Quotas in General Equilibrium

David Baqaee
UCLA

Kunal Sangani
Northwestern

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Quota Distortions

- Many policies / frictions directly constrain quantities without regard to prices.
  - E.g., import quotas, visa caps, zoning restrictions, emissions limits, local content requirements, land use ceilings, taxicab medallions.
  - Missing markets (land markets, credit markets, insurance markets).
- The classic approach to analyzing distortions is to recast them as implicit taxes.
- But mapping quotas to implicit taxes requires detailed info about economy.
- This paper: A general framework for analyzing economies with quota-like distortions.

Preview of Results

- Much like implicit taxes/wedges, quotas can decentralize any feasible allocation.
- But, economies with quotas are constrained eff. and obey macro-envelope conditions.
  - Comparative statics disciplined by simple sufficient statistics.
  - Not subject to Theory of Second Best.

Preview of Results

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- But, economies with quotas are constrained eff. and obey macro-envelope conditions.
  - Comparative statics disciplined by simple sufficient statistics.
  - Not subject to Theory of Second Best.
- How small quota changes and productivity shocks affect output.
- How large quota changes affect output (i.e., nonlinearities).
- Distance to the efficient frontier (misallocation cost of quotas).

Environment

- F factors in fixed supply, N goods produced with arbitrary neoclassical technologies.
- Representative consumer with homothetic preferences.
- Exogenous quota y_i^* on good i: $y_i \leq y_i^*$.
- Perfect competition given quotas, general equilibrium.
- Denote real GDP by Y.
- Much like wedges, quotas can decentralize any feasible, inefficient allocation.

Comparative Statics

- Unlike equilibria with wedges, equilibrium with quotas is constrained efficient.
- Comparative statics governed by simple sufficient statistics:

$$\frac{d\log Y}{d\log y_i^*} = \frac{rents_i}{GDP} = \Pi_i, \qquad \frac{d\log Y}{d\log TFP_i} = \frac{sales_i - rents_i}{GDP} = \lambda_i - \Pi_i.$$

where $rents_i$ are excess profits earned by producers that hold quota rights.

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- If equilibrium efficient, quotas non-binding ($\mathbf{\Pi} = 0$) and we recover Hulten (1978):

$$\frac{d\log Y}{d\log y_i^*} = 0, \qquad \frac{d\log Y}{d\log TFP_i} = \frac{sales_i}{GDP} = \lambda_i.$$

- Holding other quotas fixed, removing a quota always raises output.
  - Holding other wedges fixed, removing a wedge can lower output (Theory of 2nd Best).

Empirical Example: Zoning Restrictions on Single-Family Housing

- What are the gains from loosening zoning restrictions on single-family housing?

- To a first order, given by value of rights to build new single-family housing.
  - Gyourko and Krimmel (2021) isolate “zoning taxes” by comparing land value for parcels with rights to build new single-family housing to value of land with existing housing.

- Note: Efficiency gains expressed directly in terms of new units permitted.
  - Wedge approach would require mapping quantities into changes in effective zoning tax.

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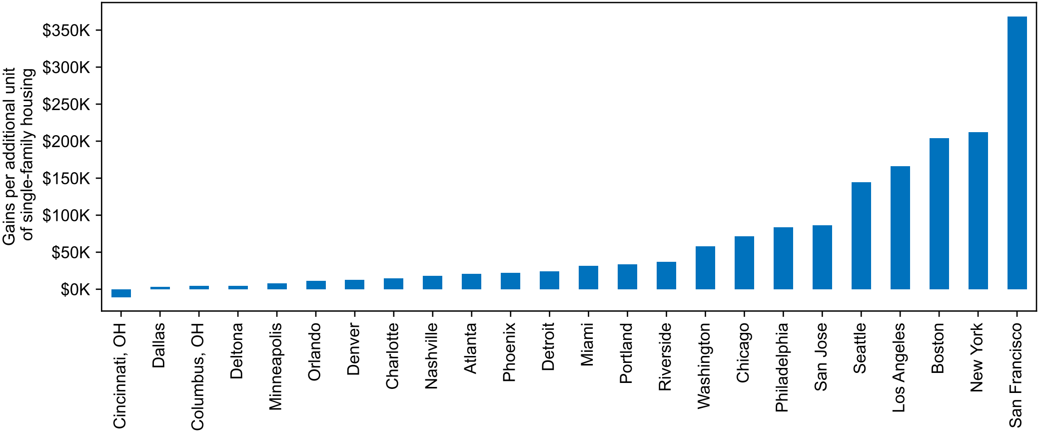

Nonlinearities

- What about the effects of a large liberalization?
- Since first-order effect depends on rents, nonlinearities depend on **change** in rents:

$$\Delta \log Y \approx \Pi_i \Delta \log y_i^* + \frac{1}{2} \underbrace{\frac{d\Pi_i}{d \log y_i^*}}_{\Delta \text{ rents}} (\Delta \log y_i^*)^2.$$

- If rents rise with quota, first-order approx. understates gains from large liberalization.
- Can solve for Δ rents using input-output network & elasticities. (à la Baqaee and Farhi 2019).
- Or obtain Δ rents from ex-post variation: Taxicab medallions in New York.

