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Labor Unions and Product Quality Regulation: Comparative Advantage Implications for Open Economies

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Abstract

This paper analyzes the economic implications of product quality regulation in a unionized sector, utilizing a general equilibrium framework for a regulated economy. The conditions under which workers and capital owners may gain or lose are shown to be sensitive to factor intensities and the technologies utilized in the regulated sector. The analysis is extended to regulated open economies, and the trade implications for comparative advantage are noted.

I. Introduction

In recent years, the U.S. government and policy makers have become increasingly concerned over improved product quality and improved product safety. This has been particularly true with regards to the manufacturing

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of automobiles and the public's desire for safer, more fuel-efficient transportation. Types of quality and safety standards enacted by the government in this area included gas milage requirements, emission standards, seat belts, and impact-resistant bumpers. While these regulations have their benefits, they also have their costs. Indeed, such regulations will affect the factor distribution of income with some individuals gaining and others losing.

The primary purposes of this paper are two-fold: firstly, to examine the economic implications of product quality and safety regulations with regard to their effects on factor rewards, factor allocations, and product prices, in the presence of unionization. This study will address the conditions under which unionized labor, non-unionized labor, and capital owners will gain or lose with the implementation of such regulations. The results will be of use to policymakers interested in the costs and adjustments of regulation and will also facilitate the development of methods to ease the adjustment process associated with regulation or deregulation of product quality and product safety. Secondly, we study the economic implications of quality and safety regulations for international trade. These regulations provide a basis for trade and suggest another way of explaining comparative advantage in the framework of regulated economies.

There has been much research done in the area of labor unionization and its effects on wages and employment. The literature incorporating a general equilibrium modelling of unionization includes Jones [1971], Johnson and Mieskowski [1970], and Bhagwati and Srinivason [1971]. Fundamental results from this literature suggests the importance of factor intensity rankings of the unionized and non-unionized sector for determining the effects of unionization upon factor rewards. For a small open economy, in particular, when the unionized sector produces the capital intensive commodity, capital owners lose and unionized labor gains when there is an increased premium paid to union labor. Hu [1973] utilized a factors-specific model to study the labor market distributions created by unions when capital is immobile between sectors.

Our paper is similar to the works of the above authors in that a general equilibrium framework will be utilized to study the effects of labor unions. However, our model differs substantially from those cited in the above literature, and builds upon our previous work, Anderson-Enomoto [1986, 1987].

In particular, in this paper, the unionized sector will be modeled as producing two products: a basic product and quality per unit of the basic product. Indeed quality will be treated in this model as a separately produced good, not as an intermediate good. For example, consider the automobile industry, unionized and producing two products, one is automobiles, the second is safety features per automobile. Production of quality requires the costly use of resources which otherwise could have been allocated to the production of more of the basic product.

Our model also may characterize the airline and mining industries. In the airline industry, fares have been deregulated but there remains a tradeoff between number of flights, the basic good produced in the industry, and passenger safety, the quality of that flight. Without additional resources, such as additional air-traffic controllers and airports, an increase in quality (decrease in airline accidents) will be forthcoming only if the number of flights is decreased. In the mining industry, safety regulations for workers play an important role. Maintenance of these standards requires the use of resources that otherwise could have been used for mining.

The second sector of the economy in our model will consist of all non-unionized industries. This sector is assumed to produce a product of unchanging, constant quality. Using this general equilibrium framework, the effects of quality and/or safety regulations on the welfare of unionized and non-unionized workers, as well as owners of capital, can be studied; whereas in the case of previously developed models, such issues could not be addressed. Our results do not depend upon the factor intensities of the unionized and non-unionized sectors as do previous models. Indeed, the two sectors are linked solely by the capital market unlike the two factor market linkage found in the standard two-sector Heckscher-Ohlin modelling of the production sector. Our results then follow from a standard specific-factors modelling given our treatment of labor union behavior. The type of union we are modeling is that of an exclusive or craft union, in which the supply of labor to the unionized sector is restricted and thereafter, wages are determined by demand and supply conditions. Thus, unlike the classic modelling of unionization by Johnson and Mieskowski [1970] as an exogenously given intersectoral wage differential, we analyze unionization as a binding entry barrier imposing complete intersectoral immobility upon labor.

