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Homogeneous and differentiated taxation in differentiated product markets*

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Abstract

We compare the outcomes of homogeneous and differentiated taxation on imperfectly competitive differentiated products markets. We focus on ad valorem tax applied to product quality and study the effects on prices and welfare. After a symmetric tax rate rise, net prices diverge if the tax is sufficiently differentiated on product quality; they converge if the tax is homogeneous between product qualities. Competition lessens such divergence and boosts such convergence. Under a differentiated taxation regime, tax revenues are higher, as are producer rents, but at the cost of a lower consumer surplus.

KEYWORDS: Ad valorem taxation, differentiated and homogeneous taxation, differentiated products, own- and cross-tax effect, quality, welfare analysis.
JEL CLASSIFICATION: *H2, L11, L13.*

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1 Introduction

To improve health outcomes and welfare in recent years policymakers have employed taxation on specific product characteristics, often associated with quality, making those products less affordable and attractive to consumers. For instance, to reduce greenhouse gas emissions and promote sustainable transportation, many OECD countries have introduced various forms of CO2-related taxes based on the engine capacity of automobiles (OECD 2022), often seen as an indicator of quality.[1] Other examples of taxes targeting product characteristics are the alcohol tax (Kenkel 2005, Carbonnier 2013, and Nelson and Moran 2020), the fat tax (Muller et al. 2017) and the sugar tax (Bonnet and Réquillart 2013). Also alcohol, fat, and sugar are characteristics that can easily be associated with a product's quality, able to affect either directly or indirectly consumers and firms behavior (see among others, Fichera and von Hinke 2020 and Dubois et al. 2021).[2] Despite these policy interventions, the extent to which consumers and firms bear the burden or the gain of this type of tax remains unclear.

The welfare impact of taxation in competitive and monopolistic markets is widely studied and well understood (for a review, see Anderson et al. 2001). By contrast, its effect on imperfectly competitive markets has received less consideration (among the few, see Cremer and Thisse 1994 and Schmidt 2009),[3] and even less attention has been given to the use of differentiated taxation in imperfectly competitive markets (see discussion in Weyl and Fabinger 2013, Häckner and Herzing 2016, and Häckner and Herzing 2022). The literature evidences that in markets with differentiated products, the final impact on prices and welfare depends on firms' strategic interactions and existing asymmetries in cost and product characteristics.

In this work, we compare the effects of ad valorem differentiated and homogeneous taxation regimes applied to differentiated product qualities and study the impact on (net) prices, and consumer surplus in an imperfectly competitive market structure. Using a Salop circular model where two product qualities produced by single-product firms alternate in the circle, we are able to investigate the role played by competition between quality types and the number of firms in the market. Our contribution to the existing literature lies in our examination of the impact of the interplay between competition, product market asymmetries, and two taxation regimes on equilibrium prices and welfare.

We find that a symmetric increase of the tax rate yields a divergence in net prices (i.e., net prices of high-quality products increase while those of low-quality products decrease) in the case of sufficiently differentiated products, and a convergence if the existing taxation regime is homogeneous across products of different qualities. We explain these effects in terms of tax elasticities and then highlight the role played by competition. As the number of firms in the market increases, the speed of this divergence (convergence) decreases (increases). We also

[1] Engine capacity can be seen as a proxy for automobiles quality when comparing automobile models introduced in the market within the same period. It does not proxy for quality if the comparison is between models introduced at different points due to the use of different technology (see https://www.carbuyer.co.uk/tips-and-advice/146778/engine-size-explained, accessed online on 9 March 2023).

[2] The use of product reformulation recorded in the labels adopted in the food industry has been used to curb consumers' diet decisions triggering a healthier response, see Griffith et al. 2017.

[3] Within the newly developed literature on the analysis of taxation in imperfectly competitive markets we recall the theoretical and the empirical contributions by Verboven (2002), Damjanovic and Ulph (2010), Jaffe and Weyl (2013), and Genakos and Pagliero (2022).

compare the welfare implications of symmetric and asymmetric tax regimes, and we find that tax revenues are greater under differentiated taxation; so are producers' rents but at the cost of a lower consumer surplus.

