Do Quality Regulations Enhance Welfare? A Comment on Gaigné and Larue (2016)*

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Abstract

Gaigné and Larue (American Journal of Agricultural Economics 98:1432-1449) examined the welfare implications of quality regulations within an international trade context, employing a general-equilibrium framework. Their study uses a CES (Constant Elasticity of Substitution) model and finds that stricter public standards might improve welfare. However, this conclusion was actually derived from a partial-equilibrium analysis. This note conducts a thorough general-equilibrium analysis and demonstrates that their anticipated outcome does not hold within their CES framework.

Key words: Quality regulations, CES, welfare

1 Introduction

Quality regulations are indispensable across various industries, ensuring that products and services adhere to established standards of safety, reliability, and efficiency.

In their Proposition 6, Gaigné and Larue (2016a) assert that a marginal increase in the quality standard beyond market equilibrium could potentially bolster welfare. Their proposition is general and embedded within an international trade framework. Intuitively, stricter regulatory policies induce higher fixed and variable production costs for both domestic and foreign producers, thereby favoring highly productive firms while driving less efficient ones out. This reallocation of resources is considered to yield welfare gains, a finding with significant ramifications, particularly within the food industry (Gaigné and Larue, 2016b; Gaigné and Gouel, 2022).

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Although the authors developed a general-equilibrium model incorporating multiple countries, their welfare analysis remained rooted in partial equilibrium. Specifically, their examination focused on two countries, i and j, wherein the quality standard of country j directly influenced the price index of country i, overlooking the indirect effects from other countries.

This study revisits the nexus between quality regulations and welfare through a general-equilibrium lens, integrating the interplay among various market cutoffs in goods and labor markets. To simplify the analysis, we confine our examination to a closed economy. Surprisingly, our findings diverge from those of Gaigné and Larue (2016a), indicating that an increase in the quality standard always decreases welfare.

It is pertinent to note that Gaigné and Larue (2016a) assumed CES (Constant Elasticity of Substitution) preferences. However, the findings of Dhingra and Morrow (2019) demonstrate that market equilibrium coincides with the optimum under such preferences. A departure from CES preferences may be necessary to address such kind of market distortions (Macedonia and Weinberger, 2022).

The subsequent sections of this paper are structured as follows: Section 2 establishes the model, which is a simplified version of Gaigné and Larue (2016a) tailored for a closed economy. Section 3 delves into the analysis of the laissez-faire economy. Section 4 scrutinizes whether welfare experiences enhancement with an uptick in the quality standard from the laissez-faire economy. Finally, Section 5 summarizes this note.

2 Model

This section reconstructs the model introduced by Gaigné and Larue (2016a) to analyze welfare within a closed economy setting. The economy comprises a single sector producing differentiated goods, or varieties.[1]

The total population of this country is denoted as L. Consumers exhibit homogeneous preferences described by the utility function

$$U = \int_{\Omega} \theta(v)^{\beta} q(v)^{\frac{\epsilon-1}{\epsilon}} dv, \tag{1}$$

where Ω represents the set of available varieties, $q(v)$ and $\theta(v)$ denote the quantity and quality of variety $v \in \Omega$, and ϵ (> 1) stands for the substitution elasticity between varieties, while β (> 0) represents the degree of preference for quality.

Labor serves as the sole input in production and is chosen as the numeraire, resulting in a wage rate of $w = 1$.

[1]The original model of Gaigné and Larue (2016a) has one more sector producing a homogeneous aggregate good. The existence of this sector does not change the conclusion here.

Firms encounter a fixed entry cost, f_e, upon entering the market. Upon entry, they draw a productivity parameter ϕ from the interval $[1, \infty)$, which dictates their level of productivity. Firm productivity follows a Pareto distribution described by $1-G(\phi) = \phi^{-\gamma}$.

During the production process, firms incur two fixed costs and one variable cost. The first fixed cost, f, is a prerequisite for initiating production and is uniform across all firms. The second fixed cost, $\theta(v)^\eta/\eta$ varies based on the chosen quality level $\theta(v)$. Meanwhile, the variable cost, $\theta^\alpha(v)/\phi$, is contingent upon both the selected quality level and firm productivity ϕ. Parameters $\eta > 0$ and $\alpha > 0$ are uniform across all firms.