Given this approach which effectively makes union and non-union labor distinct factors, our model may be considered a generalization of the factor-specific literature, Mayer [1974], Mussa [1974], and, more recently, Neary [1985], wherein safety standards impact upon the economic effects of unionization. In particular, our analysis highlights the sensitivity of results to the relative factor intensities utilized in the unionized sector in the production of the basic product and of quality. This is an important finding and has not previously been addressed in the factor-specific literature. In particular, we show the well-known results of the factor-specific model are a special case of our model, occurring whenever capital intensities are identical in the production of quality and the basic product.

The outline of this paper is as follows. In section II we describe the equilibrium conditions that characterize the quality-regulated economy given a unionized and non-unionized sector. In section III we analyze the short-run, impact effects of tighter quality regulations in the unionized sector. In section IV, the long-run effects of quality regulation that allow optimal adjustments in the allocations of capital between sectors are studied. The implications of the long-run analysis for international trade and comparative advantage are examined in section V. Then in section VI, we highlight the three cases of unionized-sector factor intensities in determining the economic implications of product quality regulation. We conclude with a summary of our findings.

II. The Model

Consider an economy comprised of two sectors; one unionized, the other non-unionized. The unionized sector is assumed to produce two goods; a basic product X and quality per unit of X denoted by q. Both of these products are produced under conditions of constant returns to scale wherein factor productivities are assumed positive and diminishing. In this general equilibrium framework, we will characterize the production technology in the unionized sector by the following transformation function,[1] first developed in

1. Although complete separability between the production of output and of quality imposes a restrictive structure upon the technology, we adopt this characterization for analytical simplicity and tractability.

Leland [1977], and studied further in Anderson-Enomoto [1986, 1987],

$$X = X(q, L_U, K_U) \tag{1}$$

which is linearly homogeneous in q, L_U, and K_U; the quality of product X, and labor and capital allocations devoted to the unionized sector, respectively.[2] This relation shows production of X depending upon not only the labor and capital allocated to the unionized sector, but also upon a mandated quality standard set by an outside regulating body. Given L_U and K_U, the industry faces a tradeoff between production levels of X and q. This transformation function is characterized by $X_q < 0$, $X_L > 0$, and $X_K > 0$.

Assuming homothetic preferences, relative market demand for commodity X is given by

$$RD^X = RD^X(p, q) \tag{2}$$

where $p \equiv p_X/p_N$ is the relative price of X in terms of the numeraire good N, which is the good produced by the non-unionized sector, and where

$$\partial RD^X/\partial p \equiv RD^X_p < 0 < RD^X_q \equiv \partial RD^X/\partial q \tag{3}$$

Production in the non-unionized sector is characterized by the following lin-

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2. The homogeneity property of the transformation function follows directly from the constant returns to scale assumption in the production of X and q. When L_U and K_U, the labor and capital allocations in the unionized sector, and q are increased by β percent, production of X must increase by β percent. To see this, let L_q and L_x represent the amounts of labor allocated to the production of quality and the basic product X, respectively, where $L_q + L_x = L_U$. Similarly for capital, $K_q + K_X = K_U$. Now if L_U and K_U are both increased by β percent and q is also increased by β percent, this implies that L_q and K_q must have increased by β percent due to the constant returns to scale assumption imposed on q production. However, also note that when L_U and K_U are increased by β percent, so are L_x and K_x, thus causing output of X to increase by β percent due to the constant returns to scale assumption imposed on the production of X. Thus the transformation function $X = X(q, L_U, K_U)$ is linearly homogeneous in q, L_U, and K_U. (Recall that quality is treated in our model as a separately produced good. It is jointly consumed with the basic product, but its production leaves the industry with less resources for the production of the basic product. Hence, q and X are substitutes in production rather than complements, while they are complements in consumption.) For a more formal demonstration, see our paper, Anderson-Enomoto [1986].

early homogeneous production function,

$$N = N(L_N, K_N) \tag{4}$$

which exhibits positive and diminishing marginal products in L_N and K_N, the labor and capital allocations for the non-unionized sector.

