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# **Innovative Pricing Model in Uzbekistan's Pharmaceutical Sector: Balancing Access and Sustainability**

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## **Abstract**

The pharmaceutical sector in Uzbekistan (2018–2021) faces the dual challenge of ensuring affordable medicines for the population while enabling a viable pharmaceutical industry. This study reviews market trends and regulatory reforms in Uzbekistan's health sector and proposes a quantitative pricing model that integrates economic and social objectives. The model incorporates demand elasticity, cost structures, and regulatory constraints (e.g. reference pricing and mark-up caps) to determine optimal prices. We formulate a multi-objective optimization framework that balances revenue (profitability) with consumer access (affordability), yielding pricing rules reminiscent of Ramsey-Boiteux pricing. Key innovations include adaptive indexation to exchange rates, differentiated mark-ups by drug category, and a formalism for domestic vs. imported drugs. Numerical illustrations demonstrate how the model can set prices at levels that satisfy social welfare constraints while allowing sustainable profits. This comprehensive approach suggests policy directions for Uzbekistan and similar Central Asian markets.

## **Introduction**

Access to essential medicines is a critical social goal, especially in emerging markets where healthcare budgets are constrained. In Uzbekistan, pharmaceuticals constitute a large share of health spending (about 35.7% in 2019), and out-of-pocket payments remain high. At the same time, the government is promoting domestic pharmaceutical industry growth. Thus, pricing of medicines must reconcile affordability for patients with sustainable business for manufacturers and distributors. Recent reforms (2017–2020) have given the state greater role in regulating prices, including limits on mark-ups and the introduction of reference pricing. This paper analyzes Uzbekistan's market (2018–2021) and designs a quantitative pricing framework that optimally balances these objectives. We draw on market data, health policy reports, and economic theory to build an "innovative pricing model" tailored to Uzbekistan's context, with potential lessons for Central Asia.

## **Uzbekistan Pharmaceutical Market (2018–2021)**

Between 2018 and 2021, Uzbekistan's pharmaceutical market was modest but growing. In 2017 the market size was about USD 640 million with per-capita drug consumption of about USD 20.1. Forecasts estimated growth to ~USD 888 million by 2022 (a CAGR ~6.7%). Generics account for a large portion of the market – roughly 49.5% of 2017 market value – and domestic production is small. Indeed, Uzbek manufacturers meet only about 27–32% of total medicine demand, so over 90% of medicines are imported. In 2017 imports were USD 382 million, projected to rise to USD 657 million by 2022 (11.5% CAGR), reflecting reliance on foreign suppliers from Russia, Germany, India etc. In volume terms, local producers cover only about one-third of needs.

Public funding for health is limited – Uzbekistan spent about USD 673 PPP per capita on health in 2021 – so patients bear much of the cost of medicines. High out-of-pocket payments and low insurance coverage (mandatory health insurance only starting in 2021) make affordability a key concern. At the same time, Uzbekistan seeks to develop its pharmaceutical industry; recent reforms (creating a pharmaceutical development agency, tax incentives, free economic zones) aim to boost local production. Table 1 summarizes key market indicators.

**Table 1: Key Market Indicators**

Indicator	Value
Market size	USD 640m (2017); projected USD 888m by 2022 (CAGR $\approx$ 6–7%)
Generic share	$\sim$ 49.5% of value in 2017
Domestic production	$\approx$ 27% of needs (32% by volume); nearly all domestic output is generics
Imports	$\approx$ USD 382m (2017) to USD 657m (2022); >90% of pharmaceutical supply
Health spending	35.7% on medicines (2019); low public spending, high OOP

These conditions create pressure for low prices on the one hand (socially significant medicines should be cheap) and for industry viability on the other.

## Regulatory and Policy Reforms

Several key policies (2017–2020) shaped pricing. In August 2017 the government issued a resolution "On Additional Measures to Improve Medicine Supply". This mandated maximum mark-ups on essential (socially significant) medicines: originally 15% for wholesalers, 20% for retailers. Domestic medicines also received VAT exemption to encourage local industry. In late 2017, Presidential Decrees created the Pharmaceutical Industry Development Agency and restructured procurement. A state firm, Uzmedimpex, was empowered to do centralized procurement of key medicines.

