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# Welfare Calculation by Consumer Surplus – a Phlogiston of Economics?

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# Welfare Calculation by Consumer Surplus – a Phlogiston of Economics*

*Abstract: in economics, the concept of consumer surplus is widespread. On this basis, taxes, subsidies, and tariffs are welfare-reducing. But by reconstructing the methodological requirements of a consumer surplus argumentation, alternative constructions are possible. In two relevant cases, it will be shown that those alternatives yield opposite outcomes, making the usage of consumer surplus for welfare calculations useless.*
*JEL-classifikation: B41, D61, H20, F10*
*Keywords: consumer surplus, welfare measurement, deadweight loss, Harberger triangle, taxes, tariffs*

Even if often criticized,[1] in the over one-hundred and seventy-year history,[2] the determination of welfare based on the calculation of consumer surplus remains, until this day, a widely accepted approach in economics. Specifically, using a derivative of 'Harberger's triangle' is the standard instrument to calculate net welfare loss due to price distortion. To provide an example of such uncontested practice in the literature, one may cite the widespread German introductory textbook by the most long-standing member of the 'Sachverständigenrat' (equivalent to the Council of Economic Advisers). It illustrates the general concept from pg. 71 onwards, then discusses the impact of monopolization, cartels, etc., as of pg. 122 leading to pg. 199 and the discussion on the ramification of State action, including the substantial issue of taxes (Bofinger 2015).

The concept of consumer surplus is not only the substance of introductory textbooks but for many decades, it has represented one of the central tools of empirical economic analysis and policymaking. It is particularly evident in the area of Public Finance and International Economics. Here it is used without restrictions even by those arguing somewhat

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[1] E.g. see the survey by (Slesnick 1998).

[2] For the history, see Ekelund/Hébert (1985). Their main message is still valid today: 'Like it or not, consumer surplus theory, as cost-benefit analysis, is the bread and butter of the practicing economist.' (p. 420)

outside the mainstream, such as very prominent Figures like the Nobel Prize laureates Stiglitz (Stiglitz and Rosengard 2015) or Krugman (Krugman, Obstfeld, and Melitz 2014).

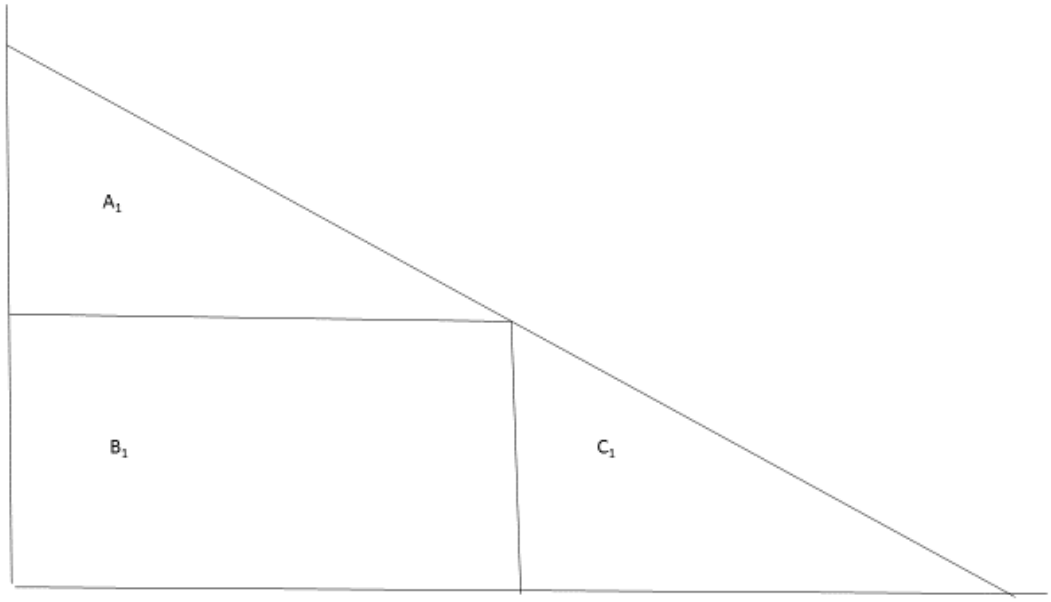
The practical significance of the consumer surplus approach is therefore rather significant. Generations of economics students have been convinced by 'state-of-the-art' depictions that taxes, tariffs, and subsidies always connote a loss of welfare. It is precisely this generalization, which is to be challenged here. This will be provided firstly by a short overview of the concept and its primary form of application, followed by a methodological reconstruction of its fundamental assumptions. Two examples will illustrate the inconsistency of the approach.

