# Price Controls Cause Chaos

## Misallocation, Robust Bounds, and the 1973–74 Gasoline Crisis

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## February 1974

- Aggregate gasoline shortfall: $\approx 9\%$ nationwide
- Price controls kept pump prices below market price
- Textbook prediction: each market gets a proportional $\sim 9\%$ reduction
- Shadow prices equalize; Harberger triangle measures cost

**What actually happened?**

Not modest belt-tightening, but **feast or famine**.

*"Gasoline was in short supply in major urban areas, but there were more than abundant supplies in rural and vacation areas, where the only shortage was of tourists."*

— Yergin (1991)

# The Patchwork of Rationing

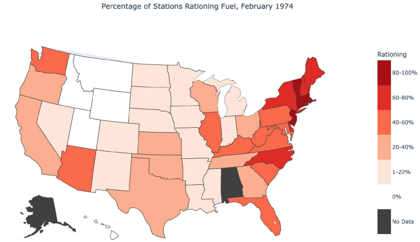



Figure 1: Percentage of gasoline stations rationing fuel by state, February 1974. Rationing includes stations completely out of fuel and those limiting purchases (e.g., maximum gallons per customer). Data are from AAA surveys of sampled stations.

*Percentage of stations rationing fuel by state, Feb 1974. Data: AAA surveys.*

# The Puzzle

**Severe rationing:**

- Connecticut: $> 90\%$ of stations
- Massachusetts: $> 90\%$
- New Jersey, Rhode Island: $> 60\%$

**No rationing at all:**

- Idaho, Montana, Utah, Wyoming: $0\%$
- Hawaii: $0\%$

**The overserved states are the problem**

Under efficient allocation, a $9\%$ shortfall $\rightarrow$ proportional reduction *everywhere*.

States with **zero rationing** were **overserved**: enough to satisfy demand even at the controlled price.

## The question is **not** why some states rationed.

With a $9\%$ national shortfall, shortages somewhere are inevitable.

## The question is why other states exhibited **no rationing**.

Why should some markets clear while others run dry?

**Answer**

Efficient allocation requires *price variation*. A binding ceiling explicitly forbids it.

## This Paper: Three Contributions

1. **The Chaos Theorem**

   Price controls generically produce corner allocations. Some markets get everything; others get nothing. Small parameter changes cause discontinuous jumps.

2. **Robust Bounds on Welfare**

   Sharp welfare bounds without assuming a demand functional form. Computation reduces to a 1D optimization.

3. **1973–74 Gasoline Crisis**

   Misallocation losses are **1–9$\times$ the Harberger triangle**. The quantity reduction is under $\frac{1}{3}$ of total welfare cost.

## Roadmap

Two-Market Intuition

General Framework

The Chaos Theorem

Robust Bounds on Welfare

The 1973–74 Gasoline Crisis

Misallocation Beyond Geography

Conclusion

## Setup: Two Submarkets

- Two local markets with demands $D_1(p)$ and $D_2(p)$
- Binding price ceiling $\bar{p}$ creates a total shortage:

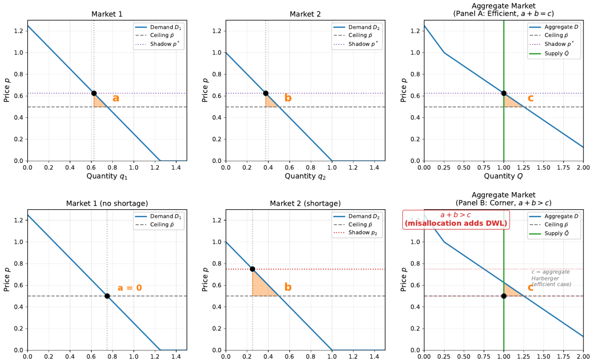
$$D(\bar{p}) - S(\bar{p}) > 0$$

- Total supply under the ceiling: $\bar{Q} \equiv S(\bar{p})$
- Feasible allocations: $q_1 + q_2 = \bar{Q}$, with $q_i \leq D_i(\bar{p})$

**Question**

How is $\bar{Q}$ split between the two markets?