3 A laissez-faire economy

Consider a firm with productivity ϕ. Using the well-known constant markup property of CES utility (see, e.g., Lemma 2.1 of Zeng (2021)), the optimal price for quality level θ is

$$p(\phi, \theta) = \frac{\epsilon}{\epsilon - 1} \frac{\theta^\alpha}{\phi}, \tag{2}$$

and the output is

$$q(\phi, \theta) = \frac{\theta^{\beta\epsilon}(p(\phi, \theta))^{-\epsilon}}{P^{1-\epsilon}} L = \frac{\theta^{(\beta-\alpha)\epsilon}}{P^{1-\epsilon}} \left(\frac{\epsilon - 1}{\epsilon}\right)^\epsilon \phi^\epsilon L, \tag{3}$$

where

$$P = \left[\int_\Omega \theta^{\beta\epsilon}(v) p^{1-\epsilon}(v) dv\right]^{\frac{1}{1-\epsilon}}$$

is the price index, and L is the population. The firm chooses the best quality level to maximize the net profit

$$\pi(\phi, \theta) = \frac{p(\phi, \theta) q(\phi, \theta)}{\epsilon} - \frac{\theta^\eta}{\eta} - f = \frac{1}{\epsilon} \frac{\theta^\Lambda}{P^{1-\epsilon}} \left(\frac{\epsilon - 1}{\epsilon}\right)^{\epsilon-1} \phi^{\epsilon-1} L - \frac{\theta^\eta}{\eta} - f, \tag{4}$$

where $\Lambda = \alpha + (\beta - \alpha)\epsilon$. The first-order condition (FOC) with respect to θ is expressed as

$$\Lambda \frac{p(\phi, \theta) q(\phi, \theta)}{\epsilon} - \theta^\eta = 0, \tag{5}$$

which determines the optimal quality level $\theta(\phi)$ as a function of ϕ. The second-order condition is expressed as $-(\eta - \Lambda)\theta^{\eta-2} < 0$. Thus, following Gaigné and Larue (2016a), we assume

$$\eta > \Lambda > 0 \tag{6}$$

in the subsequent analysis.

Lemma 1 *Under (6), $\theta(\phi)$ is an increasing function.*

Proof: The following equality can be derived from (2), (3), and (5):

$$\theta^{\eta-\Lambda}(\phi) = \frac{\Lambda}{\epsilon P^{1-\epsilon}}\left(\frac{\epsilon-1}{\epsilon}\right)^{\epsilon-1} L\phi^{\epsilon-1}.$$

Thus, $\theta(\phi) \propto \phi^{\frac{\epsilon-1}{\eta-\Lambda}}$ holds. Using (6) and the fact that $\epsilon > 1$, it is clear that $\theta(\phi)$ increases with ϕ. □

The dashed curve of Figure 1 shows a numerical example of $\theta(\phi)$ with the following parameters

$$\alpha = 0.6, \beta = 0.7, \gamma = 6, \eta = 3, \epsilon = 4, f_e = 3, f = 1, \tag{7}$$

which satisfy (6).

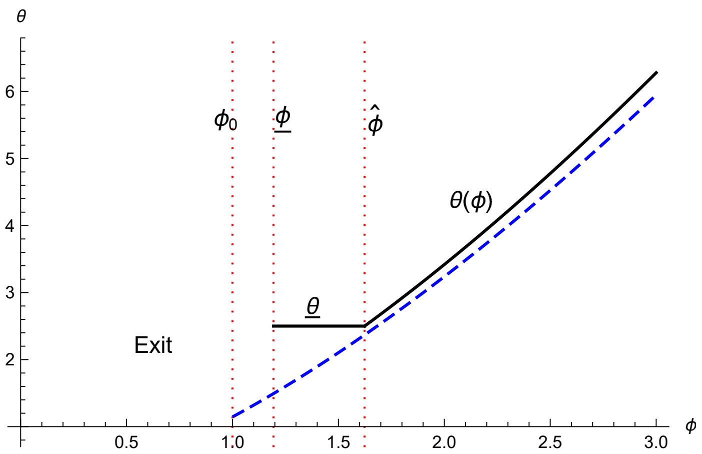

Figure 1: A numerical example

The net profit of this firm is

$$\theta^{\eta}\left(\frac{1}{\Lambda} - \frac{1}{\eta}\right) - f,$$

which is non-negative iff

$$\theta \geq \theta_0 \equiv \left(\frac{\eta\Lambda f}{\eta - \Lambda}\right)^{\frac{1}{\eta}}. \tag{8}$$