Critically, price-setting authority for the "List of Socially Significant Medicines" was assigned to the Ministry of Health. A network of "social pharmacies" was established by 2018 to sell these medicines affordably.

In June 2020, Uzbekistan introduced a reference pricing system for prescription drugs. Under this system, the Ministry compares the exporter's prices in its home country and selected reference markets, then sets a maximum allowable price (a price cap) for that medicine in Uzbekistan. The reference countries list initially included CIS and some EU markets. To handle currency volatility, the system provides for automatic indexation: if the Uzbek som depreciates, maximum prices (in UZS) are adjusted twice a year (or immediately if >5% change). OTC (non-prescription) drugs, which had been subject to mark-up limits since 2017; however, during 2018–2021 these OTC markups remained 15%–20%. (Note: our model focuses on prescription and socially significant medicines, where regulation persisted in 2018–2021.)

### Key points of the regulatory context:

- **Mark-up caps:** Since 2017, wholesale mark-up  $\leq$ 15%, retail  $\leq$ 20% on base cost. These limits apply to essential (socially significant) drugs.
- **Reference pricing:** Introduced 2020 for prescription medicines. Government sets a maximum allowable price (reference price) per drug based on international comparisons. Sales prices may not exceed this reference.
- **Indexation:** Automatic biannual (Jan/Jul) adjustments of reference prices based on exchange rate changes. If the som falls >5%, off-cycle adjustment occurs immediately.
- **VAT and Taxes:** Domestic medicine manufacturing has been VAT-exempt; a 2% import duty was planned for imports. During 2018–2021, key inputs and outputs enjoyed various tax breaks.

- **Health Insurance (2021):** From 2021 Uzbekistan began rolling out compulsory health insurance, which should improve reimbursement for medicines (raising effective demand).

Regulatory efforts also include creating an innovation cluster ("Tashkent Pharma Park") to foster R&D and licensing reforms. Together, these measures signal the government's dual aims: social protection (affordable essential drugs) and industry development (promote domestic production and investment).

## Objectives of a Pricing Model

Given this context, the pricing model must simultaneously address:

- **Affordability (Access):** Keep prices low enough that patients can obtain needed medicines. This may mean low or zero markups on basic drugs, and price ceilings tied to incomes or budgets.
- **Industry Sustainability:** Allow pharmaceutical firms (especially emerging local producers) to cover costs and earn reasonable returns, encouraging investment and higher quality.
- **Regulatory Compliance:** Respect government rules (markup caps, reference prices, indexation, quality standards).
- **Innovation Incentives:** Enable higher prices (or subsidies) for new treatments, balancing R&D incentives against access.

We operationalize these objectives in a quantitative framework. We treat price  $P$  (e.g. per unit) as the control variable, influenced by production cost  $C$ , demand elasticity, and regulations. Our model uses a multi-objective optimization: maximize a weighted sum of (i) producer profits and (ii) social welfare (consumer surplus or coverage), subject to price constraints. A central concept is the trade-off parameter  $\lambda$  reflecting the government's emphasis on affordability vs. industry revenue. This yields first-order conditions akin to Ramsey pricing (setting mark-ups inversely proportional to elasticity) but adapted to the Uzbek context.

## Pricing Model Framework

### Demand and Cost Structure

We consider a representative medicine (or a class of medicines). Let  $Q(P)$  be the quantity demanded at price  $P$ . For simplicity, assume a linear demand:

$$Q(P) = a - bP, \quad a, b > 0$$

so that demand slope  $-b$  and choke price  $a/b$ . (Alternatively, one could use  $Q = AP^{-E}$  for constant elasticity  $E$ .) The drug has a marginal cost (ex-factory cost)  $C$  (per unit), which includes production and procurement costs. We assume a constant marginal cost as a baseline; fixed costs and R&D costs can be incorporated via a markup  $\mu$ .

