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From Shadow to Light: The Case for Wholesale Dual-Track Reform in Electricity Markets

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The Case for Wholesale Dual-Track Reform in Electricity Markets

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Abstract

In many developing countries, regulated electricity tariffs are set below cost, leaving public utilities with chronic losses and restricted subsidies. As a result, supply at the regulated price is limited and rationed consumers turn to informal suppliers at high markups. We analyze a wholesale dual-track reform in which the utility sells electricity to informal suppliers at a market-based wholesale price, who then resell it alongside their own generation. Unlike the classic dual-track framework, which introduces a second track downstream, the second track here operates upstream. We show that the reform raises total production and increases consumer welfare. The key channel operates through the utility's budget constraint: the wholesale price-cost margin generates revenues that relax the budget constraint, enabling expanded provision at the regulated retail price. Whether informal suppliers lose depends on the wholesale price. We characterize the set of wholesale prices for which the reform is Pareto improving. The reform requires neither tariff increases nor new infrastructure, relying instead on institutional design that redirects rents from informal provision toward expanded public supply.

Keywords: Electricity; Rationing; Informal provision; Dual-track pricing; Wholesale pricing; Developing countries

JEL Classification: L51; L94; O13; Q41; Q48

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1 Introduction

Unlike in developed countries, where power outages typically reflect capacity constraints or unforeseen disruptions, outages in developing countries are frequently deliberate. For loss-making utilities operating under regulated tariffs set below cost, rationing becomes a cost-saving measure: expanding production generates losses that limited government subsidies cannot cover (Foster and Rana, 2019; Foster and Witte, 2020). The problem is compounded by widespread non-payment and weak enforcement, as electricity is often perceived as a right rather than a commodity. The result is a vicious cycle in which underpriced electricity leads to financial distress, which leads to rationing, which leads to deteriorating infrastructure and further supply shortfalls (Burgess et al., 2020).

The welfare costs of this status quo are large. In Sub-Saharan Africa, electricity reliability is among the most binding constraints on economic activity: the majority of firms experience frequent outages and rely on generators or informal provision as coping strategies, while regulated retail tariffs are often set below cost-recovery levels, constraining utilities' finances and investment (World Bank, 2019a). Across the Middle East and North Africa, the quasi-fiscal deficits of electricity sectors (comprising implicit subsidies to producers, users, and workers) average 4.4 percent of GDP, resources that could instead finance needed infrastructure investments (Camos Daurella et al., 2017; Obeid, 2019). In India, firms and households respond to unreliable public supply by turning to costly alternatives (e.g., diesel generators, solar panels, or informal providers) with significant productivity losses and environmental consequences (Allcott et al., 2016; Lin and Kassem, 2025; Jha et al., 2022).

Standard policy responses face significant obstacles. Tariff increases, while potentially restoring financial viability, undermine the original rationale for subsidized pricing (i.e., ensuring access for low-income households) and risk driving consumers toward illegal connections or off-grid alternatives, further eroding utility revenues. These challenges motivate the central question of this paper: can an alternative institutional design improve welfare without dismantling existing pricing arrangements?

We propose and analyze a wholesale dual-track reform in which a financially constrained public utility would continue selling electricity to consumers at a regulated price while simultaneously selling to alternative (informal) suppliers at a higher, market-based wholesale price. The alternative suppliers would then resell this electricity alongside their own higher-cost production to serve residual demand. The key mechanism is that wholesale margins, which is the difference between the wholesale price and the utility's marginal cost, generate

revenues that relax the utility's budget constraint, financing expanded provision at the regulated retail price. This design differs from classic dual-track price reforms, which keep the administratively planned "track" while introducing a parallel market track, then gradually expanding the market track and shrinking the planned one. In our setting, however, the second track operates upstream: informal suppliers purchase at the wholesale price and resell to consumers facing rationing. The proposed reform thus exploits the utility's excess capacity and redirects rents currently captured by informal providers toward improved public supply. We establish three main results. First, when the regulator sets the wholesale price equal to the alternative suppliers' production cost, the reform unambiguously increases total electricity production and improves consumer welfare. The intuition is that expanded utility production, even when resold through alternative suppliers, increases total supply. Second, alternative suppliers are harmed only under full rent extraction: when the wholesale price is set so that utility capture the entire inframarginal rent from informal supply, alternative suppliers' profits fall relative to the status quo. Third, we characterize a set of politically viable reforms, that is, the set of wholesale prices that benefit consumers while ensuring alternative producers are no worse off than under the status quo. This third result demonstrates that Pareto improvements are achievable: the proposed reform can expand supply and reduce prices without creating losers among market participants.

This paper contributes to several strands of the literature. First, we relate to the literature on price controls, rationing, and secondary markets (e.g. Bulow and Klemperer, 2012; Loertscher and Muir, 2022). Existing work typically treats resale as an ex post arbitrage activity. We instead analyze an upstream institutional reform in which the regulated incumbent would deliberately supply the informal sector, reshaping the organization of secondary provision. In doing so, we connect to a broader set of work on energy affordability and political constraints that motivate persistent departures from cost-reflective pricing, and the policy instruments used to mitigate their distributional consequences.