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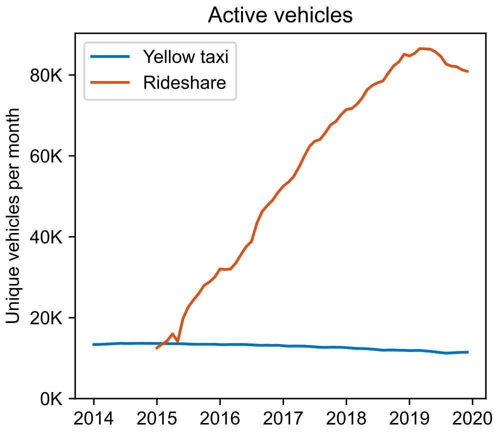
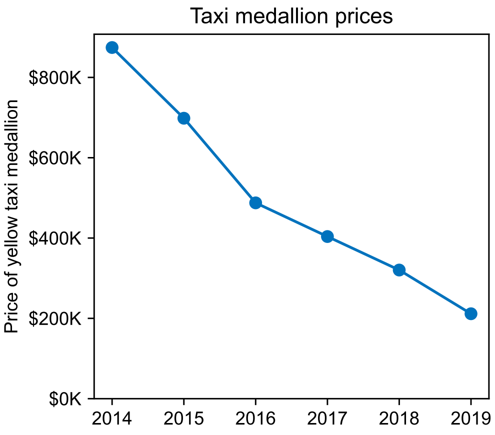
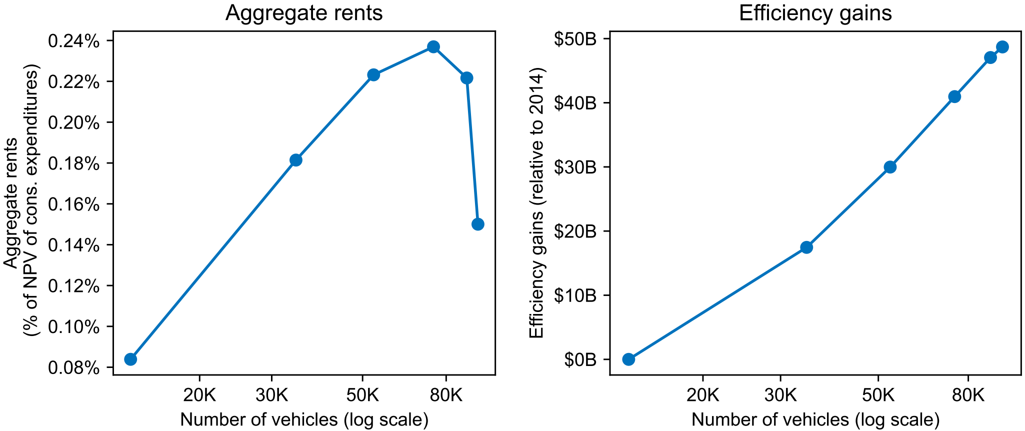
- Use arrival of rideshare apps in NYC to quantify gains from relaxing quota on cabs.





Nonlinearities: Taxicab Medallions

- Assume medallion price reflects NPV of steady-state rents (Π_i = NPV rents / wealth).
- Gains from relaxing taxicab quota are $\Delta \log Y_t \approx \left(\Pi_{it} + \frac{1}{2} d\Pi_{it}\right) \Delta \log y^*_{it}$.



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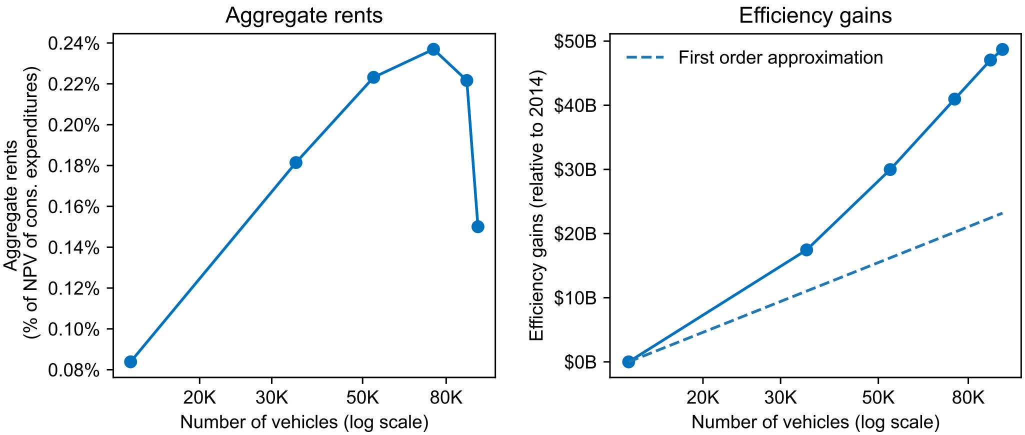

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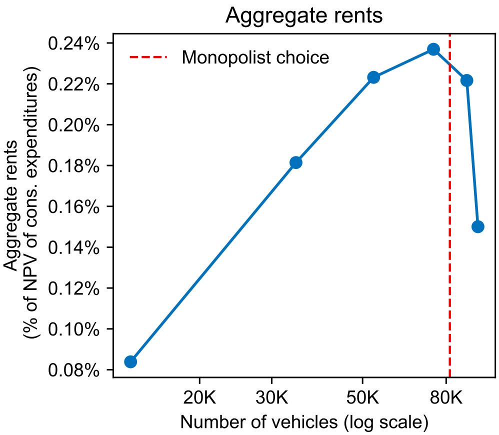