# Efficient vs. Corner Allocation



## Panel A: The Harberger Benchmark

- Shadow prices equalize across markets at $p^*$
- Each market bears a proportional share of the shortage
- Deadweight loss = areas $a + b = c$ (the Harberger triangle)

This is what the textbook predicts.

**But...**

The Harberger triangle is not the *average* outcome. It is the **minimum** welfare loss compatible with a binding ceiling.

## Panel B: The Corner Allocation

- Market 1 receives its full demand at $\bar{p}$
- Market 2 gets whatever is left
- Shadow prices **diverge**: Market 1 has low shadow price, Market 2 has very high shadow price
- Welfare loss $a + b \gg c$

Nearly an order of magnitude larger than the Harberger triangle.

**The geometry**

The constraint $q_1 + q_2 = \bar{Q}$ defines a *line segment*. The endpoints $E_1$ and $E_2$ are corner solutions—and these are the generic equilibria.

# The Feasible Set Is a Line Segment

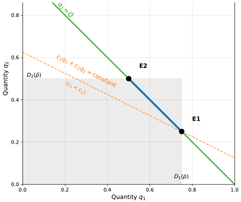



Figure 3: The feasible set is a line segment. Corners $E_1$ and $E_2$ are the only generic equilibria under price controls.

Between $E_1$ and $E_2$ lies a continuum of feasible allocations. Without price controls, arbitrage would push the economy toward the efficient interior: if gasoline were more valuable in Market 2, traders would profit by redirecting supply until shadow prices equalized. But a binding ceiling eliminates this incentive. With money prices frozen at $\bar{p}$

Corners $E_1$ and $E_2$ are the only generic equilibria. With costs $c_1 < c_2$, supply flows entirely to Market 1. Interior allocations are generically impossible.

## Why Corners?

The logic in four steps

1. **Prices frozen** $\rightarrow$ sellers earn the same revenue everywhere
2. **Seller indifference** $\rightarrow$ allocation by *cost minimization*
3. **Cost minimization is a linear program** on the feasible set
4. **Linear programs solve at corners**

**The knife-edge**

Under market prices, a slight cost advantage for PA over NJ redirects *a few tanker loads*.
Under price controls, it redirects **all of them**. A one-cent advantage is as good as one dollar.

# Prices vs. Price Controls: Incremental vs. Categorical

## Free Market

- Arbitrage profits *proportional* to price gap
- Small cost advantage $\rightarrow$ small reallocation
- Fine-grained, incremental adjustment

## Price Controls

- Revenue equalized across destinations
- Small cost advantage $\rightarrow$ **entire flow redirected**
- All-or-nothing extremes

*The economy loses its capacity for incremental adjustment and instead lurches between all-or-nothing extremes.*

— Sowell (1980, p. 137)

# From Two Markets to Many

- $n$ segmented submarkets; inverse demand $P_i(\cdot)$ in each
- "Submarket" is deliberately flexible:
  - Geographic: states, cities, countries
  - Temporal: summer vs. winter
  - Product: gasoline vs. diesel vs. heating oil
  - Production stage: crude $\rightarrow$ refined products
- A binding ceiling $\bar{p}$ fixes total supply at $\bar{Q} = S(\bar{p})$

**Feasible set:**

$$\mathcal{F} = \left\{ q \in \mathbb{R}^n_+ : \sum_{i=1}^{n} q_i = \bar{Q},\ 0 \leq q_i \leq \bar{q}_i \ \forall\, i \right\}$$

A convex polytope. Its **vertices** have $q_i \in \{0, \bar{q}_i\}$ for all but at most one market.

## Welfare and Misallocation

**Consumer surplus** in market $i$ at allocation $q_i$:

$$W_i(q_i) = \int_0^{q_i} \left[P_i(x) - \bar{p}\right] dx$$

**Efficient allocation** $q^*$: equalize shadow prices across all served markets.

### Misallocation Deadweight Loss

$$L^{\text{Mis}}(q) = W(q^*) - W(q) = \sum_{i=1}^{n} \int_{q_i}^{q_i^*} P_i(x)\, dx$$

The welfare destroyed by distributing the fixed supply $\bar{Q}$ inefficiently. These are the *dollars left on the table* when goods don't flow to their highest-value uses.