## Introduction of the Concept

It is presumably due to its elegant simplicity that consumer surplus seems so long so successful.[3] In the usual textbook style, it demands only an extremely simple chart with nothing but a demand and a supply curve to start (mostly parallel to the axis, for long-term and constant technology of the studies' implication). It immediately shows that area $A_1$ represents consumer surplus, $B_1$, the transactions that have taken place, and $C_1$, if referred to, the consumer's desires unattainable at this price *(Figure 1).* To simplify, $A_1$ can be interpreted as a measure of welfare because consumers have to pay less than the highest total they are willing to spend.

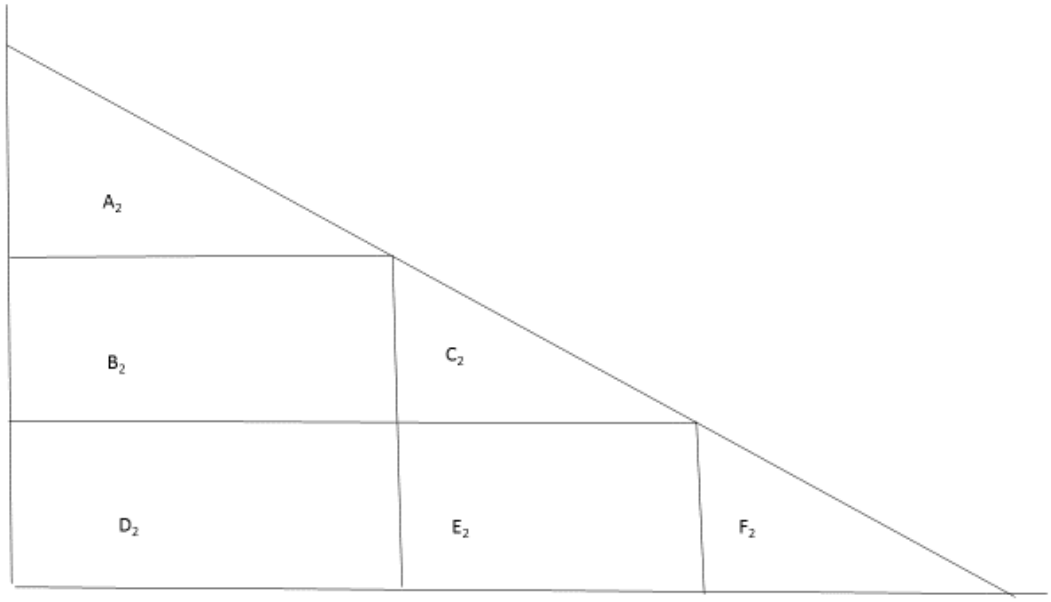
[3] This does not exclude those, who are critical of the thereof derived economic policy conclusions: 'College students learn about the gains from trade… from a diagram which is the staple of every introductory economics textbook. The professor draws a couple of demand and supply curves, points to where the market prices are with and without tariffs. He carefully labels areas representing income gain and loss to different groups in society … He adds and substracts all these areas as appropiate, and voilà! We are left with two triangels that represent the… ‚deadweight loss' of the tariff. It is a handy demonstration, and I must admit that I take a certain pleasure whenever I go through these motions – the joy of bringing the uninitiated into the fold.' Rodrik (2011, p. 55)

*Figure 1*




Based on this relatively simple looking graph of the essential supply and demand curve, and corresponding with the typical textbook example, the impact of introducing taxes will be illustrated (*Figure 2*). Originating in the aforementioned basic illustration of consumer surplus, consisting of $A_2 + B_2 + C_2$, the introduction of taxes created the sole remainder of $A_2$. The interpretation of tax revenue ($B_2$) as already being utilized to provide something useful for the sample consumer generates a net loss (usually called ‚deadweight-loss ') $C_2$.