Second, our analysis relates to the dual-track pricing literature (Lau et al., 2000; Che and Facchini, 2007). Classic dual-track reforms preserve a regulated allocation at the official price while allowing additional quantities to be traded at market prices. Such mechanisms played a prominent role in China's and Vietnam's economic transition. Our suggested reform is to shift the dual track upstream: the public utility continues to charge a single regulated retail price, while market pricing operates through wholesale sales to informal suppliers. This distinction is particularly relevant in settings in which regulated retail tariffs are difficult to adjust and informal provision plays a significant role. It complements recent work that argues

for electricity policy frameworks that treat distributional and political constraints as central primitives, rather than as add-ons to a cost-minimization benchmark (Nock et al., 2020). Third, we relate to the literature on vertical relations and wholesale pricing (Beard et al., 2001; Reisinger and Tarantino, 2015; Miklós-Thal and Shaffer, 2021). Standard models emphasize wholesale pricing as a strategic instrument in vertically related markets, often with exclusionary or foreclosure motives. In contrast, wholesale sales in our setting serve a financing role: they generate revenues that relax the incumbent’s budget constraint and expand total output. Our mechanism is also related to evidence on contractual and payment innovations in electricity access—such as pay-as-you-go arrangements—that improve revenue recovery and expand service in contexts where conventional tariff collection or enforcement is weak (Barry and Creti, 2020).

Finally, our analysis contributes to the literature on state capacity and public goods provision (Bardhan, 2016; Besley and Persson, 2011). While this literature emphasizes how weak fiscal and legal capacity constrains public service delivery, our results suggest that limited state capacity does not necessarily force a choice between inefficient rationing and full liberalization. Instead, intermediate institutional arrangements that leverage existing informal markets can improve welfare without requiring stronger enforcement or tariff reform. This perspective aligns with evidence that the effectiveness of power-sector reforms depends critically on institutional quality and the broader governance environment (Nepal and Jamasb, 2012), and with policy responses that rely on compensatory instruments (e.g., targeted bill assistance) when tariff reform is politically constrained (Alberini and Umaphathi, 2021).

The remainder of the paper proceeds as follows. Section 2 develops a benchmark model of an electricity market with rationed public provision and informal alternative supply. Section 3 introduces the proposed wholesale dual-track reform and analyzes its welfare consequences when the regulator extracts maximal wholesale margins. Section 4 characterizes politically viable reforms that would benefit alternative producers. Section 5 concludes.

2 Benchmark Model

This section develops a model of an electricity market characterized by rationed public provision and unregulated alternative supply. Three agents interact in this market: a public electricity provider (utility) that operates under financial constraints, an alternative supplier operating outside the formal pricing and regulatory framework, and a representative consumer. We characterize each agent’s problem in turn, then derive the market equilibrium.

2.1 The Public Electricity Provider

The public utility operates under institutional and financial constraints that preclude meeting full end-user demand. It has a linear production technology with unit cost $c_u > 0$ and a capacity constraint K .

The utility price is regulated at a level $\bar{p} < c_u$, below the unit cost of production.¹ To compensate for operating losses, the utility receives a government subsidy S . Given this subsidy, the utility produces a quantity q_u determined by the break-even condition

$$(\bar{p} - c_u)q_u + S = 0, \tag{1}$$

which implies

$$q_u = \frac{S}{c_u - \bar{p}}. \tag{2}$$

We assume that the subsidy is sufficiently limited such that

$$q_u < K. \tag{3}$$

Under this assumption, electricity is underprovided not due to capacity limitations, but because limited financial resources prevent the utility from financing additional loss-making output. Consumers therefore face a rationing constraint and can purchase at most q_u units of electricity at the regulated price \bar{p} .

2.2 The Representative Consumer

We now present consumer preferences and characterize demand under this rationing constraint. The representative consumer has quasi-linear preferences over a composite good x and electricity consumption e , represented by the utility function

$$U(x, e) = x + v(e), \tag{4}$$

where $v : \mathbb{R}_+ \rightarrow \mathbb{R}$ is strictly concave, twice continuously differentiable, and satisfies $\lim_{e \rightarrow +\infty} v'(e) = 0$.

Let e_u denote electricity consumption from the public utility, e_a consumption from the alternative supplier, and $e = e_u + e_a$ total electricity consumption. Given the consumer's

¹We assume the regulator knows the cost c_u , but for political reasons considers this cost "too high" and therefore sets the regulated price below production cost.

income R , the alternative supplier's price p_a (with $\bar{p} < p_a$), and the rationing constraint (2), the consumer solves

$$\max_{e_a, e_u} R - p_a e_a - \bar{p} e_u + v(e_a + e_u) \quad (5)$$

$$\text{subject to: } e_u \leq q_u. \quad (6)$$

The first-order conditions are

$$v'(e_a + e_u) = p_a \quad (7)$$

$$v'(e_a + e_u) - \lambda = \bar{p} \quad (8)$$

$$\lambda(q_u - e_u) = 0, \quad \lambda \geq 0, \quad (9)$$

where λ is the Kuhn–Tucker multiplier associated with the rationing constraint.