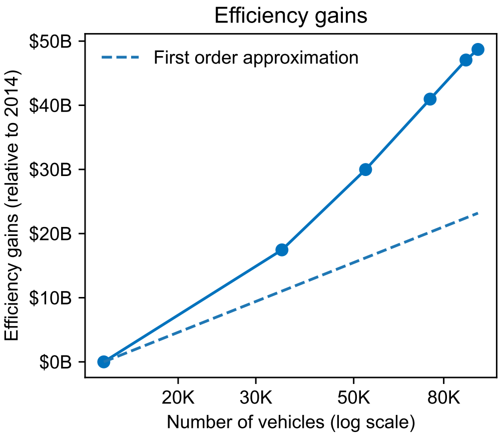

Empirical Example: Taxicab Medallions

- Gains from relaxing quota from 2014 to 2019 steady-state level.
  - Cumulating gains over each year: $\Delta \log Y \approx \sum_t \left(\Pi_{it} + \frac{1}{2} d\Pi_{it}\right) \Delta \log y_{it}^*$.

	Change from 2014–2019
Output gains	\$48.7B
Gains per New York MSA household	\$5,440
% of NPV of transportation expenditures	2.58%

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- To a first-order,

$$\Delta \log Y \approx p \frac{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^* (t)\, dt}{\int_0^\infty e^{-\int_0^t r(s)ds} dt}$$

  where p is the asset price.

- Asset price reflects steady-state rents.

Nonlinearities with Anticipated Path of Quota Changes

- Prior calculation assumes each year is a new steady-state.
- Suppose initial steady-state quota $\bar{y}$ and shock $\Delta y^*(t)$ that unfolds over time.
- To a second-order,

$$\Delta \log Y \approx p \frac{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^*(t)\, dt}{\int_0^\infty e^{-\int_0^t r(s)ds} dt} + \frac{1}{2} \Delta p \frac{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^*(t)^2\, dt}{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^*(t)\, dt},$$

  where p is the asset price, and Δp is change in asset price.
- Asset price reflects steady-state rents. Change in asset price reflects Δ rents.

Nonlinearities in Dynamic Environment

$$\Delta \log Y \approx p \frac{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^*(t)\, dt}{\int_0^\infty e^{-\int_0^t r(s)ds} dt} + \frac{1}{2} \Delta p \frac{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^*(t)^2\, dt}{\int_0^\infty e^{-\int_0^t r(s)ds} \Delta y^*(t)\, dt},$$

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- If quota changes fully anticipated, use observed $\Delta y^*(t)$ and asset price change.
- For one-time, persistent change $\Delta y^*(t) = \Delta y^*$, so formula becomes:

$$\Delta \log Y \approx p \Delta y^* + \frac{1}{2} \Delta p \Delta y^* \approx \Pi \Delta \log y^* + \frac{1}{2} \Delta \Pi \Delta \log y^*.$$

Thus, for a sequence of unanticipated, persistent quota changes (indexed by h'):

$$\Delta \log Y \approx \sum_0^h \left(\Pi(h') + \frac{1}{2} \Delta \Pi(h') \right) \Delta \log y^*(h').$$

where $\Pi(h)$ is market value of asset at h (i.e., earlier calculation is special case).

Empirical Example: Taxicab Medallions

- Gains from relaxing quota over 2014–2019.
  - Unanticipated: Cumulate gains over each year: $\Delta \log Y \approx \sum_t \left(\Pi_{it} + \frac{1}{2} d\Pi_{it}\right) \Delta \log y^*_{it}$.

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Distance to the Efficient Frontier

- What are gains from eliminating a quota altogether?

- To a second-order, gains are average of first-order effect at distorted pt and efficient pt:

$$\Delta \log Y \approx \frac{1}{2}\Pi_i(\Delta \log y_i^*) + \frac{1}{2}(0),$$

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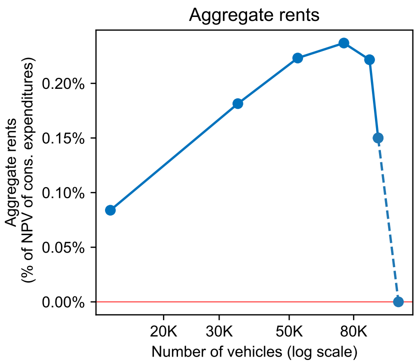

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- Estimate increase in quota necessary to decrease rents to zero.
- If rents fall quickly when quota relaxed, close to efficiency $\Rightarrow$ smaller gains.

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- Gains from relaxing quota over 2014–2019.
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- Not efficient at the end. What is the remaining distance to frontier?
  - Use elasticity of rents to quota in final year: $\Delta \log Y \approx \frac{1}{2} \Pi_i \left[- \frac{d \log \Pi_i}{d \log y^*_i} \right]^{-1}$.