In the next section, we first review the case of a single-quality product market supplied by a monopolist. Then in section 3, we extend our analysis to a differentiated (quality) products market and separately study the effects of a homogeneous and differentiated taxation regime. Section 4 concludes.

2 Single-product market

We consider the case when taxation varies according to the quality of the product. Assuming that consumers have preferences over quality à la Mussa and Rosen (1978), we let an ad valorem tax rate $0 < \tau < 1$ be imposed on a producer supplying a single quality product. Denoting with p the gross price paid by consumers and with $\widehat{p}$ the net price received by the manufacturer, the indirect utility of a consumer-type υ buying one unit of quality k is defined as $\upsilon k - p$, with $p = \widehat{p}\,(1+\tau)$, $k > 0$, and $\upsilon \in (\underline{\upsilon}, \overline{\upsilon})$. When the product is supplied in a monopolistic market, consumers also have the option of not buying the product, obtaining a reservation utility normalized to zero. Instead, when products are supplied under imperfect competition, consumers can choose between different quality products and the outside option. This differentiated product market case is studied in the next section.

In a market where consumers' taste for quality is uniformly distributed along a line of unitary length, i.e. $\underline{\upsilon} = 0$ and $\overline{\upsilon} = 1$, we define the consumer who is indifferent between buying or not buying the product as $\widetilde{\upsilon} = p/k$. It follows that the profit of a monopolistic firm with a constant marginal cost, c is defined as:

$$\pi_M = \int_{\widetilde{\upsilon}}^{1} (\widehat{p} - c)\, d\upsilon = (1 - \widetilde{\upsilon})\,(\widehat{p} - c)\,/k. \tag{1}$$

For a given net price, an increment in the tax rate drives market demand down. Operating on the inelastic part of the demand curve, for an equilibrium net price $\widehat{p}^{*} = \frac{k + c(1+\tau)}{2(1+\tau)}$, we observe that the taxation will be partially absorbed by the firm without passing it entirely onto consumers, regardless of the product's quality. A fall in the firm's net price will protect the firm's market share.

Given the sum of consumer and producer surpluses, in a monopolistic market, welfare is given by,

$$W_M^{*} = \int_{\widetilde{\upsilon}}^{1} (\upsilon k - p^{*})\, d\upsilon + \int_{\widetilde{\upsilon}}^{1} \left(\widehat{p^{*}} - c\right) d\upsilon = \frac{(3+\tau)\,(k - c\,(1+\tau))^{2}}{8\,(1+\tau)\,k}. \tag{2}$$

We observe that, for a positive change in the taxation rate, total welfare decreases at a decreasing speed, i.e. $\frac{\partial W_M^{*}}{\partial \tau} < 0$ and $\frac{\partial^2 W_M^{*}}{\partial \tau^2} > 0$. As the tax rate rises, the consumer price goes up and the demand for the product gets smaller at a decreasing rate. Therefore, even when the monopoly internalizes part of the tax burden, some consumers are pushed out of the quality-market segment expanding the deadweight loss.

3 Differentiated products market

Building on Salop (1979), we develop a stylized model of monopolistic competition with an outside good where we include both vertical and horizontal product-space differentiation. In this framework, a consumer can buy the preferred product or choose not to buy it. Active consumers are positioned uniformly on a circle with a circumference of $1-\mu$, where $0<\mu<1$ represents the outside option. This identifies the market interval where a consumer always prefers one of the inside market products. This way of modeling the outside option fits a nested scenario where a consumer first chooses whether or not to buy a product, before deciding which quality to buy.

Firms can manufacture products of either high quality or low quality, defined by $k \in \left\{\overline{k}, \underline{k}\right\}$. Each firm is allowed to be located at one point only on the $1-\mu$ circle line, and their position along this circle line is symmetrical, meaning that for a product of quality k, all firms charge the same price.[4] Let J denote the number of firms in the market. Their location is determined exogenously at an equal distance of $(1-\mu)/J$ from another. Product types (of high-quality and low-quality) alternate along the circle line, so that in clockwise order we find $\overline{k} \in \{1,3,...,J-3,J-1\}$ and $\underline{k} \in \{2,4,...,J-2,J\}$, where J is assumed to be an even number for convenience. Consumers prefer high-quality or low-quality products, and they buy at most one unit among all available J products.