Given this basic framework,[3] the equilibrium conditions that describe this quality-regulated economy can now be set forth:

$$RD^X(p, q) = RS^X \tag{5}$$

$$w_U = pX_L(q, L_U, K_U) \tag{6}$$

$$w_N = N_L(L_N, K_N) \tag{7}$$

$$r = pX_K(q, L_U, K_U) = N_K(L_N, K_N) \tag{8/9}$$

$$K_U + K_N = K \tag{10}$$

Equation (5) is the market-clearing condition expressed in terms of relative supply and demand. When the quality standard is exogenously set for the product of the unionized sector, the relative price of X will adjust so as to equate the quantity of X demanded with the quantity of X produced by the unionized sector. Equations (6) and (7) are the efficiency conditions for labor. Wages are equated to their respective value of marginal products in both the unionized and non-unionized sectors. However, due to the unionization of labor and the subsequent membership requirements that restrict the mobility of labor, the intersectoral differential between union and nonunion wages is endogenously determined. We will assume that at the initial quality standard level, $w_U > w_N$; that is, the real union wage rate in terms of the numeraire good N exceeds the nonunion wage rate.

Equations (8) and (9) are the efficiency conditions for capital. They state that capital allocations will be determined so as to equalize the value of marginal products of capital in both the unionized and non-unionized sectors and

3. As the referee has observed, our theoretical framework is fundamentally a three sector model with one factor (capital) completely mobile between sectors, whereas one factor (unionized labor) is mobile between two. We wish to acknowledge the referee's referring us to the Gruen-Corden [1970] paper, which in a different context develops a formally identical three sector structure.

thus define the equilibrium rental price of capital. Equation (10) is the full-employment condition for capital. Capital is assumed to be fully allocated between the unionized and non-unionized sectors of the economy, where K denotes the economy's endowment of capital. We further assume that the labor allocations to the two sectors are fixed, the specific factors in our analysis. Equations (5)-(10) can be solved to obtain the equilibrium values of the price ratio, factor prices, and capital allocations. Comparative statics analysis of these fundamental variables can be conveniently decomposed into impact and adjustment effects as product quality standards change. To motivate long-run analysis, we begin with a study of short-run, impact effects.

III. Impact Effects of Quality Regulation

Consider the market clearing condition in (5). In the short-run, capital cannot be reallocated among sectors. Furthermore, since our modelling of unionization as an entry barrier makes union and non-union labor distinct specific factors, the only short-run intersectional effect linking the two sectors operates through the demand side of the economy. Thus solving (5) with the short-run relative supply, $\overline{RS^X}(q, L_U, K_U) \equiv X(q, L_U, K_U)/N(L_N, K-K_U)$ yields the short-run equilibrium price ratio

$$p = p(q, L_U, K_U) \tag{11}$$

An increase in mandated quality standards generates excess demand for the union product which requires an increase in the equilibrium price in the short-run. Either an increase in capital allocated to the unionized sector or an increase in the stock of union labor available generates excess supply: both result in the price falling. These short-run impact effects are immediate from (5); *i.e.*,

$$\partial p / \partial q = \left(\overline{RS_q^X} - RD_q^X\right)\left(RD_p^X\right)^{-1} > 0 \tag{12-a}$$

$$\partial p / \partial L_U = \overline{RS_L^X}\left(RD_p^X\right)^{-1} \equiv \left(X_L / N\right)\left(RD_P^X\right)^{-1} < 0 \tag{12-b}$$

Next, consider the impact effects upon factor rewards of changing the product quality

$$\partial p / \partial K_U = \overline{RS_K^X}(RD_p^X)^{-1} \equiv (NX_K + XN_K)N^{-2}(RD_p^X)^{-1} < 0 \quad \text{(12-c)}$$

standards. The real rewards to unionized labor and capital, w_U and r_U, respectively, are defined by the short-run equilibrium functions,

$$w_U(q, L_U, K_U) \equiv p(q, L_U, K_U)X_L(q; L_U, K_U) \tag{13}$$

$$r_U(q, L_U, K_U) \equiv p(q, L_U, K_U)X_K(q; L_U, K_U) \tag{14}$$

Each factor receives the value of marginal productivity where price is evaluated at the short-run equilibrium level. How an increased level of mandated quality impacts upon labor's and capital's marginal productivity is fundamental to determining the short-run effects upon w_U and r_U. This is clear from differentiating (13) and (14) to obtain

$$\partial w_U/\partial q = X_L(\partial p/\partial q) + pX_{Lq} \tag{15}$$

$$\partial r_U/\partial q = X_K(\partial p/\partial q) + pX_{Kq} \tag{16}$$

The first term in each expression is positive, showing the increased value of marginal product due to product price increasing. The second terms display the direct effect upon factor productivity as mandated quality rises. Signing them depends upon factor intensity rankings in the unionized sector. In particular, it can be shown that[4]

$$X_{Lq} \gtreqless 0 \gtreqless X_{Kq} \quad \textit{iff } k_x \gtreqless k_q \tag{17}$$

where k_X and k_q denote the capital-labor ratios utilized in the production of the basic product X and the production of quality in the unionized sector. Suppose that $k_X > k_q$; this defines the unionized technology as *quality-enhanced production of the unionized product is relatively capital-intensive.*

