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OPTIMAL GRADUALISM

IS GRADUALISM DESIRABLE?

- **Technology, trade, and reforms** might make everyone better off in long run…
- But create costly adjustment period for some workers

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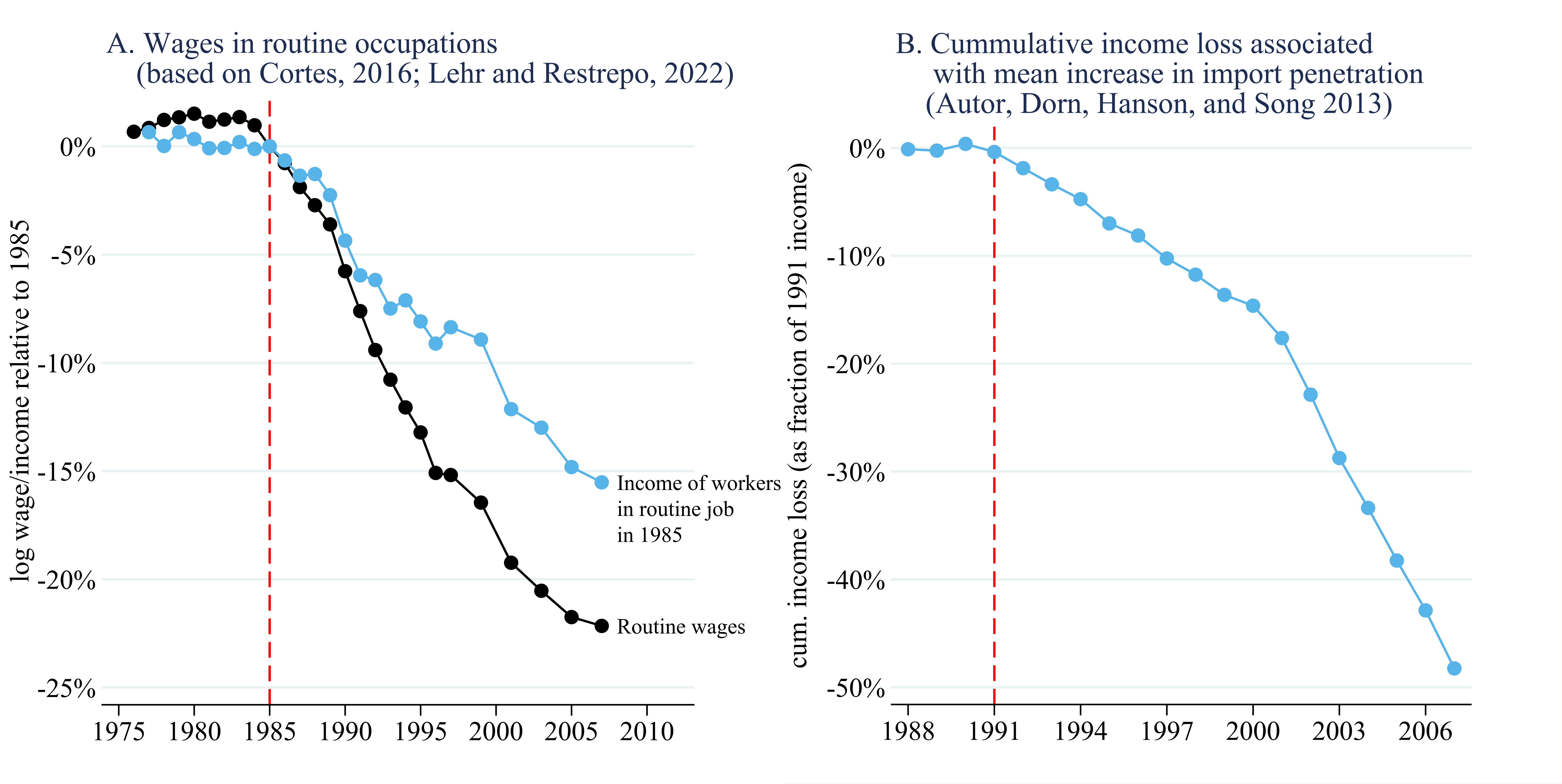

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Question 2: Does society benefit from slower technological progress?

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Yes. **Positive optimal tax in short run and zero tax in long run**
Even if (i) this crowds out reallocation effort
(ii) there are income-based assistance programs/taxes

Question 2: Does society benefit from slower technological progress?

Not in most cases, in particular **if optimal taxes in place**

THIS PAPER

- **Theory:** model of technological disruptions and formulas for optimal taxes
- **Empirical applications:**
  - **Routine jobs automation** (Cortes, 2016) and **China shock** (Autor et al. 2014)
  - calibrate model to match income decline for exposed workers
  - optimal policy calls for temporary taxes of 10%, phased out over time
  - **Colombia's 1990 trade liberalization**: optimal reform more gradual

A MODEL OF TECHNOLOGICAL DISRUPTIONS

- Small open economy with r fixed
- Mass 1 of workers with ℓ_x allocated to island $x \in \mathcal{X}$ (jobs, products, occupation)
- Final good produced by combining islands' output
- Initial steady state with common wage $\bar{w} = 1$ across islands
- At time $t = 0$, new technology arrives. For $x \in \mathcal{D}$, good x can be replaced by k_x produced (or exchanged) for $1/A_{x,t}$ units of final good
- Government sets tax $\tau_{x,t}$ on new technology and does lump-sum rebate T_t
- Workers in $x \in \mathcal{D}$ reallocate at Poisson rate α_x

A MODEL OF TECHNOLOGICAL DISRUPTIONS

Final good $$y_t = f(\{y_{x,t}\}_{x \in \mathscr{X}})$$

Disrupted islands $$y_{x,t} = \ell_{x,t} + k_{x,t}, \quad w_{x,t} = (1 + \tau_{x,t})/A_{x,t} \text{ if } x \in \mathscr{D}$$

Other islands $$y_{x,t} = \ell_{x,t} \text{ if } x \notin \mathscr{D}$$

Reallocation $$\dot{\ell}_{x,t} = -\alpha_x \cdot \ell_{x,t} \text{ if } x \in \mathscr{D}$$

Resource constraint $$y_t = C_t + \sum_{x \in \mathscr{D}} (k_{x,t}/A_{x,t}),$$

Indirect utility $$U_{x,0} = \mathscr{U}_x \left(\{w_{x,t} + T_t, w_t + T_t\}_{t=0}^{\infty}, a_{x,0}; \alpha_x \right) - \kappa(\alpha_x)$$

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⇒assume single undisrupted island with $\ell_t = 1 - \sum_{x \in \mathcal{D}} \ell_{x,t}$ and wage w_t

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OPTIMAL POLICY

Objective: Pick $\{\tau_{x,t}\}_{t=0}^{\infty}$ to maximize welfare along transition $\int_h \mathscr{W}(U_h) \cdot dh$

Definition: $\chi_{x,t}$ = **marginal social value of income** at island x time t per worker

- For disrupted islands, this can be computed as

$$\chi_{x,t} = g_x \cdot e^{-\rho t} \cdot u'(c_{x,d,t})$$

- For undisrupted island, this can be computed as

$$\chi_t = \frac{\ell_0}{\ell_t} \cdot g \cdot e^{-\rho t} \cdot u'(c_t) + \sum_{x \in \mathscr{D}} (1 - e^{-\alpha_x t}) \cdot \frac{\ell_{x,0}}{\ell_t} \cdot g_x \cdot e^{-\rho t} \cdot \mathbb{E}[u'(c_{x,t,t_r}) \,|\, t_r < t]$$

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Consumption disrupted hhs that have not reallocated

Pareto weight for hhs initially at x

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Pareto weight for undisrupted hhs

Consumption for undisrupted hhs

Consumption for disrupted hhs that reallocated at t_r

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OPTIMAL POLICY

Key Lemma: a variation in taxes that induces a change in wages $\{dw_{x,t}\}$ and the utilization of the new technology by $\{dk_{x,t}\}$ changes welfare by

$$dW_0^{reform} = \int_0^\infty \bar{\chi}_t \cdot \left(\underbrace{\sum_x \tau_{x,t} \cdot \frac{dk_{x,t}}{A_{x,t}}} + \underbrace{\sum_x \ell_{x,t} \cdot \left(\frac{\chi_{x,t}}{\bar{\chi}_t} - 1 \right) \cdot dw_{x,t}} \right) \cdot dt$$

Aggregate efficiency (fiscal externality)

Distributional considerations

OPTIMAL TAX WITH EXOGENOUS REALLOCATION

Proposition 1: Let $m_{x,t} = k_{x,t}/A_t$. Optimal tax sequence with exogenous α_x satisfies

$$\tau^*_{x',t} = \sum_x \frac{\ell_{x,t} \cdot w_{x,t}}{m_{x',t}} \cdot \left(\frac{\chi_{x,t}}{\bar{\chi}_t} - 1 \right) \cdot \left(- \frac{d \ln w_{x,t}}{d \ln k_{x',t}} \right)$$

Intuition: Reducing $k_{x,t}$ leads to **decline in income via fiscal externality (LHS)**

vs **distributional gains from change in wages (RHS)**

OPTIMAL TAX WITH EXOGENOUS REALLOCATION

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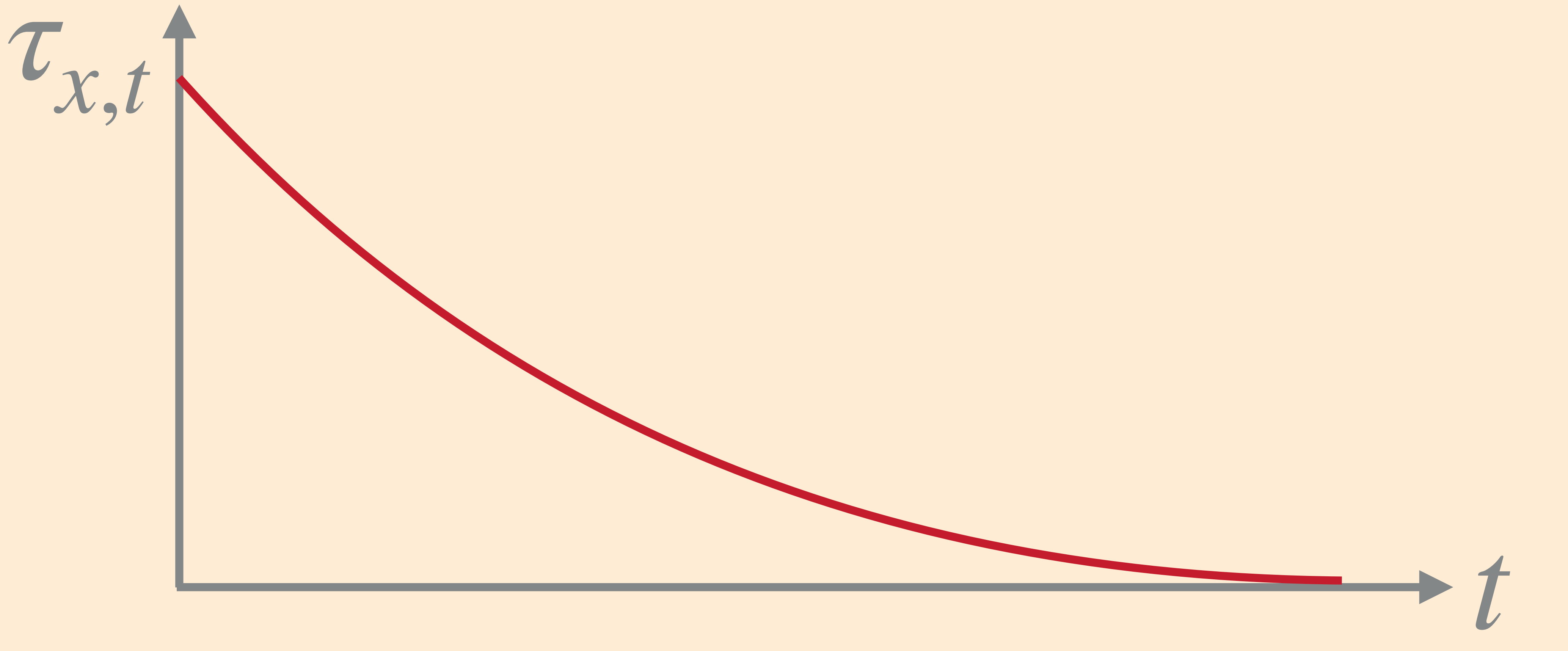
1 **Force towards gradualism:** benefits from reducing future use of new tech small