The wholesale price is  $P_w = C(1 + \mu_w)$  (where  $\mu_w \leq 0.15$  by regulation). The retail price to patients is  $P = P_w(1 + \mu_r)$  (with  $\mu_r \leq 0.20$ ). Thus nominally  $P = C(1 + \mu_w)(1 + \mu_r)$ . In practice, government may set  $P$  directly or cap it. All prices are assumed net of VAT (Uzbek domestic products had VAT exemption, so VAT is omitted for them).

Profit for the supply chain (producer+distributor) per unit is  $P - C$ . We define total profit (industry surplus) as:

$$\pi(P) = (P - C)Q(P)$$

Consumer surplus (a proxy for social welfare from access) under linear demand is:

$$CS(P) = \int_0^Q Q(P)(a/b - P)dq = \frac{1}{2}Q(P)(a/b - P)$$

where  $a/b$  is the reservation price. Substituting  $Q(P) = a - bP$  gives  $CS = (a - bP)^2/(2b)$ .



Total welfare (or social value) can be taken as  $W = CS + \lambda\pi$ , where  $0 \leq \lambda \leq 1$  is a weight reflecting the importance of industry revenue. If  $\lambda = 0$ , welfare maximization would drive prices toward marginal cost (maximizing access); if  $\lambda = 1$ , it becomes pure profit maximization. Uzbekistan's regulators implicitly choose a  $\lambda$  by how strongly they enforce low prices versus allowing higher profits.

### Regulatory Constraints (Mark-ups & Reference Pricing)

Regulations impose additional constraints on  $P$ . The model must ensure:

- **Mark-up limits:**  $(P/C) - 1 \leq (1+\mu_w)(1+\mu_r) - 1 \approx \mu_w + \mu_r + \mu_w\mu_r \leq 0.15 + 0.20 + (0.15)(0.20) = 0.38$  in total, effectively  $P \leq 1.38C$  for an import with max markups. (In practice, wholesale and retail caps apply sequentially.)
- **Reference price cap:**  $P \leq P_{\text{ref}}$ , the reference price determined by foreign benchmarks. In our model this acts as an exogenous upper bound on  $P$ .
- **Affordability / Social price:** For "socially significant medicines," the government may desire an even lower target  $P_{\text{max}}$  (potentially  $P_{\text{max}} \leq C$  for some essential generics). We include this as  $P \leq P_{\text{afford}}$  if applicable. For modeling, one could set  $P_{\text{afford}} = \alpha \cdot C$  or tie it to income.

Thus feasible prices satisfy:

$$C \leq P \leq \min\{(1+\mu_w)(1+\mu_r)C, P_{\text{ref}}, P_{\text{afford}}\}$$

For domestic generics, a special formula (per Legal500 report) may be used: retail price = cost plus allowed net profit  $\gamma$  (for example,  $\gamma = 10\%$  in 2017 for social pharmacies). That would imply  $P = C(1+\gamma)$  for key generics.

### Optimization Problem

We define a (simplified) social welfare objective function:

$$\Phi(P) = CS(P) + \lambda\pi(P), \quad 0 \leq \lambda \leq 1$$

Maximizing  $\Phi$  with respect to  $P$  (ignoring constraints) yields the first-order condition:

$$d\Phi/dP = dCS/dP + \lambda(d\pi/dP) = 0$$

Calculating derivatives under  $Q = a - bP$ :

- $d\pi/dP = Q + (P-C)(dQ/dP) = (a-bP) - b(P-C)$ .
- $dCS/dP = -bQ$  (one can derive  $dCS/dP = -Q$  for linear demand). Actually, since  $CS = (a-bP)^2/(2b)$ ,  $dCS/dP = -(a-bP)b/b = -bQ$ .

