canada (Stockwell et al., 2012) and by modeling studies in the UK (Purshouse et al., 2010; Holmes et al., 2014). This paper, however, focuses on taxation because it is a fiscal measure whereas the minimum pricing and restriction of price-based promotion are regulation measures that need intensive policy enforcement.

There are several types of excise tax methods employed by different countries. (Barzel, 1976; Subik and Richard, 1980; Myles, 1996; Keen, 1998; Rerchuphan, 2005; World Health Organization, 2010b; Sornpaisarn et al., 2014). Excise taxation methods can be divided into two main groups: uniform and combination taxation. Uniform taxation includes specific taxation (hereafter abbreviated to Sp) and ad valorem taxation (hereafter abbreviated to AV). Combination taxation are tax methods that combine these two uniform taxations in varied ways. As defined in the WHO Technical Manual on Tobacco Tax Administration (WHO, 2010b), ‘mixed specific and ad valorem taxation (hereafter abbreviated to MSA)’ is a combination tax method that imposes both SP and AV on each alcoholic beverage simultaneously, while ‘ad valorem with specific floor taxation (hereafter abbreviated to ASF)’ is a combination tax method that calculates both SP and AV for each alcoholic beverage, but imposes an actual tax based on the higher value between the two tax calculations. The latter tax method is called ‘ad valorem with specific floor taxation’ because AV is imposed on alcoholic beverages if the AV tax value is higher than the SP’s value but if the AV tax value is lower, then SP tax is imposed as a floor value (minimum value).

There are large variations in alcohol excise tax methods used by governments around the world. The Global Report on Alcohol and Health (2014) reported 92% (154 countries of 167 reporting countries) applied excise taxes on alcohol products (WHO, 2014). Among 141 countries providing detailed information on tax methods, 68% (96 countries) applied AV; 64% (91 countries) applied SP; and 2% (3 countries) applied other tax methods (Rehm and Shield, 2014). Moreover, Rehm and Shield (2014) found that 78 countries applied one type of uniform tax on alcoholic beverages while 63 countries applied more than one tax method on alcoholic beverages in their countries. These 63 countries either applied more than one uniform tax, in which different types of taxes were used for different beverage types [i.e. the Australian government applied SP for all beverages except for wine where AV was applied (Doran et al., 2013)] or a combination tax on all alcoholic beverages was used. Twenty countries of 63 which applied more than one tax method reported that their governments applied a combination tax: 13 counties applied MSA and seven countries applied ASF (Rehm and Shield, 2014). Complexity in the area of taxation is not caused only by types of tax methods, but by tax rates determined by governments (Bird and Wallace, 2010; OECD, 2014) and tax revenue generations for governments (OECD, 2014) in different countries. Use data from countries in the South Africa Continent as examples. Benin imposed 10% ad valorem tax rate on beer, wine and spirits; Ghana imposed 30% ad valorem tax rate on beer and 25% ad valorem tax rate on spirits whereas South Africa imposed specific tax rates at 46.4 South African Rand (R) per liter for malt/beer and 7.8 South African Cent per liter for traditional beer, R 3.7 per liter for fortified still wine, R 6.2 per liter for sparkling wine and R 2.0 per liter for unfortified wine, R 77.7 per liter of absolute alcohol for spirits (Bird and Wallace, 2010). Tax on alcohol as a percent of excise tax revenue was ranged from 22% for Ghana to 39% for Rwanda (Bird and Wallace, 2010). It is clear that alcohol excise taxation is a very complex issue. This study aims to describe only one basic aspect: the aspect of tax methods.