4. The regulated sector can be thought of generating a mini-Heckscher Ohlin sector. Denoting π as the (implicit) relative price of quality in terms of X, define, for a given relative output price p, the regulated sector's revenue function as

$$R(\pi; L_U, K_U) \equiv \max_q \{\pi q + X(q; L_U, K_U)\}.$$

Then $R_{L\pi} = X_{Lq}R_{\pi\pi}$ follows from the Envelope theorem, where $R_{\pi\pi} = \partial q/\partial \pi > 0$ and $R_{L\pi} = \partial w/\partial \pi \gtreqless 0$ as $k_x \gtreqless k_q$ which is the trade theoretic Stolper-Samuelson theorem applied to this model. Hence $X_{Lq} = R_{L\pi}R_{\pi\pi}^{-1}$ and similarly $X_{Kq} = R_{K\pi}R_{\pi\pi}^{-1}$ are signed by the capital-intensity ranking as indicated in the text. For further details, see Neary [1985].

Then increased quality increases (decreases) labor's (capital's) marginal productivity. Similar reasoning applies to the case where $k_q > k_X$. Applying the marginal productivity criterion in (17) to (15) and (16), at least one of the factors, and possibly both, will be better off (higher rewards) in the short-run when mandated quality is increased.

Impact effects upon factor rewards in the non-unionized sector contrast significantly from those discussed above. Reallocation of capital impacts upon these factors, but not changes in quality levels. Denoting the non-union wage and rental on capital by w_N and r_N, short-run equilibrium values are given by

$$r_N(K_U) \equiv N_K(L_N, K - K_U) \text{ and } w_N \equiv N_L(L_N, K - K_U) \tag{18}$$

Given time to adjust capital allocations to equalize rentals distinguishes short-run from long-run equilibrium analysis in our model. Optimal capital allocations are determined by the adjustment mechanism,

$$dK_U/dt = \phi(K_U, q, L_U) \tag{19}$$

where $\phi(K_U, q, L_U) \equiv \lambda\{r_U(q, L_U, K_U) - r_N(K_U)\}$ and λ is a positive speed of adjustment constant. If, in the short-run, capital's return is greater in the unionized sector ($r_U > r_N$), then capital will be reallocated from the non-unionized until the rentals differential is eliminated. Solving $\phi(K_U, q, L_U) = 0$ for K_U yields the long-run optimal capital allocation function,

$$K_U = K_U^*(q, L_U) \tag{20}$$

where $K_N^*(q, L_U) \equiv K - K_U^*(q, L_U)$ denotes the optimal capital allocation to the non-union sector. Differentiating (20) with (14) and (18) yields, when simplified,[5]

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5. The properties of the capital allocation function, $K_U = K_U^*(q, L_U)$, can be obtained directly from the ϕ function. In particular, the derivatives in (21) were obtained from (i) $\partial K_U^*/\partial q = -\phi_q/\phi_K$ and (ii) $\partial K_U^*/\partial L_U = -\phi_L/\phi_K$, where $\phi_K \equiv X_K(\overline{RS_K^X}/RD_p^X) + (pX_{KK} + N_{KK})$ from stability of the capital adjustment mechanism in (19). Also, it can be shown that:

   (a) $\phi_q \equiv X_K(\overline{RS_q^X} - RS_q^X)(RD_p^X)^{-1} + pX_{Kq}$

   (b) $\phi_L \equiv X_K(\overline{RS_L^X} / RD_p^X) + pX_{KL}$

   Then, in particular, capital will be reallocated to the regulated sector whenever the mandated level of quality is increased if and only if $\phi_q > 0$.

