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Minimum Quality Standards and Compulsory Labeling: More than the Sum of its Parts.

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Abstract

This paper studies the effect of a minimum quality standard, a compulsory labeling scheme, and the combination of both instruments in a vertical differentiation model when not all quality dimensions of products can be observed byconsumers. Both a minimum quality standard on the non-observable quality dimension and a labeling scheme that informs consumers about the non-observable quality dimension have no impact on the observable quality dimension, increase prices, and have no impact on demand. The combination of a minimum standard and a labeling scheme increases prices, reduces or enhances investment in the observable quality dimension, and alters market shares depending on the minimum quality level. Compared to the case of no regulation, social welfare may decrease or increase under the minimum quality standard, the compulsory labeling scheme or the combined scheme, depending on the level of the minimum quality standard and the market size.

JEL Classification: L13, L15, L51

Keywords: minimum quality standards, labeling, vertical differentiation

1 Introduction

This paper studies the effect of a minimum quality standard, a compulsory labeling scheme, and the combination of both instruments in a vertical differentiation model when not all quality dimensions of products can be observed by consumers.

In the European Union, product quality is not only driven by consumer preferences, but also by political preferences. Two instruments are commonly applied to increase

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product quality: Compulsory labeling schemes and minimum quality standards. Compulsory labeling is usually deemed as “soft” instrument that does not change the product design directly, whereas minimum quality standards are considered “hard” instruments, because they force firms directly to change their products according to political preferences. One prominent example for market interventions is the reduction of energy consumption and of negative environmental impacts of energy using and energy related products.

Energy-related quality aspects are difficult to monitor for consumers, especially when products are not energy consuming, but “energy-related” like shower heads or thermal insulation products for buildings. At the same time, labeling schemes become more and more complex. For example, the energy labeling scheme for vacuum cleaners[1] contains up to five quality dimensions plus the well-known overall rating ranging between D and A^{+++}. This multidimensional labeling scheme indicates that consumers need additional information on several quality dimensions for their purchase decision. On the other hand, labeling alone sometimes seems not to be sufficient to make labeled quality dimensions relevant for purchase decisions. Prior to the light bulb ban in the European Union consumers did not care much about the labeled energy efficiency classes. So because “soft” labeling alone did not result in the politically desired reaction of consumers, it was complemented by a “hard” minimum quality standard.

In order to improve the energy and environmental performance of products both labeling schemes (Energy Labeling Directive 2010/30/EU) and minimum quality standards (Ecodesign Directive 2009/125/EC) are used. An ever growing list of products falls under the Energy Labeling Directive and/or the Ecodesign Directive in the European Union. The “Working Plan 2012-2014 under the Ecodesign Directive”[2] lists 57 groups of products for which an energy labeling scheme and/or a minimum energy efficiency standard already applies or is foreseen for the near future. Products in the Working Plan are e.g. fans, light bulbs, vacuum cleaners, dishwashers, televisions, shower heads, power cables and thermal insulation products for buildings.

Both directives address the same products in principle. This may cause problems compared to the single use of only one instrument, because overlapping instruments may impede each other. This paper shows that and how the combined use of a labeling scheme and a minimum quality standard affects overall product quality, competition, and welfare. While the single use of a minimum quality standard or a labeling scheme do not affect market shares, their combined use does. The single use of a minimum

[1] Commission Delegated Regulation (EU) No. 665/2013.

[2] SEC(2012) 434.

quality standard or a labeling scheme do not affect the unregulated quality dimension, but their combined use does, depending on the level of the minimum standard. While there are potential welfare gains of applying one instrument only, welfare effects of their combined use are ambiguous. The combined effect of both instruments is more than simply the sum of its parts.