*Figure 2*




Because such figures are used to illustrate not only a product tax but also nearly all types of taxation, students of economics are taught early on that taxations are tied to an allocative loss of welfare and should therefore be as low as possible or 0. Even if there should be further elaborate explanations within the later curriculum that there may be a need to finance public goods or outbalance negative externalities, the initial impression is strong and influential.[4]

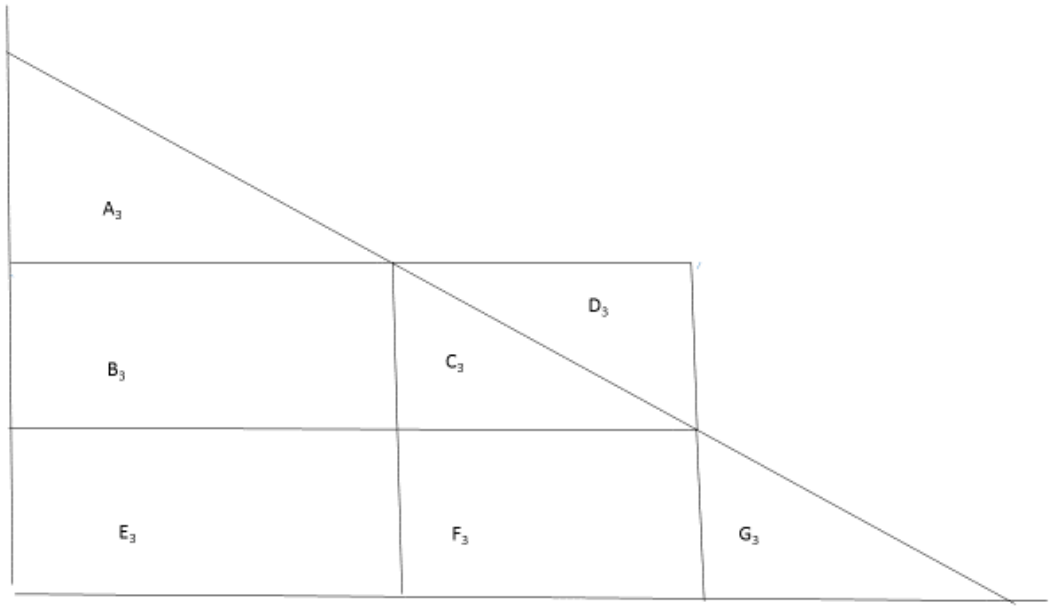
The problem lies not only within textbooks' information and their inevitable simplification of figures and instances. It also remains 'state-of-the-art' for professional, working economists. The illustration and calculation of deadweight losses caused by taxation have been done by the thousands, as searches through economic databanks show. This approach to public discourse becomes evident when considering the decision made by the American government of 1991 to introduce a factor of 1.25 in the cost-benefit-analysis for public investments due to the distortion caused by tax financing (Hines 1999).[5]

[4] A nice example of such is a newspaper report based on a talk of the former German federal minister of finance Steinbrück's at the London School of Economics. He was advocating a transaction tax but a young student fiercely opposed him, this would be inefficient due to the tax wedge, 'learned by every student in the first year', die tageszeitung 5.2.2013

[5] Until today, it applies: 'Because taxes generally distort relative prices, they impose a burden in excess of the revenues they raise. Recent studies of the U.S. tax system suggest a range of values for the marginal excess burden, of which a reasonable estimate is 25 cents per dollar of revenue… the presentation of results for public

Like the introduction of taxation, according to consumer surplus theory, there is a single interpretation of the impact of subsidies: they diminish welfare. One may argue that the consideration of positive externalities, which apply most formidably to education, may lead to different results. However, the consumer surplus default is a negative one (*Figure 3*). By comparison with the original consumer surplus $A_3$ by way of subsidy, it is necessary to mobilize financial means comprising $B_3 + C_3 + D_3$. But this only allows for a rise in benefits for consumers of $B_3 + C_3$. Therefore, there remains a net loss of $D_3$.