$$\partial K_U^* / \partial q = \frac{X_K(RD_q^X - \overline{RS_q^X}) - (RD_p^X) p X_{Kq}}{X_K(\overline{RS_K^X}) + (RD_p^X)(p X_{KK} + N_{KK})} \tag{21-a}$$

$$\partial K_U^* / \partial L_U = -\frac{p X_{KL}(RD_p^X) + X_K(\overline{RS_L^X})}{X_K(\overline{RS_K^X}) + (RD_p^X)(p X_{KK} + N_{KK})} \tag{21-b}$$

where the denominator is positive by stability considerations. Not surprisingly, the reallocation of capital when the level of mandated quality standards changes is sensitive to factor intensity rankings in the unionized sector. From (21-a), $X_{Kq} \geq 0$ is a sufficient condition for the regulated sector to receive additional capital during the adjustment process. More generally, signing ϕ_q from (19) determines the direction of the capital reallocation. Next, from (21-b), an increase in the labor allocation to the regulated, unionized industry may induce a capital reallocation from the unregulated, nonunionized industry. This is easily explained. Equilibrium price falls in the short-run, whereas capital's marginal product rises, recalling (14). Hence, whenever the marginal productivity effect dominates the price effect to raise the return to capital, this invites a capital migration to the unionized sector, via the adjustment in (19).

IV. Long-Run Effects of Quality Regulation

Allowing for adjustments in the optimal capital allocations in response to short-run induced rental differentials, the long-run effects upon equilibrium price and factor rewards may now be studied. Substituting the capital allocation function from (20) into (11) yields long-run equilibrium price in terms of the level of mandated quality and labor allocation to the regulated industry,

$$p^*(q, L_U) \equiv p[q, L_U, K_U^*(q, L_U)] \tag{22}$$

Long-run equilibrium wages are given by

$$w_U^*(q, L_U) \equiv w_U[q, L_U, K_U^*(q, L_U)] \tag{23-a}$$

$$w_N^*(q, L_U) \equiv w_N[q, L_U, K_U^*(q, L_U)] \tag{23-b}$$

When capital is optimally allocated between industries, the rentals differen-

tial is eliminated; hence the long-run equilibrium rentals on capital, r, is

$$r^*(q, L_U) \equiv r_U[q, L_U, K_U^*(q, L_U)] \tag{24}$$

where $r^*(q, L_U)$ is also given by $r_N(K_U^*(q, L_U))$. From these relations, it is clear that the long-run comparative statics derivatives can be decomposed into short-run and adjustment effects, the latter induced by capital reallocations.

Differentiating (22) yields for the long-run equilibrium price the decomposition

$$\partial p^*/\partial q = \partial p/\partial q + (\partial p/\partial K_U)\partial K_U^*/\partial q \tag{25}$$

which highlights the relation between the long-run effects, $\partial p^*/\partial q$ and $\partial K_U^*/\partial q$. Price rises in the short-run when the mandated quality level is increased, but price will fall whenever capital is reallocated to the regulated, unionized industry. Thus, the adjustment effect depends upon factor intensity rankings as analyzed above. Substituting into (25) and simplifying yields

$$\partial p^*/\partial q = \left\{\frac{(RD_q^X)(pX_{KK} + N_{KK})}{X_K(\overline{RS_K^X}) + (RD_p^X)(pX_{KK} + N_{KK})}\right\}\partial p/\partial q - \left\{\frac{pX_{Kq}(\overline{RS_K^X})}{X_K(\overline{RS_K^X}) + (RD_p^X)(pX_{KK} + N_{KK})}\right\} \tag{26}$$

If quality-enhanced production of the regulated, unionized product is (weakly) capital intensive ($k_X \geq k_q$ or $X_{Kq} \leq 0$), then the positive short-run price effect signals a positive long-run price effect. This result can be further illustrated by rewriting (26) with (12-a) as

$$\partial p^*/\partial q = \frac{(\overline{RS_q^X} - RD_q^X)(pX_{KK} + N_{KK}) - pX_{Kq}(\overline{RS_K^X})}{X_K(\overline{RS_K^X}) + (RD_p^X)(pX_{KK} + N_{KK})} \tag{26'}$$

Next, consider the long-run effects upon factor rewards. From (23) and (24), differentiation yields

$$\partial w_N^*/\partial q = -k_N(\partial r^*/\partial q) = k_N N_{KK}(\partial K_U^*/\partial q) \tag{27}$$

$$\partial w_U^*/\partial q = pX_{Lq} + X_L(\partial p^*/\partial q) + pX_{LK}(\partial K_U^*/\partial q) \tag{28}$$