Long run: $\ell_{x,t} \to 0$ implies $\tau_{x,t} \to 0$

Optimal tax for immediate shock



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2 **Force towards higher taxes:** distributional considerations summarized by χ's

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3 **Force towards higher taxes:** large negative elasticity of wages of disrupted workers wrt technology utilization

OPTIMAL TAX WITH ENDOGENOUS REALLOCATION EFFORT

Proposition 2: Optimal tax sequence with endogenous α_x satisfies

$$\tau^*_{x',t} = \sum_x \frac{\ell_{x,t} \cdot w_{x,t}}{m_{x',t}} \cdot \left(\frac{\chi^{end}_{x,t}}{\bar{\chi}^{end}_t} - 1 \right) \cdot \left(- \frac{d \ln w_{x,t}}{d \ln k_{x',t}} \right)$$

$\chi^{end}_{x,t}$ and χ^{end}_t account for **reduced incentives for reallocation**

$$\chi^{end}_{x,t} \approx \chi_{x,t} + \mu_x \cdot \varepsilon \cdot \mathcal{U}_{x,\alpha,d,t}$$

$$\chi^{end}_t \approx \chi_t + \sum_{x \in \mathcal{D}} (\ell_{x,0}/\ell_t) \cdot \mu_x \cdot \varepsilon \cdot \mathcal{U}_{x,\alpha,n,t}$$

- $\mathcal{U}_{x,\alpha,d,t} < 0$ and $\mathcal{U}_{x,\alpha,n,t} > 0$: adverse incentives from redistribution
- ε: responsiveness reallocation effort α_x
- $\mu_x \geq 0$: social value of reallocation

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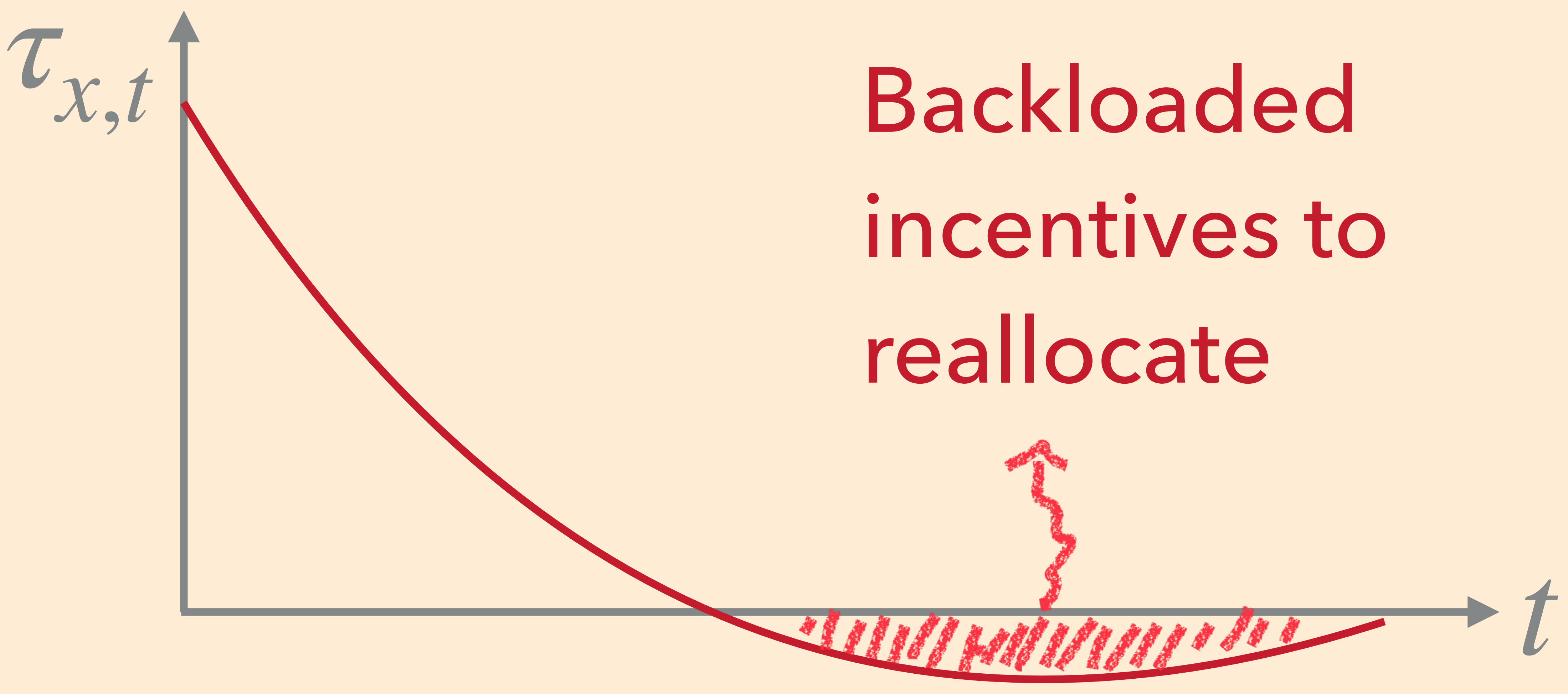
Optimal tax for immediate shock



OPTIMAL TAX WITH OTHER GOVERNMENT TOOLS

- Income taxes and assistance programs with marginal tax rate $\mathscr{R}_t \in [0,1]$
- Endogenous work effort $n_{x,t}$ responds with elasticity ε_ℓ

Proposition 3: When income taxes are available, optimal tax sequence satisfies*

$$\tau^*_{x',t} - \mathscr{R}^*_t \cdot \varepsilon_\ell \cdot \frac{d \ln \text{avg wage}}{d \ln k_{x',t}} = (1 - \mathscr{R}^*_t) \cdot \left[\sum_x \frac{\ell_{x,t} \cdot n_{x,t} \cdot w_{x,t}}{m_{x',t}} \cdot \left(\frac{\chi_{x,t}}{\bar{\chi}_t} - 1 \right) \cdot \left(-\frac{d \ln w_{x,t}}{d \ln k_{x',t}} \right) \right]$$

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Dampened distributional considerations

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Dampened distributional considerations

- If $\varepsilon_\ell > 0,$ taxing tech has tagging value (Naito,1999; Costinot-Werning, 2023)
- **Note:** Formula for $\mathscr{R}^*_t$ in paper (as in Tsyvinski-Werquin 2017)

TAX IT DON'T TRASH IT

- Slower path for $A_{x,t}$ does not lead to higher welfare
- Start from undistorted allocation with $\tau_{x',t} = 0$:
  - Perturbation 1: reducing $k_{x',t}$ via taxes

$$\text{Welfare change} \propto -\tau_{x',t} + \sum_x \frac{\ell_{x,t} \cdot w_{x,t}}{m_{x',t}} \cdot \left(\frac{\chi_{x,t}}{\bar{\chi}_t} - 1 \right) \cdot \left(-\frac{d \ln w_{x,t}}{d \ln k_{x',t}} \right)$$

  - Perturbation 2: reduction in $A_{x',t}$

$$\text{Welfare change} \propto -1 + \sum_x \frac{\ell_{x,t} \cdot w_{x,t}}{m_{x',t}} \cdot \left(\frac{\chi_{x,t}}{\bar{\chi}_t} - 1 \right) \cdot \left(-\frac{d \ln w_{x,t}}{d \ln A_{x',t}} \right)$$

- Faster increase in $A_{x,t}$ always welcomed if optimal taxes in place.

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Second-order fiscal externality on AE

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  - Perturbation 2: reduction in $A_{x',t}$

First-order reduction in AE

$$\text{Welfare change} \propto -1 + \sum_x \frac{\ell_{x,t} \cdot w_{x,t}}{m_{x',t}} \cdot \left(\frac{\chi_{x,t}}{\bar{\chi}_t} - 1 \right) \cdot \left(-\frac{d \ln w_{x,t}}{d \ln A_{x',t}} \right)$$

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APPLICATIONS

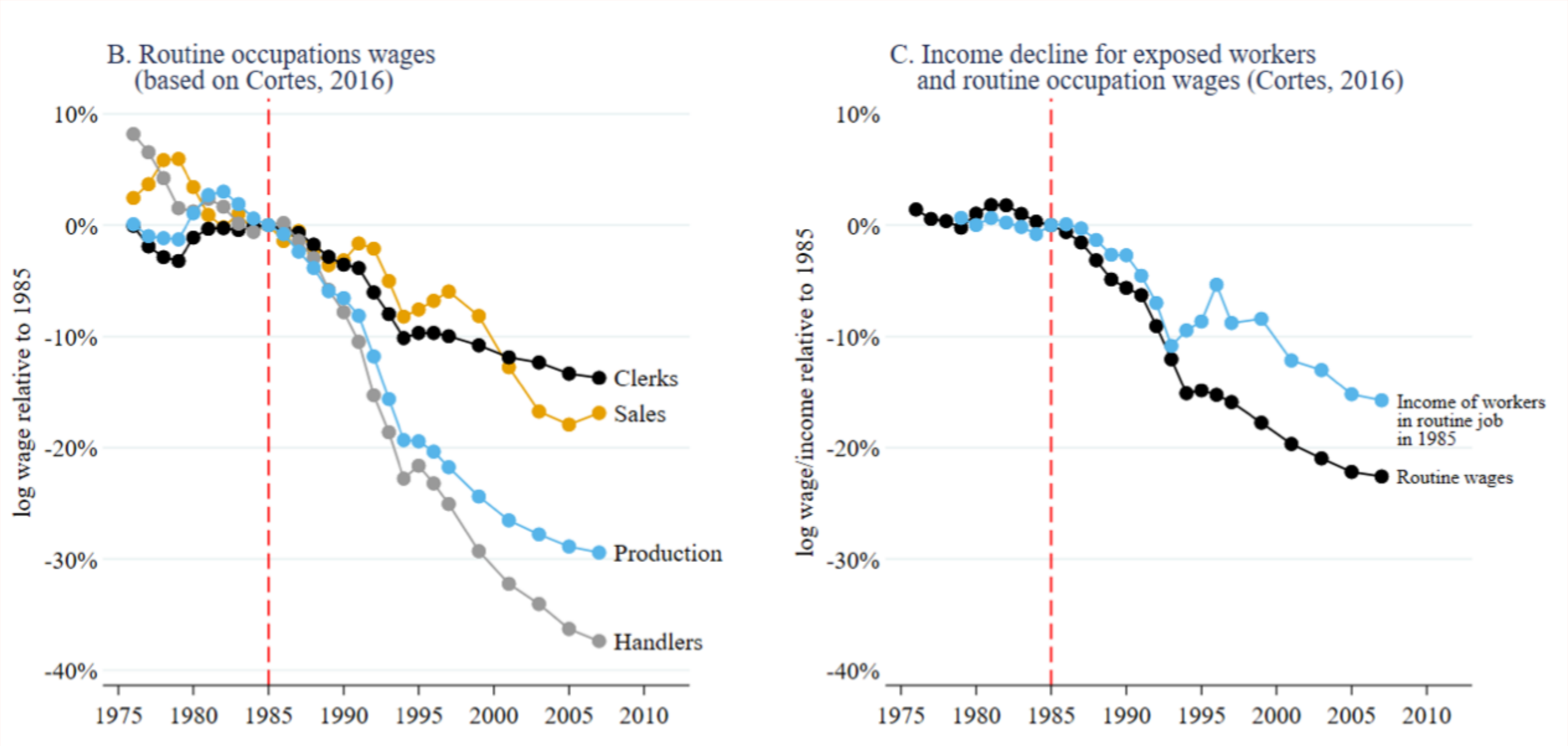
Automation of routine jobs

The China Shock

Colombia's trade liberalization

THE AUTOMATION OF ROUTINE JOBS

- Using PSID, **Cortes (2016)** documents wage decline in routine jobs since 1985.
- And large incidence on workers who held these jobs in 1985 (blue line on right).