	Change from 2014–2019		Distance
	Unanticipated	Anticipated	to frontier
Output gains	\$48.7B	\$61.0B	\$1.7B
Gains per New York MSA household	\$5,440	\$6,815	\$190
% of NPV of transportation expenditures	2.58%	3.23%	0.09%

Nonlinearities: Multiple Quotas

- Method scales up to multiple interacting quotas

$$\Delta \log Y \approx \mathbf{\Pi}' d \log \mathbf{y}^* + \frac{1}{2} (d \log \mathbf{y}^*)' \frac{d\mathbf{\Pi}}{d \log \mathbf{y}^*} (d \log \mathbf{y}^*),$$

- Quota demand system $\frac{d\mathbf{\Pi}}{d \log \mathbf{y}^*}$ summarizes responses of rents to quotas.

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- Similarly, gains from eliminating quotas simultaneously given by:

$$\Delta \log Y \approx -\frac{1}{2} \mathbf{\Pi}' \left[\frac{d\mathbf{\Pi}}{d \log \boldsymbol{y}^*} \right]^{-1} \mathbf{\Pi}.$$

- If *i*'s rents fall when *j*'s quota relaxed, then

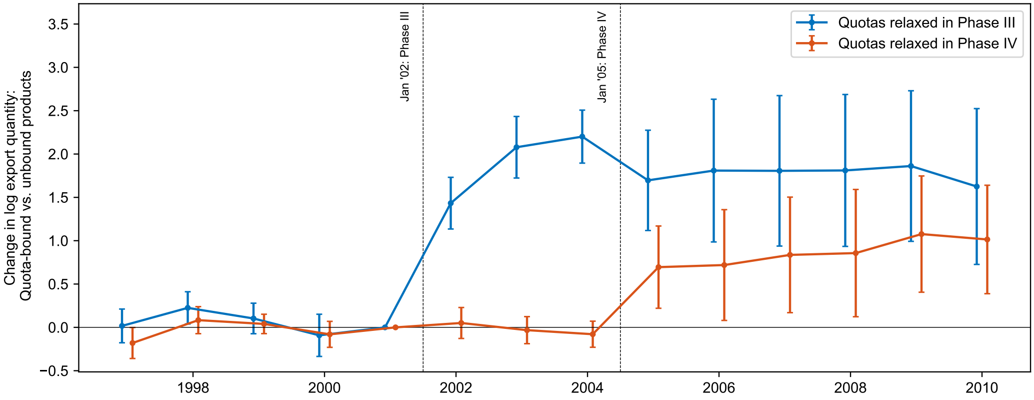
gains from relaxing both quotas $<$ sum of gains from relaxing each.

Empirical Example: China's Textile & Clothing Exports

- 1975–1994 Multi-Fiber Agreement capped China's textile & clothing exports to US, EU.
- Staged phase-out:
  - Jan 2002 (Phase III): Knit fabrics, gloves, dressing gowns, brassieres, etc.
  - Jan 2005 (Phase IV): Silk, wool, and cotton textiles, other apparel categories, etc.
- Obtain quota demand system using initial rents & response of exports to liberalization.
- Use quota auction prices for initial rents: $\Pi_{\text{Phase III}} = \$38\text{B}$, $\Pi_{\text{Phase IV}} = \$394\text{B}$.

Empirical Example: China's Textile & Clothing Exports

- Reaction of export quantities as quotas are removed.
- As second group liberalized, quantity of first group falls. (Nonlinear interaction.)



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- Estimated quota demand system:

$$\Pi = \begin{bmatrix} \Pi_{\text{Phase III}} \\ \Pi_{\text{Phase IV}} \end{bmatrix} = \begin{bmatrix} \$38\text{B} \\ \$394\text{B} \end{bmatrix}, \qquad \frac{d\log \mathbf{\Pi}}{d\log \mathbf{y}^*} = \begin{bmatrix} -0.472 & -0.200 \\ -0.019 & -1.258 \end{bmatrix}.$$

Intervention	Efficiency gains (2001 USD \$B)
(A) Relaxing Phase III quotas only	\$40

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Intervention	Efficiency gains (2001 USD $B)
(A) Relaxing Phase III quotas only	$40
(B) Relaxing Phase IV quotas only	$158

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(C) Relaxing both Phase III and IV quotas	$185

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Difference: $\text{C} - (\text{A} + \text{B})$	\$13

- Gains from relaxing both quotas $<$ sum of estimated gains from relaxing each.

Conclusion

- General framework for analyzing economies with quota distortions.
- Comparative statics simple because of constrained efficiency.
- Nonlinearities, distance to efficient frontier using quota demand system.
- Can be identified with local variation, e.g., response of rents to quota changes.
- Other applications in paper: H-1B visa cap, Argentina's capital controls.

Extra Slides

Distance to Frontier: Argentina's Capital Controls

- In September 2019, Argentina reimposed capital controls, restricting amount that households and firms could access foreign exchange markets.
- Restrictions led to decline in capital outflows from \$7.2B to $<$\$1.5B per month.
- What are the efficiency losses from these restrictions?
  - Permitted transactions take place at official exchange rate $\bar{e}$.
  - Unconstrained transactions take place at black-market exchange rate e.
  - Gap between $\bar{e}$ and e are profits earned by permit to exchange under controls.