Again, the capital allocation effect, $\partial K_u^*/\partial q$, bulks large in the determination of quality- induced changes in factor rewards. From (27), note that the non-union wage and capital's long-run rental move in opposite directions as mandated quality changes. Capital's real return increases whenever capital has been reallocated to the unionized sector and decreases whenever capital flows to the non-unionized sector in response to increased levels of mandated quality. This result is expected; it reflects the law of diminishing returns to capital underlying the technologies in these two sectors.

The effect of more stringent quality regulation upon the union wage requires more careful analysis. This long-run effect, $\partial W_U^*/\partial q$, may be decomposed into three separate influences, as highlighted in (28). The first term of (28) is the direct effect which an increase in quality has upon unionized labor's marginal productivity. This direct effect is sensitive to factor rankings as shown in (17). Whenever labor productivity is directly improved, $X_{Lq} > 0$, we shall say there has been a positive direct wage effect from quality improvements. This positive effect occurs whenever quality-enhanced production of the regulated product is relatively capital intensive.

The second effect results from the increased quality level affecting the product price. Whenever product price increases, as will occur when the first direct effect is positive, the value of labor's marginal product increases, ceteris paribus, and hence the union wage tends to increase. Finally, there's a third effect due to the quality-induced capital reallocation. When capital migrates to the regulated sector (if and only if $-\phi_q > 0$), unionized labor's marginal product increases, again tending to increase the union wage.

We next examine the implications of the long-run equilibrium price function in (22) for international trade. In particular, we show a basis for trade exists for two countries with regulated quality levels which differ systematically with respect to mandated quality and labor allocated to the regulated industry. In the framework of our model of quality regulation, these provide explanations for comparative advantage.

IV. Quality Regulation, International Trade and Comparative Advantage

In this section, we investigate the implications of quality regulation for international trade. For this purpose, an alternative to the capital allocation

function, $K_U = K_U^*(q, L_U)$, is required to allow analysis of the excess demand for the regulated product. Equating the rental on capital in each sector, recall (9), yields the regulated sector's demand for capital,[6]

$$K_U = K_U^d(p, q, L_U) \tag{29}$$

i.e., K_U^d is obtained from $pX_K(q, L_U, K_U) = N_K(L_N, K - K_U)$. Substituting this demand function into the short-run relative supply function yields the long-run relative supply of X,

$$RS^S(p, q, L_U) \equiv \overline{RS^X}[q, L_U, K_U^d(p, q, L_U)] \tag{30}$$

This function generates the usual "law" of supply; properties of long-run relative supply are

$$\begin{aligned} RS_p^X &= \left(\overline{RS_K^X}\right)\partial K^d / \partial p \\ &\equiv -(X_K^2 / N)(pX_{KK} + N_{KK})^{-1} \end{aligned} \tag{31-a}$$

$$\begin{aligned} RS_L^X &= (\overline{RS_L^X}) + (\overline{RS_K^X})\partial K^d / \partial L_U \\ &\equiv (X_L / N) - pX_{KL}(X_K / N)(pX_{KK} + N_{KK})^{-1} \end{aligned} \tag{31-b}$$

$$\begin{aligned} RS_q^X &= (\overline{RS_q^X}) + (\overline{RS_K^X})\partial K^d / \partial q \\ &\equiv (X_q / N) - pX_{Kq}(X_K / N)(pX_{KK} + N_{KK})^{-1} \end{aligned} \tag{31-c}$$

The sign of X_{Kq} is required for (31-c). In particular, note that when quality-enhanced production of the regulated product is (weakly) capital-intensive, supply will vary inversely with the level of mandated quality.

Now define the relative excess demand function for the regulated commodity,

$$ED^X(p; q, L_U) \equiv RD^X(p, q) - RS^X(p, q, L_U) \tag{32}$$

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6. Solve $pX_K(q, L_U, K_U) = N_K(L_N, K - K_U)$ for K_U to obtain the demand for capital function, where we suppress K and L_N as arguments as we have throughout the analysis in this paper. Now, the relation between the demand for capital, K_U^d, is straightforward. Both are long-run equilibrium functions. They are related by the identity, $K_U^*(q, L_U) \equiv K_U^d[p^*(q, L_U), q, L_U]$; simply evaluate the demand for capital function at the long-run equilibrium price function, $p = p^*(q, L_U)$, to obtain the optimal capital allocation function, $K_U^*(q, L_U)$.