A number of studies have mathematically examined which types of excise tax methods are better than others in terms of tax burden, total goods consumption, variety of product quality and tax revenue generation. However, in almost all studies, comparative assessments have been conducted only between two basic uniform tax methods: SP and AV (for examples, see Barzel, 1976; Myles, 1996; Keen, 1998; Grazzini, 2000; Lockwood, 2004; Droege and Schroder, 2005; Smith, 2005; Collie, 2006; Cnossen, 2010; Lapan and Hennessy, 2011; Blackorby and Murty, 2013). These studies (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010) found that, under an oligopoly market, strengths of SP include it (in the economic perspective) promotes qualities and varieties of products, and free entry of companies into the market. It (in the public health perspective) does better in correcting externality (external consequences on other persons caused by alcohol drinkers) by increasing alcohol price and reducing total alcohol consumption. SP’s weaknesses cover it (in the economic perspective) generates less tax revenue and it (in the equity perspective) imposes more taxes on the poor which is called ‘regressive tax’. Conversely, strengths of AV include it (in the economic perspective) generates more tax revenue and it (in equity perspective) imposes more taxes on the rich which is called ‘progressive tax’. AV’s weaknesses include it (in economic perspective) demotes qualities and varieties of products, and free entry of companies into the market. It (in the public health perspective) does worse in correcting externality because it decreases alcohol price and increases total alcohol consumption. An oligopoly market is one where there are few producers, distributors or consumers of certain goods, making it easier to manipulate prices for select products (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010). In our review, we found only one article studying attributes of combination taxation, namely MSA, compared how the optimal combination of AV and SP should be used (Myles, 1996).

The objective of this study is to examine the magnitudes and patterns of tax burden per unit of ethanol produced by various types of combination tax methods, compared with those produced by SP and AV, using simulation methodology. Furthermore, this study examines different patterns of tax burden per unit of ethanol produced by SP, which is based on units of ethanol, and those produced by SP which is based on units of beverage to determine if any differences exist. An ultimate goal is to strengthen tax policy decision making.

MATERIALS AND METHODS

Tax burden was analyzed per unit of ethanol for various types of alcohol excise tax methods by conducting research on 100 simulated alcoholic beverages which were constructed using a three-step procedure (see Table 1). First, the authors created 100 hypothetical alcoholic beverages falling equally under ten beverage categories and differed in ethanol content from one to ten units of ethanol per bottle. Within each category, the beverages differed in their value of the perceived-quality from one unit to ten units of perceived-quality per unit of beverage. The perceived-quality in alcoholic beverages measured consumers’ opinions about the beverage’s ability to fulfill his or her expectations. For example, such measures might include years of brewing,
Table 1. Simulation method for constructing hypothetical 100 alcoholic beverages and their attributes

<table>
<thead>
<tr>
<th>Step</th>
<th>Value assignment and calculation method</th>
</tr>
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</table>
| 1. Constructing 100 alcoholic beverages | 1.1. Constructing 100 simulated beverages falling under 10 beverage categories which differ in ethanol content from one to ten unit of ethanol per bottle.  
1.2. In each category, assigning 10 beverages with different perceived-qualities (i.e. year of brewing) per bottle from one to ten unit of perceived-quality. |
| 2. Assigning prices of ethanol and perceived-quality and values of tax rates for both SP and AV taxation | 2.1. Assigning the value of ethanol at $1 per unit of ethanol  
2.2. Assigning the value of perceived-quality at $1 per unit of perceived-quality  
2.3. Assigning SP tax rate at $1 per unit of ethanol  
2.4. Assigning AV tax rate at 50% exclusive rate of beverage price |
| 3. Calculating pre-taxed beverage price per bottle and pre-taxed beverage price per unit of ethanol and calculating average tax burden per unit of ethanol of all simulated beverages | 3.1. The pre-taxed price per bottle of each beverage was calculated from its values in step 1 time its values in Step 2. For example, a beverage with ethanol 2 units of ethanol/bottle and 1 unit of perceived-quality has a beverage price of $3 ([2 units of ethanol * $1] + [1 unit of perceived-quality * $1]).  
3.2. The pre-taxed price per unit of ethanol of each beverage was calculated using the calculation gotten from Step 3.1 divided by the number of ethanol per bottle of that beverage. For example, the pre-taxed price per unit of ethanol of the beverage mentioned in 3.1 was $1.5/unit of ethanol ($3/2 units of ethanol).  
3.3. The tax values per bottle of each beverages were calculated under five taxation methods as follows: (using the example of 3.1)  
3.3.1. SP: $2 (2 units of ethanol * $1)  
3.3.2. AV: $1.5 (50% of $3)  
3.3.3. MSA-SP with a SP tax rate of $0.8 per unit of ethanol and an AV tax rate of 10% of beverage price: $1.9 ([2 units of ethanol * $0.8] + [10% of $3])  
3.3.4. MSA-AV with a SP tax rate of $0.2 per unit of ethanol and an AV tax rate of 40% of beverage price: $1.6 ([2 units of ethanol * 0.2] + [40% of $3])  
3.3.5. ASF: $2 (because the beverage’s AV tax value ($1.5) was less than its SP tax value ($2), the effective tax value was $2 as a SP floor.)  
3.4. The tax burden per unit of ethanol of each beverages were calculated under five taxation methods as follows: (using the example of 3.3)  
3.4.1. SP: $1/unit of ethanol ($2/2 units of ethanol)  
3.4.2. AV: $0.75 ($1.5/2 units of ethanol)  
3.4.3. MSA-SP: $0.95 ($1.9/2 units of ethanol)  
3.4.4. MSA-AV: $0.8 ($1.6/2 units of ethanol)  
3.4.5. ASF: $1 ($2/2 units of ethanol) |