Because $\bar{p} < p_a$, the consumer exhausts available supply from the utility before turning to the alternative supplier. The rationing constraint therefore binds: $e_u = q_u$. The consumer supplements this allocation with electricity from the alternative supplier, and the optimal allocation satisfies

$$v'(e_a + q_u) = p_a \quad (10)$$

From (10), the consumer's demand for alternative electricity is

$$e_a = v'^{-1}(p_a) - q_u. \quad (11)$$

2.3 The Alternative Supplier

Financial constraints lead the public utility to ration electricity supply, creating residual demand that the alternative supplier serves. We model this supplier as a local monopolist, reflecting entry barriers and localized control over generation and distribution typical of informal electricity markets in developing countries.²

Electricity from the public utility and the alternative supplier is perfectly substitutable. However, the alternative supplier's unit cost c_a exceeds that of the public utility ($c_u < c_a$), reflecting its informal or small-scale nature.

²This is for example the case in Lebanon, see World Bank (2019b)

Taking public supply q_u as given, the alternative producer chooses output q_a to maximize profit:

$$\max_{q_a} v'(q_a + q_u)q_a - c_a q_a. \quad (12)$$

The profit function $\pi(q_a) = v'(q_a + q_u)q_a - c_a q_a$ is strictly concave in q_a , guaranteeing the existence of a unique optimum. The following lemma establishes a sufficient condition for interior production.

Lemma 1. *Assume that $v'(q_u) > c_a$. Then the alternative producer's optimal output is strictly positive, i.e. $q_a(q_u) > 0$.*

Proof. Let the alternative producer choose $q_a \geq 0$ to maximize

$$\pi_a(q_a; q_u) = v'(q_a + q_u)q_a - c_a q_a.$$

The first-order condition is

$$v'(q_a + q_u) + q_a v''(q_a + q_u) = c_a. \quad (13)$$

At $q_a = 0$, marginal profit equals $v'(q_u) - c_a > 0$, so $q_a = 0$ cannot be optimal. Since v' is decreasing and v' and v'' are continuous, there exists a unique $q_a(q_u) > 0$ solving (13). Concavity of the profit function implies that this solution is profit-maximizing. \square

2.4 Market Equilibrium and Rationale for Reform

An equilibrium in the benchmark model consists of quantities (q_u, q_a, e_u, e_a) and a price p_a such that: (i) the utility produces q_u satisfying its break-even constraint (1); (ii) the consumer optimally allocates expenditure given prices and rationing; (iii) the alternative producer maximizes profit taking q_u as given; and (iv) the market for alternative electricity clears, $e_a = q_a$.

By Lemma 1, equilibrium exists with positive alternative supply whenever $v'(q_u) > c_a$. That is, whenever residual willingness to pay exceeds the alternative supplier's marginal cost. Total electricity consumption is $q_u + q_a$, where q_a solves (13).

The equilibrium characterized above exhibits two notable features. First, the utility operates below capacity ($q_u < K$) despite positive residual demand from consumers willing to pay

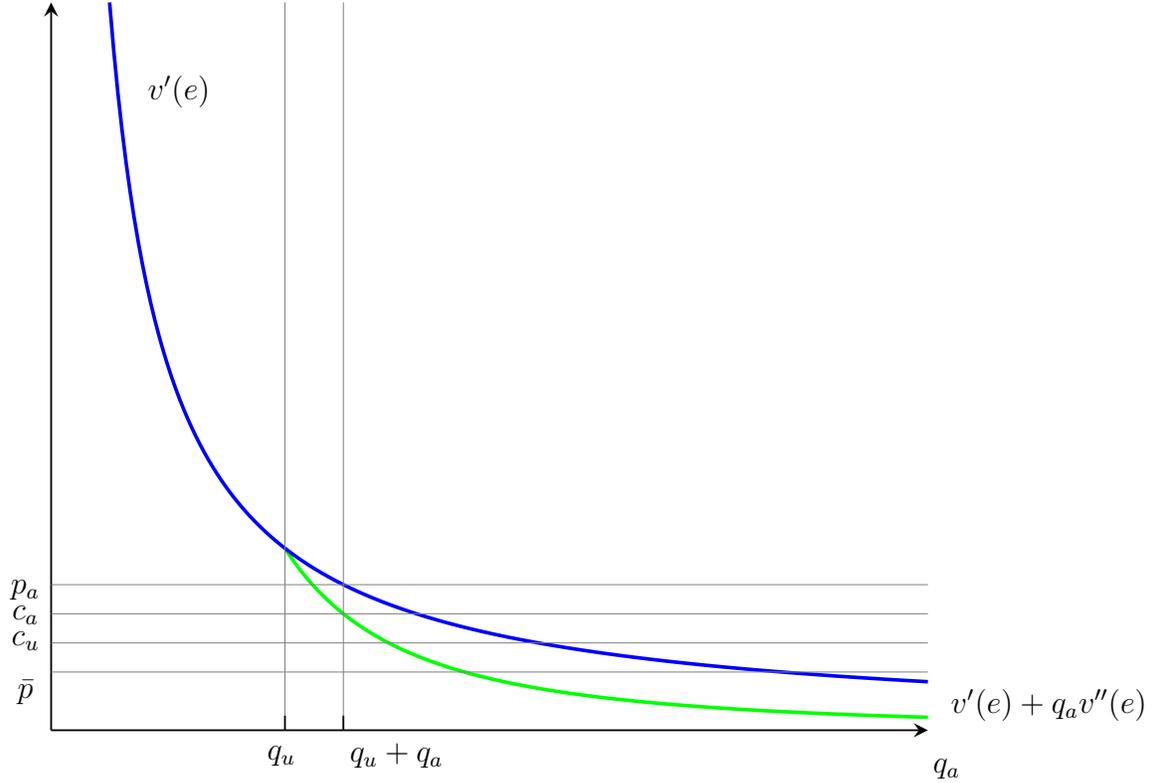


Figure 1: Pre-Reform Equilibrium

above marginal cost. Second, this residual demand generates rents for the alternative supplier, who charges a price $p_a = v'(q_u + q_a) > c_a$ above marginal cost. Figure 1 illustrates the market equilibrium.