We take the horizontal and vertical product differentiation as given and we focus on the effect of possible asymmetries in taxation, product quality, and marginal costs. This setup gives flexibility, allowing us to study firms' behavior when competition is softened by the presence of adjacent discriminated quality products. Indeed, clustering products of the same type would intensify competition, reducing the neighboring consumer choice. To capture the competition between quality products rather than within them, our model alternates high-quality and low-quality products in the market space.[5]

In this setting, a consumer who wishes to buy one unit of a product of quality k gets a non-negative monetary utility described as

$$\max_{k} \left\{\upsilon_k - t x_k - p_k\right\} \geq 0, \;\; k \in \left\{\overline{k}, \underline{k}\right\}, \tag{3}$$

with $\upsilon_k \equiv \upsilon k$ identifying the effective reservation price for a product of quality k, x_k defining the distance of the consumers to the firm k, and t measuring the disutility faced by the consumer to travel up to the firm's location.[6] We denote the homogeneous ad valorem tax rate with τ and the differentiated tax rate for the k^{th} product's quality, with τ_k. When an ad valorem taxation regime, which varies according to the quality of the products is in force, a consumer is indifferent

[4] Our model develops a short-run analysis without taking into account any entry and exit into the market, and we remain agnostic on the outside option.

[5] Mazzeo (2002) gives empirical evidence of this modeling strategy.

[6] For the imperfectly competitive market, consumer willingness to pay also includes the disutility yielded by traveling up to the firm's location, and thus $\upsilon_k - t x_k$ corresponds to υ as defined in the monopoly market case, as there, $x_k = 0$ and $k = 1$.

to buying either the high-quality or the low-quality good when

$$\upsilon_{\overline{k}} - tx_{\overline{k}} - \underbrace{\widehat{p}_{\overline{k}}\left(1+\tau_{\overline{k}}\right)}_{p_{\overline{k}}} = \upsilon_{\underline{k}} - t\left(\frac{1-\mu}{J} - x_{\overline{k}}\right) - \underbrace{\widehat{p}_{\underline{k}}\left(1+\tau_{\underline{k}}\right)}_{p_{\underline{k}}}, \tag{4}$$

where $p_{\overline{k}}$ and $p_{\underline{k}}$ are the gross prices paid by consumers for the alternative quality products $\overline{k}$ and $\underline{k}$, whereas $\widehat{p}_{\overline{k}}$ and $\widehat{p}_{\underline{k}}$ identify the net (of taxation) prices set by firms, with $\upsilon_{\overline{k}}$ and $\upsilon_{\underline{k}}$ characterizing the effective reservation prices for the two quality products. Note that taxation occurs on vertical rather than horizontal product differentiation. This modeling approach allows a comparison with the monopoly case, also reflecting many real-world examples that include taxation on vertical product characteristics, e.g. CO2 emissions, alcohol content, fat content, and sugar content.[7]

For a firm that produces quality $k = \overline{k}$ its market demand is defined as

$$D_{\overline{k}}\left(\widehat{p}_{\overline{k}}, \widehat{p}_{\underline{k}}\right) = 2\widetilde{x}_{\overline{k}} = \left[\frac{1-\mu}{J} + \frac{\upsilon_{\overline{k}} - \upsilon_{\underline{k}} + \widehat{p}_{\underline{k}}\left(1+\tau_{\underline{k}}\right) - \widehat{p}_{\overline{k}}\left(1+\tau_{\overline{k}}\right)}{t}\right], \tag{5}$$

where $\widetilde{x}_{\overline{k}}$ indicates the location of the indifferent consumer. Within the same quality market segment, we assume that all firms have a constant marginal cost of production c_k, and write the firm's maximization problem as

$$\max_{\widehat{p}_k} \pi_k : \left\{\left(\widehat{p}_k - c_k\right) D_k\right\}.$$