Let

$$\phi_0 = \left(\frac{\epsilon}{L\Lambda}\right)^{\frac{1}{\epsilon-1}} \frac{\epsilon}{(\epsilon-1)P}\theta_0^{\frac{\eta-\Lambda}{\epsilon-1}}, \tag{9}$$

which is the root of $\theta(\phi_0) = \theta_0$. The uniqueness of this root is ensured by Lemma 1. In the numerical example depicted in Figure 1, $\theta_0 \approx 1.14471$ and $\phi_0 = 1$. As observed in this figure, firms with $\phi \geq \phi_0$ choose quality $\theta(\phi)$, while firms with $\phi < \phi_0$ choose to exit.

Let M denote the mass of produced varieties. The price index of this economy is characterized by

$$P^{1-\epsilon} = \frac{M}{1-G(\phi_0)} \int_{\phi_0}^{\infty} \theta^{\beta\epsilon} p(\phi, \theta(\phi))^{1-\epsilon} dG(\phi). \tag{10}$$

In equilibrium, the entry cost f_e equals the expected profit:

$$f_e = \int_{\phi_0}^{\infty} \pi(\phi, \theta(\phi)) dG(\phi). \tag{11}$$

Finally, the labor market clearing condition is expressed as

$$L = \frac{M}{1-G(\phi_0)} \left\{ f_e + \int_{\phi_0}^{\infty} \left[f + \frac{\theta^{\eta}(\phi)}{\eta} + \frac{\theta^{\alpha}(\phi)}{\phi} q(\phi, \theta(\phi)) \right] dG(\phi) \right\}. \tag{12}$$

Equations (9), (10), and (11) can be analytically solved for ϕ_0, M, and P. They yield

$$\phi_0 = \left[\frac{(\epsilon-1)\eta}{\Delta} \frac{f}{f_e} \right]^{\frac{1}{\gamma}},$$

$$P = \frac{\epsilon}{\epsilon-1} \left(\frac{f\epsilon\eta}{\eta-\Lambda} \right)^{\frac{\eta-\Lambda}{\eta(\epsilon-1)}} \left(\frac{\epsilon}{\Lambda} \right)^{\frac{\Lambda}{\eta(\epsilon-1)}} \left[\frac{\Delta}{(\epsilon-1)\eta} \frac{f_e}{f} \right]^{\frac{1}{\gamma}} L^{\frac{1}{1-\epsilon}}, \tag{13}$$

$$M = \frac{\Delta}{f\gamma\epsilon\eta} L, \tag{14}$$

where

$$\Delta \equiv \gamma(\eta - \Lambda) - (\epsilon - 1)\eta > 0 \tag{15}$$

is assumed to ensure the positivity of M. They automatically satisfy (12). It is noteworthy that the parameters of (7) satisfy (15).

4 A regulated economy

Assume that a quality regulation is imposed to ensure a minimum quality level $\underline{\theta}$, which is higher than θ_0 of (8). As documented in Gaigné and Larue (2016a), there are two cutoffs $\underline{\phi}, \hat{\phi} \in [1, \infty)$ such that all firms with $\phi \in [1, \underline{\phi})$ exit, firms with $\phi \in [\underline{\phi}, \hat{\phi}]$ start production with the minimum quality level $\underline{\theta}$, and firms with $\phi \in [\hat{\phi}, \infty)$ produce with their private quality levels. The latter two are referred to as constrained and unconstrained firms, respectively.