So the condition is:

$$-bQ + \lambda[(a-bP) - b(P-C)] = 0$$

Substitute  $Q = a - bP$ :

$$\begin{aligned} -b(a-bP) + \lambda(a-bP-bP+bC) &= 0 \\ -b(a-bP) + \lambda(a-2bP+bC) &= 0 \end{aligned}$$

Solve for  $P$ :

$$\begin{aligned} -b(a-bP) + \lambda(a+bC-2bP) &= 0 \\ -ab + b^2P + \lambda a + \lambda bC - 2\lambda bP &= 0 \\ (b^2 - 2\lambda b)P &= ab - \lambda a - \lambda bC \\ P^* &= [a(b-\lambda) - \lambda bC] / [b(b-2\lambda)] \end{aligned}$$

This gives the interior optimum price as a function of  $\lambda$ . For example:

- If  $\lambda = 1$  (profit-only),  $P^* = (a+bC)/(2b)$  (the familiar monopoly optimum).
- If  $\lambda = 0$  (pure welfare),  $P^* = C$  (marginal cost pricing), yielding zero markup.

- For intermediate  $\lambda$ ,  $P^*$  lies between  $C$  and the monopoly price. One can verify  $P^* > C$  if  $\lambda > 0$ ; as  $\lambda \rightarrow 0$ ,  $P^* \rightarrow C$ .

In practice,  $\lambda$  reflects policy emphasis on affordability. A smaller  $\lambda$  (more social weighting) yields lower markups. We note that this result (optimal  $P$ ) must also respect the regulatory cap  $P_{\text{ref}}$  and markups. Thus the actual chosen price is:

$$P_{\text{chosen}} = \min\{P^*, P_{\text{max}}\}$$

where  $P_{\text{max}} = \min\{(1+\mu_w)(1+\mu_r)C, P_{\text{ref}}, P_{\text{afford}}\}$ .

### Elasticity-Adjusted Markups (Ramsey Pricing)

A more general form of this solution is the Ramsey pricing rule: for multiple drugs indexed by  $i$ , to achieve a social welfare optimum, one sets

$$(P_i - C_i)/P_i \propto 1/E_i$$

where  $E_i$  is price-elasticity of demand of drug  $i$ . In our single-good case ( $E = bP/(a-bP)$ ), solving  $(P-C)/P = \lambda/E$  leads to the same condition above. Thus, drugs with very inelastic demand (low  $E_i$ ) bear higher markups ( $P_i - C_i$ ), whereas highly elastic, low-necessity drugs get lower markups. This aligns with social priorities: essential life-saving drugs (inelastic) may be priced low or at marginal cost (if  $\lambda$  is small), while "luxury" or less-essential drugs (more elastic) could carry higher margins.

### Proposed Innovative Pricing Model

Building on the above, we propose a specific pricing formula suitable for Uzbekistan's regulated market. Let us denote:

- $C_d$ : cost of a domestically produced medicine (incl. locally procured inputs).
- $C_i$ : cost of an imported medicine (incl. CIF price in UZS).
- $\mu_w, \mu_r$ : allowable wholesale/retail mark-ups (15%, 20%).
- $E$ : price elasticity of demand (assumed known or estimated).
- $G$ : GDP per capita (for affordability considerations).

We suggest the following scheme:

- 1. Compute unconstrained optimal price  $P^*$ :** Use the derived formula (or numerical optimization) for given  $a, b, C$ . Alternatively, use a simplified Ramsey/markup rule:  $P^* \approx C + (\lambda/E)$ ,  $\lambda \in (0,1]$ . For initial design, choose  $\lambda$  reflecting policy (e.g.  $\lambda = 0.3$  for strong public emphasis).
- 2. Apply mark-up caps:** Ensure  $P^* \leq (1+\mu_w)(1+\mu_r)C$ . If  $P^*$  exceeds this, set  $P' = (1+\mu_w)(1+\mu_r)C$  (the maximum allowed by law).
- 3. Apply reference pricing:** Let  $P_{\text{ref}}$  be the government's calculated reference price (the average of comparator countries, or an indexed prior price). Then the final price is  $P = \min\{P', P_{\text{ref}}\}$ . If  $P_{\text{ref}} < P'$ , the model indicates producers accept a lower price (if still profitable) to meet the reference rule.
- 4. Affordability check:** Optionally, if  $P > \alpha \cdot G$  (for some threshold  $\alpha$ ), adjust  $P$  downward. For example, set  $P_{\text{afford}} = \min\{P, \theta G\}$ , with  $\theta$  say 0.01 (1% of per capita GDP) to keep price per package within a minimal share of income.
- 5. Differentiation by drug category:** For essential generic medicines, one may set  $\lambda$  very low (approaching 0), effectively making  $P \approx C$  (no markup). For novel branded drugs, a higher  $\lambda$  applies. This tiered approach can be implemented by classifying drugs into groups and assigning group-specific  $\lambda_i$ .

Mathematically, one can summarize the price setting for drug  $i$  as:

$$P_i^* = \arg \max\{C_i S_i(P) + \lambda_i \pi_i(P)\} \text{ subject to } P \leq (1+\mu_w)(1+\mu_r)C_i, P \leq P_{\text{ref},i}$$

In practice, solving for  $P_i^*$  yields (for linear demand)  $P_i^* = (a_i + b_i C_i)/(2b_i)$  when  $\lambda_i = 1$ , or the weighted formula earlier when  $\lambda_i < 1$ . We then enforce  $P_i = \min\{P_i^*, (1.15)(1.20)C_i, P_{ref,i}\}$ .

## Model Innovation

This model incorporates several innovative elements:

**Exchange-Rate Indexation:** Since imports cost changes with the som/USD rate, we include automatic indexation. Let  $X$  be the USD/UZS rate. If  $X$  increases by >3–5%, the reference price  $P_{ref}$  is adjusted by  $X$  proportion. We implement this by taking costs  $C_i = (C_i^0) \times (X/X_0)$ , reflecting the currency shift, which feeds into  $P^*$ . The periodic revision schedule (Jan, Jul) is modeled by discrete updates.

**Uniform Minimum Price for Clones:** The regulation forbids different brands of the same drug from having different price reference baselines. In the model, we enforce that if drug A and B are generics of the same active ingredient, they share a common reference cost  $C_{base}$ , so  $P_A = P_B$  at baseline. This avoids price dispersion for identical compounds.

**Domestic Incentive:** Domestic producers receive VAT and export tax breaks. We reflect this as reducing their effective  $C_d$ . For instance, a domestic manufacturer's cost might be  $C_d = C_{raw}(1 - \tau)$  where  $\tau = 0.2$  captures tax savings. Thus  $P^*$  can be higher (profit larger) without raising final price, improving sustainability of local firms.

**Quality/Innovation Premium:** For new innovative drugs, we may allow an extra premium  $\delta$  above cost (e.g. via a higher  $\lambda$  or even a fixed surcharge) to reward R&D. This is in line with global "value-based pricing" ideas (not yet implemented in Uzbekistan but conceptually possible).

## Quantitative Analysis and Formulas

We now detail the quantitative formulas underpinning the model.

**Demand Elasticity:** Define price elasticity  $E = -(dQ/Q)/(dP/P) = bP/(a - bP)$ . In our linear model at  $P^*$ , elasticity is  $E^* = bP^*/(a - bP^*)$ . A more elastic market ( $E$  large) will tighten the optimal  $P$ .

**Unconstrained profit-maximizing price:** For completeness, if Uzbekistan did not impose social weights ( $\lambda = 1$ ), the classic monopoly optimum is

$$P_{profit} = (a + bC)/(2b)$$

yielding markup  $(P_{profit} - C) = (a - bC)/(2b)$ .

**Consumer surplus at optimum:** At  $P = P^*$ , consumer surplus is  $CS^* = (a - bP^*)^2/(2b)$ . For example, if  $a = 100$ ,  $b = 1$ ,  $C = 20$ ,  $\lambda = 0.5$ , solving yields  $P^* \approx 45$  (say). Then  $CS^* \approx (100 - 45)^2/2 = 3025/2 = 1512.5$ . (Units arbitrary.)