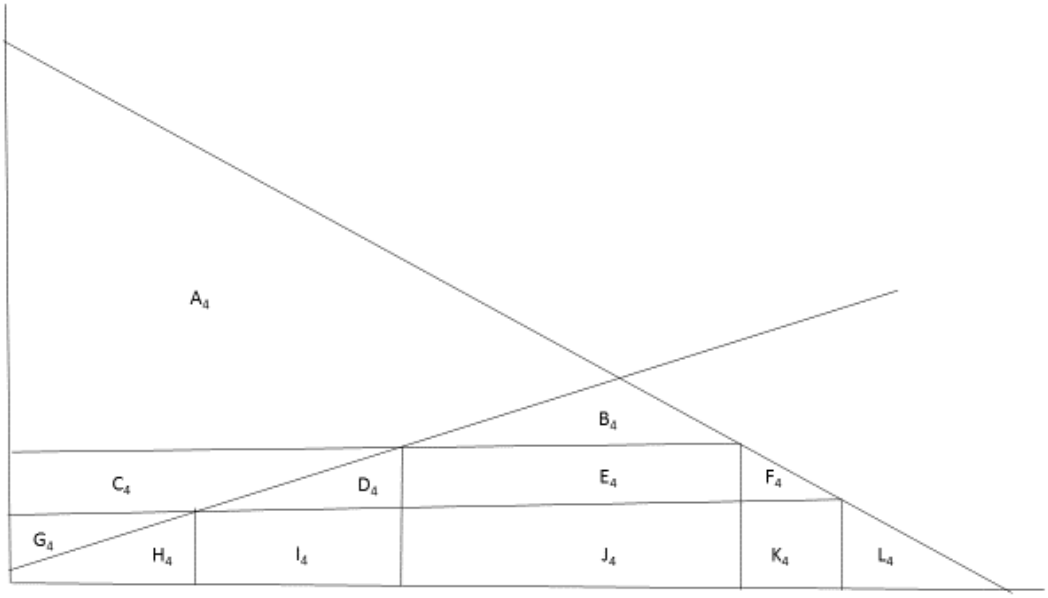
*Figure 3*




The third example of the importance of this approach is tariffs. Based on consumer surplus, it again becomes evident that tariffs create a loss of welfare. This time, a rising supply curve is necessary for illustrating this instance, as seen in *Figure 4.*

investments that are not justified on cost-saving grounds should include a supplementary analysis with a 25 percent excess burden. Thus, in such analyses, costs in the form of public expenditures should be multiplied by a factor of 1.25 and net present value recomputed.' https://www.whitehouse.gov/omb/circulars_a094 (Accessed: 3.9.2017).

*Figure 4*




Without the application of tariffs, a producer surplus G4 and a consumer surplus of A4 + B4 + C4 + D4 + E4 + F4 are created. Following the introduction of tariffs, the producer surplus encompasses now then not only $G_4$ but also $C_4$. However, the consumer surplus is restricted to $A_4 + B_4$. When subtracting the tariff revenue $E_4$, there remains a net welfare loss of $D_4 + F_4$.

In comparing *Figures* 2 and 4, it becomes immediately evident why, for economists, tariffs have an especially negative reputation. Should state revenue in the amount of $B_2$ be aspired, and if this is set equal to $E_4$, a single efficiency-loss-triangle may be achieved by taxation (here: $C_2$). However, two such triangles appear in the case of tariffs (here: $D_4$ and $F_4$).

A cautionary note: the same instance of more complex considerations, which can lead to a change in results, applies again. Taking into account e.g. externalities of learning, may somewhat remove the thematic aversion of tariffs as protection for domestic production (Stiglitz and Greenwald 2014). However, this does not form the majority view within economics. Admittedly, Ricardo-based models presumably exerted the more significant effect for arguing in favor of global free trade. But consumer surplus based condemnation of customs duties had its share of evaluations like this: 'Economists' belief in the virtues of free trade are so great and so long-standing that an economist who expressed skepticism was at risk of losing his "union card "- or at least his credibility as a serious economist' (Stiglitz 2017, p. 130).