Distance to Frontier: Argentina's Capital Controls

- Option 2: $\Delta \log Y \approx -\frac{1}{2}\Pi_i d \log y_{i^*} \approx -\frac{1}{2}(\log e/\bar{e})\, dy_{i^*}$.
  Measure distortion dy_{i^*} as gap relative to 2016–2019 outflows.

- Option 3: Elasticity of exchange rate to currency purchases, $\log e/\bar{e} = \theta\,(dy_i^*/\mathrm{GDP})$.
  Then, $\frac{\Delta Y}{\mathrm{GDP}} \approx -\frac{1}{2}\frac{1}{\theta}(\log e/\bar{e})^2$. (Blanchard et al. 2015, Adler et al. 2019.)

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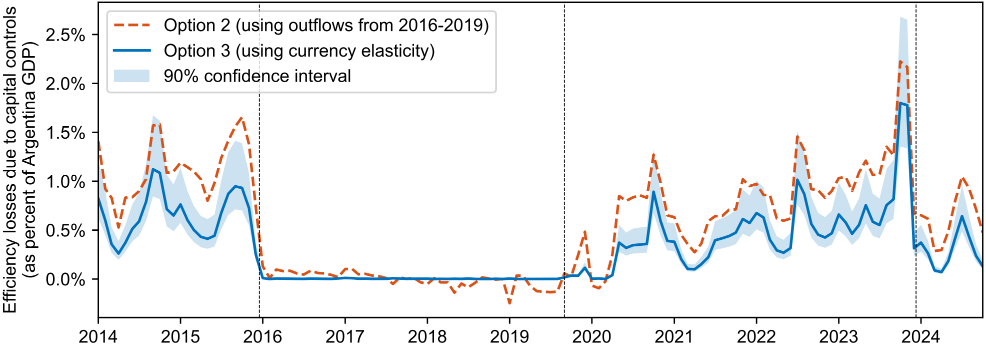
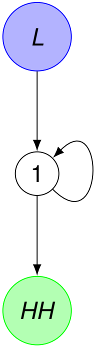


Selected Related Literature

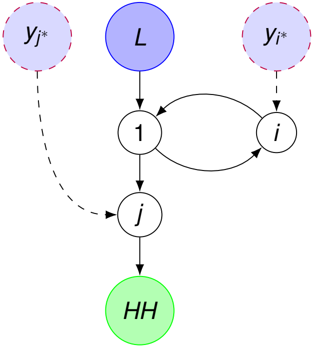
- **Misallocation with wedges.**
  - E.g., Harberger (1954), Basu and Fernald (2002), Chari et al. (2007), Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Petrin and Levinsohn (2012), Baqaee and Farhi (2020), Bigio and La'O (2020), Edmond et al. (2023).
- **Microeconomic shocks and aggregate efficiency.**
  - Efficient economies: Domar (1961), Hulten (1978), Foerster et al. (2011), Gabaix (2011), Acemoglu et al. (2012), Atalay (2017), Baqaee and Farhi (2019).
  - Inefficient economies: Baqaee (2018), Grassi (2017), Liu (2019), Reischer (2019), Baqaee and Farhi (2020), Buera and Trachter (2024).
- **Studies of specific quotas / quantity distortions.**
  - (*Trade*): Feenstra (1988), Feenstra (1992), Brambilla et al. (2010), Khandelwal et al. (2013), (*Housing*): Glaeser and Gyourko (2018), Hsieh and Moretti (2019).
- Less related: Public finance literature on using quotas vs. taxes to achieve policy objectives. (E.g., Weitzman 1974, Dasgupta and Stiglitz 1977).

Implementing an Allocation Using Quotas: Example

- Round-about economy. Feasible allocations: $\{(y_1, c_1, x_{11}) \mid c_1 + x_{11} \leq y_1 = F_1(L, x_{11})\}$.



(a) Original.



(b) With quotas.

- In fact, more general than wedges: can implement allocation when L, x_{11} are perfect substitutes / complements.

Matching observables in wedge and quota economies

- A given allocation can typically be implemented by many different sets of wedges.
- $\Rightarrow$ Same allocation implemented with wedges vs. quotas can differ in prices/profits.

Proposition (Matching observables in wedge and quota economies)

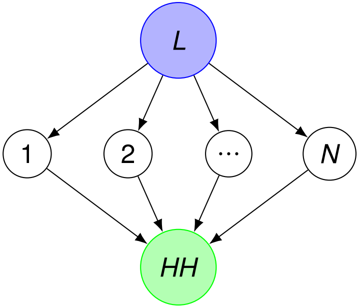
Consider an economy with quotas in which all producer prices p_i and factor wages w_f are strictly positive. Consider a second economy in which the same allocation of resources is implemented with wedges, τ.

If $\tau_i \geq 1$ for all i and, for each good or factor i, either the good is directly consumed by the household $c_i > 0$ or there exists some producer j such that $\partial F_j / \partial x_{ji} > 0$ and $\tau_j = 1$, then prices, sales, and profits are identical across the two economies.

- Intuition: Profits measured relative to one unconstrained user of each resource.

Illustrative Example 1: Reallocations Under Quotas vs. Wedges

Figure: Horizontal economy.