**Social welfare function:** We might target maximizing  $SW = CS + \lambda\pi$ . Substituting  $CS$  and  $\pi$ :

$$SW(P) = (a - bP)^2/(2b) + \lambda(P - C)(a - bP)$$

Setting  $dSW/dP = 0$  yields the earlier equation and solution. In an appendix, one can derive a closed form:

$$(2\lambda + 1)P^2 - 2(a + \lambda bC)P + (a^2 + 2\lambda aC) = 0$$

solve for  $P$ .

**Indexation formula:** If the exchange rate change factor is  $\Delta X = X_t/X_{t-1}$ , and  $\Delta X > 1.03$ , then  $C_i(t) = C_i(t-1) \cdot \Delta X$  and thus  $P^*(t) = P^*(t-1) \cdot \Delta X$  (approximately), subject to caps. This automates currency pass-through.

**Min-Max pricing:** Ultimately, the model sets

$$P_i = \min\{P_i^*, P_{cap,i}\}, P_{cap,i} = \min[(1 + \mu w)(1 + \mu r)C_i, P_{ref,i}, P_{afford,i}]$$

This ensures no rule is violated.



**Example computation (hypothetical):** Suppose a generic antibiotic has  $C_i = \$10$ , demand parameters  $a = 200$ ,  $b = 2$  (so  $Q(0) = 100$ , E moderate), and policy weight  $\lambda = 0.2$  (social emphasis). The unconstrained optimum is found by solving  $-2(a - 2P) + 0.2(a - 2P - 2P + 2C) = 0$ . Substituting numbers,  $-2(200 - 2P) + 0.2(200 - 4P + 20) = 0$ . Solve this equation for  $P$ . One finds  $P \approx \$11$  ( $\approx 10\%$  markup). Cap  $(1.15)(1.20)C = \$13.8$ ; if  $P_{\text{ref}} = \$12$ , the final price  $P = \$11$  (since  $P^* < P_{\text{ref}}$ ). The profit margin per unit is modest, but consumer surplus is high.

These formulas illustrate that with a low  $\lambda$ , the model naturally keeps  $P$  close to cost. If  $\lambda$  were higher (e.g. 0.8),  $P^*$  would be substantially higher, but still bounded by the 1.38 factor or by reference price.

## Discussion: Balancing Access and Sustainability

Our model yields several insights for policy:

**Tiered Markups:** Enforce lower or zero markups on essential generics (setting  $\lambda \approx 0$  so  $P \approx C$ ), while allowing higher markups on less-essential or patented drugs (larger  $\lambda$ ). This achieves progressive pricing. It is akin to the legal rule that all forms of the "same" drug share a minimum price, which in effect caps luxury-pricing on low-income earners.

**Indexation Eases Volatility:** Automatic forex indexation of reference prices (as instituted in 2020) is important. Our model's incorporation of indexation means importers can maintain stable profit margins despite currency swings, preventing sudden shortages. If indexation were absent, a sharp devaluation (like in Sep 2017) would either bankrupt importers or force supply cuts.

**Domestic Incentives:** VAT exemption and other subsidies (captured as reduced  $C_d$ ) allow domestic firms to be profitable at lower consumer prices. For instance, if VAT were 20% but exempted, a drug with nominal  $C = 100$  actually costs 80 effectively; our model can treat  $C = 80$  to reflect this. This helps push local share from  $\sim 27\%$  toward higher levels.

**Health Insurance Impact:** As compulsory health insurance comes into force (2021 and beyond), effective demand increases (patients pay less out-of-pocket). The model can incorporate this by increasing the intercept of demand (shifting demand curve outward). A higher  $a$  leads to a higher optimal  $P$  (since  $P^* \approx (a + bC)/(2b)$  for  $\lambda = 1$ ). Thus, insurance allows slightly higher sustainable prices without hurting access, which should benefit industry margins. However, formulary management within insurance (promoting generics, reference pricing) will still be crucial.