Differentiating the firm's profit with respect to its own net price $\widehat{p}_k$ gives us the firm's best response function. For example, for a firm producing quality $\overline{k}$ its best response function is expressed as the composite intercept $a_{\overline{k}}$ and the slope $b_{\overline{k}}$ which is

$$R_{\overline{k}}\left(\widehat{p}_{\underline{k}}\right) = \frac{1}{2}\left[\underbrace{\frac{t\left(1-\mu\right)}{J\left(1+\tau_{\overline{k}}\right)} + \frac{\upsilon_{\overline{k}} - \upsilon_{\underline{k}}}{1+\tau_{\overline{k}}} + c_{\overline{k}}}_{a_{\overline{k}}} + \underbrace{\frac{1+\tau_{\underline{k}}}{1+\tau_{\overline{k}}}}_{b_{\overline{k}}}\widehat{p}_{\underline{k}}\right]. \tag{6}$$

From above, it emerges that an increase of the ad valorem taxation on the own quality product $\tau_{\overline{k}}$ yields a drop in both the intercept and the slope of the best response of quality $\overline{k}$ firm (i.e. own-taxation effect).[8] Instead, a change in the tax rate of the other quality product $\tau_{\underline{k}}$ makes the best response slope of quality $\overline{k}$ firm steeper (i.e. cross-tax effect), leaving the intercept unchanged. More precisely, a change of $\tau_{\overline{k}}$ leads to a change in both the intercept $a_{\overline{k}}$, that is $\frac{\partial a_{\overline{k}}}{\partial \tau_{\overline{k}}} < 0$, and the slope $b_{\overline{k}}$, i.e. $\frac{\partial b_{\overline{k}}}{\partial \tau_{\overline{k}}} < 0$, while a change of the competitor's product tax, $\tau_{\underline{k}}$ only yields a positive effect on $b_{\overline{k}}$, i.e. $\frac{\partial b_{\overline{k}}}{\partial \tau_{\underline{k}}} > 0$, whereas it does not affect the intercept, which remains neutral to any variation of the tax rate, i.e. $\frac{\partial a_{\overline{k}}}{\partial \tau_{\underline{k}}} = 0$. Under the assumption

[7] Indeed, it is possible to modify the model to accommodate for taxation on horizontal product characteristics, by modifying the degree of product differentiation to $(1+\tau_k)t$. However, this is not the focus of this work, as the examples that motivate our study are based on taxation on product quality or product characteristics that impact consumer behavior.

[8] Similarly, for the firm producing quality $\underline{k}$.

of a linear demand function, in a market characterized by the presence of $J/2$ pairs of firms supplying heterogeneous quality products, an increase in the ad valorem product taxation (for example of product $\underline{k}$) leads to an increase in the firm's rival net price. The overall strategic effect is captured by the following equilibrium prices

$$\widehat{p}_{\overline{k}}^{*}=\frac{1}{3}\left[\frac{M+\Delta v+c_{\underline{k}}\left(1+\tau_{\underline{k}}\right)}{1+\tau_{\overline{k}}}+2c_{\overline{k}}\right],\quad \widehat{p}_{\underline{k}}^{*}=\frac{1}{3}\left[\frac{M-\Delta v+c_{\underline{k}}\left(1+\tau_{\overline{k}}\right)}{1+\tau_{\underline{k}}}+2c_{\underline{k}}\right], \tag{7}$$

with $\widehat{p}_{\overline{k}}^{*}$ and $\widehat{p}_{\underline{k}}^{*}$ indicating the net equilibrium prices of the high-quality and low-quality products, respectively, when $\tau_{\underline{k}}\neq\tau_{\overline{k}}$, with $M\equiv 3\left(1-\mu\right)t/J$, and $\Delta v\equiv v_{\overline{k}}-v_{\underline{k}}$. We observe that the impact on the net price due to a change in the tax rate depends on the sum of the own-tax and cross-tax effects (augmented Ramsey rule). In particular, a change in the tax rate of a substitute product induces manufacturers to readjust their own prices accordingly (i.e. the cross-tax effect).