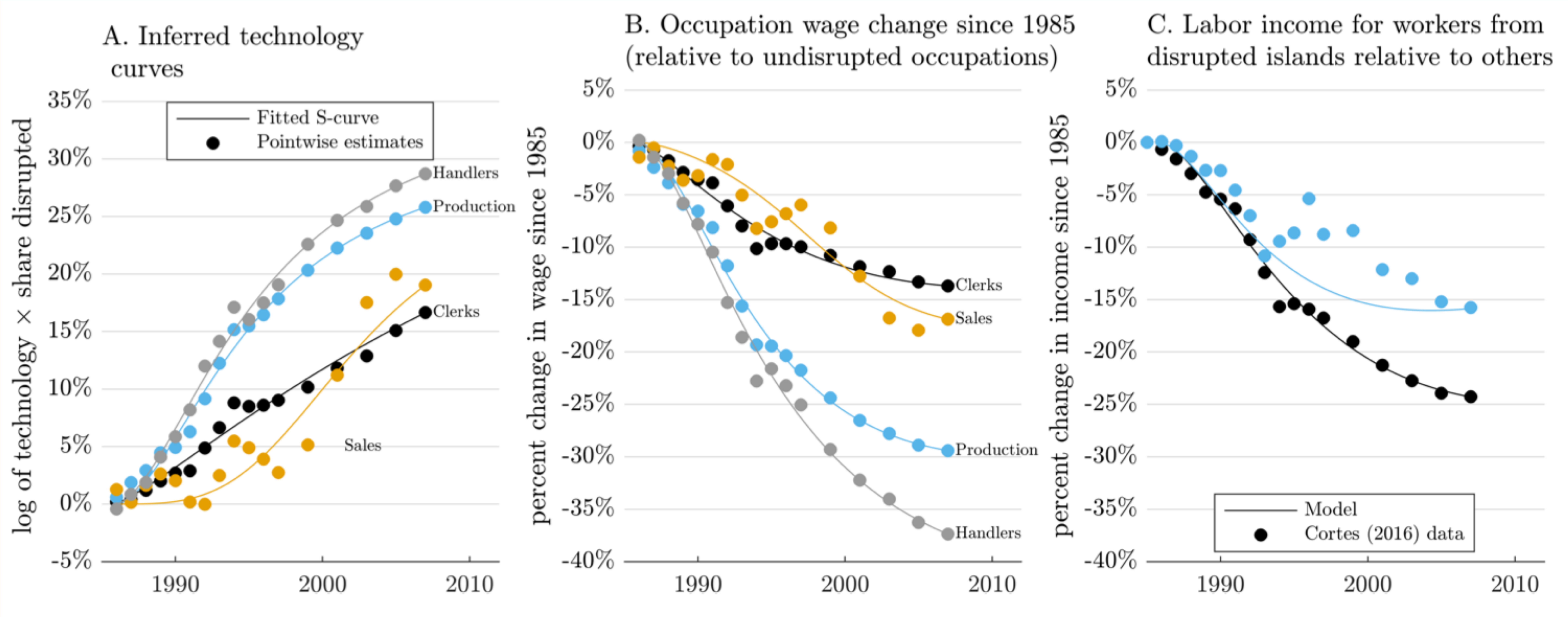


THE AUTOMATION OF ROUTINE JOBS

- Output is CES of islands with elasticity of substitution $\sigma = 0.85$ (Goos et al. 2014)
- 4 disrupted islands. Island $x \in \mathscr{D}$ represents the share $s_{o(x)}$ of jobs in occupation $o(x)$ (sales, clerks, production, material handling) being replaced.
- $s_{o(x)}, A_{x,t}, \alpha$ jointly calibrated to match:
  1. estimates of cost-saving gains of 30% (Acemoglu-Restrepo, 2020) $\Rightarrow A_{x,2007}$
  2. path for occupational wages in Cortes (2016) $\Rightarrow A_{x,t}, s_{o(x)}$
  3. average incidence of 70% across routine jobs from Cortes (2016) $\Rightarrow \alpha = 2.7\,\%$
- Remaining parameters: $r = \rho = 5\,\%$; inverse IES of 2.

THE AUTOMATION OF ROUTINE JOBS

- Model reproduces all the key moments in Cortes (2016) for income and wages:



THE AUTOMATION OF ROUTINE JOBS

- Consumption paths (relevant for policy) obtained from model in four scenarios:

  I. hand-to-mouth

  II. shared transition risk but no borrowing/saving outside initial island

  III. borrowing/saving but transition risk

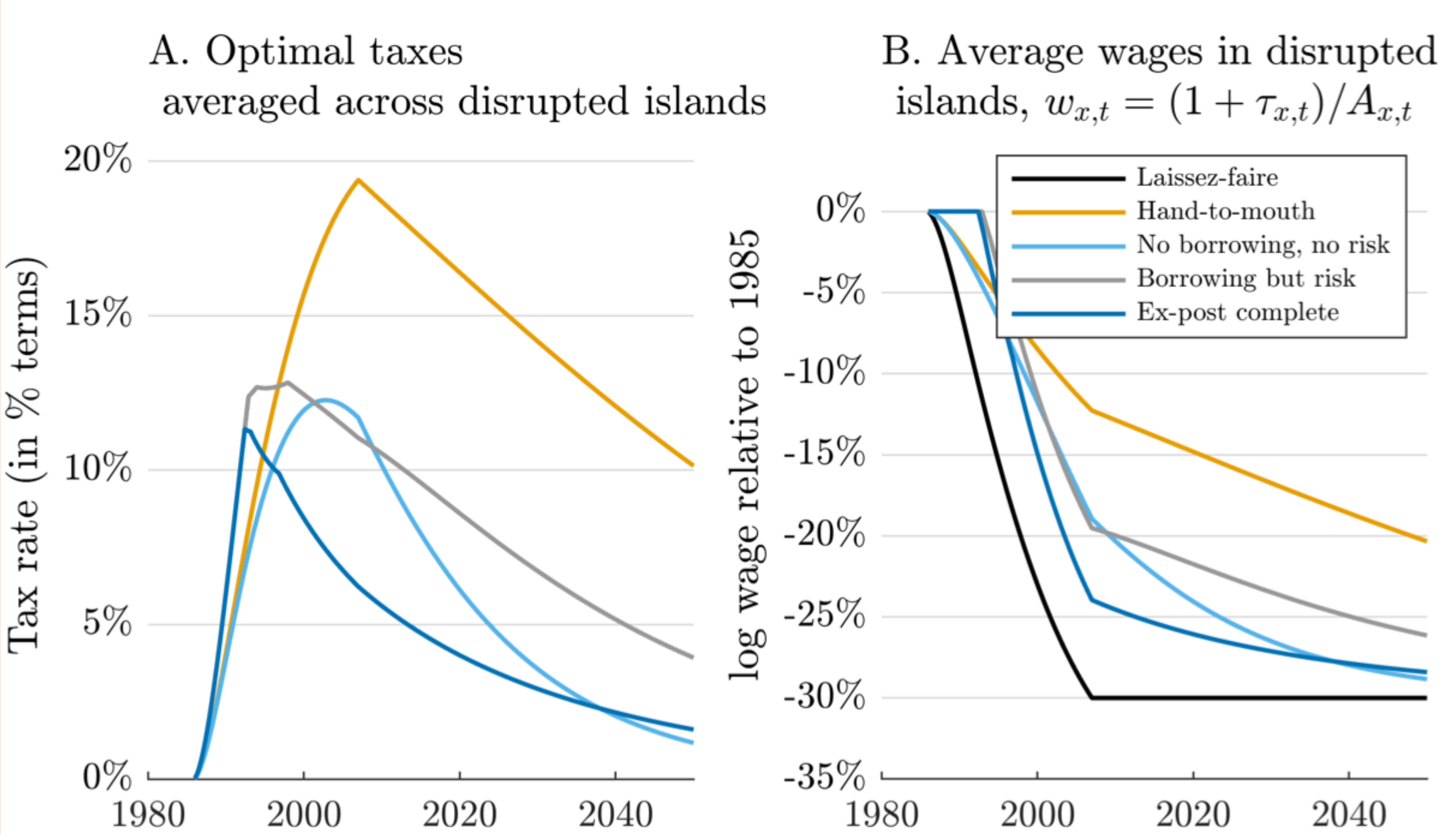
  IV. ex-post complete markets

- Last two scenarios assume zero initial assets (Kaplan et al. 2017)

- Scenarios illustrate sources of welfare gains from distorting automation/trade (as in decomposition by Dávila-Schaab, 2022)

THE AUTOMATION OF ROUTINE JOBS

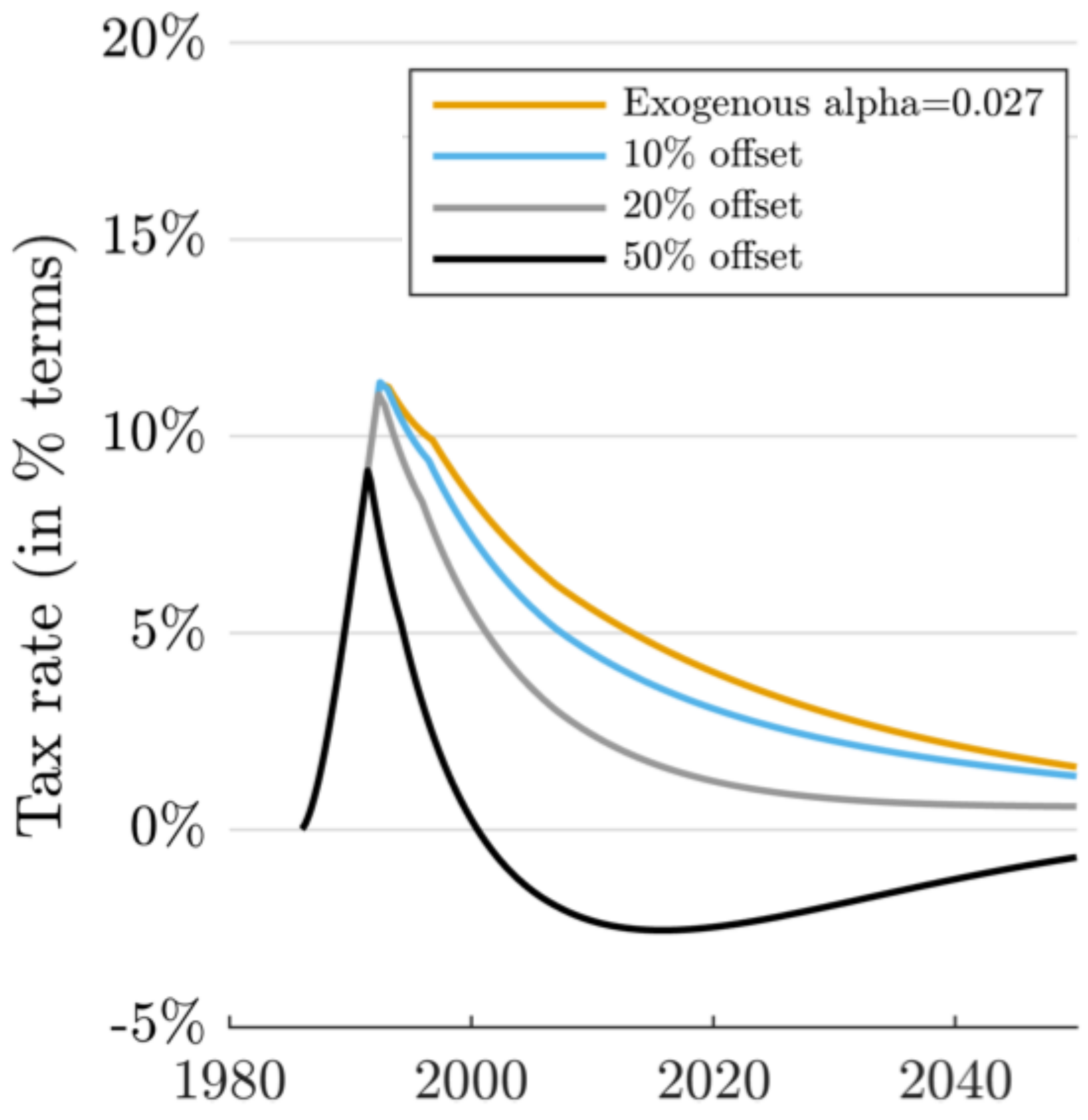
- **Optimal taxes with exogenous effort**
  - Optimal short run tax of 10–18%
  - Large welfare gains for disrupted households (from 5-7% loss under LF to 1–2% with optimal tax)
  - Optimal to delay when hhs can save