## Methodological Reconstruction

Regarding the respective textbook or empirical analyses, which argue based on the consumer surplus approach as laid out above, it may bring forward the somewhat surprising realization that there is little reflection on this concept's methodological groundings. The situation appears as a 'Deus-ex machina' for the reader: consumer surplus simply exists and is fine the way it is. In the course of impartial consideration, especially the lack of questioning the meaning of the 'other triangle' within the diagrams should catch one's eye.[6] In the elementary illustration given in *Figure 1*, area $C_1$ displays the situation in which the consumers wish to attain the good but are unable to afford or don't want to buy at the current price. Therefore, the question should arise whether their welfare position should also be of importance and if this might lead to an alternative to the typical consumer surplus approach.

Based on this relatively simple observation, the following will outline five requirements to be met by every measurement of welfare, given in the framework of this partial concept. The requirements naturally must include the well-known consumer surplus approach but do not exclude other considerations from the onset on. To form a general basis, the first requirement is:

1. *For measurement of welfare purely based on the consumer's position, no other information is necessarily required apart from a falling demand curve that intersects both with the price and quantity axis and a horizontal or increasing supply curve.*

A decreasing demand curve and a constant or increasing supply curve represent the standard economics case and need not be discussed further. The concentration on the consumer's position merely infers that producer surplus should not play a role in the main argument. In consumer surplus literature, the term producer surplus refers to the accumulation of extra profits by particularly efficient producers, not psychological perceptions as in consumer surplus. Thus, there is no methodological doubt on how producer surplus is measured. In this framework, it is, therefore, as easy to calculate as government revenues or expenditures.

The limitation on demand curves, which each have a point of intersection with the axis, seems unnecessary. The typical argumentation is that consumer surplus-based empirical calculations usually only examine relatively small pricing changes, and it is made of no

[6] Even the initial graph of consumer surplus illustrates this asymmetry. In Marshall's ‚Principle of Economics' Fig. 21 is a depiction in which the demand curve cuts the y-axis, but ends somewhere in nowhere without cutting the x-axis (Marshall 1890, p. 429). Viewed from today, it seems that the author tried to avoid at all costs, to draw attention to what is happening at the bottom right of the diagram.

significance if and when the suppositional demand curve touches abscissa and ordinate. However, it is both unimaginable to assume a continuous purchase interest with an infinite price and an endless demand with a price of 0. Besides, the fixing of the intercepts also allows for two quantitatively sensible localisations for the concept of measuring welfare, namely the specification of ceiling and floor (maximum and minimum levels). These considerations lead to those requirements:

2. *At a maximum price $p_{max}$ (with $q = 0$), a positive measurement of benefits should equal zero, and a negative should encompass the entire area beneath the demand curve.*
3. *At a minimum price $p_0 = 0$ (with $q_{max}$), a positive measurement of benefits should encompass the entire area beneath the demand curve, and a negative should equal 0.*

The possibility of a negative measurement may irritate. However, it is nothing less than the acknowledgment of 'disutilities' as possible and necessary parallel constructions of 'utilities.' It is rather common in economics. In labor economics, e.g., it has been long stated that the 'suffering,' which is caused by employment, must be compensated by financial incentives.[7]

Next, the outcome of price changes beyond the extremes constructed by propositions 2 and 3 must be defined. For an economically substantiated claim, it is necessary that:

4. *In the price segment between $p_{max}$ and $p_{0,}$ a decreasing price leads to a growth in positive welfare measurement or a decline for negative measurement.*

Lastly, another prescription has to be formulated concerning the combination of more psychologically-based variables with the real monetary flow:

5. *In the case of a positive measurement, the overall welfare is determined by adding to the consumer's welfare producer surplus and government revenue and subtracting resource costing payment flows, like subsidies. This principle is accordingly applied in reverse for negative welfare measurement.*

It should be noted that this does not claim whether overall welfare development has a positive or negative sign. For example, it is evident in Figure 3 that even in the case of classical consumer surplus, depending on the shape of the demand curve, the sum of $A_3 + B_3 + C_3 – B_3 – C_3 – D_3$ may be negative.

These five conditions form the framework for possibly useful welfare measurements without setting preliminary limitations in terms of a specific version of said measurement. It

[7] Marshall adopted this notion into his description of the chapter ‘Supply’. (Book IV, Ch. 1, Introductory): ‘Marginal disutilty. Although labor is sometimes its own reward, we may regard its supply as governed by the price which is to be got for it.’ (Marshall 1890, p. XVII)

becomes immediately evident that besides consumer surplus (in short CS) as $A_1$ in *Figure 1*, then the area of $C_1$ also meets the requirements above. In the following, it shall be labeled consumer loss (hereafter referred to as CL).