Sp, specific taxation; AV, ad valorem taxation; MSA-SP, mixed specific and ad valorem taxation favoring specific; MSA-AV, mixed specific and ad valorem taxation favoring ad valorem.

packaging, advertising images, etc. Since ethanol is chemically similar in alcoholic beverages, the perceived-quality per unit of ethanol is usually an indicator of the price a consumer is willing to pay for an alcoholic beverage. Second, the price of ethanol, perceived-quality and the value of tax rates for both SP and AV were assigned. Third, the beverage pre-taxed price per bottle ($/bottle) and the beverage pre-taxed price per unit of ethanol (BPPE, $/unit of ethanol) were estimated for all hundred simulated alcoholic beverages. According to the calculated beverage pre-taxed price and the BPPE, the tax burden per bottle and the average tax burden per unit of ethanol were calculated under the five following taxation models: (1) AV, (2) MSA favoring AV (hereafter abbreviated to MSA-AV), (3) MSA favoring SP (hereafter abbreviated to MSA-SP), (4) SP and (5) ASF. MSA-SP means that the SP tax rate is greater than the AV tax rate, whereas the MSA-AV means that the SP tax rate is less than the AV tax rate.

A mathematical simulation and a comparative tax value calculation were conducted to calculate and compare the tax burden per bottle between those produced by SP, which taxes alcohol products based on units of ethanol, and those produced by SP that taxes alcohol products based on units of beverage. We also conducted a comparative tax value calculation employing real tax rates used in Sweden in 1992 in which the government applied SP with unit of beverage as a tax base as an example (Ponicki et al., 1997).

RESULTS

Figure 1 shows the average simulated tax burden per unit of ethanol (Y-axis) per ten alcoholic beverage categories arranged by the amount of perceived-qualities per bottle from one to ten on the X-axis. This figure illustrates the simulated SP tax burden, the simulated MSA-SP tax burden, the simulated MSA-AV tax burden and the AV tax burden for all ten beverage categories which are lined horizontally to steepest, respectively.

The SP tax burden per unit of ethanol is equal for all ten simulated beverages because this method taxes the units of ethanol contained in the beverage regardless of the beverage price which depends on the number of perceived-qualities the beverage contains, as shown by the horizontal line. Increasing perceived-qualities under the SP taxation has no tax cost. On the other hand, the AV tax burden per unit of ethanol is associated with the number of perceived-qualities per beverage unit as shown by the steepest straight line in Fig. 1.
regardless of the number of units of ethanol. Decreasing perceived-qualities under AV can reduce tax burden. The tax burden per unit of ethanol produced by MSA is related to the number of perceived-qualities per unit of ethanol; however, the extent of the association depends on the proportion of the AV tax burden to the proportion of the SP tax burden. The pattern of association between perceived-qualities and the tax burden produced by the MSA-SP tax method is closer to those of SP (the lower steep line) whereas the pattern of association with the MSA-AV is closer to those of the AV tax method (the higher steep line).

Figure 2 demonstrates the simulated tax burden produced by ASF (the bend line), the SP tax burden (the horizontal line) and the AV tax burden (the steep line). By definition, the actual ASF tax burden is equal to the AV tax burden if the AV tax burden is higher than the SP tax burden (this is the case for the greater perceived-quality beverages: beverages numbered 4–10) and equal to the SP tax burden if vice versa (this is true for the lower perceived-quality beverages: beverages numbered 1–3). Hence, the ASF tax burden is displayed in a bend line fashion: the inexpensive alcoholic beverages are taxed by the SP tax method while the expensive alcoholic beverages are taxed by the AV tax method. Thus, under ASF, increasing the ethanol content of inexpensive alcoholic beverages has no tax cost and decreasing perceived-qualities of expensive alcoholic beverages can reduce tax burden.