Excess demand varies inversely with price and the stock of unionized labor allocated to this regulated industry. When $k_X \geq k_q$, our (weak) capital intensity condition, excess demand varies directly with the regulated level of mandated quality. When the market clears, long run equilibrium price is obtained. Thus, $ED^X(p; q, L_U) = 0$ generates $p = p^*(q, L_U)$, which had been previously obtained in (22) through the optimal capital allocation process.

Now consider two countries, A and B, identical except for the level of mandated quality required in the production of X. Suppose $q^A > q^B$, then $p^A > p^B$. Country B, having the lower regulated level of quality, has a comparative advantage in X. The direct relation between price and quality provides a basis for trade and an explanation for comparative advantage in our model. This may be summarized as follows.[7]

Proposition 1: *When quality-enhanced production of the regulated, unionized product is weakly capital-intensive, then a basis for trade exists for two countries identical save for the level of mandated quality. The country having the lower level of regulated quality will have a comparative advantage in the production of the regulated product.*

Two countries, differing only with respect to the stock of labor allocated to the regulated sector, will also find a basis for trade. An increase in LU does not impact upon relative demand but does increase relative supply, thereby reducing the equilibrium price. These implications for trade are given in

Proposition 2: *A basis for trade exists for two countries identical except for the labor allocated to the regulated industry. The country having the greater labor supply employed in the regulated sector will have a comparative advantage in the production of the regulated product.*

In the last section, the long-run comparative statics results for factor rewards highlighted the importance of the factor intensity rankings utilized in the unionized, regulated sector in the production of quality and the basic product. To more fully investigate the economic consequences of quality

7. The referee has suggested an interesting interpretation of this proposition. Restriction of output level through the regulation of mandated quality is equivalent to a tax. Thus, not surprisingly, the country with a lower output tax will have a comparative advantage in the taxed commodity.

regulation, we next consider the three cases of factor intensity rankings.

VI. Factor Intensities in the Unionized Sector

Case A: $k_q = k_x$

Consider first the case when the capital-labor ratios in X and q production are identical. Then using the factor intensity criterion in (17), the price and capital allocation effects in (21-a) and (26)′ simplify as follows:

$$\partial K_U^* / \partial q = X_K(RD_q^X - \overline{RS_q^X})\Delta^{-1} \tag{33}$$

$$\partial p^* / \partial q = (\overline{RS_q^X} - RD_q^X)(pX_{KK} + N_{KK})\Delta^{-1} \tag{34}$$

where $\Delta \equiv X_K(\overline{RS_K^X}) + (RD_P^X)(pX_{KK} + N_{KK}) > 0$. Thus, the new equilibrium, after adjustments are made to the higher level of mandated quality, is characterized by a greater relative price for the regulated product X and more capital is utilized in the unionized sector.

An alternative derivation to (25) relating the price effect to the capital adjustment effect can be obtained from the identity,

$$K_U^*(q, L_U) \equiv K_U^d[p^*(q, L_U), q, L_U] \tag{35}$$

Relating the capital allocation function to the demand for capital function, differentiate this identity with respect to q,

$$\partial K_U^*/\partial q = (\partial K_U^d/\partial q)\partial p^*/\partial q + (\partial K_u^d/\partial q) \tag{36}$$

Recalling that $\partial K_U^d/\partial p = -X_K(pX_{KK}+N_{KK})^{-1} > 0$ and $\partial K_U^d/\partial q = -pX_{Kq}(pX_{KK}+N_{KK})^{-1}$ give the derivatives for the capital demand function. In this first case of identical factor intensities, $X_{Kq} = 0$; hence (36) clearly shows the fundamental result that both long-run price and capital allocated to the regulated sector increases. That is, identical factor rankings simplifies (36) as

$$\partial K_U^*/\partial q = (\partial K_U^d/\partial p)\partial p^*/\partial q \tag{36′}$$