Nonetheless, there are more possibilities. Economists are trained to examine cost and benefit parallel as well as evaluate the net effect. What happens if one were to compose $A_1 – C_1$? If one were to move from a given price towards $p_{0,}$ there should not be an issue due to $C_1$ becoming 0, leaving $A_1$ to encompass the entire area. The third conditionality would therefore be complied with in terms of a positive welfare measurement. However, the second conditionality would be infringed if one were to move toward $p_{max}$ because it would cause a negative turn instead of the proposed 0. But this can be avoided if the total area of $A_1 + B_1 + C_1$ was tentatively added to $A_1 – C_1$. However, this creates the result of 2 $A_1$, whereas conditionality 3 accounts for only 1 $A_1$. To correct this instance, we must divide the total $(A_1 – C_1) + (A_1 + B_1 + C_1)$ by 2. The calculation for a continuously positive measurement, therefore, is as follows: $A_1 + ½ B_1$. Due to the juxtaposition of cost and benefit and its positive measure of welfare, it shall be labeled as balanced positive consumer position ($CP^+$).

The same applies to a negative measurement based on $C_1 - A_1$. In this case, the final result is thus: $C_1 + ½ B_1$. The label for this calculation method shall accordingly be called balanced negative consumer position ($CP^-$).

Following the fulfilment of requirements 1-3 as well as per definition the fifth, one issue arises: is in those two the fourth condition fulfilled? This question will be referred to *Figure 2* as it implicitly illustrates the case of price drops. For consumer surplus it is immediately visible, that $A_2 + B_2 + C_2 > A_2$. The same result occurs for consumer loss, since $F_2 < C_2 + E_2 + F_2$. Similarly, $CP^+$ with $A_2 + B_2 + C_2 + ½ D_2 + ½ E_2 > A_2 + ½ B_2 + ½ D_2$ and also $CP^-$ with $F_2 + ½ D_2 + ½ E_2 < C_2 + E_2 + F_2 + ½ B_2 + ½ D_2$ comply with the conditionality implied.

Besides the usually assumed singularity acknowledged as consumer surplus, it is now evident that more concepts carry the same DNA. Therefore, raising the question of whether it is possible to compose criteria upon which a hierarchy of concepts may be created. CS is the 'first-mover' and well established, not a logical but a de facto advantage. But two more arguments may be considered. The first is normative. Within Rawl's 'Theory of Justice,' which is often referred to in economics, the author argues that the prosperity of the 'least favored of society' should be a valuation standard (Rawls 1971). When comparing CS and CL, one could argue that the latter would be preferential as it better represents the low-income strata in society rather than the high-income bracket such as in the former.

The second consideration concerns $CP^+$ and $CP^-$. Firstly, in comparison with CS and CL, they hold the advantage of assessing costs and benefits, usually highly esteemed by economists. Additionally, as evident in the stipulation of particular circumstances in which the demand curve is mirrored by 45°, there results in a situation in which half of the price also represents half of the maximum benefit. There is a pleasant, intuitive correspondence about the quantitative level of welfare changes due to price changes. However, there is also the 'aesthetic' disadvantage, which occurs during the integration of real cash flows, such as taxes, causing a doubling of areas.

In sum: The four concepts all show a particular set of benefits and drawbacks. Therefore, none seem to issue significance to establish a hierarchy in which one distinct advantage outweighs the others. Essentially CS, CL, $CP^+$, and $CP^-$ all have to be seen as equals.

## Two examples of application

Diverging methods of measurements are not uncommon in science. For example, temperature and the variety of measurement techniques utilized have created their specific scientific area: thermometry. However, a prerequisite for a valid method to be added to the accepted circle is that real temperature changes must be structurally reflected across all methods. It can be illustrated based on an everyday example; upon adjusting one's bath water by adding more hot water to it, a finger, a classic mercury thermometer, and a modern electric-based thermometer should all yield a rise in water temperature and not a drop or stagnancy.