## Worst-Case Allocations

**Theorem 1 (Worst Case)**

The worst-case allocation—the one that *maximizes* deadweight loss—sits at a **vertex** of $\mathcal{F}$:

$$q_i \in \{0, \bar{q}_i\} \quad \text{for all but at most one market}$$

**Intuition:**

- Welfare (gross surplus) is concave $\rightarrow$ its minimum is at an extreme point
- The worst case concentrates supply in markets where it generates the *least* value
- Markets with high choke prices receive nothing; markets with low shadow prices are flooded

There exists a cutoff $\lambda$: markets with $P_i(0) \geq \lambda$ get nothing; those with $P_i(\bar{q}_i) \leq \lambda$ get everything.

## Without Price Controls: Smooth Markets

- Parameters $\theta$ govern demands $P_i(x;\theta)$, costs $c_i(\theta)$, supply $\bar{Q}(\theta)$
- Under free markets, the allocation that maximizes surplus is:

$$q^*(\theta) = \arg\max_{q \geq 0} \left\{ \sum_i \int_0^{q_i} P_i(x;\theta)\, dx - \sum_i c_i(\theta) q_i \right\} \quad \text{s.t.} \sum_i q_i = \bar{Q}(\theta)$$

- Objective is strictly concave $\Rightarrow$ unique $q^*(\theta)$
- By Berge's Maximum Theorem: $q^*(\theta)$ is **continuous** in $\theta$

**Small changes in parameters $\rightarrow$ small changes in allocations and welfare.**

## Under Price Controls: Cost Minimization

Now impose a binding ceiling $\bar{p}$. All units sell at $\bar{p}$, so profit-maximizing suppliers **minimize delivery costs**:

$$\min_{q \in \mathcal{F}(\theta)} \; c(\theta) \cdot q$$

This is a **linear program**. With generically distinct costs:

- Markets are filled in order of *increasing cost*
- At most one market is partially filled
- When two markets have nearly equal costs, an infinitesimal change can **flip the entire allocation**

The equilibrium allocation becomes **discontinuous** in parameters.

## The Chaos Theorem

**Theorem 2 (Chaos)**

Suppose two adjacent vertex allocations $v$ and $w$ are both optimal at some parameter $\theta^*$. If the welfare difference $\Delta W \neq 0$ (a generic condition), then for every neighborhood of $\theta^*$:

1. The optimal allocation **jumps discontinuously** between $v$ and $w$
2. Welfare jumps by $+|\Delta W|$ along one path and $-|\Delta W|$ along another

Welfare is **not locally monotone**: arbitrarily small perturbations can move welfare up or down by discrete amounts.

A pipeline repair, a regulatory tweak, a refinery outage—*any* small change in relative costs can flip the entire allocation, with potentially catastrophic welfare consequences.

## The Chaos of Price Controls: Intuition

**Free Markets**

$\theta$ changes by $\epsilon$

$\Rightarrow q^*$ changes by $O(\epsilon)$

$\Rightarrow W$ changes by $O(\epsilon)$

Continuous, predictable

$\xrightarrow{\textbf{Impose ceiling } \bar{p}}$

**Price Controls**

$\theta$ changes by $\epsilon$

$\Rightarrow q$ jumps by $\Delta \gg \epsilon$

$\Rightarrow W$ jumps by $|\Delta W| \gg \epsilon$

Discontinuous, chaotic

*Price controls introduce fundamental unpredictability.*
*Allocations become hypersensitive to "nuisance parameters"*
*that would be irrelevant under market clearing.*

# Simulation: 100 Markets on a Grid

## Three random cost draws; free market (top) vs. price controls (bottom)

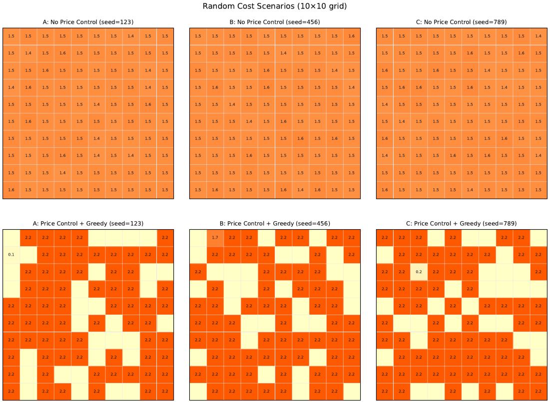



Figure 4: Allocation of a fixed supply ($\bar{Q} = 150$) across 100 cities under free markets (top) versus price controls (bottom). Each column is a different random draw of delivery costs. Under free markets, quantities vary smoothly. Under price controls, low-cost cities fill to capacity while approximately 30 cities go unserved.