- Quotas: effect of relaxing quota on firm 1:

$$d \log Y = \Pi_1 d \log y_{1^*}.$$

Resources always come from unconstrained users.

- Wedges: effect of reducing τ_1 to increase output by $d \log y_1$ is

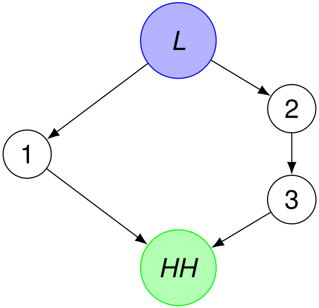
$$d \log Y = \Pi_1 d \log y_1 - \frac{L_1}{L - L_1}(\bar{\Pi} - \Pi_1) d \log y_1.$$

where $\bar{\Pi}$ is the economy-wide profit share.

- Resources reallocated from all other firms, including more distorted users. Need to know Π_1 relative to $\bar{\Pi}$.

Illustrative Example 2: Interdependent Producers

Figure: Interdependent firms.



- What are the gains from relaxing distortion on firm 2?
- Wedges:

$$\begin{aligned} d\log Y &= \sum_i \Pi_i \frac{\partial \log y_i}{\partial \log \tau_2} d\log \tau_2 \\ &= \theta \left[\Pi_1 - (\Pi_1 + \Pi_2 + \Pi_3)(L_1/L)\right] d\log \tau_2. \end{aligned}$$

- Reducing τ_2 not always beneficial, and comparing $\Pi_2 \lessgtr \Pi_1$ not sufficient to know whether beneficial.
- Quotas: Reducing distortion always increases output.

$$d\log Y = \Pi_2 d\log y_{2^*}.$$

Empirical Example 2: Zoning Restrictions on Single-Family Housing

- What are the gains from loosening zoning restrictions on single-family housing?

- To a first order, given by profits of rights to build new single-family housing.
  - Gyourko and Krimmel (2021) isolate “zoning taxes” by comparing land value for parcels with rights to build new single-family housing to value of land with existing housing.

- Note: Efficiency gains expressed directly in terms of new units permitted.
  - Wedge approach would require mapping quantities into changes in effective zoning tax.

- Applies even in economies with other (quantity-based) distortions.

Empirical Example 2: Zoning Restrictions on Single-Family Housing

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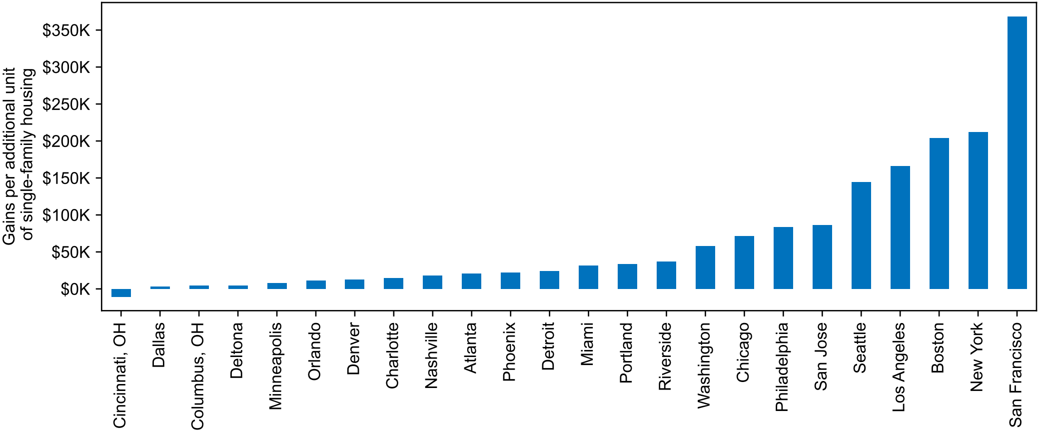


Special Case: Monopolist

- A tractable special case: Monopolist chooses output quota to maximize real profits.

Proposition (Nonlinearities with a Monopolist)

Suppose i produced by monopolist that chooses y_i to maximize real profits, taking all other quotas and production technologies as given. Then, effect of changes in the monopolist's quantity on output are

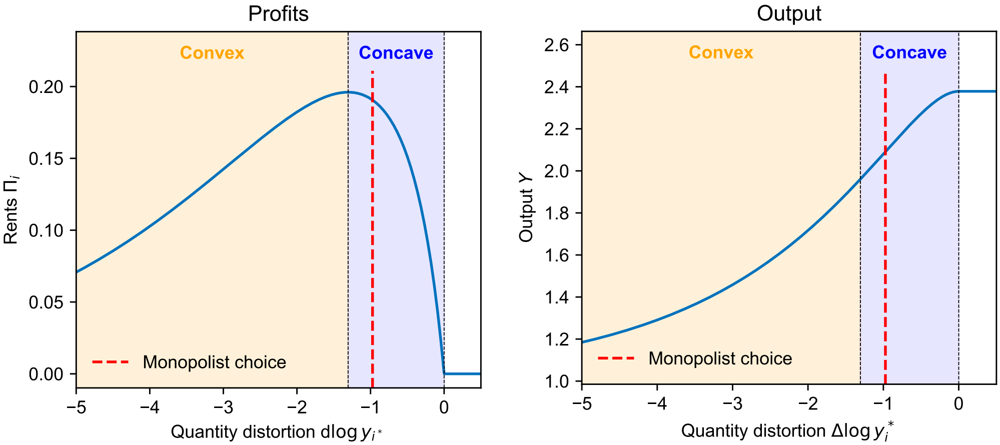
$$\Delta \log Y \approx \Pi_i d \log y_i - \frac{1}{2} \Pi_i^2 (d \log y_i)^2.$$

- Intuition: Monopolist's first-order condition determines response of profits to quantity.