We assume products with two quality dimensions. The first dimension is observable and relevant for consumers, while the other is relevant, but not observable. For example, consumers can monitor the energy efficiency of electrical household appliances only at considerable cost. Alternatively, it may be assumed that the second dimension is observable to consumers, but not relevant unless the government imposes a compulsory labeling scheme (as suggested by Schmeiser, 2014). The second dimension of the product quality may relate to energy intensity or harmful emissions. Because consumers do not observe and are not willing to pay for this quality dimension, there are no incentives for firms to invest in quality improvements concerning the hidden dimension and they provide the lowest possible quality level. We assume that the government can costlessly observe the quality level and apply minimum quality standards or compulsory labeling schemes (see Bonroy & Constantatos, 2014 for a survey on the economic impact of labeling schemes). We assume that a labeling scheme makes the hidden quality dimension observable but does not affect market power of firms (see Baltzer, 2012 for an analysis of the effects on market power).

This paper relates to the literature on minimum quality standards in several ways. The literature on minimum quality standards has stressed that quality choices of oligopolistic firms differ from socially optimal levels (Scarpa, 1998). If firms' choices of quality levels are suboptimal, the introduction of a minimum quality standard may be welfare-improving. Like Ronnen (1991) and Crampes & Hollander (1995) we consider duopolistic markets, where single product firms face minimum quality standards as exogenous constraints. We assume that the provision of quality improvements entails no fixed cost for firms, but rather variable costs, similar to Motta (1993) and Crampes & Hollander (1995). Fixed cost of quality improvements stem from quantity independent features like the design of the product or R&D investments. Variable costs of quality improvements are related to higher quality materials or more complex production processes. For the lists of products mentioned above, like electrical household appliances or insulation products, variable cost of quality improvements seem to be more relevant, as an enhanced quality level requires more complex production processes or higher quality materials.

Against this background, we study the effect of a minimum quality standard, a labeling scheme, and the combination of both instruments on prices and quality levels in a vertical differentiation model following Ecchia & Lambertini (1997). It assumes a duopolistic market structure with one firm selling a high-quality product and the other selling a low-quality product. We endogenize the quality levels of both quality dimensions and assume variable cost of quality improvements. Consumers are heterogeneous with respect to their preference for quality. Both a minimum quality standard on the non-observable quality dimension and a labeling scheme that informs consumers about the non-observable quality dimension have no impact on the observable quality dimension, increase prices, and have no impact on demand, given that only one of the two instruments is applied. The combination of a minimum standard and a labeling scheme results in considerably different results. It reduces (enhances) investment in the observable quality dimension, if the standard is sufficiently low (high). It increases prices and shifts demand from the low-quality firm to the high-quality firm (from the high-quality firm to the low-quality firm), if the standard is sufficiently low (high). A labeling scheme without a minimum quality standard is welfare increasing, if the market sufficiently small. A minimum quality standard may decrease or increase welfare depending on the level of the standard. Welfare may increase or decrease in the combined scheme compared to the use of a minimum quality standard only.

These results suggest that combining two instruments for only one policy goal may result in complex interactions, ambiguous welfare implications and unintended effects on competition. So the European Commission should consider the combined use carefully in order to avoid welfare losses and distorted competition. In some cases, the application of one instrument only may be preferable compared to a combined use.

The rest of the paper is organized as follows. In the next section, the vertical differentiation model is presented. Section 3 studies the case of no government intervention, the effects of a minimum quality standard, a compulsory labeling scheme, and the combination of both. Section 4 analyzes welfare, section 5 concludes.

2 The Model

Following Ecchia & Lambertini (1997), consider a duopolistic market with vertical product differentiation. Two firms supply a product that is characterized by two quality dimensions s and v. Both quality dimensions can be supplied in two levels, H and L, with $s_H > s_L$, and $v_H > v_L$. Each firm chooses only one quality level with respect to both quality dimensions. Whereas the quality dimension s is (directly) observable to consumers, v is not. For example, consumers can monitor the energy efficiency of electrical household appliances only at considerable cost. Consumers base their decisions between various products only on the visible dimension like luminance of a light bulb or performance of a vacuum cleaner.