These observations motivate the analysis of a counterfactual institutional arrangement in which the public utility is permitted to transact directly with alternative producers. Such a reform could reallocate rents currently captured by the informal sector, relaxing the utility's financing constraint while maintaining the assumption that direct sales to consumers at the regulated price \bar{p} remain loss-making. We develop this reform in the following section.

3 The Wholesale Dual-Track Reform

We now extend the benchmark model by allowing the public utility to also sell electricity to alternative producers, who then resell it to consumers.³ This institutional change

³The reform's feasibility rests on established precedents. China's dual-track pricing reforms demonstrate that such systems are politically implementable, with plan and market prices successfully coexisting during economic transition. Regulated wholesale access mechanisms, operating in various forms globally including

fundamentally alters the utility’s financing constraint: revenue from wholesale transactions provides additional resources that can fund expanded provision at the regulated price. Throughout this section, we maintain the assumption that direct sales to consumers at price \bar{p} remain loss-making ($\bar{p} < c_u$).⁴

We refer to this mechanism as a *wholesale dual-track reform*. Like classic dual-track reforms studied by Lau et al., 2000 and Che and Facchini, 2007, it introduces a market-based price alongside a regulated price. Unlike those reforms, however, the two tracks do not both serve final consumers directly. Instead, the regulated track continues to govern retail sales to consumers, while the market track operates upstream: the utility sells to informal suppliers at a wholesale price p_w , set by a regulator, and these suppliers resell to consumers facing rationing.

3.1 The Reform Mechanism

To establish notation, let Q_u denote the utility’s total production under the reform, and let q_u^* denote the share sold to consumers at the regulated price \bar{p} . The remaining output, $Q_u - q_u^*$, is sold to alternative producers at the wholesale price p_w .

The utility’s budget constraint under the reform is

$$p_w(Q_u - q_u^*) + \bar{p}q_u^* + S - c_uQ_u = 0. \quad (14)$$

The left-hand side comprises wholesale revenue $p_w(Q_u - q_u^*)$, retail revenue $\bar{p}q_u^*$, and the subsidy S , less total production costs c_uQ_u .

The key economic mechanism operates as follows. When $p_w > c_u$, wholesale sales generate positive margins that supplement the subsidy. These additional resources finance expanded sales at the loss-making regulated price. Solving (14) for q_u^* yields

$$q_u^* = \frac{(p_w - c_u)Q_u + S}{p_w - \bar{p}}. \quad (15)$$

France’s ARENH where incumbent utilities sold electricity to competitors at specified wholesale prices, establish the technical feasibility. Our wholesale dual-track adapts both by moving the liberalized track upstream to informal suppliers.

⁴The technical feasibility of dual-track pricing is established by China’s reform experience, where plan and market prices coexisted during economic transition. Our wholesale dual-track reform adapts this proven mechanism by positioning the second track upstream—utilities sell to informal suppliers at market-based wholesale prices rather than offering consumers direct price choice—while maintaining regulated retail obligations.

The reform's impact depends on the wholesale price relative to the utility's cost. If $p_w \leq c_u$, wholesale sales either generate losses or merely break even, providing no additional resources to finance expanded retail provision. Production therefore remains at the pre-reform level $q_u = S/(c_u - \bar{p})$, and the reform has no effect.

We focus on the economically relevant case where $p_w > c_u$, so that wholesale sales generate positive margins that can finance expanded supply at the regulated price.

3.2 Equilibrium Characterization

We assume the regulator can set the wholesale price $p_w \leq c_a$ at which alternative suppliers purchase from the utility, and seeks to maximize the quantity of electricity sold to consumers at the regulated price \bar{p} . The upper bound reflects that alternative producers will not purchase at prices exceeding their own production cost. Given this objective, we characterize the equilibrium wholesale price and resulting market allocation.

The utility maximizes electricity sold to consumers at the regulated price, subject to capacity K . Since $\partial q_u^*/\partial Q_u > 0$ when $p_w > c_u$, the utility optimally sets $Q_u = K$.

Furthermore, higher wholesale prices expand retail provision. Differentiating (15) with $Q_u = K$:

$$\frac{\partial q_u^*}{\partial p_w} = \frac{(c_u - \bar{p})K - S}{(p_w - \bar{p})^2} > 0. \quad (16)$$

The inequality holds because $K > q_u$ and the pre-reform budget constraint implies: $(\bar{p} - c_u)q_u + S = 0$.

The economic intuition is straightforward. An increase in p_w raises wholesale profit $(p_w - c_u)K$, enabling the utility to absorb larger losses on retail sales. The additional retail quantity generates a loss $(\bar{p} - c_u)(q_u - q_u^*)$, which is financed by the wholesale margins.