## What the Simulation Shows

1. **Free-market allocations are nearly identical** across scenarios—small cost differences $\rightarrow$ small allocation differences
2. **Under price controls, many markets receive zero** (yellow)—low-cost cities fill to capacity; $\sim 30$ cities get nothing
3. **Different cost draws $\rightarrow$ radically different allocations**—same demand, same supply, completely different spatial pattern

**This is the Chaos Theorem in action**

Small changes in nuisance parameters dramatically change the allocation. Welfare loss: $\sim 13\%$.

## The Identification Problem

- Chaos Theorem $\Rightarrow$ expect **corner allocations**—far from market equilibria
- Welfare depends on values at these extreme quantities
- But demand is identified only *locally*, near equilibrium

**The extrapolation problem:**

- Closed stations: $\sim 67\%$ of baseline
- Elasticity estimates: near $q = 1$, not $q = 0.67$
- From $\varepsilon = 0.2$: $P(0) = 6$
- From $\varepsilon = 0.4$: $P(0) = 3.5$
- Welfare difference: $4\%$ vs. $16\%$ of baseline

**Our approach**

No parametric demand assumption.

Largest and smallest welfare losses consistent with:

- Observed allocations
- Slope bounds (from elasticity)
- A finite choke price

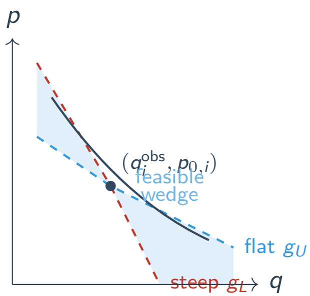
## Step 1: Slope Bounds Create a “Wedge”

What we know constrains what demand can look like

**Assumptions:**

- Observe anchor point $(q_i^{\text{obs}}, p_{0,i})$ on each demand curve
- Slope bounds: $g_{i,L} \le P_i'(q) \le g_{i,U} < 0$
- Choke bound: $P_i(0) \le M_i$

The slope bounds force $P_i$ to lie in a **wedge**—between rays with slopes $g_{i,L}$ (steep) and $g_{i,U}$ (flat) emanating from the anchor.

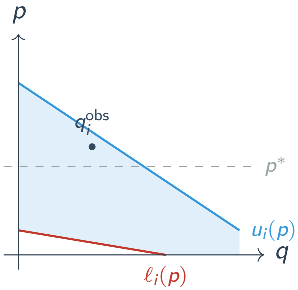


## Step 2: Invert the Wedge → Quantity Bands

- At each price $p$, the feasible quantity lies in a band:

$$\ell_i(p) \leq q_i(p) \leq u_i(p)$$

- The wedge in $(q, p)$ space becomes pointwise box constraints in $(p, q)$ space




### Step 3: Feasible shadow prices

- Define $L(p) = \sum_i \ell_i(p)$, $U(p) = \sum_i u_i(p)$
- A shadow price $p$ is feasible iff:

$$\mathcal{I} = \{p : L(p) \leq \bar{Q} \leq U(p)\}$$

# Step 4: One-Dimensional Optimization

The heart of the approach

**Key identity** (welfare gap in price space):

$$\Phi(P) = \bar{Q}p^* - \sum_i q_i^{\text{obs}} p_{0,i} - \sum_i \int_{p_{0,i}}^{p^*} q_i(p)\, dp$$

**Lemma 1 (Reduction to 1D)**

Objective is **linear** in $q_i(\cdot)$; constraints are boxes $q_i(p) \in [\ell_i(p), u_i(p)]$.
$\Rightarrow$ Worst/best cases push $q_i$ to **endpoints**. $\overline{\Phi}(p)$ and $\underline{\Phi}(p)$ become **scalar functions of** $p \in \mathcal{I}$.