The production technology is characterized by variable cost, which is convex in quality and linear in quantity. For the list of products mentioned above, this may be a reasonable assumption, as quality improvements require higher quality materials or more complex production processes. Firms incur fixed cost f for developing a product and entering the market. For simplicity we assume identical variable costs for s and v. The cost function is given as

$$C_i = t\left(s_i^2 + v_i^2\right) q_i + f. \tag{1}$$

Consumers differ in their preference for quality in both dimensions θ, which is uniformly distributed on the interval $[a, b]$[3] (Ecchia & Lambertini, 1997). Each consumer buys at most one unit of the most preferred good. We assume that s and v are perfect substitutes for consumers, if v is observable. The utility derived from no purchase is zero, while a consumer who buys one unit of the good at price p obtains a net utility of

$$U = \theta\left(s_i + v_i\right) - p_i,\ i = H, L. \tag{2}$$

A consumer with a positive net utility of the good chooses the most preferred version of the good by trading off (observed) quality against the price. A higher θ implies a higher willingness to pay for quality. It can be considered the marginal rate of substitution between income and quality (Tirole, 1988). The consumer heterogeneity can be interpreted as differences in income, in taste, or in frequency of usage.

The marginal consumer indifferent between purchasing the high-quality good and the low-quality good is given by $\theta^* = \frac{p_H - p_L}{(s_H + v_H) - (s_L + v_L)}$. Disregarding the unobservable quality dimension v this simplifies to $\theta^* = \frac{p_H - p_L}{s_H - s_L}$. Hence, demand for the good of quality H and the good of quality L respectively is given by

$$q_H = b - \frac{p_H - p_L}{s_H - s_L},\ q_L = \frac{p_H - p_L}{s_H - s_L} - a. \tag{3}$$

Firms' profits are given by

$$\pi_i = \left(p_i - t\left(s_i^2 + v_i^2\right)\right) q_i. \tag{4}$$

Competition follows a three-stage game: In the first stage, the government decides whether to apply a minimum quality standard, a labeling scheme, or both instruments

[3] Assume $b = a + 1$ and $b \geq \frac{5}{4}$ to guarantee equilibrium existence.

simultaneously. In the second stage, firms choose quality levels. In the third stage, firms compete in prices.

3 Regulatory Scenarios

3.1 No Regulation

Consider first a system with no government intervention. Firms are free to choose quality levels. Without regulation, the quality dimension v is unobservable to consumers and is not relevant for their purchase decision. Firms have no incentive to invest in v and set the quality level to $v_H = v_L = 0$. This is equivalent to the no regulation results of Ecchia & Lambertini (1997). In equilibrium, firms set quality levels s_H and s_L (see Appendix). Both quality levels increase in the maximum willingness to pay b and decrease in the marginal cost of quality improvement t.

Firms set equilibrium prices p_H and p_L (see Appendix). Both prices increase in the maximum willingness to pay b and decrease in the marginal cost of quality improvement t.

The duopoly is symmetric, quantities are $q_H = q_L = \frac{1}{2}$. Firms' profits are identical.

3.2 Minimum Quality Standard on v

Now assume that the government introduces a minimum quality standard $V > 0$ on quality dimension v. As this has no effect on the visibility or relevance for consumers v remains irrelevant for the purchase decision of consumers and their perceived utility. Firms have no incentive to invest in v more than necessary and set $v_H = v_L = V$.

Equilibrium quality decisions on s are unaffected by the minimum quality level of v and are the same as under no regulation: $s_H^M = s_H$, $s_L^M = s_L$ (see Appendix). Since consumers cannot observe v, but only s, the total quality $(s + v)$ of the product remains unchanged in their view.

Firms set prices p_H^M and p_L^M. Both prices are higher than under no regulation ($p_H^M > p_H$, $p_L^M > p_L$) and increase in V. Firms pass through the cost of investment in quality dimension v completely to the consumers, i.e. $p_i^M = p_i + c_i(v_i)$.

The duopoly is symmetric, quantities are the same as under no regulation. As firms pass through additional costs and quantities remain unchanged, profits are the same as under no regulation.