This case may be transferred to the situation in this paper. The minimal conditionality for a sensible application of the welfare measurement based on consumer position is as follows:

*Changes in the measuring situation must lead to a change in the same direction by all as reasonably defined measurement methods. Otherwise, such methods are useless.*

Returning to the previously outlined bathwater example, e.g., physical dysfunctions of the person testing the water as in some forms of neuropathy or a toy thermometer where the mercury scale is only painted on, fail to provide the correct information of a now hotter water temperature. Those methods are therefore useless.

To test if the previously mentioned propositions of CS, CL, $CP^+$, and $CP^-$ fulfill the above-formulated conditionality to move in the same direction, two relevant quantitative

cases are constructed. The meaning of relevancy here refers to the previously mentioned classic functions - what are the impacts of taxes, subsidies, and customs – which will form the base. The applied numbers are fictional but do not differ from examples used in textbooks. Using quantitative examples instead of formulas makes the argumentation immediately comprehensible, an advantage given the wide usage of consumer surplus-based calculations in the practical world.

In case A – a tax and subsidy case – the following situation is given. In a country, there are apple farmers with the demand function $q_a = 5 - p_a$, with a current market price of $p_a = 1$, and peach farmers with the demand function $q_p = 10 - p_p$, with a market price of $p_p = 8$. Producer surplus in both cases is non-existent. Let us assume, it is now possible for peach farmers, with their low sales, to push for policies that would impose a tax on the mass-produced apples in the amount of 1 €, with the proceeds fully subsidizing the peach sales. This would lead to a combination of the situations illustrated in *Figure 2* and *Figure 3* in which $B_2 = B_3 + C_3 + D_3$. Thus, when the welfare sum is calculated, this amount can be disregarded, as according to condition 5, they have opposite effects on welfare and the same size. Combining tax and subsidy presents a particularly tough test since there are now two 'triangles' of allocation losses recorded through regular CS.

According to the CS approach, two such triangles also occur in case B – where customs come into play. The demand curve for a single good here is $q = 15 – p$ and the domestic production curve is $q_d = p_d - 1$. The world market price is 3, meaning 2 units are produced domestically while 10 units are imported. Now a tariff is imposed in the amount of 1 €, elevating the effective price to 4 €. The domestic production thereby increases to 3, demand shrinks from 12 to 11, and lowers imports to 8 units. The situation is represented in *Figure 4.*

After all triangles and rectangles have been accounted for (see Appendix), based on the two case examples, the following results of welfare change based on those methods are (in the cases of CL and $CP^-$ welfare gain means reduction of the negatively polarized indicator):

| | CS | CL | $CP^+$ | $CP^-$ |
|---|---|---|---|---|
| Taxation/Subsidy | Loss | Gain | Gain | Gain |
| Customs | Loss | Gain | Gain | Gain |

In both cases, CS's loss stands opposite of three divergent results in the other measurements. Since the four methods are constructed under the same premises, they are to be regarded as equivalent. The minimum condition that changes to the object to be measured in various approaches must result in before-and-after measurements with at least an equal sign, has therefore been unfulfilled. The whole class of methods based on the five conditions mentioned above is therefore useless.

## Conclusion

As at the end of the 17th century, when the theory of Phlogiston was created, the then small world of chemical experts was quickly convinced. With the 'discovery of a substance that escaped during combustion, many previously observed strange phenomena could be well explained. The wide application of the Phlogiston approach in chemistry led to numerous other discoveries and categorizations. For over a century and a half, it was natural sciences' 'state-of-the-art. ' Unfortunately, the theory was simply wrong, as ultimately proved by Antoine Lavoisier in 1785.[8]

Consumer surplus with its long history and its status as a 'state-of-the-art' should be seen similarly. The utilization has resulted in many new considerations within economics. However, the class of thereby justifiable measuring instruments produces conflicting results, making it unsuitable for any scientific use. It should no longer be used in the future, and taxes, subsidies, and tariffs considered more in individual circumstances and with other methods to their respective effects.