It is noteworthy that (2), (3), and (4) remain valid in this regulated economy. Using the fact that $\pi(\underline{\phi}, \underline{\theta}) = 0$, the following expressions for price, output, and profit for constrained firms are obtained:

$$p(\phi, \underline{\theta}) = \frac{\epsilon}{\epsilon-1} \frac{\underline{\theta}^{\alpha}}{\phi},$$

$$
\begin{aligned}
q(\phi,\underline{\theta}) &= (\epsilon-1)\phi\Big(\frac{\phi}{\underline{\phi}}\Big)^{\epsilon}\Big(\frac{\underline{\theta}^{\eta}}{\eta}+f\Big)\frac{1}{\underline{\theta}^{\alpha}}, \\
\pi(\phi,\underline{\theta}) &= \Big(\frac{\underline{\theta}^{\eta}}{\eta}+f\Big)\Big[\Big(\frac{\phi}{\underline{\phi}}\Big)^{\epsilon-1}-1\Big].
\end{aligned} \tag{16}
$$

Meanwhile, the second equality of (3) for $\phi = \underline{\phi}$ and (16) imply

$$
f+\frac{\underline{\theta}^{\eta}}{\eta} = \frac{1}{\epsilon}\underline{\theta}^{\beta\epsilon}\Big(\frac{\epsilon}{\epsilon-1}\frac{\underline{\theta}^{\alpha}}{\underline{\phi}}\Big)^{1-\epsilon}P_{\underline{\theta}}^{\epsilon-1}L,
$$

so

$$
\underline{\phi} = \frac{\epsilon}{\epsilon-1}\frac{1}{P_{\underline{\theta}}}\underline{\theta}^{\frac{\Lambda}{1-\epsilon}}\Big[\frac{\epsilon}{L}\Big(f+\frac{\underline{\theta}^{\eta}}{\eta}\Big)\Big]^{\frac{1}{\epsilon-1}}.
$$

Noting that $\hat{\phi}$ is the cutoff firm whose private standard is equal to the public one, we have $\underline{\theta} = \theta(\hat{\phi})$, which implies

$$
\hat{\phi} = \frac{\epsilon}{\epsilon-1}\frac{1}{P_{\underline{\theta}}}\Big(\frac{\epsilon}{\Lambda L}\Big)^{\frac{1}{\epsilon-1}}\underline{\theta}^{\frac{\eta-\Lambda}{\epsilon-1}}.
$$

They imply,

$$
\frac{\hat{\phi}}{\underline{\phi}} = \Big[\frac{\underline{\theta}^{\eta}}{\Lambda(f+\underline{\theta}^{\eta}/\eta)}\Big]^{\frac{1}{\epsilon-1}} > 1,
$$

where the inequality is from $\underline{\theta} > \theta_0$ and (8).

Unconstrained firms have productivity ϕ in the interval $(\hat{\phi},\infty)$. Their private quality standard $\theta(\phi)$ is implicitly determined by (5), where price p is given by (2), and quantity q is given by (3). In the numerical example depicted in Figure 1, we select $\underline{\theta} = 2.5$ in addition to the parameters specified in (7). This implies $\underline{\phi} \approx 1.1936$ and $\hat{\phi} \approx 1.62358$. $\theta(\phi)$ is plotted as the solid curve for $\phi > \hat{\phi}$.

Let $M_{\underline{\theta}}$ denote the mass of varieties in this regulated market. Then the price index $P_{\underline{\theta}}$ satisfies

$$
\begin{aligned}
P_{\underline{\theta}}^{1-\epsilon} =& \frac{M_{\underline{\theta}}}{1-G(\underline{\phi})}\Big[\int_{\underline{\phi}}^{\hat{\phi}}\theta^{\beta\epsilon}\Big(\frac{\epsilon}{\epsilon-1}\frac{\underline{\theta}^{\alpha}}{\phi}\Big)^{1-\epsilon}dG(\phi)+\int_{\hat{\phi}}^{\infty}\theta^{\beta\epsilon}\Big(\frac{\epsilon}{\epsilon-1}\frac{\theta(\phi)^{\alpha}}{\phi}\Big)^{1-\epsilon}dG(\phi)\Big] \\
=& M_{\underline{\theta}}\ \underline{\phi}^{\gamma}\ \gamma\Big(\frac{\epsilon-1}{\epsilon}\Big)^{\gamma}\Big(\frac{\epsilon}{L}\Big)^{1-\frac{\gamma}{\epsilon-1}}P_{\underline{\theta}}^{1+\gamma-\epsilon} \\
& \Big[\frac{\underline{\theta}^{\frac{\Lambda\gamma}{\epsilon-1}}}{1+\gamma-\epsilon}\Big(f+\frac{\underline{\theta}^{\eta}}{\eta}\Big)^{1-\frac{\gamma}{\epsilon-1}}+\Big(\frac{\eta-\Lambda}{\Delta}-\frac{1}{1+\gamma-\epsilon}\Big)\Lambda^{\frac{\gamma}{\epsilon-1}-1}\underline{\theta}^{-\frac{\Delta}{\epsilon-1}}\Big].
\end{aligned} \tag{17}
$$