Since higher wholesale prices expand retail provision and $p_w \leq c_a$, the regulator optimally sets $p_w = c_a$. At this price, the quantity sold to consumers at the regulated price is

$$q_u^* = \frac{(c_a - c_u)K + S}{c_a - \bar{p}}. \quad (17)$$

We now characterize equilibrium quantities. Let q_a^* denote the quantity supplied by alternative producers to consumers under the reform. In equilibrium, consumers purchase q_u^* from the utility and q_a^* from alternative producers. Total consumption is at least K , since all utility

production either reaches consumers directly or through alternative producers (who may also engage in own production).

The post-reform equilibrium satisfies two conditions. First, consumer optimization requires

$$v'(q_u^* + q_a^*) = p_a^*, \quad (18)$$

where p_a^* denotes the post-reform price charged by alternative producers. Second, profit maximization by alternative producers requires

$$v'(q_u^* + q_a^*) + v''(q_u^* + q_a^*)q_a^* = c_a. \quad (19)$$

A sufficient condition for $p_w = c_a$ to constitute an equilibrium (requiring $q_u^* + q_a^* \geq K$) is

$$v'(K) + v''(K)(K - q_u^*) \geq c_a. \quad (20)$$

This condition ensures that alternative producers find it profitable to purchase and resell all wholesale electricity supplied by the utility.

In summary, the equilibrium is characterized by three features: the utility sells its entire capacity K , the regulator sets the wholesale price at its maximum feasible level $p_w = c_a$, and alternative producers absorb all wholesale electricity while adjusting their own production to satisfy residual demand.

3.3 Welfare Analysis

We now assess the welfare consequences of the reform when $p_w = c_a$. Total consumption equals $q_u + q_a$ before the reform and $q_u^* + q_a^*$ after. For the reform to improve aggregate consumption, we require $q_u + q_a < q_u^* + q_a^*$. This inequality is not obvious *a priori*, since expanded utility provision could crowd out alternative supply. The following proposition establishes that crowding out never dominates.

Proposition 1. *Assume that $p_w = c_a$ and that all additional electricity produced by the utility is purchased by alternative producers. Under these conditions, the wholesale dual-track reform increases total electricity consumption: $q_u + q_a < q_u^* + q_a^*$.*

Proof. The proof exploits strict concavity of the alternative producer's profit function. In the pre-reform equilibrium, equation (13) holds:

$$v'(q_u + q_a) + v''(q_u + q_a)q_a = c_a, \quad (21)$$

whereas the post-reform equilibrium satisfies

$$v'(q_u^* + q_a^*) + v''(q_u^* + q_a^*)q_a^* = c_a. \quad (22)$$

Express the total quantity as $q_u^* + q_a^* = q_u + (q_u^* + q_a^* - q_u)$. Since alternative producers resell all wholesale purchases, $q_u^* + q_a^* > q_u$.

Now observe that

$$v'(q_u^* + q_a^*) + v''(q_u^* + q_a^*)q_a^* = c_a \quad (23)$$

$$\iff v'(q_u + q_u^* + q_a^* - q_u) + v''(q_u + q_u^* + q_a^* - q_u)q_a^* = c_a \quad (24)$$

$$\Rightarrow v'(q_u + q_u^* + q_a^* - q_u) + v''(q_u + q_u^* + q_a^* - q_u)(q_a^* + q_u^* - q_u) < c_a. \quad (25)$$

The final inequality follows from $v'' < 0$ and $q_u^* + q_a^* > q_u$.

Since $v'(q_u + z)z - c_a z$ is strictly concave in z , its derivative is strictly decreasing. Comparing the first-order condition (21) and inequality (25) implies

$$q_a^* + q_u^* - q_u > q_a, \quad (26)$$

which yields $q_u^* + q_a^* > q_u + q_a$. □

Corollary 1. *The wholesale dual-track reform is consumer welfare enhancing.*

Proof. The reform increases electricity available at the regulated price ($q_u^* > q_u$). Moreover, the price charged by alternative producers falls: $p_a = v'(q_u + q_a) > p_a^* = v'(q_u^* + q_a^*)$, since total consumption rises. The consumer can afford pre-reform consumption and additional units of the composite good, hence cannot be worse off. □

3.4 Impact on Alternative Producers

We now examine how the reform affects alternative producer profits. The post-reform alternative market price necessarily falls below the pre-reform level. For profits to increase, sales volume must rise sufficiently to offset this price reduction. The following result shows this cannot occur when $p_w = c_a$.

Corollary 2. *Alternative producers are strictly worse off under the reform when $p_w = c_a$.*

Proof. Pre-reform output q_a satisfies profit maximization, so for all $q'_a \geq 0$:

$$v'(q_u + q_a)q_a - c_a q_a > v'(q_u + q'_a)q'_a - c_a q'_a, \quad (27)$$

with strict inequality by strict concavity.

Post-reform, we have $q_u^* > q_u$. Since $v'' < 0$:

$$v'(q_u + q_a)q_a - c_a q_a > v'(q_u + q'_a)q'_a - c_a q'_a \quad (28)$$

$$> v'(q_u^* + q'_a)q'_a - c_a q'_a, \quad \forall q'_a \geq 0. \quad (29)$$

The inequality holds in particular for q_a^* . □

The case $p_w = c_a$ extracts all wholesale surplus from alternative producers while simultaneously depressing the retail price they can charge. This outcome, while maximizing consumer welfare gains, generates losses for alternative producers who may possess sufficient political influence to obstruct reform adoption.⁵

This observation motivates the next section, where we characterize reforms that benefit consumers while ensuring alternative producers are no worse off than under the status quo.