Figure 3 shows the simulated tax burden per beverage produced by SP that taxes alcoholic beverages based on unit of ethanol (the diagonal line) and those produced by SP that taxes alcoholic beverages based on unit of beverage (the horizontal line). Unlike Fig. 1, in Fig. 3 the x-axis shows the number of units of ethanol per beverage and the y-axis shows the average tax burden per unit of beverage. The simulated tax burden per unit of beverage produced by SP with a unit of beverage tax base are equal for all ten simulated beverages as a result of the type of tax base, unit of beverage, and taxes on alcoholic beverage size, as shown by the horizontal line. Conversely, the simulated tax burden per beverage produced by SP with a tax base of ethanol units are associated with the number of ethanol units contained in a beverage. Therefore, the higher the number of ethanol units, the higher tax rate per beverage, as shown by the diagonal line. Increasing ethanol has no
tax cost under SP which taxes alcoholic beverages based on unit of beverage.

In 1992 the Swedish government determined the SP tax rate with a tax base of beverage units with nine tiered tax rate levels based on the percentage of alcohol contained in alcoholic beverages. Table 2 illustrates the tax burden produced by SP with a tax base of alcoholic beverage units and their corresponding calculated tax burden per unit of ethanol. Within each tax rate level, the corresponding tax burden per unit of ethanol decreases if the percentage of ethanol contained in the beverage increases. For example, if the tax rate is 8.50 Swedish Crona per liter (SEK/L) of an alcoholic beverage with 4–5% alcohol content then this rate corresponds to the tax burden of 2.1 and 1.7 SEK per one percentage of ethanol per liter of beverage (SEK/1%/L) for those beverages with 4 and 5% alcohol by volume, respectively (2.1 and 1.7 SEK/1%/L is calculated from 8.5 SEK/L divided by 4 and 5% respectively.) The tax burden per unit of ethanol of an alcoholic beverage, in a higher tax rate per beverage category, may have a lower tax burden than that of an alcoholic beverage in a lower tax rate per beverage if alcohol concentration in the former category is high enough. For example, an alcoholic beverage with 29% alcohol by volume yields a tax burden per unit of ethanol of 1.8 SEK/1%/L while the alcoholic beverage with 4% alcohol by volume yields a tax burden per unit of ethanol of 2.1 SEK/1%/L. Thus, increasing ethanol under SP with a beverage unit tax base can reduce tax burden per unit of ethanol.

DISCUSSION

Based on simulations, different tax methods produced different tax burdens per unit of ethanol for different alcoholic beverages. SP produced an equal tax burden per unit of ethanol regardless of the percentage of ethanol contained in a beverage. Increasing perceived-qualities under SP had no additional taxation cost. AV producers tend to add perceived-qualities to their products to achieve a lower tax burden per unit of perceived-quality resulting in a lower tax burden per beverage price and higher net gain. Relatively increasing perceived-qualities per unit of ethanol is called the ‘upgrading effect’ (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010). As a result, SP favors consumption of alcoholic beverages with relatively high-perceived quality. Consequently, total alcohol consumption is reduced because high perceived-quality alcoholic beverages are more expensive than low perceived-quality alcoholic beverages. It should be noted that transferring alcohol tax and the additional cost of increased perceived-qualities into consumer alcohol prices is normally called ‘tax over-shifting’ (Keen, 1998).

If reducing perceived-qualities can decrease the tax burden per unit of ethanol, as under AV, producers may tend to cut unnecessary perceived-qualities out of their alcohol products. Relatively decreasing perceived-qualities per unit of ethanol is called the ‘downgrading effect’ (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010). Thus, AV encourages the production and sale of low perceived-quality beverages, resulting in a lower than average beverage price per unit of ethanol and higher total alcohol consumption. Notably, adding more ethanol or increasing perceived-qualities under AV leads consumers to pay for both the cost of additions (i.e. ethanol) and the corresponding increase in taxes, which is called a ‘multiplier effect’ (Keen, 1998).