Proposition 1 summarizes the effect of a minimum quality standard.

Proposition 1 *Suppose a minimum quality standard on quality dimension v is introduced that is binding for both firms. Then the standard i) has no impact on quality dimension s, ii) increases both prices, and iii) has no impact on demand.*

3.3 Labeling

Now assume that the government imposes a labeling scheme concerning v that informs consumers about the level of this quality dimension instead of a minimum quality standard. This used to be the case for many household appliances and light bulbs. As v is now visible to consumers, they take v into account in making their purchase decision – and so do firms in their decision on quality levels. Since v and s are perfect substitutes with identical convex productions costs, firms choose identical levels for both dimensions $s_H^L = v_H^L$ and $s_L^L = v_L^L$ (see Appendix). Under labeling, the quality level of s is the same as under no regulation ($s_H^L = s_H$, $s_L^L = s_L$). Firms set prices p_H^L and p_L^L. Both prices are higher than under no regulation ($p_H^L > p_H$, $p_L^L > p_L$). Equilibrium quantities are unaffected by the labeling scheme, but profits of both firms increase.

Proposition 2 summarizes the effect of a labeling scheme.

Proposition 2 *Suppose a labeling scheme that informs consumers about quality dimension v is introduced. Then the labeling scheme i) has no impact on quality dimension s, ii) increases both prices, and iii) has no impact on demand.*

3.4 Combined Scheme – Minimum Standard and Labeling

A minimum quality standard and a labeling scheme have both no effect on the observable quality dimension s. Also, both instruments do not change market shares. Which instrument raises prices more, depends on the level of the standard. For $V < \tilde{V}_L$, both prices are lower under the minimum quality standard than under the labeling scheme. For an intermediate minimum quality level $\tilde{V}_L < V < \tilde{V}_H$, p_L is higher and p_H is lower under the minimum quality standard. For a high minimum quality level $\tilde{V}_H < V$, both prices are higher under the minimum quality standard (see Appendix).[4]

Now assume that the government imposes a minimum quality standard on quality dimension v and simultaneously applies a labeling scheme for v. Assume an exogenously given standard V, which is binding for both firms, so that $v_L^{ML} = V$.

The combination of both instruments concerning quality dimension v has an impact on the unregulated quality dimension s. The level of the unregulated dimension may

[4] This implies $v_L^L < \tilde{V}_L < v_H^L < \tilde{V}_H$.

increase or decrease depending on the minimum quality level V. Compared to no regulation or one instrument only, the quality levels in dimension s are lower (higher), if V is sufficiently low (high) ($s_H^{ML} < s_H = s_H^M = s_H^L$, $s_L^{ML} < s_L = s_L^M = s_L^L$ for $V < s_L$, $s_H^{ML} > s_H = s_H^M = s_H^L$, $s_L^{ML} > s_L = s_L^M = s_L^L$ for $V > s_L$).

Compared to no regulation, the H-firm's quality level in dimension v is higher ($v_H^{ML} > v_H = 0$). Compared to the minimum standard only, the H-firm's quality level in dimension v is lower (higher), if V is sufficiently low (high) ($v_H^{ML} < v_H^M$ for $V < s_H$, $v_H^{ML} > v_H^M$ for $V > s_H$). And compared to labeling only, the quality level of the H-firm in dimension v is lower, if V is in the range of the unregulated levels of s ($v_H^{ML} < v_H^L$ for $s_L < V < s_H$).

Compared to no regulation, the L-firm's quality level in dimension v is higher ($v_L^{ML} = V > v_L = 0$). Compared to the minimum standard only, the L-firm's quality level in dimension remains the same ($v_L^{ML} = V = v_L^M$). And compared to labeling only, the quality level of the L-firm in dimension v is lower, if V is sufficiently small ($v_L^{ML} < v_L^L$, for $V < v_L^L$).