THE AUTOMATION OF ROUTINE JOBS

- Optimal tax with **endogenous effort** and different levels of *offset*

Optimal tax (ex-post complete markets)



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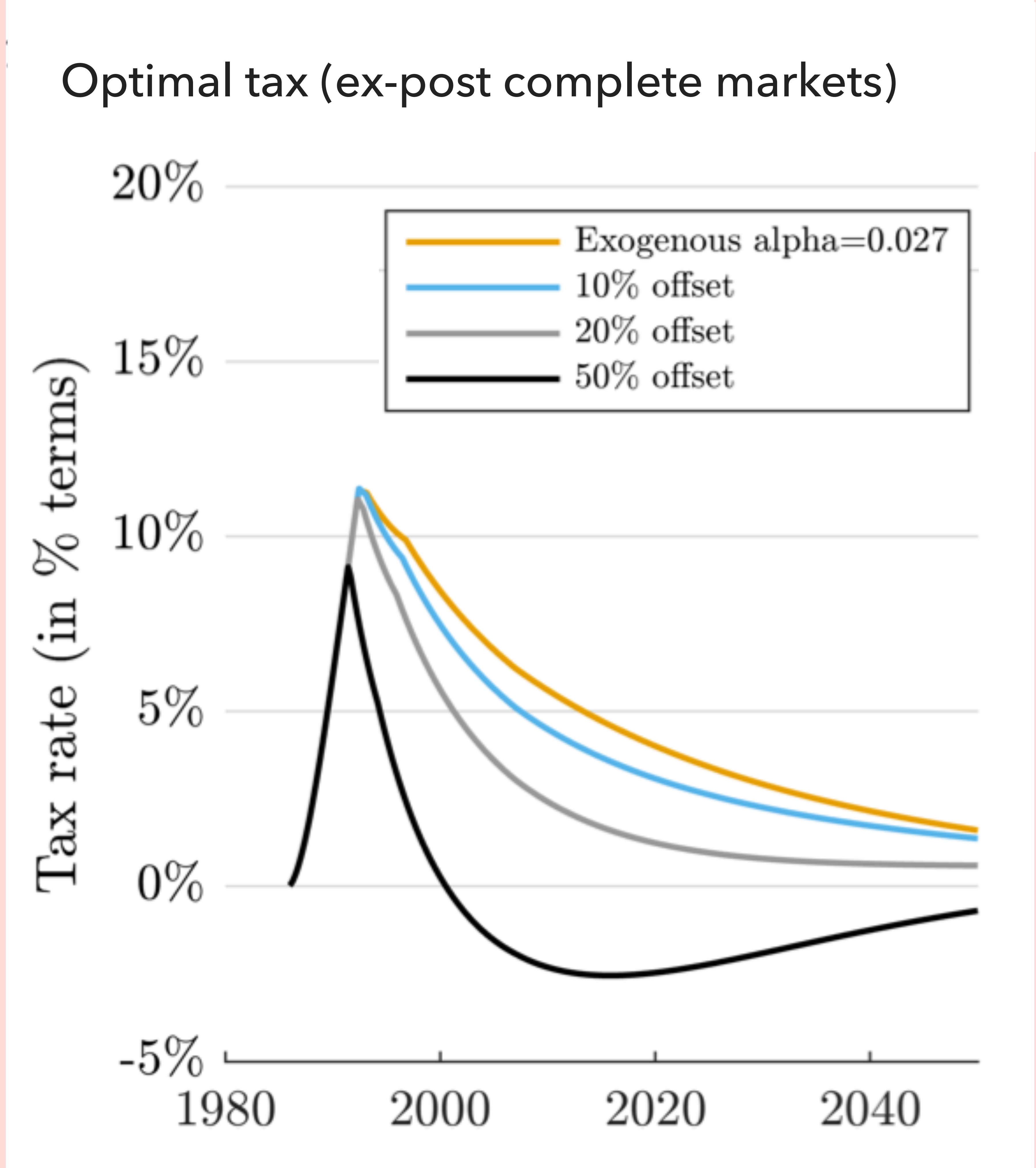
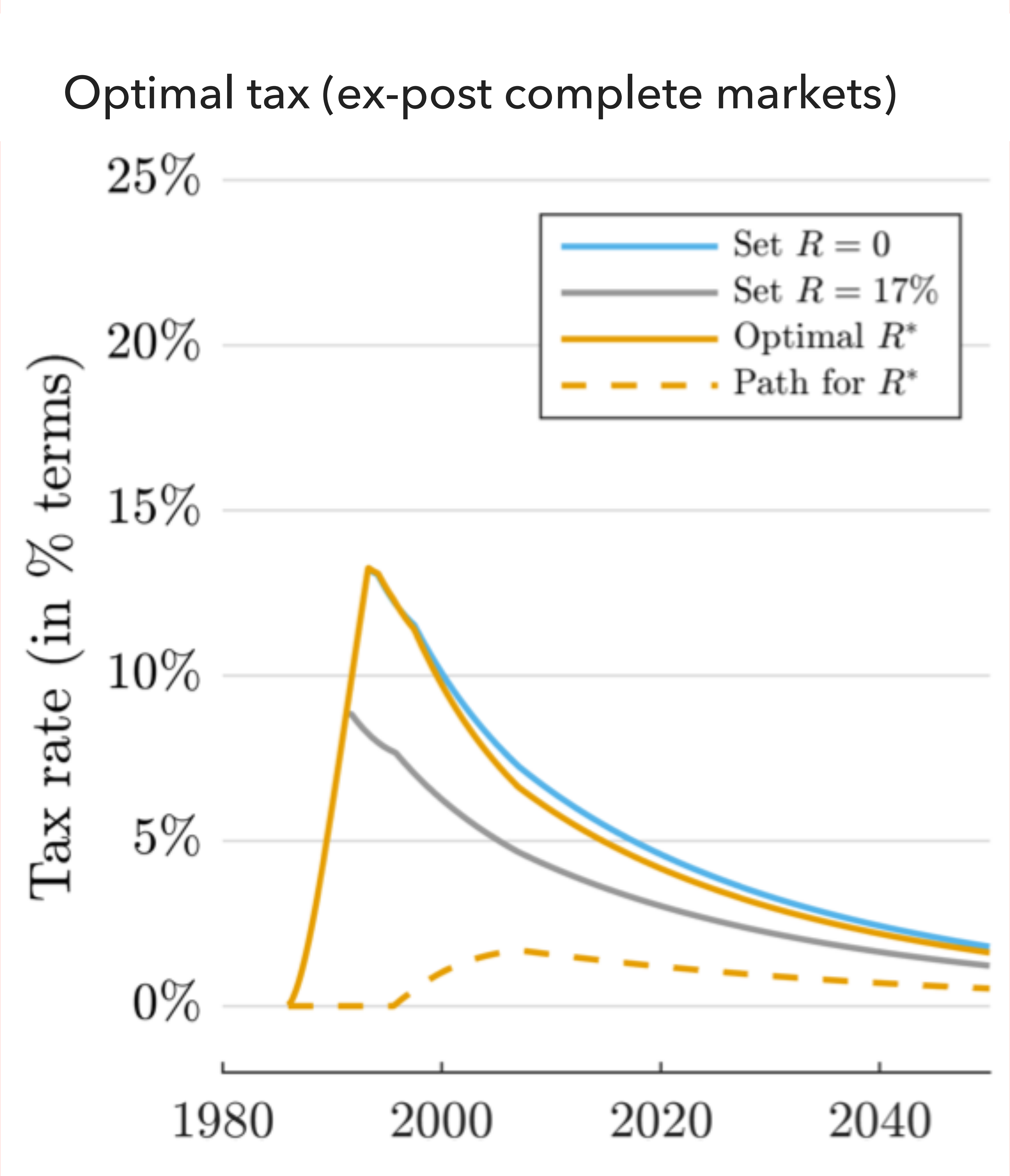


- Optimal tax with **progressive taxes and assistance programs** ($\varepsilon_\ell = 0.35$)



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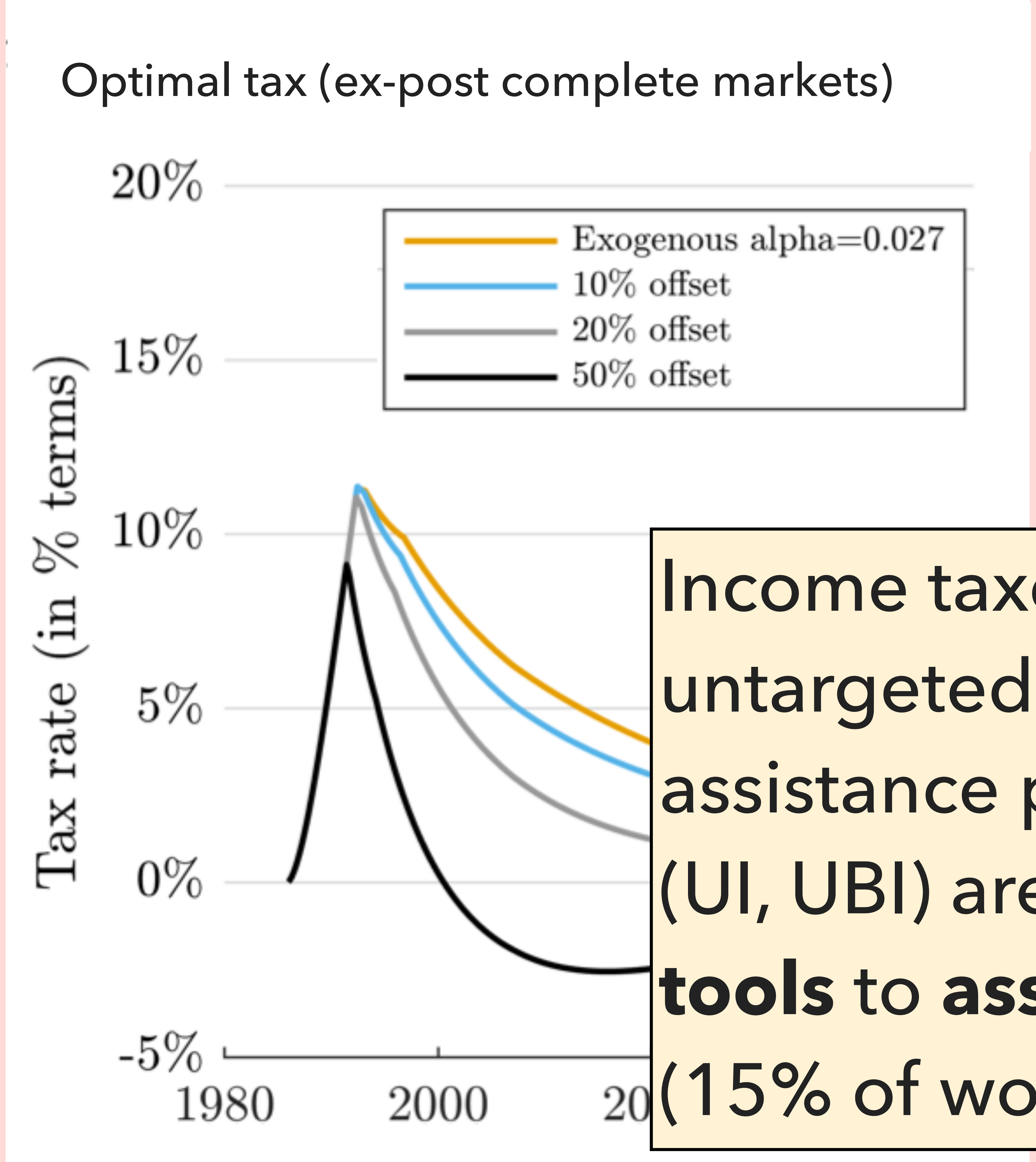