Accordingly, MSA has both an upgrading effect and a downgrading effect, promoting consumption of medium perceived-quality beverages. The attribute of MSA depends on the proportion between tax burdens produced by the two tax methods. The attribute of MSA-S is closer to SP (favoring high perceived-quality alcoholic beverages), while MSA-AV is closer to AV (favoring low perceived-quality alcoholic beverages). MSA taxation is widely used in European countries (Cnossen, 2001). Among EU countries using MSA, northern EU countries favor SP, while southern EU countries favor AV (Cnossen, 2001).

Under ASF, inexpensive alcoholic beverages are taxed by SP while expensive alcoholic beverages are taxed by AV. As a result, ASF provides an upgrading effect, promoting consumption of high

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**Fig. 3. A comparison of tax burdens per beverage between specific taxation based on unit of ethanol and specific taxation based on unit of beverage.**
perceived-quality beverages among inexpensive alcoholic beverages and the downgrading effect, which promotes consumption of low perceived-quality beverages among expensive alcoholic beverages, resulting in ultimately promoting consumption of medium perceived-quality alcoholic beverages. It should be noted that an important attribute of ASF is ‘the tax rate tipping point’ which is the point that a tax method applied is shifting from AV to SP if the price of an alcoholic beverage is lowered to a certain point (Sornpaisarn et al., 2012a). This attribute creates an anti-downgrading barrier that can protect alcohol producers from downgrading alcoholic products in an inexpensive beverage category, unlike AV that allows producers to downgrade a whole range of alcohol products (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010). Favoring the consumption of low perceived-quality alcoholic beverages by AV has a benefit of tax revenue generation, but as a trade-off total alcohol consumption may increase (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010). Favoring the consumption of high perceived-quality alcoholic beverages by SP may reduce total alcohol consumption (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010); however, it may encourage drinking initiation in countries with high rates of abstainers considering adolescent onset of drinking usually starts with low alcohol content and, high perceived-quality beverages (Sornpaisarn et al., 2012a). Favoring the consumption of low perceived-quality alcoholic beverages by AV has a benefit of tax revenue generation, but as a trade-off total alcohol consumption may increase (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010). Favoring the consumption of high perceived-quality alcoholic beverages by SP may reduce total alcohol consumption (Barzel, 1976; Myles, 1996; Keen, 1998; Smith, 2005; Cnossen, 2010); however, it may encourage drinking initiation in countries with high rates of abstainers considering adolescent onset of drinking usually starts with low alcohol content and, high perceived-quality beverages (Sornpaisarn et al., 2012a). Even though SP results in a reduction of total alcohol consumption, it can increase tax revenue generation because alcohol products of this kind are price inelastic meaning the percentage increase in price is greater than the percentage decrease in consumption (Cnossen, 2005). Favoring the consumption of medium perceived-quality alcoholic beverages by combination taxations has the potential to reduce total alcohol consumption and prevent drinking initiation simultaneously (Sornpaisarn et al., 2012a,b,c; 2015).

Another relevant issue when considering a tax method is ‘progressivity’. Progressivity is used to measure the distribution of tax burden or tax incidence across a given population. It is an equity assessment tool (Holmes et al., 2014). SP is considered regressive because it

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### Table 2. A comparison between tax burden per unit of beverage and their corresponding tax burden per unit of ethanol for alcoholic beverages with various percentage of alcohol by volume under the specific tax with tax base of units of beverage

<table>
<thead>
<tr>
<th>SP tax rate imposed on alcohol products in Sweden in 1992</th>
<th>Simulated % alcohol by volume contained in the beverage</th>
<th>The calculated excise tax burden per unit of ethanol (SEK/1%VL/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category (a)</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>---------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>3.00 SEK/Liter of beverage for alcoholic beverage with 3% alcohol content</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>8.50 SEK/Liter of beverage for alcoholic beverage with 4% alcohol content</td>
<td>2.1</td>
</tr>
<tr>
<td>3</td>
<td>12.50 SEK/Liter of beverage for alcoholic beverage with 6% alcohol content</td>
<td>1.8</td>
</tr>
<tr>
<td>4</td>
<td>17.10 SEK/Liter of beverage for alcoholic beverage with 8% alcohol content</td>
<td>2.14</td>
</tr>
<tr>
<td>5</td>
<td>26.70 SEK/Liter of beverage for alcoholic beverage with 12% alcohol content</td>
<td>1.55</td>
</tr>
<tr>
<td>6</td>
<td>52.60 SEK/Liter of beverage for alcoholic beverage with 20% alcohol content</td>
<td>2.23</td>
</tr>
<tr>
<td>7</td>
<td>110.40 SEK/Liter of beverage for alcoholic beverage with 30% alcohol content</td>
<td>1.78</td>
</tr>
<tr>
<td>8</td>
<td>182.30 SEK/Liter of beverage for alcoholic beverage with 40% alcohol content</td>
<td>2.19</td>
</tr>
<tr>
<td>9</td>
<td>250.30 SEK/Liter of beverage for alcoholic beverage with 50% alcohol content</td>
<td>2.63</td>
</tr>
</tbody>
</table>