Equilibrium prices are higher than under no regulation ($p_H^{ML} > p_H$, $p_L^{ML} > p_L$, see Appendix). Compared to the minimum standard only, prices are higher (lower) if V is sufficiently low (high) ($p_H^{ML} > p_H^M$, $p_L^{ML} > p_L^M$ for $V < s_H$, $p_H^{ML} < p_H^M$, $p_L^{ML} < p_L^M$ for $V > s_H$). Compared to labeling only, prices are lower (higher) if V is sufficiently low (high) ($p_H^{ML} > p_H^L$, $p_L^{ML} > p_L^L$ for $V < s_L$, $p_H^{ML} < p_H^L$, $p_L^{ML} < p_L^L$ for $V > s_L$).

While neither the single use of the minimum quality standard nor the labeling scheme affects market shares, the combined scheme has an impact on market shares. For V sufficiently low (high) the combined scheme shifts demand from the L-firm to the H-firm (from the H-firm to the L-firm) ($q_H^{ML} > q_H$, $q_L^{ML} < q_L$, $p_L^{ML} > p_L^M$ for $V < s_L$ and $q_H^{ML} < q_H$, $q_L^{ML} > q_L$, $p_L^{ML} > p_L^M$ for $s_L < V < s_H$).

Proposition 3 summarizes the effect of the combination of a minimum standard and a labeling scheme.

Proposition 3 *Suppose both a minimum standard and a labeling scheme are introduced. Compared to no regulation, this i) reduces (enhances) investment in quality dimension s, if V is sufficiently low (high), ii) increases prices, iii) shifts demand from the L-firm to the H-firm (from the H-firm to the L-firm), if V is sufficiently low (high).*

4 Welfare

Consider social cost ϕ that may be reduced by an enhanced quality level of products. This social cost may be caused a negative externality such as harmful emissions of power generation stemming from a low level of v. The regulator aims to maximize welfare that is given as the sum of profits, consumer surplus, and the cost of the externality R. The cost of the externality is given as $R = -(\phi - q_H v_H - q_L v_L)$. Without any regulation with respect to v both firms set their quality level to $v_H = v_L = 0$, so $R = -\phi$.

4.1 Minimum Quality Standard on v

If the government introduces a minimum quality standard on v, but no compulsory labeling, both firms set $v_H = v_L = V$.

Depending on V and t social welfare may decrease or increase under the minimum quality standard (see Appendix). Welfare may decrease (increase), if the minimum quality standard is sufficiently high (small) for a given level of t. So regulators have to take the costs of quality improvement carefully into account when setting the minimum quality standard V.

4.2 Labeling

Compared to no regulation, social welfare may decrease or increase under the labeling scheme depending on market size b (see Appendix). If markets are sufficiently small, a compulsory labeling scheme has a positive effect on social welfare. This implies that providing additional information to consumers concerning an unobservable quality dimension is only welfare increasing, if consumers do not care about this dimension too much.

4.3 Combined Scheme – Minimum Standard and Labeling

Consider now a combined scheme of a minimum quality standard and labeling as introduced in section 3.4.

Social welfare is higher (lower) under the combined scheme than under the minimum quality standard only, if the market size b is small and V is sufficiently low (high). Social welfare is higher (lower) under the combined scheme than under the minimum quality standard only, if the market size b is sufficiently large and V is sufficiently high (low).

Social welfare is higher (lower) under the combined scheme than under labeling only, if the market size b is small and V is sufficiently low (high). If the market size b is sufficiently large, social welfare is lower under the combined scheme than under labeling only.

These results imply that it is difficult for policy makers to calibrate their instruments, if more than one instrument is applied for each policy objective. There are potential welfare gains by the combination of both instruments, but welfare losses are also possible depending on the market size and the level of the minimum quality standard.

Proposition 4 summarizes the effect of a minimum quality standard, a labeling scheme, and the combination of both instruments on welfare.