**Theorem 3:** Sharp bounds attained by *piecewise-linear* demands with slopes $\in \{g_L, g_U\}$. Not sensitivity analysis—exact over *all* Lipschitz functions satisfying slope constraints.

## Historical Context

- **August 1971:** Nixon freezes all wages and prices
- Petroleum remains under controls even after other prices unfrozen
- **August 1973:** Special Rule No. 1 — mandatory petroleum controls
- **October 1973:** Oil Embargo begins; market price triples
- Controls + embargo = severe shortages
- **EPAA (1973):** Allocation system based pro-rata on 1972 levels
  - If supply falls to 90% of 1972, each buyer gets 90% of 1972 allocation
  - Plus exceptions for defense, agriculture, essential services...
  - All under an "equitable" guideline

**Key Insight**

Despite pro-rata rules, the outcome was **extreme dispersion**—exactly what the Chaos Theorem predicts.

## The Data: AAA Station Surveys, February 1974

**Station-level classification:**

- $10.1\%$ of stations: **closed** (out of fuel)
- $27.8\%$: **limiting purchases**
- $62.1\%$: operating normally

Mean out-of-fuel rate by state: $8.2\%$
But this average masks *striking heterogeneity*

**Our aggregation:**

- Two markets: **Open** (62%) vs. **Closed/Limiting** (38%)
- Open stations: $q_O = 1.06$ (demand at $\bar{p}$)
- Closed/limiting: $q_C \approx 0.67$ (residual)

This is the corner-solution structure predicted by the Chaos Theorem.

## Welfare Measures

**Harberger deadweight loss** (quantity reduction, efficient allocation):

$$L^{\text{Harb}} = \widetilde{W}(q^{\text{base}}) - \widetilde{W}(q^{*}) - \bar{p} \cdot (Q^{\text{base}} - \bar{Q}) \approx 2.03\%$$

**Misallocation loss** (inefficient distribution of reduced supply):

$$L^{\text{Mis}} = W(q^{*}) - W(q^{\text{obs}})$$

### Misallocation Ratio

$$R = \frac{L^{\text{Mis}}}{L^{\text{Harb}}}$$

$R = 0$: efficient rationing. $R = 1$: misallocation doubles the cost. $R > 1$: misallocation **dominates**.

All losses expressed as % of baseline expenditure ($p_{\text{base}} \times Q_{\text{base}}$).

# Station-Level Demand Curves (No Choke Constraint)

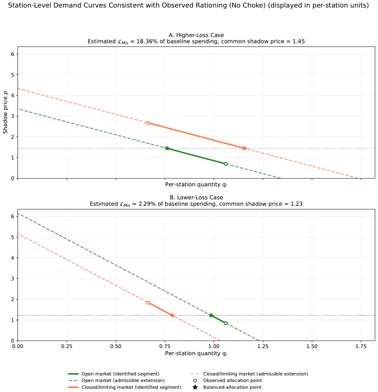



Figure 5: **Station-Level Demand Curves Without Choke.** The two panels show high-loss and low-loss demand configurations consistent with observed open and closed/limiting station quantities when no choke cap is imposed, using the baseline calibration $q_O = 1.06$ and $q_C = 0.67$. Solid segments are identified by the observed allocations and slope bounds; dashed segments are admissible extensions.

# Station-Level Demand Curves (With Choke $M = 4$)

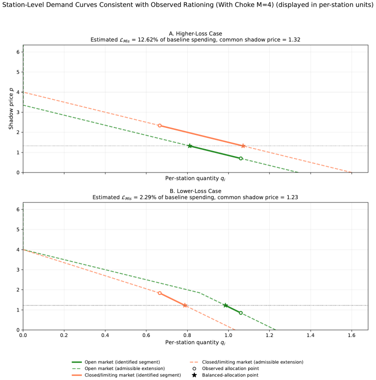



Figure 6: **Station-Level Demand Curves With Choke.** Same construction as Figure 5, using the same baseline calibration and now imposing $P(0) \leq M = 4$. The choke cap narrows admissible shadow-price ranges, which tightens the upper bound on misallocation losses.