In quantitative terms, suppose patient co-pay falls from 100% to 50% via insurance; demand might increase by factor  $\delta > 1$ . Then re-running the model with  $a' = \delta a$  yields new  $P^*$ ,  $Q^*$ , etc. The result is more units sold even if price rises modestly, increasing total revenue without overly burdening patients.

Overall, our pricing model framework is innovative in formally blending economic optimization (via  $\lambda$  and elasticity) with the practical constraints of Uzbekistan's system (markup caps, reference pricing, subsidies). It provides explicit formulas to calculate prices and markups for each drug, which regulators and firms can use. It also yields testable predictions: e.g. if elasticity or policy weight changes, what should prices be.

## Conclusion

We have developed a comprehensive, quantitative pricing model for Uzbekistan's pharmaceutical industry that strives to harmonize social and business objectives. By embedding supply and demand economics in a multi-objective optimization, our model specifies how to set drug prices under regulated mark-ups and reference price caps. This model is tailor-made for the 2018–2021 Uzbek context (and similar Central Asian markets), accommodating recent health financing reforms. It recommends strategies such as sharply lower markups on vital generics, dynamic exchange-rate indexation, and calibrated industry subsidies all grounded in explicit formulas.

This approach ensures affordability (through social weighting and caps) while preserving a sustainable pharmaceutical sector (by allowing controlled profits). Future work could calibrate the model to actual Uzbek data (estimating  $a$ ,  $b$ ,  $E$  for key drugs) and simulate welfare outcomes. Moreover, as mandatory insurance expands, the model can be extended to include insurer copays and budget constraints. Ultimately, the synergy of economic modeling and targeted regulation offers a path to universal access without starving the domestic pharmaceutical industry.

## Appendix: Additional Quantitative Derivations

**Derivation of Optimal Price (Social Optimum):** From  $SW(P) = (a - bP)^2/(2b) + \lambda(P-C)(a - bP)$ , taking  $dSW/dP = 0$  yields a quadratic in  $P$ . Expanding and collecting terms:

$$(2\lambda + 1)b^2P^2 - 2b(a + \lambda bC)P + (a^2 + 2\lambda aC) = 0$$

Solving gives

$$P^* = [(a + \lambda bC) + \sqrt{(a + \lambda bC)^2 - (2\lambda + 1)(a^2 + 2\lambda aC)}] / [(2\lambda + 1)b]$$

One selects the economically meaningful root (the "+" branch yields  $P^* > C$ ). This general solution (omitted above for brevity) reduces to our simplified formula when  $\lambda = 1$  or 0.

**Elasticity and Markup Relationship:** Solving  $dSW/dP = 0$  can be rewritten as  $(P-C)/P = \lambda/(1+\lambda E)$  for constant elasticity. For small  $\lambda$ , this approximates  $(P-C)/P \approx \lambda/E$ . Thus elasticity  $E$  directly informs markup: inelastic  $E \rightarrow$  higher allowed  $(P-C)$  for given social weight.

**Market-Level Example:** Consider two drugs: a life-saving generic (elasticity  $E_1 = 0.5$ ) and a lifestyle drug ( $E_2 = 5$ ). Let  $\lambda = 0.2$  for the generic and  $\lambda = 0.8$  for the lifestyle drug. The markup rule  $(P-C)/P = \lambda/E$  yields  $(P_1-C)/P_1 = 0.2/0.5 = 0.4$  (i.e.  $P_1 = 1.67C$ ), versus  $(P_2-C)/P_2 = 0.8/5 = 0.16$  ( $P_2 = 1.19C$ ). Despite the higher  $\lambda$  for drug 2, its large elasticity forces a smaller markup. This counterintuitive result (luxury drug has smaller markup) reflects that socially, we prefer to dampen prices on staples. Our full model would next apply the 1.38 maximum and reference price limits to these outcomes.

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