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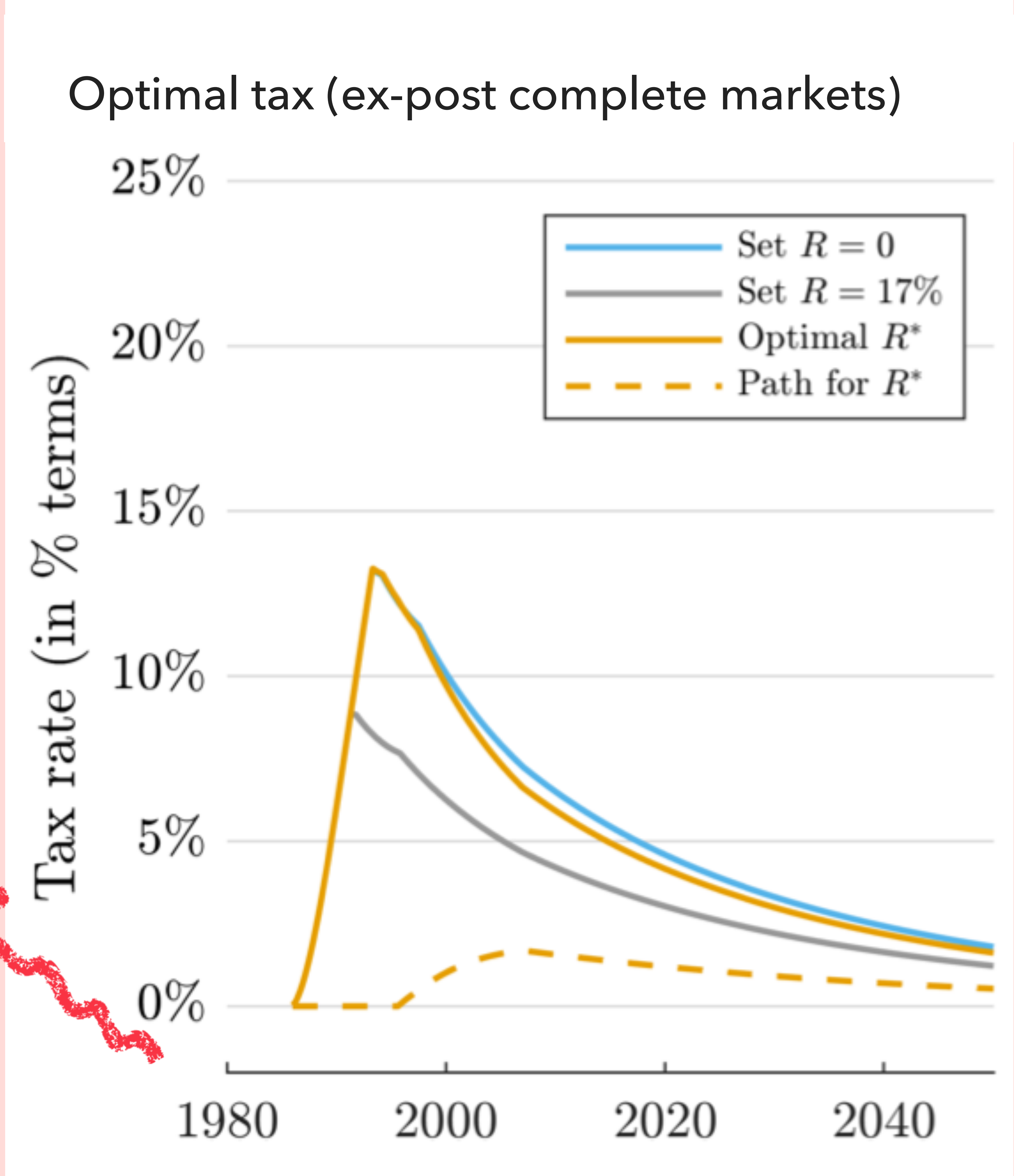
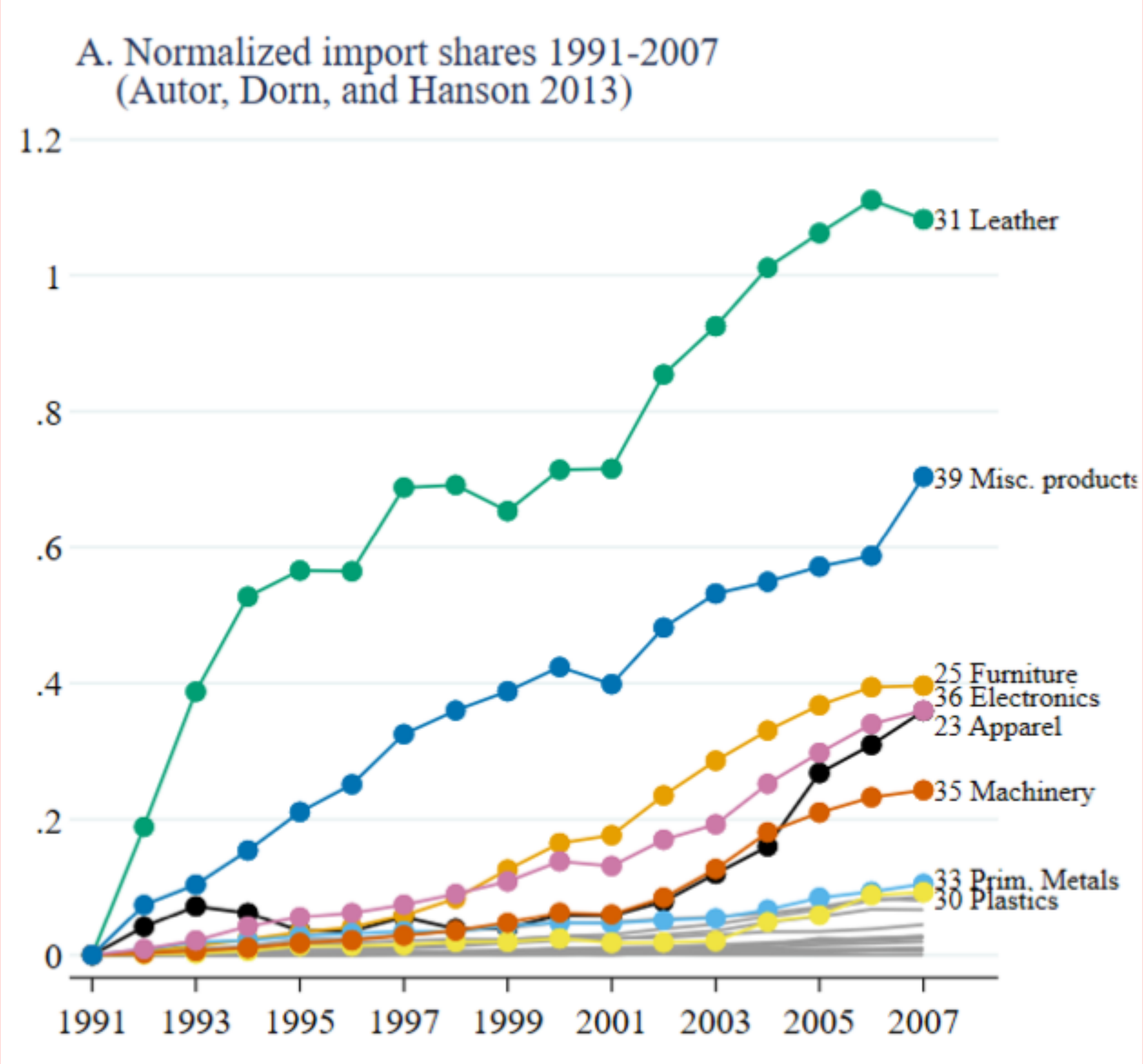
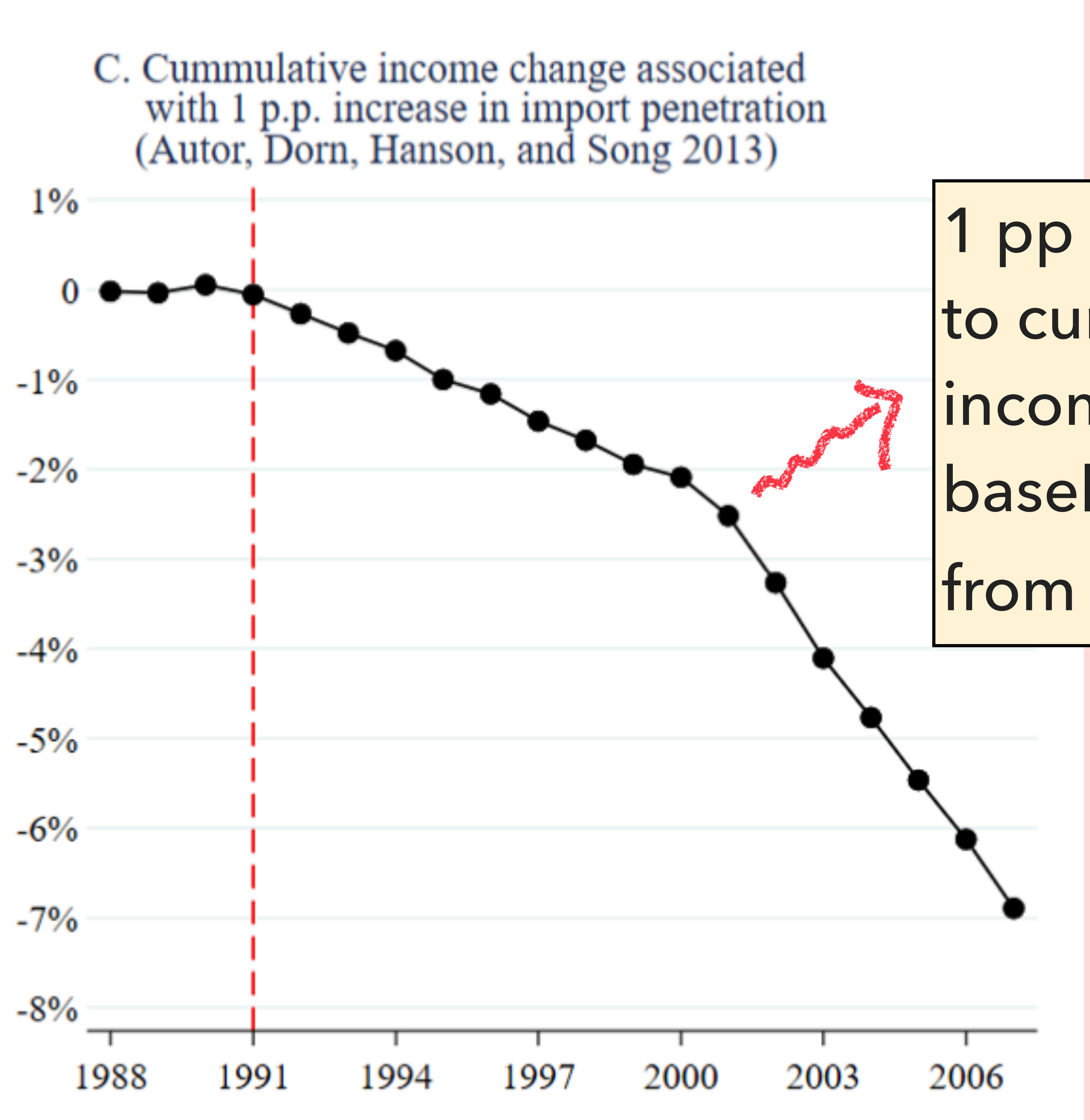


Income taxes and untargeted assistance programs (UI, UBI) are **blunt tools** to **assist losers** (15% of workforce)

THE CHINA SHOCK

- **Autor et al. (2013):** rapid increase in Chinese import penetration since 1991.
- Using SSA data, **Autor et al. (2014)** document large income decline for workers who held these jobs by 1990.