In equilibrium, the entry cost f_e is covered by the expected profit:

$$\begin{aligned} f_e = & \int_{\underline{\phi}}^{\hat{\phi}} \pi(\phi, \underline{\theta}) dG(\phi) + \int_{\hat{\phi}}^{\infty} \pi(\phi, \theta(\phi)) dG(\phi) \\ = & P_{\underline{\theta}}^{\gamma} \Big(\frac{\epsilon - 1}{\epsilon}\Big)^{\gamma} \Big(\frac{L}{\epsilon}\Big)^{\frac{\gamma}{\epsilon - 1}} \mathcal{A}(\underline{\theta}^{\eta}), \end{aligned} \tag{18}$$

where

$$\mathcal{A}(x) \equiv \frac{\epsilon - 1}{1 + \gamma - \epsilon} x^{-\frac{\Delta}{\eta(\epsilon-1)}} \Big[\Big(\frac{f}{x} + \frac{1}{\eta} \Big)^{1 - \frac{\gamma}{\epsilon - 1}} + \frac{\epsilon - 1}{\Delta} \Lambda^{\frac{\gamma}{\epsilon - 1}} \Big]$$

is a function defined on $(0, \infty)$. Finally, the labor market clearing condition is expressed as follows.

$$\begin{aligned} L = & \frac{M}{1 - G(\underline{\phi})} \Big\{ f_e + \int_{\underline{\phi}}^{\hat{\phi}} \Big[f + \frac{\underline{\theta}^{\eta}}{\eta} + \frac{\underline{\theta}^{\alpha}}{\phi} q(\phi, \underline{\theta}) \Big] dG(\phi) \\ & + \int_{\hat{\phi}}^{\infty} \Big[f + \frac{\theta^{\eta}}{\eta} + \frac{\theta^{\alpha}}{\phi} q(\phi, \theta(\phi)) \Big] dG(\phi) \Big\}. \end{aligned} \tag{19}$$

In summary, we obtain three questions (17), (18), (19) for two variables $P_{\underline{\theta}}$, $M_{\underline{\theta}}$, with one of them being redundant. They are analytically solvable, with the solution being

$$P_{\underline{\theta}} = \frac{\epsilon}{\epsilon - 1} \Big(\frac{\epsilon}{L}\Big)^{\frac{1}{\epsilon - 1}} \Big[\frac{f_e}{\mathcal{A}(\underline{\theta}^{\eta})} \Big]^{\frac{1}{\gamma}}, \tag{20}$$

$$M_{\underline{\theta}} = \frac{(1 + \gamma - \epsilon)\Delta}{\gamma \epsilon \mathcal{B}(\underline{\theta}^{\eta})} L, \tag{21}$$

where

$$\mathcal{B}(x) \equiv \Delta \Big(f + \frac{x}{\eta} \Big) + (\epsilon - 1) \Lambda^{\frac{\gamma}{\epsilon - 1}} x^{1 - \frac{\gamma}{\epsilon - 1}} \Big(f + \frac{x}{\eta} \Big)^{\frac{\gamma}{\epsilon - 1}}.$$

is a function defined on $(0, \infty)$. It is immediately verified that (20) and (21) satisfy (19). Meanwhile, (20) and (21) degenerate to (13) and (14), respectively, when $\underline{\theta} = \theta_0$.

In this economy, the wage income is 1. Given utility function (1), the indirect utility level of a representative resident is simply $1/P_{\underline{\theta}}$, which measures the welfare level.