3.1 Differentiated taxation and price competition

We now focus on the effects of a change in the tax rate on price competition between products, differing according to their quality and tax rate. Recalling the equilibrium prices defined in equation (7), we begin the analysis by exploring the case when positive changes of both taxation rates occur one at a time, in this way isolating own-taxation and cross-taxation effects. Under the same cost structure $c_{\overline{k}}=c_{\underline{k}}=c$,[9] when high-quality products are taxed at a greater rate, i.e. $\tau_{\overline{k}}>\tau_{\underline{k}}$, an increment of the tax rate of the high-quality product leads firms supplying that product to reduce their net price i.e. $\frac{\partial\widehat{p}_{\overline{k}}^{*}}{\partial\tau_{\overline{k}}}<0$. By contrast, an increment in the low-quality tax rate leads firms supplying the high-quality product to raise their net price in equilibrium, i.e. $\frac{\partial\widehat{p}_{\overline{k}}^{*}}{\partial\tau_{\underline{k}}}>0$. Therefore, the own-tax and cross-tax effects move in the high-quality product segment in opposite directions.

We repeat the same analysis for the low-quality products side of the market. We find that, in equilibrium, firms supplying low-quality products reduce their net prices for positive changes in their own tax rate as long as the difference between the two products' quality is greater or equal to the augmented marginal cost.[10] Analogously, for a positive change in the high-quality taxation rate, firms supplying low-quality products increase their net prices. When both tax rates increase symmetrically and simultaneously ($d\tau_{\underline{k}}=d\tau_{\overline{k}}=d\tau$), the outcome of the equilibrium prices depends on the total effect from own-tax and cross-taxation rates. For high-quality products, the impact on the net price is positive, in equilibrium, firms increase their net price, i.e. $\frac{\partial\widehat{p}_{\overline{k}}^{*}}{\partial\tau_{\overline{k}}}d\tau+\frac{\partial\widehat{p}_{\overline{k}}^{*}}{\partial\tau_{\underline{k}}}d\tau>0$. By contrast, on the low-quality side of the market, if the difference between the two quality products is sufficiently large, the overall effect leads to a drop in the new equilibrium (net) price, i.e. $\frac{\partial\widehat{p}_{\underline{k}}^{*}}{\partial\tau_{\overline{k}}}d\tau+\frac{\partial\widehat{p}_{\underline{k}}^{*}}{\partial\tau_{\underline{k}}}d\tau<0$ when $\Delta v\geq c\left(2+\tau_{\overline{k}}+\tau_{\underline{k}}\right)+M$. From above it follows our first result.

Proposition 1. *For a sufficiently high degree of vertical product differentiation, a simultaneous symmetric increment in the differentiated ad valorem taxation rate tailored to the quality of products leads to equilibrium net prices diverging.*

[9] In the presence of asymmetric production costs, results remain qualitatively unchanged but more cumbersome.

[10] This latter corresponds to the case when $\frac{\partial\widehat{p}_{\underline{k}}^{*}}{\partial\tau_{\underline{k}}}<0$ if $\Delta v\geq c\left(1+\tau_{\overline{k}}\right)$, when $d\tau_{\underline{k}}>0$ and $d\tau_{\overline{k}}=0$.

To note, a change in the number of firms J affects the marginal impact of a firm's own taxation on its price. Specifically, the higher J is, the stronger the impact of a simultaneous increase in both taxes on the high-quality price is, and the weaker the impact on the low-quality price.[11] However, as J increases the gap between the two prices diverges at a lower speed.

3.2 Homogeneous taxation and price competition

Under a homogeneous taxation regime, the same tax rate is applied uniformly to all quality products, to $\tau_{\overline{k}} = \tau_{\underline{k}} = \tau$, therefore the equilibrium prices in equation (7) simplify to

$$\widehat{p}^{**}_{\overline{k}} = \frac{1}{3}\left[\frac{(M+\Delta v)}{1+\tau} + c_{\underline{k}} + 2c_{\overline{k}}\right], \qquad \widehat{p}^{**}_{\underline{k}} = \frac{1}{3}\left[\frac{(M-\Delta v)}{1+\tau} + c_{\overline{k}} + 2c_{\underline{k}}\right]. \tag{8}$$