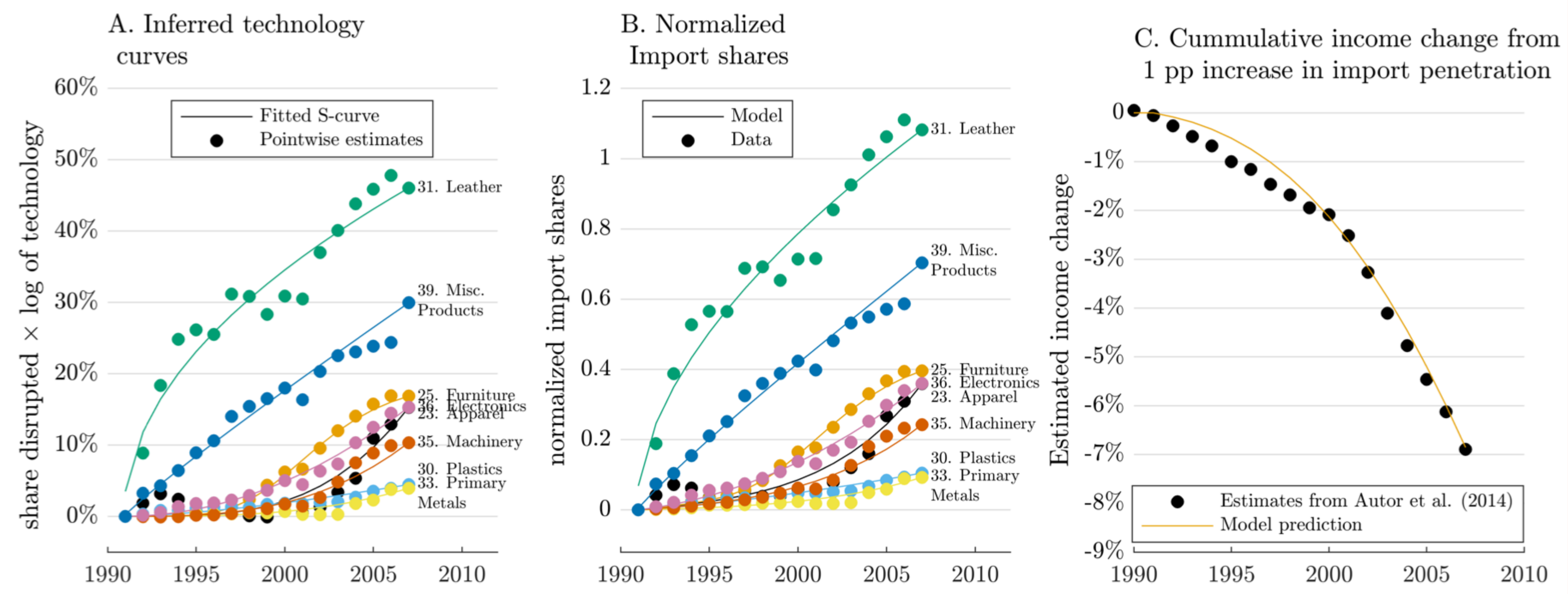
1 pp exposure leads to cumulative income loss of 7% baseline income from 1991-2007

THE CHINA SHOCK

- Output is CES of islands with $\sigma = 2$ (Broda and Weinstein et al. 2006)
- 20 disrupted islands. Island $x \in \mathscr{D}$ represents the share $s_{i(x)}$ of varieties in 2-digit industry $i(x)$ being outcompeted by China.
- $s_{i(x)}, A_{x,t}, \alpha$ jointly calibrated to match:
  1. price declines associated with China Shock (Bai and Stumpner, 2019) $\Rightarrow A_{x,2007}$
  2. path for imports by 2-digit industry in Autor et al. (2013) $\Rightarrow A_{x,t}, s_{i(x)}$
  3. income decline for exposed workers in Autor et al. (2014) $\Rightarrow \alpha = 1.8\,\%$
- Remaining parameters: $r = \rho = 5\,\%$; inverse IES of 2.

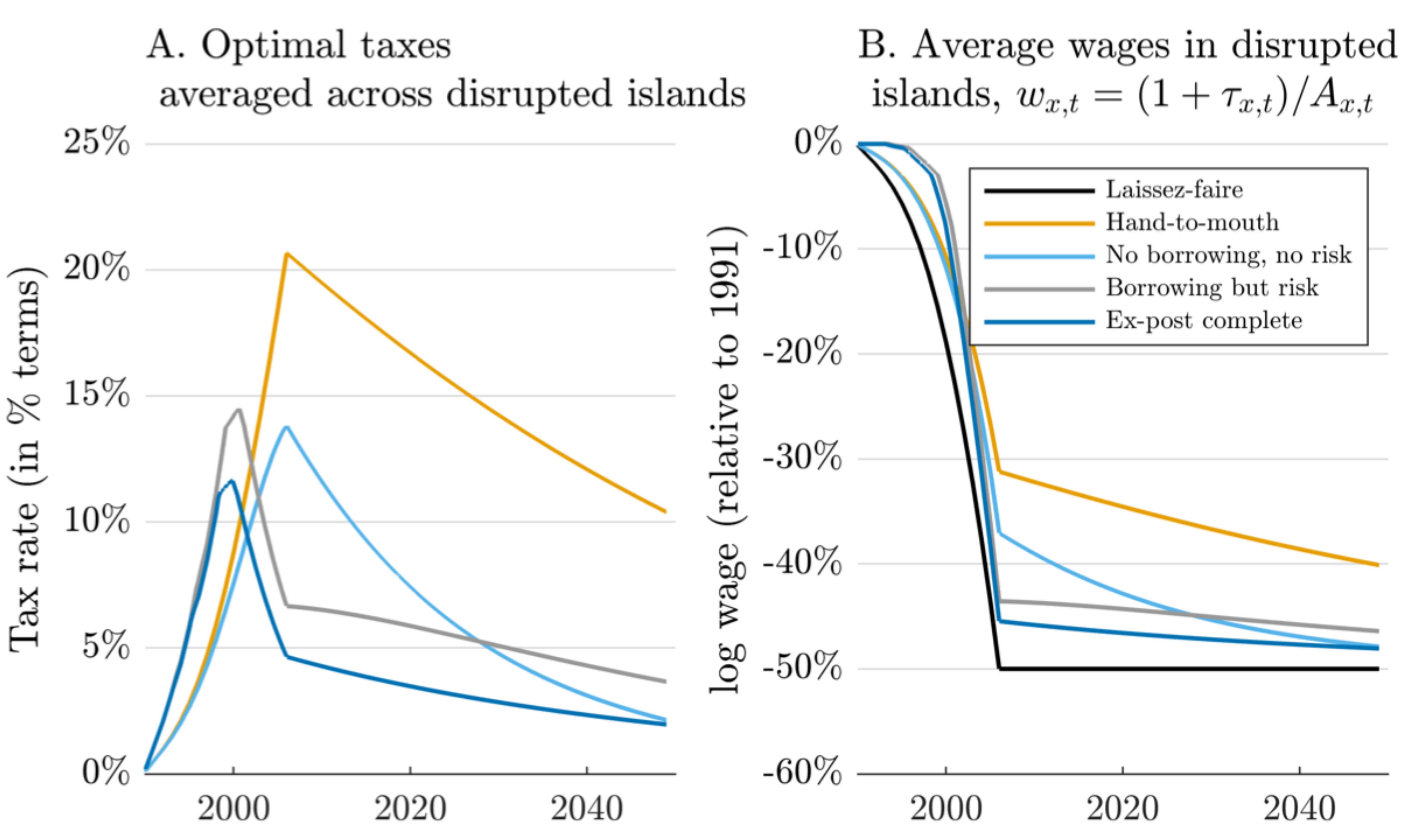
THE CHINA SHOCK

- Model reproduces key evidence for the China Shock



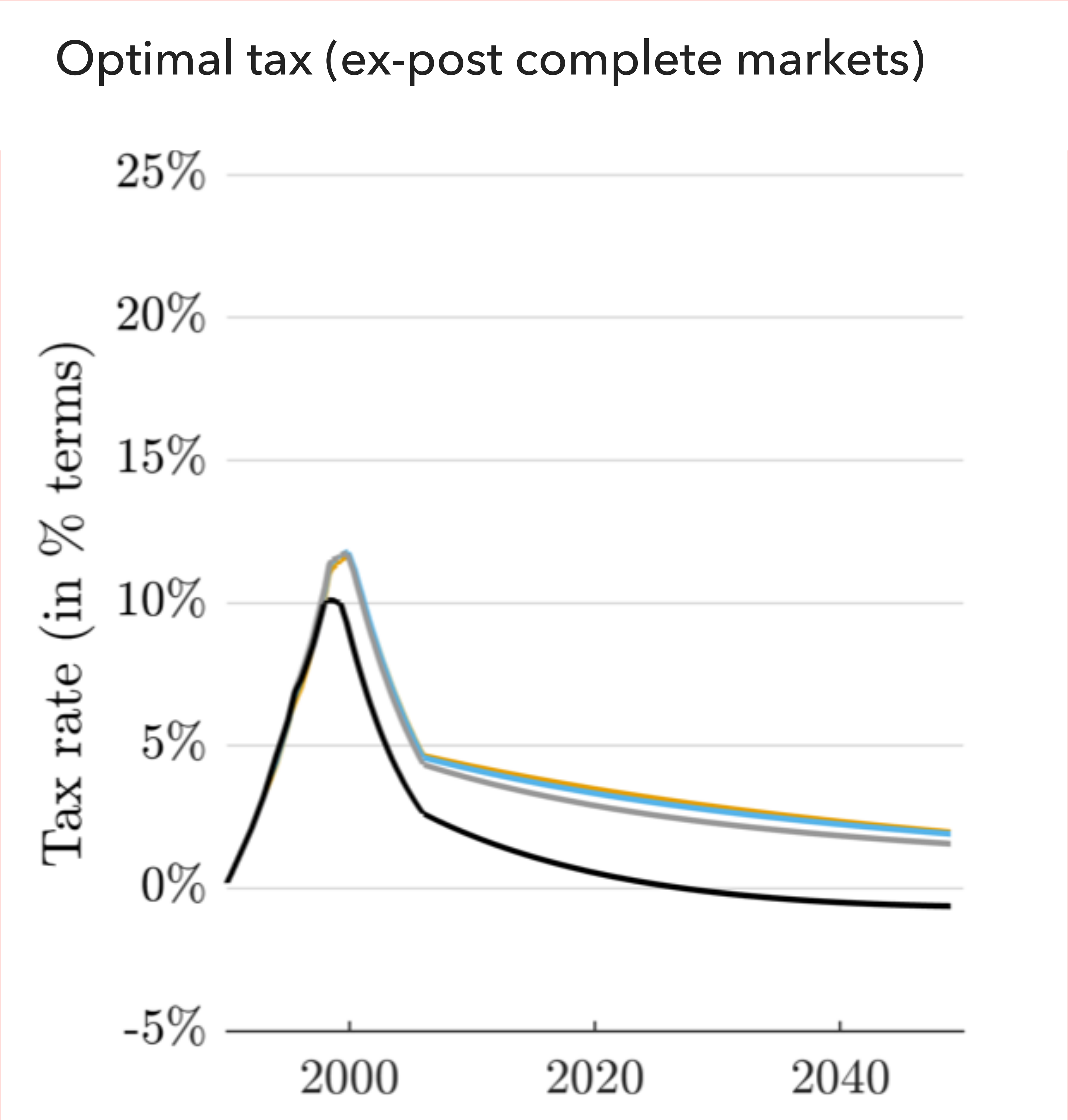
THE CHINA SHOCK

- **Optimal taxes with exogenous effort**
  - Optimal short run tax of 10–20%
  - Large welfare gains for disrupted households (from 15% loss under LF to 10% with optimal tax)
  - Optimal to delay when hhs can save