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9a = (5a)/b; SEK/L, Swedish Crona per liter of beverage; SEK/1%VL, Swedish Crona per one percent of ethanol per liter of beverage.
imposes the same amount of tax burden per unit of alcohol for all alcoholic beverages regardless of their prices. As a result, the poor pay alcohol tax at a higher percentage of the purchased price than the rich (Keen, 1998). Conversely, AV is considered progressive because it imposes the same percentage of tax burden to the total purchased price regardless of the alcohol content level, meaning that the rich pay alcohol tax at a higher rate per unit of ethanol than the poor (Keen, 1998). Combination taxes have both regressive and progressive attributes. Combination tax methods are considered regressive because their SP component is more effective on inexpensive beverages resulting in a higher tax burden on the poor. Combination tax methods are still considered regressive because their AV component is more effective on expensive beverages that impose a greater tax burden on the rich.

Although combination taxation has some benefits over uniform tax methods (i.e. preventing drinking initiation and progressivity issues), they are more complex which is a disadvantage in terms of tax administration (i.e. more complex and require more information) (WHO, 2010b).

SP can impose on alcohol products with two types of tax base: the unit of ethanol and the unit of beverage. SP with a tax base of beverage unit is widely used for taxing alcoholic beverages that have uncertain alcohol concentration, (i.e. wine) (Easton, 2002). However, as shown in Fig. 3 and Table 2, the tax burden produced by SP with a beverage unit tax base can decrease if the alcohol product has a higher alcohol concentration. This may be referred to as a ‘condensing effect’ because it encourages alcohol producers to increase the amount of ethanol in their alcohol products. The government should take into account this effect when it employs SP with a tax base of beverage unit.

A limitation of this study is that we conducted a mathematical simulation comparatively assessing only one outcome: the patterns of tax burden per unit of ethanol produced by various types of taxation. The reason for our simplification, however, was that we wanted to demonstrate the effect of taxation methods on the immediate outcome of tax burden per unit of ethanol. The other sequential outcomes of taxation (including price, consumption and related harms and tax revenue generation) are also affected by many other factors such as differential tax rate determination, how taxes pass-through price, inflation, own- and cross-price elasticity, recorded and unrecorded alcohol consumption, substitution to other drugs, socioeconomic status and drinking behaviors. For example, tax may pass-through differently between cheap and expensive alcoholic beverages (Ally et al., 2014). Price elasticity of alcohol consumption and related health harms are different among beverage types (Elder et al., 2010). To understand attributes of various types of taxation, there is a need to conduct either simulation or empirical studies to compare the effects of various taxation on price, consumption, drinking initiation and tax revenue generation in order to inform public health and fiscal policy makers in selecting the best excise taxation methods to reach their objectives.

In conclusion, governments should know the different effects of various types of excise taxation methods on tax burden per unit of ethanol since these will influence alcohol consumption, drinking initiation as well as tax revenue generation. Under the oligopoly market, ad valorem taxation encourages consumption of low perceived-quality beverages; specific taxation encourages consumption of high perceived-quality beverages; and combination tax methods encourage consumption of medium perceived-quality beverages. From a public health perspective, AV is not appropriate in taxing alcoholic beverages since it increases total alcohol consumption even though it generates more revenue as compared with SP. SP is appropriate for countries with a high prevalence of current drinkers that desire to reduce total alcohol consumption by encouraging the consumption of low ethanol content beverages. Combination taxation methods may be appropriate for countries with a low prevalence of current drinkers or a high prevalence of abstainers that desire to simultaneously reduce total alcohol consumption and prevent drinking initiation.

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**CONFLICT OF INTEREST STATEMENT**

None declared.

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