Proposition 4 *i) Compared to the case of no regulation, social welfare is higher (lower) under the minimum quality standard, if the minimum quality standard is sufficiently high (low). ii) Compared to the case of no regulation, social welfare is higher (lower) under the labeling scheme, if the market sufficiently small (large). iii) Under the combined scheme, social welfare is higher (lower) than under the minimum quality standard only, if the market size b is sufficiently small and V is sufficiently low (high). Social welfare is higher (lower) under the combined scheme than under the minimum quality standard only, if the market size b is sufficiently large and V is sufficiently high (low). Social welfare is higher (lower) under the combined scheme than under labeling only, if the market size b is small and V is sufficiently low (high). If the market size b is sufficiently large, social welfare is lower under the combined scheme than under labeling only.*

5 Conclusion

This paper has studied the effect of a minimum quality standard, a compulsory labeling scheme, and the combination of both instruments in a vertical differentiation model when not all quality dimensions of products are observable to consumers. We have assumed variable cost of quality improvement. This may be an appropriate assumption for many products that are regulated by the Ecodesign Directive and the Labeling Directive of the EU.

Both a minimum quality standard and a labeling scheme have no impact on the visible quality dimension s, increase both prices, and have no impact on market shares. The combination of a minimum standard and a labeling scheme affects investment in quality dimension s, depending on V, increases prices, shifts demand from the L-firm to the H-firm (from the H-firm to the L-firm), if V is sufficiently low (high).

For a given level of cost of quality improvement, a sufficiently low level of the minimum quality standard increases welfare compared to the case of no regulation, while a high level of the minimum quality standard decreases welfare. So the European Commission should calibrate the minimum quality standards based on the Ecodesign Directive carefully, taking variable costs of quality improvements into account.

A labeling scheme without a minimum quality standard is welfare increasing compared to the case of no regulation, if the market is sufficiently small. It is an open question, whether the willingness to pay for quality in single market of the European Union is sufficiently “small” to reach welfare improvements due to energy labeling. If the willingness to pay differs between member states, there may be welfare gains in some member states, but welfare losses in other.

The combination of both instruments leads to no clear results with respect to welfare. There are potential welfare gains by the combination of both instruments, but welfare losses are also possible. In addition, while the use of one of both instruments only does not affect competition, it is the combination of both instruments that alters market shares.

While labeling is deemed as a “soft” instrument, it has a strong influence on quality levels. If it is combined with a minimum quality level it even alters market shares while they remain unaffected by the single use of a “hard” minimum quality standard.

The results of this paper are based on a special assumption concerning the production technology: Firms are able to set the quality levels of both dimensions s and v independently. In many cases alternative production technologies may be more realistic, where quality levels of both dimensions are interdependent, e.g. an increase in v may be associated with a decrease of s or an increase of the cost of s. In this case, an increase of V may lead to a decrease of the visible quality dimension s. The transition from the traditional light bulb to energy saving lamps may be an example: While the energy efficiency increased tremendously, the light quality decreased in the perspective of many consumers. An analysis of the effects of alternative production technologies seems to be a promising topic for future research.

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A Appendix

A.1 No regulation

Equilibrium quality levels

$$s_H = \frac{4b+1}{8t}, s_L = \frac{4b-5}{8t}. \tag{5}$$

$$\frac{\partial s_H}{\partial b} > 0, \frac{\partial s_L}{\partial b} > 0$$

$$\frac{\partial s_H}{\partial t} < 0, \frac{\partial s_L}{\partial t} < 0$$

First stage equilibrium prices

$$p_H = \frac{16b^2 + 8b + 25}{64t}, \ p_L = \frac{16b^2 - 40b + 49}{64t}. \tag{6}$$

Both prices increase in the willingness to pay b ($\frac{\partial p_H}{\partial b} > 0, \frac{\partial p_L}{\partial b} > 0$) and decrease in the marginal cost of quality improvement t ($\frac{\partial p_H}{\partial t} < 0, \frac{\partial p_L}{\partial t} < 0$).