As in a monopoly market, a homogeneous tax rate applied across all quality products makes firms internalize part of the tax burden. From equation (8) it follows that under the same marginal production costs, i.e. $c_{\overline{k}} = c_{\underline{k}} = c$, the equilibrium price (and demand) of high-quality products is higher than that of low-quality products once we agree that consumers are willing to pay more for quality, i.e. $\widehat{p}^{**}_{\overline{k}} > \widehat{p}^{**}_{\underline{k}}$, and demand more $D^{**}_{\overline{k}} > D^{**}_{\underline{k}}$ when $\Delta v > 0$.[12] The difference between the two prices becomes smaller as the homogeneous taxation rate increases, i.e. $\frac{\partial \Delta \widehat{p}^{**}}{\partial \tau} < 0$ with $\Delta \widehat{p}^{**} = \widehat{p}^{**}_{\overline{k}} - \widehat{p}^{**}_{\underline{k}} = \frac{2\Delta v}{3(1+\tau)}$ defining the difference between the two optimal net prices. Following the above analysis, we state our second result.

Proposition 2. *In equilibrium, an increase of a homogeneous tax rate for differentiated quality products leads to a convergence in the net prices of high and low-quality products.*

Taking into account the role played by the number of firms competing in the market, it turns out that as J increases the two prices will converge at a higher speed.

3.3 Comparing the two tax regimes: the effect on welfare

By comparing the effects of differentiated and homogeneous taxation on welfare, it is possible to gain insight into the social dilemma that governments face when choosing between these two regimes in markets with vertically differentiated products.

The effects on tax revenues and welfare produced by changes in the taxation regime should not be undervalued. The use of a differentiated taxation rate for products having different qualities can shift consumers towards low-quality products, triggering severe negative implications for tax revenues and welfare. As discussed in the appendix for the two quality products example, the tax revenues cashed in the high-quality market segment fall, and those in the low-quality market segment rise, recording an increment in the total tax revenues. However, this gain in tax revenues comes at the cost of a loss in the consumer surplus. Due to the own-tax and cross-tax effects, sales surge in the low-quality segment and drop in the high-quality one. The strategic pricing behavior causes rents to be transferred down the quality ladder.

[11] Note that as J increases, $\frac{\partial \widehat{p}^{*}_{\overline{k}}}{\partial \tau_{\overline{k}}} d\tau + \frac{\partial \widehat{p}^{*}_{\overline{k}}}{\partial \tau_{\underline{k}}} d\tau > 0$ gets larger, whereas $\frac{\partial \widehat{p}^{*}_{\underline{k}}}{\partial \tau_{\overline{k}}} d\tau + \frac{\partial \widehat{p}^{*}_{\underline{k}}}{\partial \tau_{\underline{k}}} d\tau < 0$ gets smaller in absolute value.

[12] In the presence of asymmetric production costs, results remain qualitatively unchanged.

4 Conclusion

We develop a tractable theoretical model to study the effects on price and consumer surplus of two taxation regimes in an imperfectly competitive environment. We compare a differentiated and a homogeneous ad valorem tax rate applied to two product qualities with respect to a symmetric increase in their tax rate, remaining agnostic on the optimal tax policy.

We find that the effects of a change in the taxation regime on price competition and welfare are important. In differentiated product markets, the own-tax and cross-tax effects play a pivotal role in helping to comprehend the government's social dilemma on which taxation regime should be employed. A differentiated rather than homogeneous taxation regime delivers higher tax revenues but a lower consumer surplus, as consumers tend to choose lower-quality products. This happens because firms selling low-quality products can bear a greater proportion of the tax burden compared to those selling high-quality products. The reason for this is that firms supplying low-quality products aim to attract consumers that, before the tax rate change preferred the high-quality product, minimizing the number of consumers leaving the market. The effects on the net prices are also significant and a change in the number of firms supplying the market plays an important role.

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A Appendix

Under a differentiated ad valorem taxation regime, in equilibrium, the optimal demands for both quality products are given by

$$D^*_{\overline{k}} = \frac{1}{3t}\left[M + \Delta v + c_{\underline{k}}\left(1+\tau_{\underline{k}}\right) - c_{\overline{k}}\right], \quad D^*_{\underline{k}} = \frac{1}{3t}\left[M - \Delta v + c_{\overline{k}}\left(1+\tau_{\overline{k}}\right) - c_{\underline{k}}\right], \tag{A1}$$

with $M \equiv 3\left(1-\mu\right)t/J$, and $\Delta v \equiv v_{\overline{k}} - v_{\underline{k}}$.