4 A Pareto-Improving Wholesale Dual-Track Reform

A reform that harms alternative producers may lack political feasibility, particularly in developing countries where informal electricity providers often hold significant local influence through employment networks, community ties, or political connections (see, e.g., Fernandez and Rodrik, 1991; Acemoglu and Robinson, 2000; Burgess et al., 2020). We now characterize reforms that are Pareto-improving in the sense that they increase consumer welfare while ensuring alternative producers experience no losses relative to the status quo.

We maintain the framework of Section 3 but treat the wholesale price $p_w \in [c_u, c_a]$ as a policy instrument rather than setting it at the consumer-welfare-maximizing level c_a .

4.1 Setup

Under the reform, alternative producers can source electricity through two channels: purchases from the utility at price p_w , and own production at cost c_a . Let q_{aw} denote wholesale purchases and q_{as} own (*self*) production, with total supply $q_a^* = q_{aw} + q_{as}$.

⁵The reform also fails to achieve Pareto efficiency, since the alternative electricity price remains above c_a .

The alternative producer's problem is

$$\begin{aligned}
& \max_{q_{aw}, q_{as}} v'(q_u^* + q_a^*) q_a^* - p_w q_{aw} - c_a q_{as} & (30) \\
& \text{subject to: } q_{aw} \leq K - q_u^*, \\
& q_a^* = q_{aw} + a_{as}, \\
& q_{aw}, q_{as} \geq 0,
\end{aligned}$$

where $q_u^* = [(p_w - c_u)K + S]/(p_w - \bar{p})$ from equation (15). The constraint reflects that wholesale purchases cannot exceed available supply $K - q_u^*$.

Figure 2 illustrates the market equilibrium. With a wholesale price equal to p_w (higher than c_u and lower than c_a) the utility increases its production up to K . A quantity q_u^* is sold at price \bar{p} to the consumer and another quantity q_{aw}^* is sold at price p_w to the alternative producer. The increase in the quantity of affordable electricity from q_u to q_u^* shifts the marginal receipt of the alternative producer to the right. The quantity of electricity for which this new marginal receipt equals the unit cost c_a is strictly higher than K . It is thus profitable for the alternative producer to further increase its supply (using its own technology). The market price paid by the consumer is consequently lower than its pre-equilibrium value.

4.2 Pareto-Improving Wholesale Prices

We first establish that reforms benefiting alternative producers always exist. At $p_w = c_u$, the utility earns zero margin on wholesale sales but still supplies electricity up to its excess capacity. Alternative producers can then purchase at cost $c_u < c_a$, replicating pre-reform output while strictly reducing costs. This guarantees gains relative to the status quo.

At $p_w = c_a$, Corollary 2 establishes that alternative producers are strictly worse off. Since the value function $V_a(p_w)$ associated with the alternative producer's problem (30) is continuous and decreasing in p_w (see Appendix), an intermediate threshold must exist.

Proposition 2. *There exists a threshold price $\underline{p}_w \in (c_u, c_a)$ such that the wholesale dual-track reform yields a net benefit to alternative producers if and only if $p_w < \underline{p}_w$.*

Proof. Let $V_a(p_w)$ denote maximum profit from problem (30). We have $V_a(c_u) > \pi_a$ and $V_a(c_a) < \pi_a$, where π_a denotes pre-reform profit. Since V_a is continuous and strictly decreasing, there exists a unique \underline{p}_w satisfying $V_a(\underline{p}_w) = \pi_a$. Monotonicity implies $V_a(p_w) > \pi_a$ for $p_w < \underline{p}_w$. \square