# Shadow Price Ranges

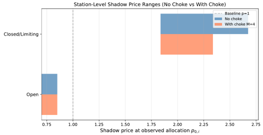



Figure 7: **Station-Level Shadow Price Ranges, With and Without Choke.** Horizontal bars show admissible shadow-price intervals at observed quantities for open and closed/limiting stations in the baseline calibration. Blue bars are no-choke ranges; orange bars impose $P(0) \leq M = 4$, which tightens the upper range for closed/limiting stations.

Table 1: Sensitivity to Controlled Price (Robust Intervals)

| $\bar{p}$ | $q_{open}$ | $q_{closed}$ | $\mathcal{L}_{Mis}$ interval (%) | $\mathcal{L}_{Harb}$ (%) | $\mathcal{R}$ interval |
|---|---|---|---|---|---|
| 0.5 | 1.15 | 0.52 | $[5.87, 46.99]$ | 2.03 | $[2.90, 23.20]$ |
| 0.8 | 1.06 | 0.67 | $[2.29, 18.36]$ | 2.03 | $[1.13, 9.06]$ |
| 1.0 | 1.00 | 0.76 | $[0.83, 6.61]$ | 2.03 | $[0.41, 3.26]$ |

*Notes:* Open station quantity is demand at $\bar{p}$; closed/limiting receive the residual so aggregate shortage equals 9%. Quantities $(q_{open}, q_{closed})$ are baseline-calibration values (with $\varepsilon = 0.3$), while welfare objects are reported as robust intervals. Intervals in this table are no-choke joint robust bounds over admissible station anchors. With choke $M = 4$, upper endpoints are lower (e.g., at $\bar{p} = 0.8$, $\mathcal{R}_{upper}$ falls from 9.06 to 6.23).

Blue: no-choke ranges. Orange: with choke $P(0) \leq M = 4$. Choke tightens closed/limiting upper bound.

## Station-Level Results

At baseline ($\bar{p} = 0.8$, $\varepsilon \in [0.2, 0.4]$):

**Headline Result**

$$\frac{L^{\text{Mis}}}{L^{\text{Harb}}} \in [1.13,\ 9.06]$$

Misallocation loss: $[2.29\%, 18.36\%]$ of baseline spending. With choke $M = 4$: upper $\to 6.23$.

Harberger triangle ($\approx 2\%$): less than $\frac{1}{3}$ of total welfare cost.

**Sensitivity to $\bar{p}$:**

| $\bar{p}$ | $R$ interval |
|---|---|
| 0.5 | $[2.90, 23.20]$ |
| **0.8** | $[\mathbf{1.13}, \mathbf{9.06}]$ |
| 1.0 | $[0.41, 3.26]$ |

Deeper controls $\to$ wider interval, higher upper bound.

# State-Level Analysis: 48 Markets

**Why disaggregate to states?**

- Adding-up $\sum_i q_i = \bar{Q}$ genuinely binds across 48 markets
- Giving more to CT means taking from CA
- This *disciplines* the bounds

**State-Level Result**

$$\frac{L^{\text{Mis}}}{L^{\text{Harb}}} \in [0.26,\ 2.38]$$

Tighter: adding-up discipline + assumes efficient within-state allocation.

**The gap between levels**

Station-level: **total** misallocation (across + within states)

State-level: only *across-state*

CT's 90% $\rightarrow$ one average, obscuring open vs. closed within CT.

# State Shadow-Price Bounds

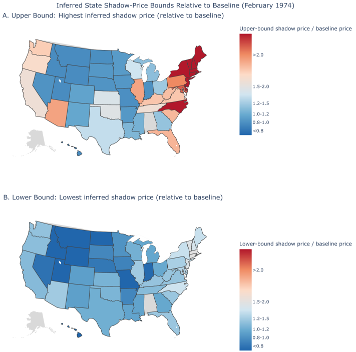



Figure 8: **State-Level Shadow-Price Bounds Relative to Baseline Price.** Colors show inferred shadow price divided by baseline price at each state's observed allocation. Panel A (top) reports the upper bound (highest value consistent with assumptions), and Panel B (bottom) reports the lower bound (lowest value consistent with assumptions). Red indicates higher inferred shadow prices; blue indicates lower inferred shadow prices.