Whereas, when the tax rate is applied homogeneously across all quality products, the equilibrium demands are the following

$$D^{**}_{\overline{k}} = \frac{1}{3t}\left[M + \Delta v + \left(1+\tau\right)\left(c_{\underline{k}} - c_{\overline{k}}\right)\right], \quad D^{**}_{\underline{k}} = \frac{1}{3t}\left[M - \Delta v + \left(1+\tau\right)\left(c_{\overline{k}} - c_{\underline{k}}\right)\right]. \tag{A2}$$

To investigate the welfare analysis under the two taxation regimes, we contrast the changes induced by the two alternative tax regimes into the pivotal elements of welfare. We start by investigating how tax revenues are affected by changes in the taxation rate. We recall that after the change in the ad valorem differentiated taxation regime, the total tax revenues are $T_{Dif} = \left(\tau_{\overline{k}} + d\tau_{\overline{k}}\right)\left(\widehat{p}^*_{\overline{k}} D^*_{\overline{k}}\right) + \left(\tau_{\underline{k}} + d\tau_{\underline{k}}\right)\left(\widehat{p}^*_{\underline{k}} D^*_{\underline{k}}\right)$, whereas for the homogeneous taxation regimes are $T_{Hom} = \left(\tau + d\tau\right)\left(\widehat{p}^{**}_{\overline{k}} D^{**}_{\overline{k}} + \widehat{p}^{**}_{\underline{k}} D^{**}_{\underline{k}}\right)$.

We assume that the original tax rate applied under a homogeneous tax regime is lower than that employed for the high-quality product under a differentiated regime, but it is higher than the tax rate applied on the low-quality product under the same differentiated tax regime, i.e., $\tau_{\underline{k}} < \tau < \tau_{\overline{k}}$. We compare government revenues extracted within the same quality market segment between the two taxation regimes, by introducing the same type of changes in the taxation rate, i.e. $d\tau_k = d\tau$. Thus in the low-quality market segment, differentiated taxation generates a higher tax revenue than homogeneous taxation. The opposite is true for high-quality products, i.e. $\partial \Delta T_{\underline{k}}/\partial \tau_{\underline{k}} > 0$ and $\partial \Delta T_{\overline{k}}/\partial \tau_{\overline{k}} < 0$ where $\Delta T_k \equiv \left(\tau_k + d\tau\right)\left(\widehat{p}^*_k D^*_k\right) - \left(\tau + d\tau\right)\left(\widehat{p}^{**}_k D^{**}_k\right)$, with $k = \underline{k}, \overline{k}$. Tax revenues are shifted from the high tax (high-quality) segment down to the low tax (low-quality) segment when moving from a homogeneous to a differentiated ad valorem taxation regime. In Proposition 1, we have seen that when high-quality products are taxed more than low-quality products, a symmetric increase in taxation leads to a rise in the net producer price in the low-quality segment, outstripping the decline in the net producer price in the high-quality segment. Such net price movements created by own- and cross-tax elasticities lead to the possibility that tax revenues can, in theory, go up in the low-quality segment and down in the high-quality one. This is more likely to happen if the market share of the low-quality segment expands and that of the high-quality contracts. We consider tax revenues to be welfare neutral, although they will increase overall under the differentiated ad valorem taxation regime.

In terms of consumer surplus, recalling the equilibrium demands under the differentiated and homogeneous taxation regimes, equations (A1) and (A2), respectively; we know that once consumers value quality, both demands are below what it is assumed to be socially optimal, i.e. $D^*_k\left(\widehat{p}^*_{\overline{k}}, \widehat{p}^*_{\underline{k}}\right) < D^*_k\left(c,c\right)$ with $k = \underline{k}, \overline{k}$. In particular, focusing on the optimal demands in equilibrium, we detect that the loss of welfare is larger under a differentiated taxation regime for both quality products, i.e. $\left[D^*_k\left(c,c\right) - D^*_k\left(\widehat{p}^*_{\overline{k}}, \widehat{p}^*_{\underline{k}}\right)\right] > \left[D^{**}_k\left(c,c\right) - D^{**}_k\left(\widehat{p}^{**}_{\overline{k}}, \widehat{p}^{**}_{\underline{k}}\right)\right]$. Assessing