- Profits sufficient to calculate how gains from increasing production peter out.

Illustration: Monopolist

- Monopolist always chooses quantity in concave region.



Illustrative Example: Multiple Quotas

- Consider horizontal economy. Response to changes in quotas on firms 1 and 2:

$$\Delta \log Y \approx \underbrace{\Pi_1 d\log y_{1^*} + \Pi_2 d\log y_{2^*}}_{\text{First order}}$$
$$+ \underbrace{(1/2)\left(H_{11}\left(d\log y_{1^*}\right)^2 + H_{22}\left(d\log y_{2^*}\right)^2 + 2H_{12}\left(d\log y_{1^*}\right)\left(d\log y_{2^*}\right)\right)}_{\text{Second order}}.$$

- H_{12} determines whether relaxing y_{1^*} amplifies/reduces gains from relaxing y_{2^*}.

- In horizontal economy, $H_{12} > 0$ if

$$\theta < 1 - \frac{(\lambda_1 - \Pi_1)(\lambda_2 - \Pi_2)}{(1 - \lambda_1 - \lambda_2)\Pi_1 \Pi_2}.$$

Necessary condition is that $\theta < 1$, i.e., outputs of firms 1 and 2 are complements.

Distance to Frontier: Argentina's Capital Controls

- In September 2019, Argentina reimposed capital controls, restricting amount that households and firms could access foreign exchange markets.
- Restrictions led to decline in capital outflows from \$7.2B to $<$\$1.5B per month.
- What are the efficiency losses from these restrictions?
  - Permitted transactions take place at official exchange rate $\bar{e}$.
  - Unconstrained transactions take place at black-market exchange rate e.
  - Gap between $\bar{e}$ and e are profits earned by permit to exchange under controls.

Distance to Frontier: Argentina's Capital Controls

- Applying "Option 2" for distance to the frontier:

$$\Delta \log Y \approx -\frac{1}{2}\Pi_i d \log y_i^* \approx -\frac{1}{2}\left(\log e/\bar{e}\right) dy_i^*.$$

- Measure distortion dy_i^* as gap relative to 2016–2019 outflows.

Distance to Frontier: Argentina's Capital Controls

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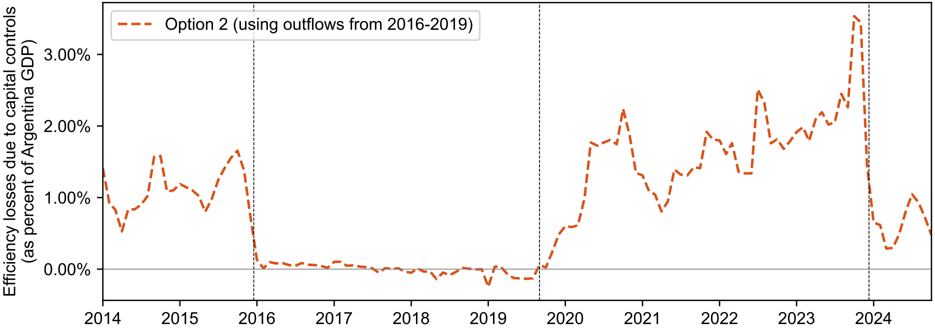

Vertical lines indicate end of capital controls (Dec 17 2015), reinstatement of capital controls (Sep 1 2019), and devaluation of peso (Dec 10 2023).

Distance to Frontier: Argentina's Capital Controls

- *Currency elasticity* θ: Depreciation in nominal exchange rates caused by purchases of foreign currency equal to one percent of GDP. (Blanchard et al. 2015; Adler et al. 2019).

- "Option 3" uses θ to estimate size of distortion dy_i^*:

$$\theta = \frac{\log e/\bar{e}}{dy_i^*/\text{GDP}} \qquad \Rightarrow \qquad \frac{\Delta Y}{\text{GDP}} \approx -\frac{1}{2}\frac{1}{\theta}\left(\log e/\bar{e}\right)^2 .$$

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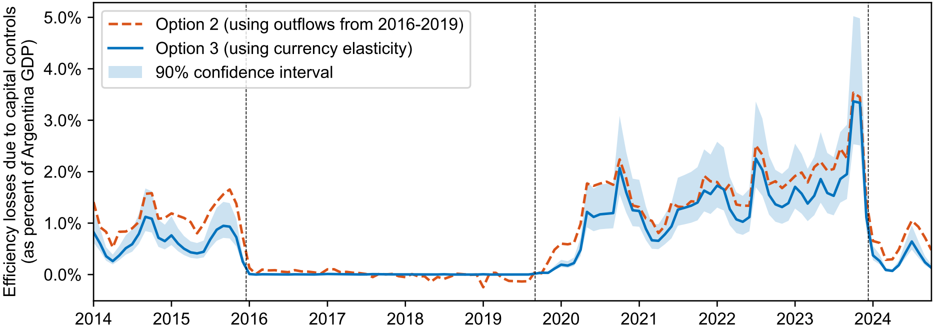