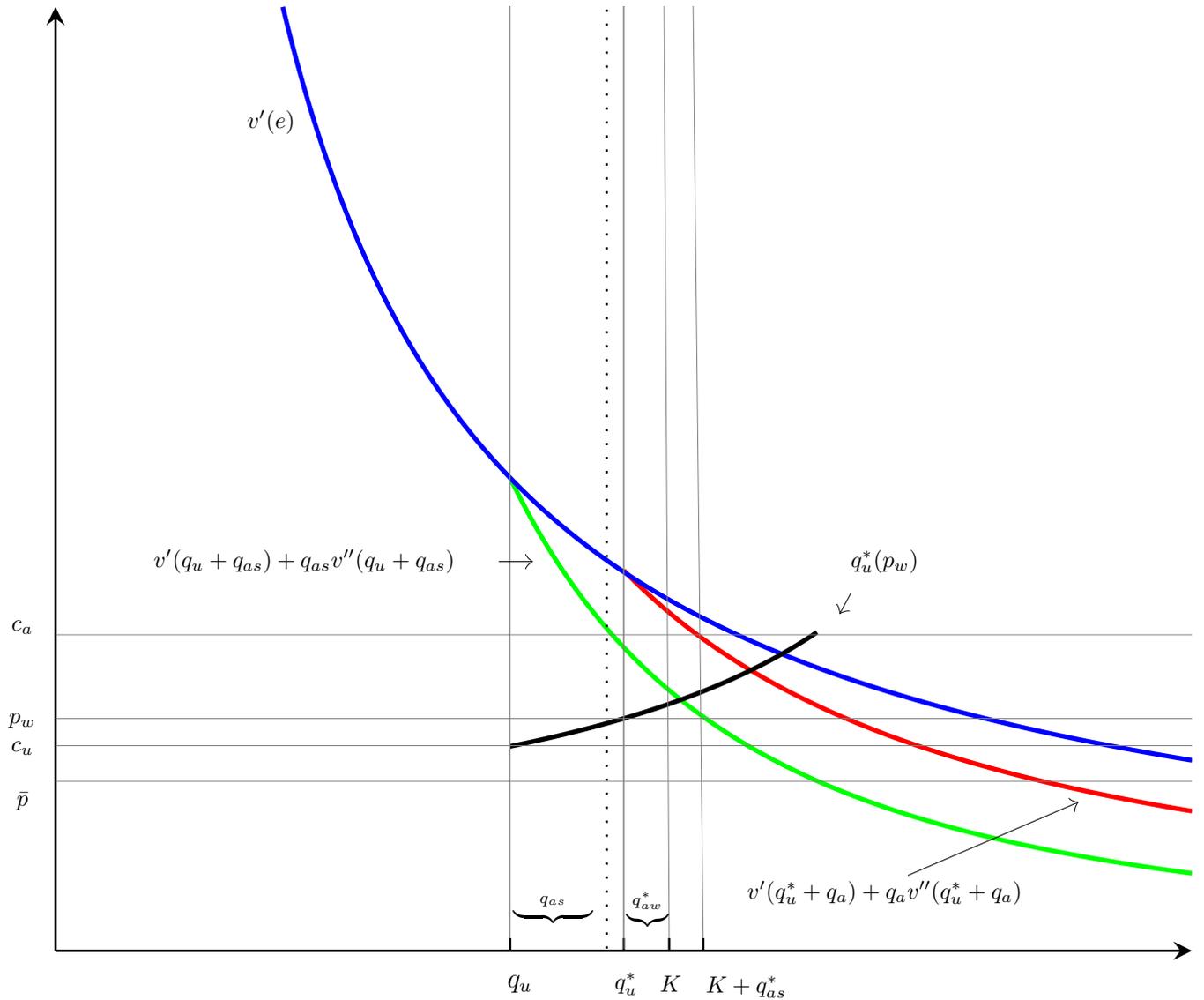


Figure 2: Market equilibrium.

The threshold \underline{p}_w depends on model primitives: consumer preference curvature, utility capacity K , the cost differential $c_a - c_u$, and the subsidy S . Higher capacity or larger cost differentials expand the scope for mutually beneficial reform.

4.3 Effectiveness and Consumer Welfare

For the reform to achieve its intended effects, alternative producers must purchase all available wholesale electricity, otherwise, the utility fails to generate sufficient wholesale revenue to finance the maximum feasible expansion of retail provision. We say the reform is *effective* if

$$q_{aw} = K - q_u^*.$$

Effectiveness requires that the marginal profit from purchasing an additional wholesale unit remain non-negative at the constraint. This is more demanding at higher wholesale prices (which raise procurement costs) and larger wholesale quantities (which depress retail prices). A sufficient condition for effectiveness across all $p_w \in [c_u, c_a]$ is therefore

$$v''(K) \frac{(c_u - \bar{p})K - S}{c_u - \bar{p}} + v'(K) - c_a \geq 0. \quad (\text{CS})$$

This condition evaluates marginal profit from wholesale purchases at the most demanding case: the highest wholesale price c_a and the largest wholesale quantity. Economically, it requires that at full capacity utilization, alternative producers find wholesale purchases attractive even at the least favorable terms.

Proposition 3. *Assume condition (CS) holds. For any $p_w \in [c_u, c_a]$, consumers' welfare improves under the reform.*

Proof. For $p_w > c_u$, the utility expands retail provision using wholesale margins, so $q_u^* > q_u$. The argument of Proposition 1 then implies total consumption strictly increases. For $p_w = c_u$, retail provision is unchanged but alternative producers reduce costs by substituting utility purchases for own production, implying weakly lower prices. In both cases, consumers face weakly lower alternative prices and weakly greater availability at the regulated price. \square

The analysis reveals a fundamental trade-off: higher wholesale prices generate larger consumer gains through expanded utility provision but reduce gains for alternative producers through higher procurement costs and lower retail prices.

The threshold \underline{p}_w characterizes the boundary of political feasibility. A regulator seeking to maximize consumer welfare subject to the political constraint would set $p_w = \underline{p}_w$. A regulator seeking to maximize alternative producer support might set p_w closer to c_u . The model may thus provide a framework for analyzing the political economy of electricity reform, where distributional concerns constrain the set of feasible policies.

5 Conclusion

This paper studies electricity markets in developing countries where public utilities operate below capacity despite substantial unmet demand. We argue that this pattern reflects not infrastructure limitations but financial constraints: with regulated tariffs set below cost

and limited subsidies, utilities ration supply because expanding production is financially unsustainable. An informal sector emerges to serve residual demand at higher prices, capturing rents that could otherwise finance public provision.

We propose and analyze a wholesale dual-track reform in which the utility sells electricity to informal suppliers at a wholesale price, who then resell it to rationed consumers. Unlike classic dual-track reforms that offer final consumers two prices, the second track here operates upstream. Wholesale margins relax the utility's budget constraint, financing expanded provision at the regulated price. We show that this reform increases total consumption and improves consumer welfare. However, when the regulator extracts maximal margins, informal suppliers are harmed, creating most likely political resistance to implementation. We characterize the set of wholesale prices under which the reform benefits consumers while leaving informal suppliers no worse off, identifying conditions for politically viable welfare improvements.