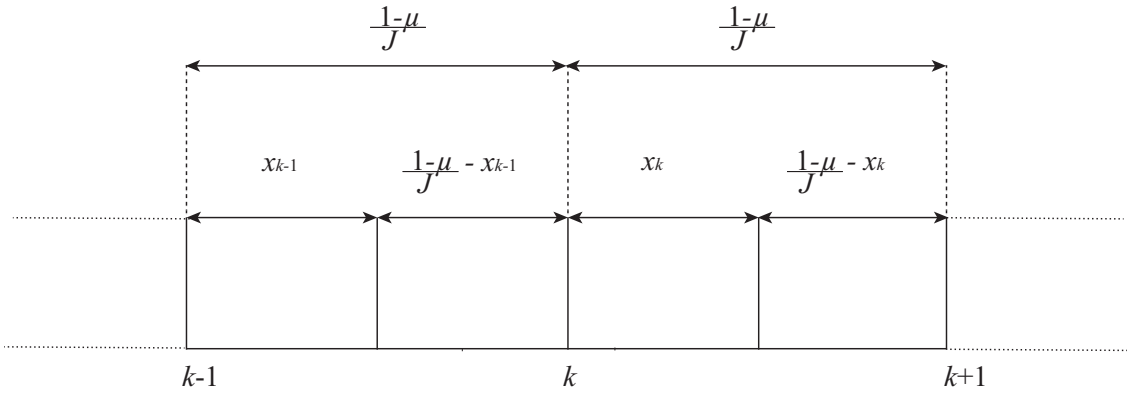
the dimension of these two deadweight losses, we observe that in a taxation regime that applies different rates to different quality products, the loss is higher than when a homogeneous taxation regime is implemented. The magnitude of the deadweight loss from a differentiated taxation regime depends on the difference between tax rates applied to both quality products.

We compute the consumer surplus. For consumers choosing either the low-quality or the high-quality product, the consumer surplus is the sum of consumption benefit minus aggregate transportation cost, namely,

$$CS_k = \frac{J}{2}\left\{ [\upsilon_k - \widehat{p}_k (1+\tau_k)] \times D_k - \int_0^{x_k} txdx - \int_0^{(1-\mu)/J - x_{k-1}} txdx \right\} \text{ with } k = \underline{k}, \overline{k},$$

where $D_k = x_k + \left(\frac{1-\mu}{J} - x_{k-1}\right)$ defines the mass of x_k consumers located on the right, and $\left(\frac{1-\mu}{J} - x_{k-1}\right)$ on the left of product k. In Figure A1 we illustrate graphically, how the market for different product qualities k, is divided in our Salop representation.

Figure A1: Consumer surplus for product k



To measure the deadweight loss yielded by the introduction of taxation, we compare and contrast both consumer surpluses before and after a tax is introduced for both taxation regimes, i.e. $CS_k(\widehat{p}_k)$ versus $CS_k(\widehat{p}_k, \tau_k)$, with $k = \underline{k}, \overline{k}$. We use the same method for both the homogeneous and differentiated taxation regimes. Within the same taxation regime, we note that consumers who choose the low-quality good are penalized more under a homogeneous taxation regime, whereas consumers who buy the high-quality product face a higher loss under a differentiated taxation regime. Finally, looking at the total effect, it emerges that the loss of consumer surplus is higher when a differentiated taxation regime is in place.

Due to the own-tax effect, sales expand in the low-quality segment and shrink in the high-quality segment. In the short run, price competition mitigates the own-tax effect, as the net producer price increases in the low-quality segment and decreases in the high-quality segment to protect market shares. The tax is designed to drop sales, and the strategic pricing behavior causes rents to be transferred down the quality ladder. The low-quality product segment exploits it. The tax induces net producer prices to increase at the expense of market shares. While demand for high-quality products drops, prices act to protect market shares in the face of higher taxation, and we observe more aggressive price competition within the low-quality segment.