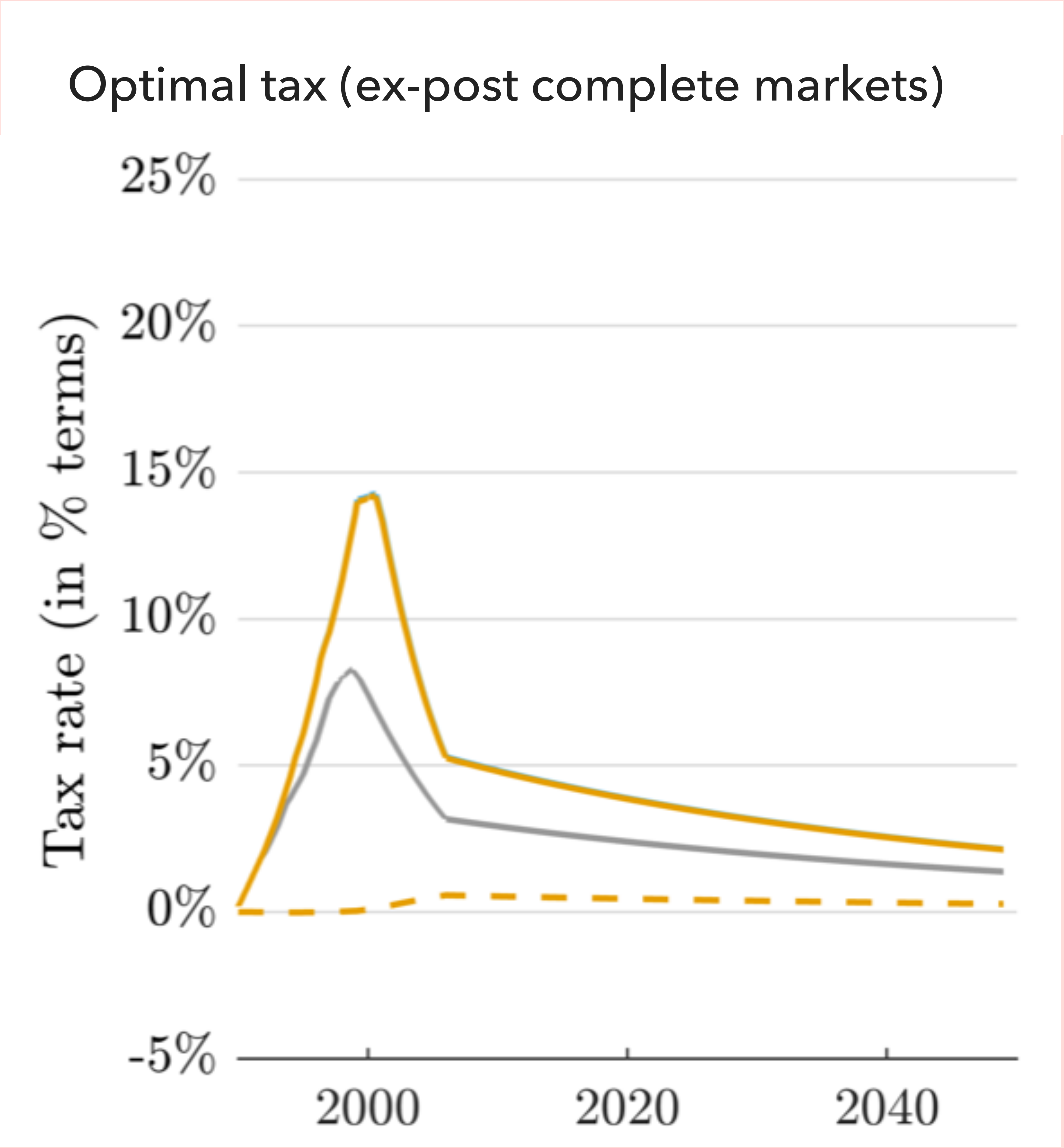


THE CHINA SHOCK

- Optimal tax with **endogenous effort** and different levels of *offset*

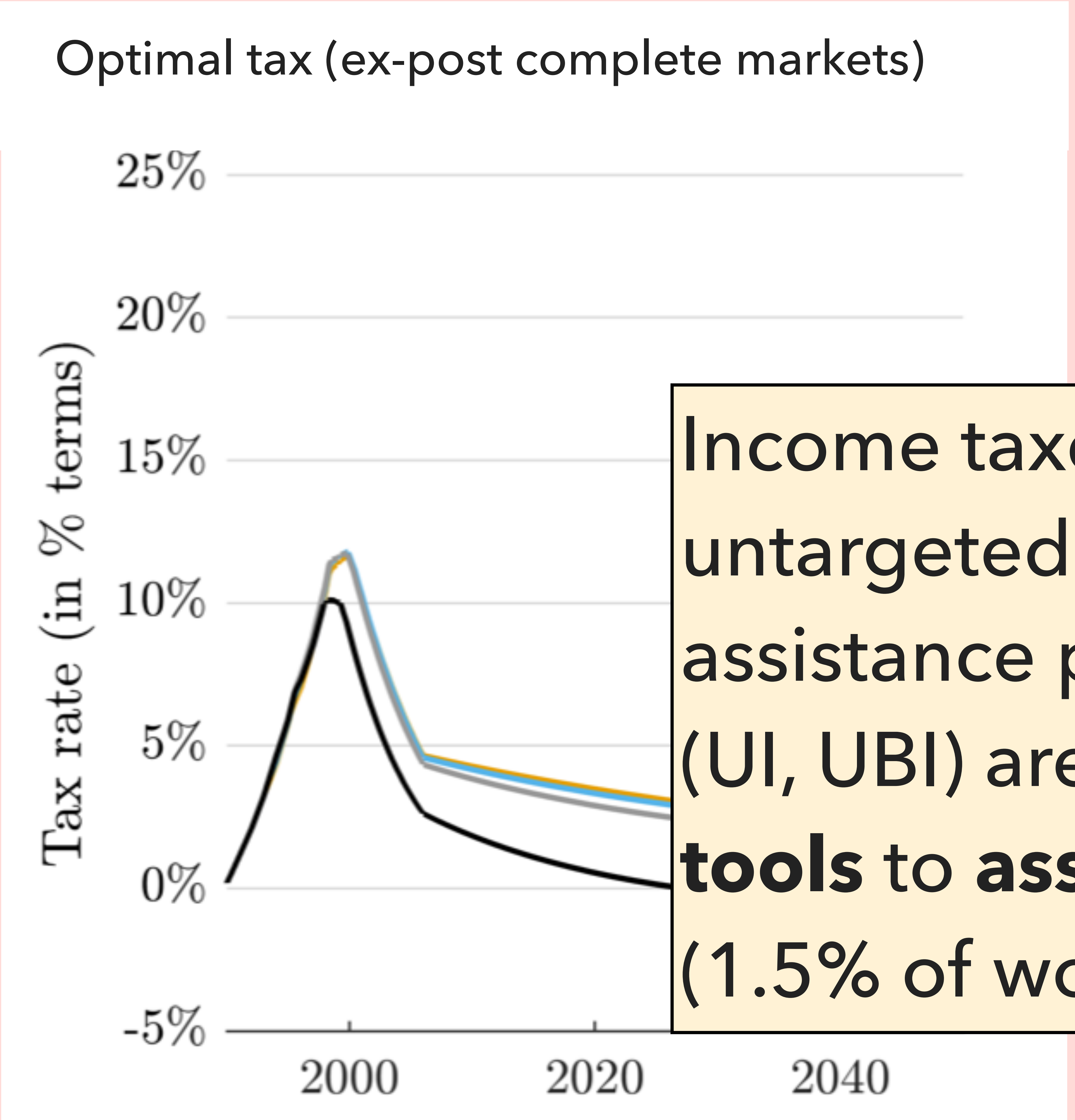


- Optimal tax with **progressive taxes and assistance programs** ($\varepsilon_\ell = 0.35$)