Furthermore, as mandated quality of the unionized product is increased, capital's reward increases due to the increases in price and the subsequent

increase in capital's value of marginal product in the unionized product. The non-union wage falls since labor's productivity in the non-unionized, non-regulated sector has fallen as capital migrates to the regulated sector. Finally, the union wage increases owing to (*i*) the price effect on unionized labor's value of marginal productivity and (*ii*) the capital adjustment effect which increases unionized labor's productivity.[8]

Case B: $k_q > k_x$

Next, consider the case in which production of quality uses the relatively capital-intensive technique. Then, by (17), we have $X_{Kq} > 0 > X_{Lq}$; hence,

$$\partial p^*/\partial q \gtreqless 0 \text{ and } \partial K_U^*/\partial q > 0.$$

Recalling (31-c), with $X_{Kq} > 0$, the relative supply response is ambiguous, *i.e.*, $\partial RS^X/\partial q \gtreqless 0$. Given the initial equilibrium price, increased quality generates a reallocation of capital to the unionized sector. This effect is captured by the $\partial K_U^d/\partial q = -pX_{Kq}(pX_{KK} + N_{KK})^{-1} > 0$ term in (31-c). This "capital-allocation" effect tends to increase supply. In addition, the mandated increase in quality production is costly in the sense of foregone production of the primary product X. This negative "opportunity cost" effect is the X_q term in (31-c). Which of these two effects dominates determines the supply response to increased quality. Consequently, the tendency for excess demand to be generated in the market may be undone by the "capital allocation" effect. For this reason the quality-induced change in the equilibrium price is sign ambiguous.

Capital's rental increases as capital is reallocated to the unionized sector. The non-union wage falls as the available labor force in the non-unionized sector has less capital with which to work. The change in the union wage is more difficult to determine as indicated by (28). Additional capital tends to increase the productivity and wages of unionized labor, but the increased

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8. With identical factor intensities, the quality-induced change in the union wage, given in (28), simplifies as

$$\partial W_U^*/\partial q = X_L(\partial^* p/\partial q) + pX_{LK}(\partial K_U^*/\partial q) \qquad (28)'$$

which highlights the two effects which contribute to the increase in the union wage.

quality production directly decreases the same since $X_{Lq} < 0$. Furthermore, as more quality is produced, the amount of labor per unit of capital released from the basic production of x exceeds that required for q-production. This excess supply of labor in the unionized sector at the initial wage tends to lower union wages. It is for these reasons and influences that the change in union wages is ambiguous.

Case C: $k_X > k_q$

The third and final case occurs when $k_X > k_q$, which implies $X_{Lq} > 0 > X_{kq}$ from (17). This is the special case we have previously identified as quality-enhanced production of the regulated product being relatively capital-intensive. Here, an increase in quality leads to an increase in long-run equilibrium price, but the capital reallocation to the unionized sector need not occur.

The ambiguity in signing the capital adjustment effect can be laid bare by recalling the identity in (35), namely, $K_u^*(q, L_u) \equiv K_u^d[p^*(q, L_u), q, L_u]$. The quality-induced increase in p tends to increase the demand for capital in the unionized-sector, by increasing capital's value marginal productivity. There is a second direct effect, $\partial K_u^d/\partial q$, which tends to reduce demand for K_U at initial factor prices. The reason is clear: since the production of quality is labor intensive (in Case C), increased quality production will not require as much capital per worker as released from basic X production.

Given the inability to sign the capital allocation effect, it follows immediately from our discussion of (27) and (28) that the effects upon factor rewards due to the increased level of mandated quality will also be sign ambiguous. However, when capital does migrate to the unionized sector, so that the above price effect dominates as will occur whenever $\phi_q > 0$, then the rental on capital and the union wage rise, whereas the non-union wage must fall.

VI. Summary

In this paper we have developed an analytical framework for product-quality regulation of a unionized product in which unionization is modelled as an entry barrier that imposes complete intersectoral labor immobility. Thus in our essentially specific-factors model, we show whenever the mandated level of quality in a unionized sector changes, the change in factor rewards

depend upon the factor intensities utilized in the production of the basic product and of quality produced in the unionized sector. These comparative statics results have been decomposed into short-run and capital reallocation (adjustment) effects, distinguished by the specification of the relative supply of the union-produced good. In addition, we have noted the economic implications of quality and safety regulations for international trade. These regulations, which are comparable to an output tax, provide a basis for trade and are summarized in our two propositions that offer a new way of explaining comparative advantage in the framework of regulated open economies.

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