Our findings carry policy implications beyond the specific mechanism studied. In many developing countries, load shedding is pushing wealthier consumers toward solar panels and other off-grid alternatives, threatening a fiscal death spiral in which utility revenues decline further as the customer base erodes. The poorest households, unable to afford such alternatives, bear the brunt of deteriorating public supply. Reforms that expand provision without requiring tariff increases—such as the wholesale dual-track mechanism analyzed here—may offer a path to improved outcomes before this dynamic becomes entrenched.

Our framework can be extended in several directions. First, our analysis assumes the informal sector operates as a local monopoly; alternative market structures, from competitive fringe suppliers to oligopolistic competition, would generate different welfare and distributional implications. Second, introducing consumer heterogeneity would allow for richer analysis of how reforms affect different income groups, a consideration central to the political economy of utility pricing. Third, while we treat the wholesale price as a regulatory instrument, extending the model to allow bargaining between the utility and informal suppliers would clarify how the distribution of reform gains depends on relative market power. Finally, the logic of our reform by redirecting rents from informal provision toward expanded public supply, may apply to other sectors characterized by rationed public provision and parallel informal markets, including healthcare and education.

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A Proofs

Lemma 2. $V_a(p_w)$ is continuous in p_w for $p_w \in (c_u, c_a)$.

Proof. Define the constraint correspondence $\Gamma(p_w)$ by

$$\Gamma(p_w) = \left\{ (q_{aw}, q_{as}) \mid 0 \leq q_{as} \leq \frac{(c_u - \bar{p})K - S}{p_w - \bar{p}}, 0 \leq q_{as} \leq \bar{q}_{as} \right\} \quad (31)$$

where \bar{q}_{as} satisfies⁶

$$v'(q_u + \bar{q}_{as})\bar{q}_{as} - c_a\bar{q}_{as} = 0. \quad (32)$$

This is the largest production level a representative alternative producer would choose, since higher output would yield negative profit.

The alternative producer's objective is continuous in (q_{aw}, q_{as}) . By Berge's Maximum Theorem (see, e.g., Stokey, Lucas, and Prescott (1989), p. 62), $V_a(p_w)$ is continuous if the correspondence Γ is compact-valued and continuous. Compact-valuedness is immediate. We now establish continuity by showing upper and lower hemicontinuity.

Upper hemicontinuity. Let $(p_{w,k})_k$ be a sequence converging to p_w . Let $(q_{aw,k}, q_{as,k})_k$ be any sequence with $(q_{aw,k}, q_{as,k}) \in \Gamma(p_{w,k})$ for all $k \in \mathbb{N}$. This sequence lies in the compact set $\left[0, \frac{(c_u - \bar{p})K - S}{c_u - \bar{p}}\right] \times [0, \bar{q}_{as}]$, so we can extract a convergent subsequence $(q_{aw,k_l}, q_{as,k_l})_{l \in \mathbb{N}}$. Let $(q_{aw,\infty}, q_{as,\infty})$ denote its limit. Since for each term of the subsequence,

$$0 \leq q_{aw,k_l} \leq \frac{(c_u - \bar{p})K - S}{p_{w,k_l} - \bar{p}} \quad (33)$$

$$0 \leq q_{as,k_l} \leq \bar{q}_{as}, \quad (34)$$

passing to the limit yields

$$0 \leq q_{aw,\infty} \leq \frac{(c_u - \bar{p})K - S}{p_w - \bar{p}} \quad (35)$$

$$0 \leq q_{as,\infty} \leq \bar{q}_{as}. \quad (36)$$

Hence $(q_{aw,\infty}, q_{as,\infty}) \in \Gamma(p_w)$, establishing upper hemicontinuity.

Lower hemicontinuity. Let $(p_{w,k})_k$ be a sequence converging to p_w , and let $(q_{aw}, q_{as}) \in \Gamma(p_w)$. We must show there exists T and a sequence $(q_{aw,k}, q_{as,k})_{k \geq T}$ with $(q_{aw,k}, q_{as,k}) \in \Gamma(p_{w,k})$ for all $k \geq T$, converging to (q_{aw}, q_{as}) .

⁶We assume such \bar{q}_{as} exists.

If (q_{aw}, q_{as}) lies in the interior of $\Gamma(p_w)$, then for k sufficiently large, $(q_{aw}, q_{as}) \in \Gamma(p_{w,k})$, and we may take the constant sequence. If q_{aw} is equal to the upper bound, observe that as $p_{w,k} \rightarrow p_w$, the bound $\frac{(c_u - \bar{p})K - S}{p_{w,k} - \bar{p}}$ converges to $\frac{(c_u - \bar{p})K - S}{p_w - \bar{p}}$. We can therefore construct a sequence $(q_{aw,k}, q_{as,k})$ satisfying the constraints of $\Gamma(p_{w,k})$ that converges to (q_{aw}, q_{as}) . This establishes lower hemicontinuity.

Since Γ is compact-valued and continuous, and the objective function is continuous, Berge's Maximum Theorem implies $V_a(p_w)$ is continuous. \square