## *Appendix*

The apple farmers of example A are implicitly depicted in *Figure 2*, the peach farmers in *Figure 3*. Therefore, the areas can be calculated as followed:

$A_2 = 4\,½$, $B_2 = 3$, $C_2 = ½$, $D_2 = 3$, $E_2 = 1$, $F_2 = ½$,

$A_3 = 2$, $B_3 = 2$, $C_3 = ½$, $D_3 = ½$, $E_3 = 14$, $F_3 = 7$, $G_3 = 24\,½$.

[8] Encyclopedia Britannica (http://academic.eb.com/levels/collegiate/article/phlogiston/59739), Accessed: 6.9.2017

As established before, $B_2$ is consistent with the sum of $B_3 + C_3 + D_3$.
Before the implementation of taxes on apples and subsidies on peaches, the following values amount to the overall profit of apple and peach farmers:

$CS = A_2 + B_2 + C_2 + A_3 = 10$,

$CL = F_2 + C_3 + F_3 + G_3 = 32½$

$CP^+ = A_2 + B_2 + C_2 + A_3 + ½ D_2 + ½ E_2 + ½ B_3 + ½ E_3 = 20$

$CP^- = F_2 + C_3 + F_3 + G_3 + ½ D_2 + ½ E_2 + ½ B_3 + ½ E_3 = 42½$.

The implementation of taxes on apples and the conversion of revenue into a subsidy of peaches results in $B_2 = B_3 + C_3 + G_3$ amounting, and therefore eliminable from the equations to new values (indicated by the underline):

$\underline{CS} = A_2 + A_3 + B_3 + C_3 = 9$,

$\underline{CL} = C_2 + E_2 + F_2 + G_3 = 26½$

$\underline{CP^+} = A_2 + A_3 + B_3 + C_3 + ½ B_2 + ½ D_2 + ½ E_3 + ½ F_3 = 22½$

$\underline{CP^-} = C_2 + E_2 + F_2 + G_3 + ½ B_2 + ½ D_2 + ½ E_3 + ½ F_3 = 40$.

The positive measurements CS and $CP^+$ show a negative ($\underline{CS} < CS$), as well as a negative ($\underline{CP^+} > CP^+$) change in welfare. Each negatively polarised measurement reports a relative decrease and a welfare gain ($\underline{CL} < CL$, $\underline{CP^-} < CP^-$).

The implementation of customs duties in case B is illustrated in *Figure 4.*
The transfer of its areas results in:

$A_4 + B_4 = 60½$, $C_4 = 2½$, $D_4 = ½$, $E_4 = 8$, $F_4 = ½$, $G_4 = 2$, $H_4 = 4$, $I_4 = 3$,

$J_4 = 24$, $K_4 = 3$, $L_4 = 4½$.

The initial condition of the situation of world market price leads to:

$CS = A_4 + B_4 + C_4 + D_4 + E_4 + F_4 + G_4 = 74$

$CL = L_4 - G_4 = 2½$

$CP^+ = A_4 + B_4 + C_4 + D_4 + E_4 + F_4 + ½ G_4 + ½ H_4 + ½ I_4 + ½ J_4 + ½ K_4 + G_4 = 94$

$CP^- = L_4 + ½ G_4 + ½ H_4 + ½ I_4 + ½ J_4 + ½ K_4 - G_4 = 20½$

Following the implementation of customs:

$\underline{CS} = A_4 + B_4 + C_4 + E_4 + G_4 = 73$

$\underline{CL} = F_4 + K_4 + L_4 – C_4 – E_4 – G_4 = -4½$

$\underline{CP^+} = A_4 + B_4 + C_4 + E_4 + G_4 + ½ C_4 + ½ D_4 + ½ E_4 + ½ G_4 + ½ H_4 + ½ I_4 + ½ J_4 = 95$

$\underline{CP^-} = F_4 + K_4 + L_4 – C_4 – E_4 – G_4 + ½ C_4 + ½ D_4 + ½ E_4 + ½ G_4 + ½ H_4 + ½ I_4 + ½ J_4 = 17½$.

Likewise, the positive measurements CS and $CP^+$ amount to a negative ($\underline{CS} < CS$) and a positive ($\underline{CP^+} > CP^+$) change in welfare. However, the negatively polarised measurements each illustrate a relative decrease and, therefore, an increase in welfare ($\underline{CL} < CL$, $\underline{CP^-} < CP^-$).

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