Proposition 1 *Under (6) and (15), an increase in the minimum quality level from the laissez-faire market equilibrium decreases the welfare level.*

Proof: It is evident that both

$$\mathcal{A}_3(x) \equiv \frac{f}{x} + \frac{1}{\eta}, \quad \mathcal{A}_4(x) \equiv \frac{f \gamma \eta}{x + f\eta} + 1 - \epsilon$$

are decreasing functions. Therefore,

$$\mathcal{A}_2(x) \equiv \eta[\Lambda A_3(x)]^{\frac{\gamma}{\epsilon-1}} A_4(x) - \Delta$$

is a decreasing function under (6). It is negative for $x > \theta_0^\eta$ because $A_2(\theta_0^\eta) = 0$ holds. Let

$$\mathcal{A}_1(x) \equiv f\eta[(1+\gamma-\epsilon)\eta - \Delta] - x\left[\Delta + (\epsilon-1)\left(\frac{f}{x} + \frac{1}{\eta}\right)^{\frac{\gamma}{\epsilon-1}} \eta \Lambda^{\frac{\gamma}{\epsilon-1}}\right].$$

Then $\mathcal{A}_1(\theta_0^\eta) = 0$ and $\mathcal{A}_1'(x) = \mathcal{A}_2(x)$. Thus we know that $\mathcal{A}_1(x)$ is negative for $x > \theta_0^\eta$. Finally, using

$$\mathcal{A}'(x) = \frac{1}{(1+\gamma-\epsilon)\eta^2} x^{-2+\frac{\Delta}{\eta(1-\epsilon)}} \left(\frac{f}{x} + \frac{1}{\eta}\right)^{\frac{\gamma}{1-\epsilon}} \mathcal{A}_1(x),$$

we know that $\mathcal{A}(x)$ is decreasing for $x > \theta_0^\eta$. According to (20), the price index increases and welfare falls when the quality standard is increased from the laissez-faire market equilibrium. □

The finding of Proposition 1 contrasts with Proposition 6 of Gaigné and Larue (2016a). While Gaigné and Larue (2016a) solely examine the direct impact on prices of a new quality standard (as demonstrated by their equation (23) derived for a fixed mass of unconstrained and constrained firms), our analysis integrates both direct and indirect effects, encompassing alterations in all thresholds within goods and labor markets.

Proposition 1 confirms the assertion made by Dhingra and Morrow (2019) that market allocations are efficient in a monopolistic competition model with CES demand. Therefore, such a framework is unable to analyze policies targeting the rectification of market distortions, even with the inclusion of endogenous quality selection.

5 Conclusion

The question of whether raising quality standards can enhance welfare carries substantial policy implications. Gaigné and Larue (2016a) tackled this question using a general-equilibrium model, suggesting a potentially positive outcome. However, their welfare analysis remained rooted in partial equilibrium. Our study re-evaluates this question through a general-equilibrium lens. Surprisingly, our findings contradict their assertion, indicating a negative welfare impact. While the model's analytical tractability benefits from the assumption of CES preferences, a more comprehensive understanding may necessitate adopting a non-CES model, as advocated by Dhingra and Morrow (2019) and Macedonia and Weinberger (2022).

References

Dhingra, S. and Morrow, J. (2019). Monopolistic competition and optimum product diversity under firm heterogeneity. *Journal of Political Economy* 127(1):196–232.

Gaigné, C. and Gouel, C. (2022). Trade in agricultural and food products. In: C.B. Barrett and D.R. Just (eds.) *Handbook of Agricultural Economics*, vol. 6, chap. 88, pp. 4845–4931. Elsevier B.V.

Gaigné, C. and Larue, B. (2016a). Quality standards, industry structure, and welfare in a global economy. *American Journal of Agricultural Economics* 98(5):1432–1449.

Gaigné, C. and Larue, B. (2016b). Public quality standards and the food industry's structure in a global economy. *Review of Agricutural and Environmental Studies* 97:141–148.

Macedonia, L. and Weinberger, A. (2022). Quality heterogeneity and misallocation: The welfare benefits of raising your standards. *Journal of International Economics* 134:103544.

Zeng, D.Z. (2021). Spatial economics and nonmanufacturing sectors. *Interdisciplinary Information Sciences* 27(1):57–91.