Red = higher shadow prices; blue = lower. High-rationing states in red.

# State-Level Shadow Prices by State

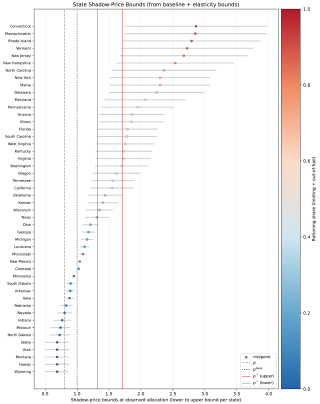



Figure 9: **State-Level Shadow-Price Bounds by State.** Each gray horizontal segment shows a state's admissible shadow-price interval at its observed allocation. The dot marks the interval midpoint and is colored by rationing share (higher rationing corresponds to higher values on the color scale). Dashed/dotted vertical lines mark the controlled and baseline prices; solid vertical lines mark the common shadow prices from the upper- and lower-bound joint solutions.

51

# The Chaos Mechanism Is General

Same logic whenever controls suppress price variation across segments

**Product-mix misallocation:**

- A barrel of crude $\rightarrow$ gasoline, diesel, heating oil, jet fuel...
- Controlled prices + small cost wedges $\rightarrow$ large shifts in fuel mix
- Shortages rotated unpredictably across fuels

**Temporal misallocation:**

- Heating oil prices frozen at *summer 1971* levels
- Weakened incentives to store for winter
- Winter shortages, school closures
- "Freezing prices led to freezing people"

*"Phases 3 and 3A have created price anomalies that frequently prevent the movement of products in proper directions."* — 1973 Congressional testimony

# The Baby Chicks

## Input–output misallocation under price controls

In summer 1973, chicken farmers **gassed, drowned, and suffocated roughly one million baby chicks**.

**The mechanism:**

- Retail chicken prices: **controlled**
- Feed costs: *not controlled*
- Revenue capped along the grow-out path
- Small feed-cost increases $\rightarrow$ abandon "raise chicks" segment entirely

*"It's cheaper to drown 'em than to put 'em down and raise 'em."*

— AP, 1973

**Same pattern elsewhere:**

- Dairy farmers slaughtered cows
- Hog farmers culled breeding stock
- Temporarily $\uparrow$ meat, future $\downarrow$

**Corner solution**

Controls flattened returns across time.
Small cost wedges $\rightarrow$ **vertex**: all supply to "now," zero to "later."

# Supply-Chain Amplification

- Allocation rules designated priority end uses
- But policymakers **underestimated input–output linkages**

**Example: Propane $\rightarrow$ plastic pipe $\rightarrow$ oil wells**

- Oil production was prioritized
- Propane: essential for plastic piping used in oil extraction
- Plastics industry initially *lacked* priority designation
- Pipe shortages disrupted the very oil production that policy sought to protect

**Price controls metastasize**

Shortage-chaos $\rightarrow$ demand for quantity management $\rightarrow$ yield regulations, inventory mandates, bureaucratic allocation. Once prices can't do their job, "the market" delivers **corner outcomes with no welfare ordering**.

## Summary of Results

1. **Chaos Theorem:** Under price controls, equilibrium generically lands at **corners** where some markets are fully served and others get nothing. Small parameter changes cause discontinuous jumps.

2. **Robust Bounds:** Without assuming a demand functional form, misallocation losses can be bounded using only observed allocations, slope bounds, and a choke price. Sharp bounds are attained by piecewise-linear demands.

3. **Empirical Evidence:** In the 1973–74 gasoline crisis, misallocation losses were **1–9× the Harberger triangle**. The quantity reduction accounts for under one-third of total welfare cost.

*Whenever a ceiling fragments an integrated market—*

*gasoline, rental housing, agriculture, medical care—*

*the main cost is not the familiar triangle,*
*but the* ***hidden misallocation*** *behind it.*

Thank you.