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Quota Demand System: China's Textile and Clothing Exports

- 1975–1994 Multi-Fiber Agreement capped China's textile & clothing exports to US, EU.
- Agreement to phase-out quotas from 1995–2005 as part of WTO Uruguay Round.
- Staged phase-out allows us to study interaction between quotas.
  - Most quotas removed in Jan 2002 (Phase III) and Jan 2005 (Phase IV).
  - Phase III: Knit fabrics, gloves, dressing gowns, brassieres, and textile luggage products.
  - Phase IV: Silk, wool, and cotton textiles, carpets, most apparel categories.

Quota Demand System: China's Textile and Clothing Exports

1. Use quota auction prices for initial quota profits.
2. Use response of export quantities to phase-out to recover quota demand system, H.
3. Use H to estimate gains from relaxing any subset of quotas.

Quota Demand System: China's Textile and Clothing Exports

1. Use quota auction prices for initial quota profits.
   - Market prices for quotas to export in each product category in 2001.
   - Quota profits for Phase III and Phase IV goods, $\Pi_{\text{Phase III}} = \$38\text{B}$, $\Pi_{\text{Phase IV}} = \$394\text{B}$.
2. Use response of export quantities to phase-out to recover quota demand system, H.
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Quota Demand System: China's Textile and Clothing Exports

1. Use quota auction prices for initial quota profits.

2. Use response of export quantities to phase-out to recover quota demand system, *H*.

   - Because profits go to zero when quotas are removed, *H* solves:

$$\Pi_{\text{Phase III}} = (d \log y^{\text{III}}_{\text{Phase III}})\, H_{11},$$
$$\Pi_{\text{Phase III}} = (d \log y^{\text{IV}}_{\text{Phase III}})\, H_{11} + (d \log y^{\text{IV}}_{\text{Phase IV}})\, H_{12},$$
$$\Pi_{\text{Phase IV}} = (d \log y^{\text{III}}_{\text{Phase IV}})\, H_{21} + (d \log y^{\text{IV}}_{\text{Phase IV}})\, H_{22},$$

     where $d \log y^{\text{III}}_x$ ($d \log y^{\text{IV}}_x$) is the change in exports for x goods following Phase III (IV).

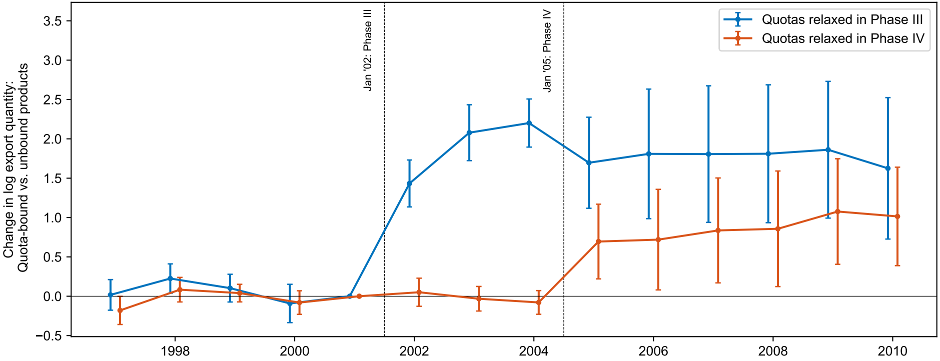
   - Symmetry implies $H_{12} = H_{21}$.

3. Use *H* to estimate gains from relaxing any subset of quotas.

Quota Demand System: China's Textile and Clothing Exports

$$\log y_{ict} = \beta_t^{\text{Phase III}} (\text{Binding}_c \times 1\{c \text{ quota relaxed in Phase III}\} \times 1\{\text{year} = t\})$$
$$+ \beta_t^{\text{Phase IV}} (\text{Binding}_c \times 1\{c \text{ quota relaxed in Phase IV}\} \times 1\{\text{year} = t\}) + \alpha_t + \delta_i + \varepsilon_{ict},$$

- E.g., $\beta_t^{\text{Phase III}}$ is change in Phase III good exports in t relative to unconstrained goods.



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1. Use quota auction prices for initial quota profits.
2. Use response of export quantities to phase-out to recover quota demand system, H.
3. Use H to estimate gains from relaxing any subset of quotas.
   - Estimated inverse quota demand system:

$$\Pi = \begin{bmatrix} \Pi_{\text{Phase III}} \\ \Pi_{\text{Phase IV}} \end{bmatrix} = \begin{bmatrix} \$38\text{B} \\ \$394\text{B} \end{bmatrix}, \qquad H = \begin{bmatrix} -17.9 & -7.6 \\ -7.6 & -495.6 \end{bmatrix}.$$

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Intervention	Efficiency gains (2001 USD $B)
(A) Relaxing Phase III quotas only	$40
(B) Relaxing Phase IV quotas only	$158
(C) Relaxing both Phase III and IV quotas	$185
Difference: $\text{C} - (\text{A} + \text{B})$	$13

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