Quantities are

$$q_H = q_L = \frac{1}{2}. \tag{7}$$

Firms' profits are

$$\pi_h = \pi_l = \frac{3}{16t}. \tag{8}$$

A.2 Minimum quality standard on v

$$s_H^M = \frac{4b+1}{8t}, \ s_L^M = \frac{4b-5}{8t}. \tag{9}$$

Equilibrium prices

$$p_H^M = \frac{64V^2t^2 + 8b\,(2b+1) + 25}{64t}, \ p_L^M = \frac{64V^2t^2 + 8b\,(2b-5) + 49}{64t}.$$

Both prices are higher than under no regulation ($p_H^M > p_H$, $p_L^M > p_L$) and increase in $V(\frac{\partial p_H^M}{\partial V} > 0, \frac{\partial p_L^M}{\partial V} > 0)$. Firms pass through the cost of investment in quality dimension v completely to the consumers, i.e. $p_i^M = p_i + c_i\,(v_i)$.

The duopoly is symmetric, quantities are

$$q_H^M = q_L^M = \frac{1}{2}. \tag{10}$$

As firms pass through additional costs and quantities remain unchanged profits are the same as under no regulation

$$\pi_H = \pi_L = \frac{3}{16t}. \tag{11}$$

A.3 Labeling

Firms choose identical levels for both dimensions:

$$s_H^L = v_H^L = \frac{4b+1}{8t}, s_L^L = v_L^L = \frac{4b-5}{8t}. \tag{12}$$

Prices are

$$p_H^L = \frac{16b^2+8b+25}{32t},\ p_L^L = \frac{16b^2-40b+49}{32t}. \tag{13}$$

$$\pi_H^L = \pi_L^L = \frac{3}{8t}. \tag{14}$$

For $V < \tilde{V}_L = \frac{\sqrt{16b^2+49-40b}}{86}$ both prices are lower under the minimum quality standard than under the labeling scheme. For an intermediate minimum quality level $\tilde{V}_L < V < \tilde{V}_H = \frac{\sqrt{8b+16b^2+25}}{86}$ p_L is higher and p_H is lower under the minimum quality standard. For a high minimum quality level $\tilde{V}_H < V$, both prices are higher under the minimum quality standard.[5]

A.4 Combined Scheme

The high quality firm sets identical quality levels for both quality dimensions, s and v.

$$s_H^{ML} = v_H^{ML} = \frac{2b-1+\Psi+8Vt}{12t}, \tag{15}$$

with $\Psi = \sqrt{2\left(5+2b\left(b+8\right)-8Vt\left(b+4-Vt\right)\right)}$. The low quality firms chooses a lower quality level for dimension s

$$s_L^{ML} = \frac{2b-1+\Psi+8Vt}{12t} - \frac{3}{4t}, v_L^{ML} = V. \tag{16}$$

Prices are

$$\begin{aligned} p_H^{ML} &= \frac{125+16b\left(2b+7\right)-8Vt\left(37-2b-34Vt\right)+8\left(2b-1+5Vt\right)\Psi}{216t} \\ p_L^{ML} &= \frac{217+4b\left(b-1\right)-8Vt\left(44-7b-38Vt\right)+2\left(b-5+16Vt\right)\Psi}{216t}. \end{aligned} \tag{17}$$

[5] $v_L^L < \tilde{V}_L < v_H^L < \tilde{V}_H$.

Equilibrium quantities are

$$q_H^{ML} = \frac{4b + 7 - 8Vt - \Psi}{9},\ q_L^{ML} = \frac{\Psi + 8Vt - 2(2b-1)}{9}. \tag{18}$$

Profits are

$$\pi_H^{ML} = \frac{(4b + 7 - 8Vt - \Psi)\left(2\left(7b + 2b^2 + 23\right) - 4Vt(7 + 4b - 4Vt) - (1 - 2b + 4Vt)\Psi\right)}{972t} \tag{19}$$

$$\pi_L^{ML} = \frac{(8Vt - 2(2b-1) + \Psi)\left(\left(13 + 2b - 2b^2\right) - 4Vt(1 - 2b + 2Vt) + (5 - b + 2Vt)\Psi\right)}{486t} \tag{20}$$

A.5 Welfare

Available upon request.