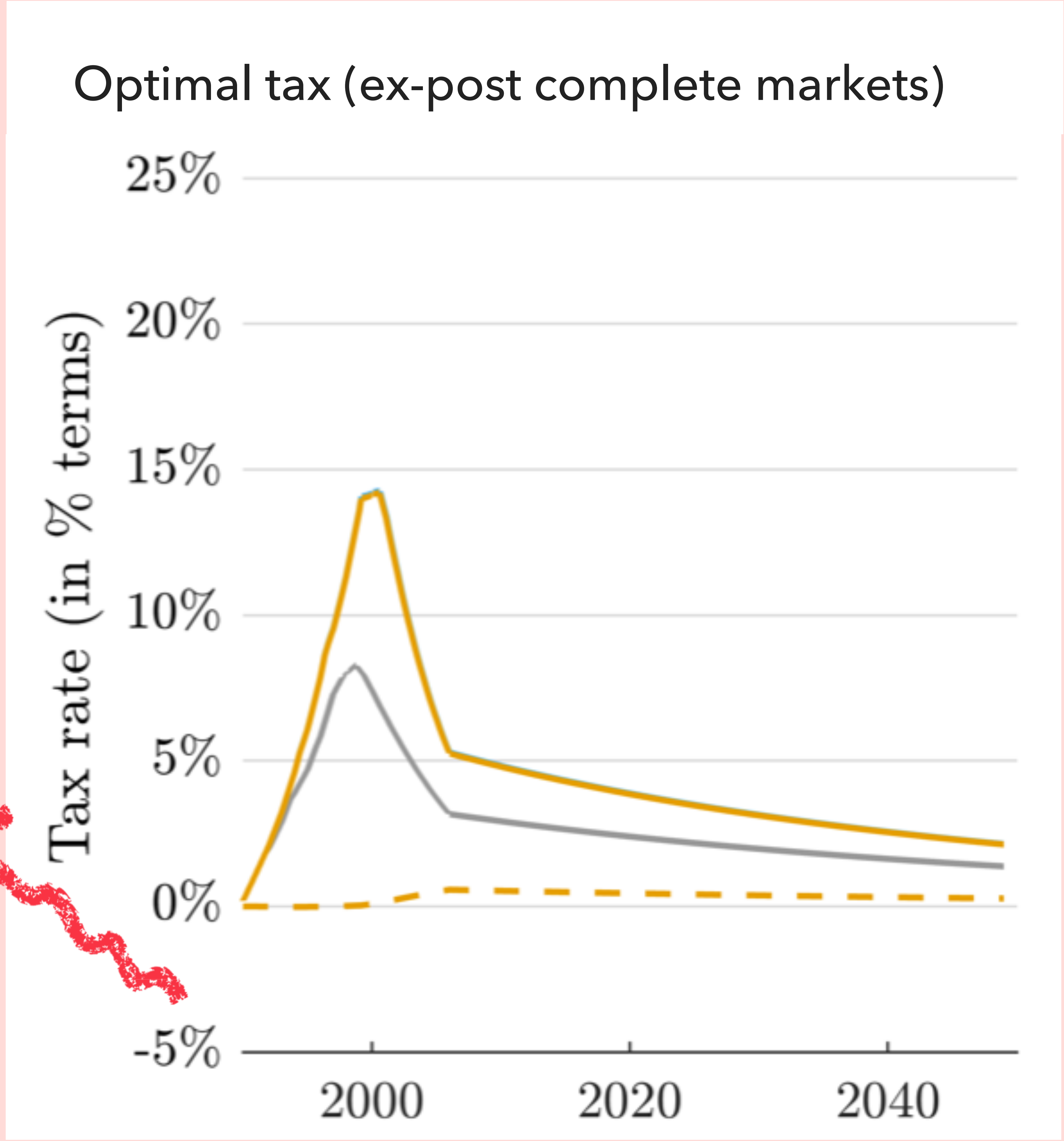


THE CHINA SHOCK

- Optimal tax with **endogenous effort** and different levels of *offset*



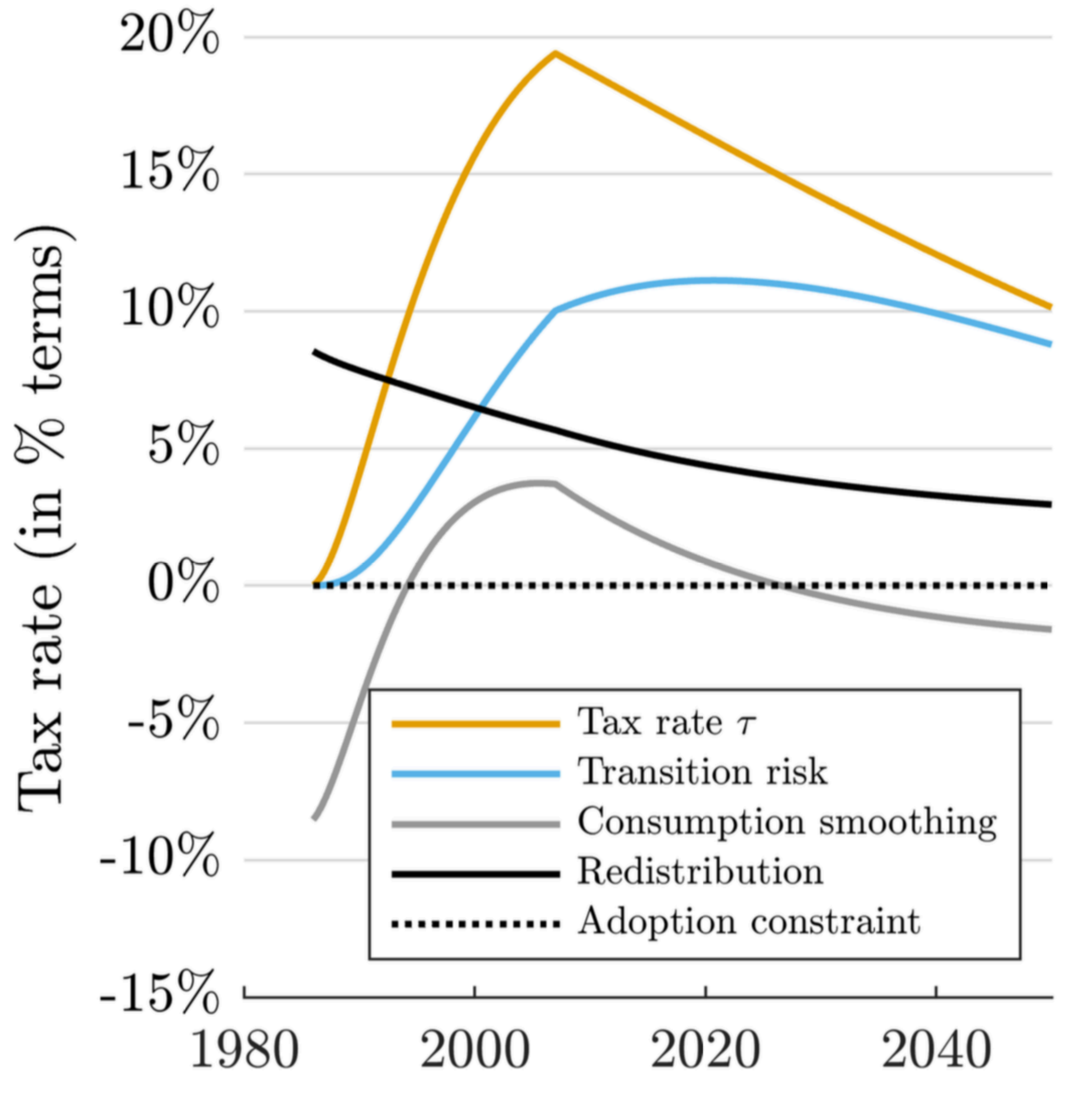
- Optimal tax with **progressive taxes and assistance programs** ($\varepsilon_\ell = 0.35$)



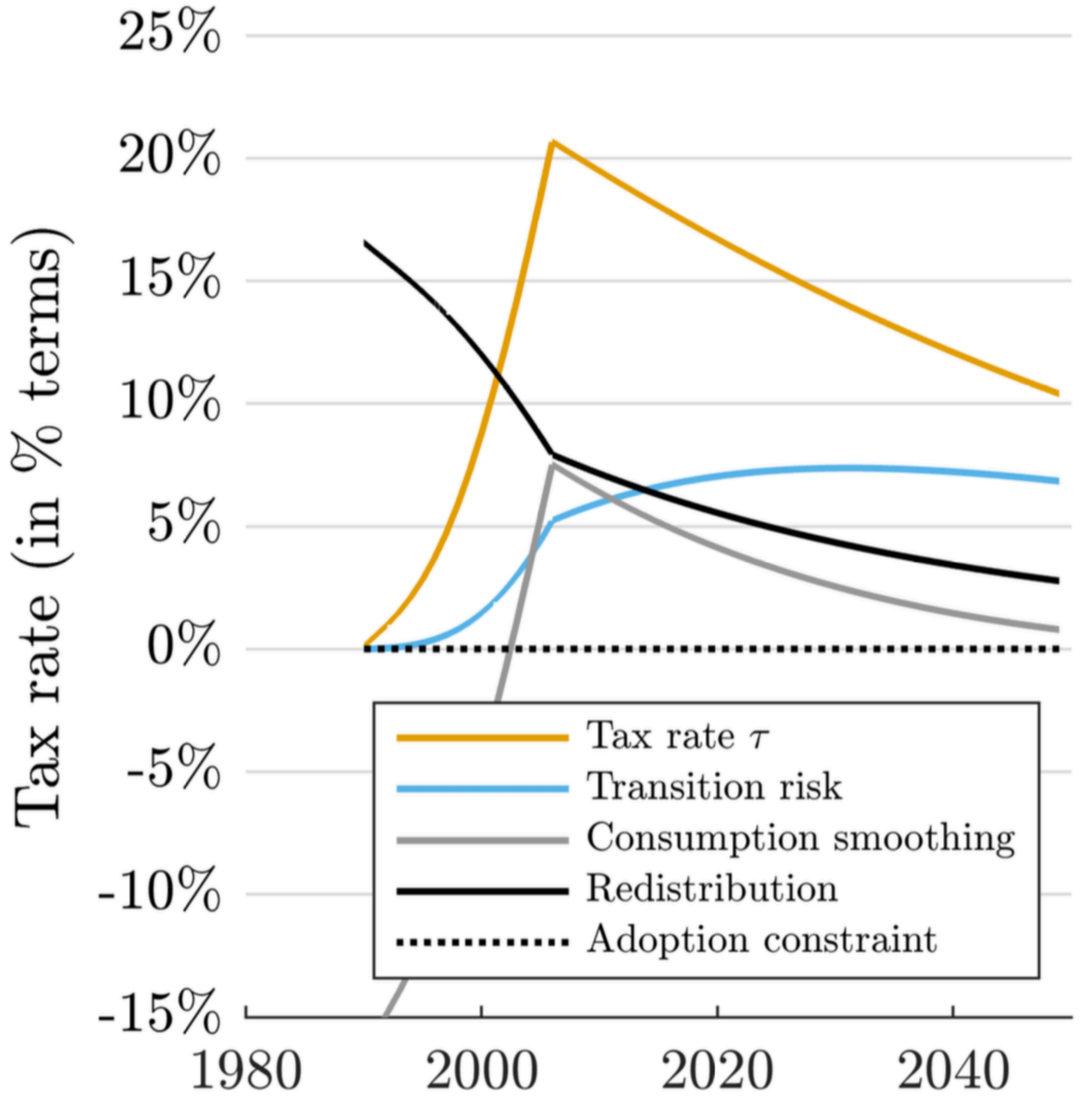
Income taxes and untargeted assistance programs (UI, UBI) are **blunt tools** to **assist losers** (1.5% of workforce)

THE SOURCES OF WELFARE GAINS (DAVILA-SCHAAB)

Optimal tax on automation (hand-to-mouth scenario with decomposition)

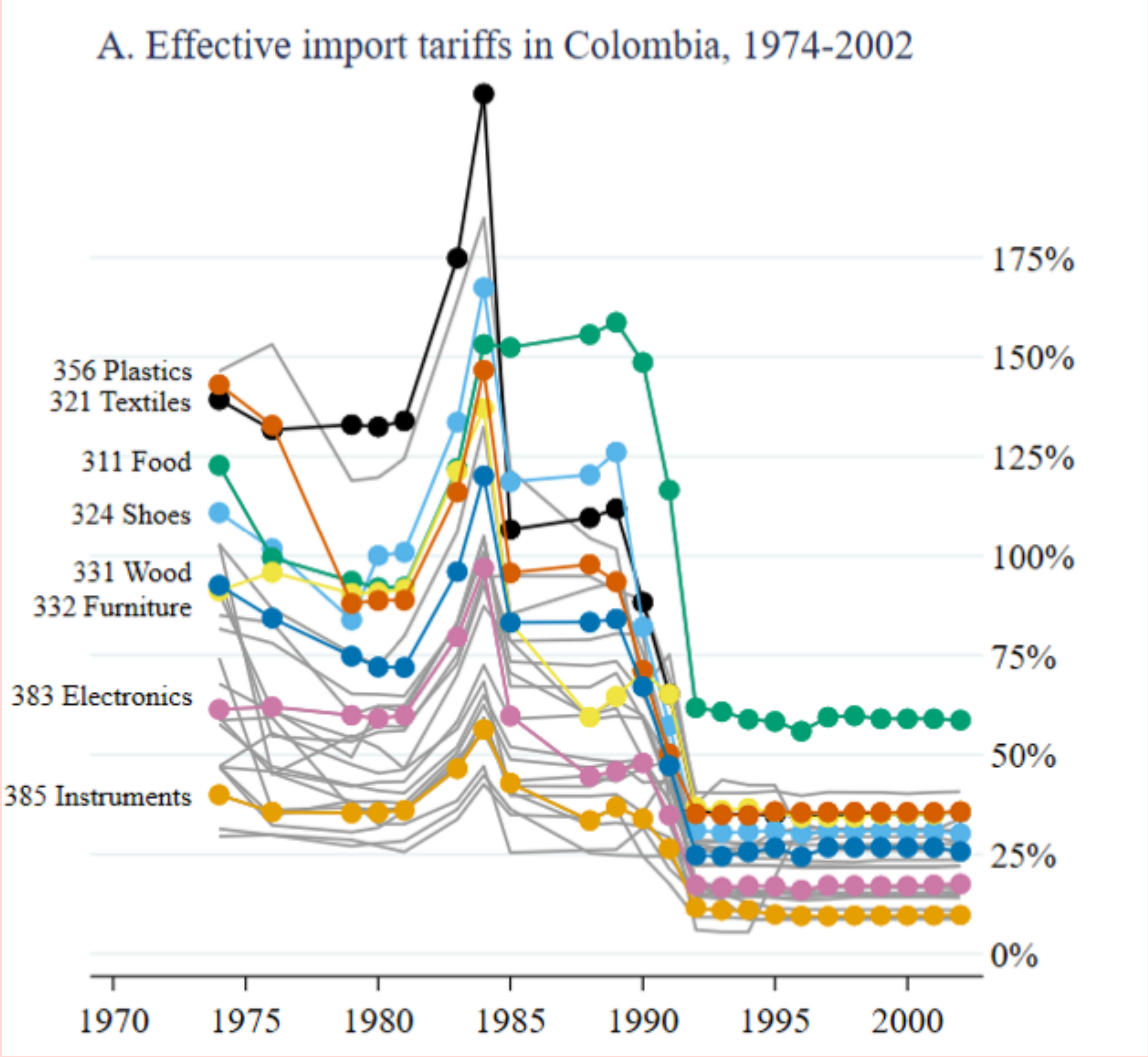


Optimal tax on Chinese imports (hand-to-mouth scenario with decomposition)



COLOMBIA'S TRADE LIBERALIZATION

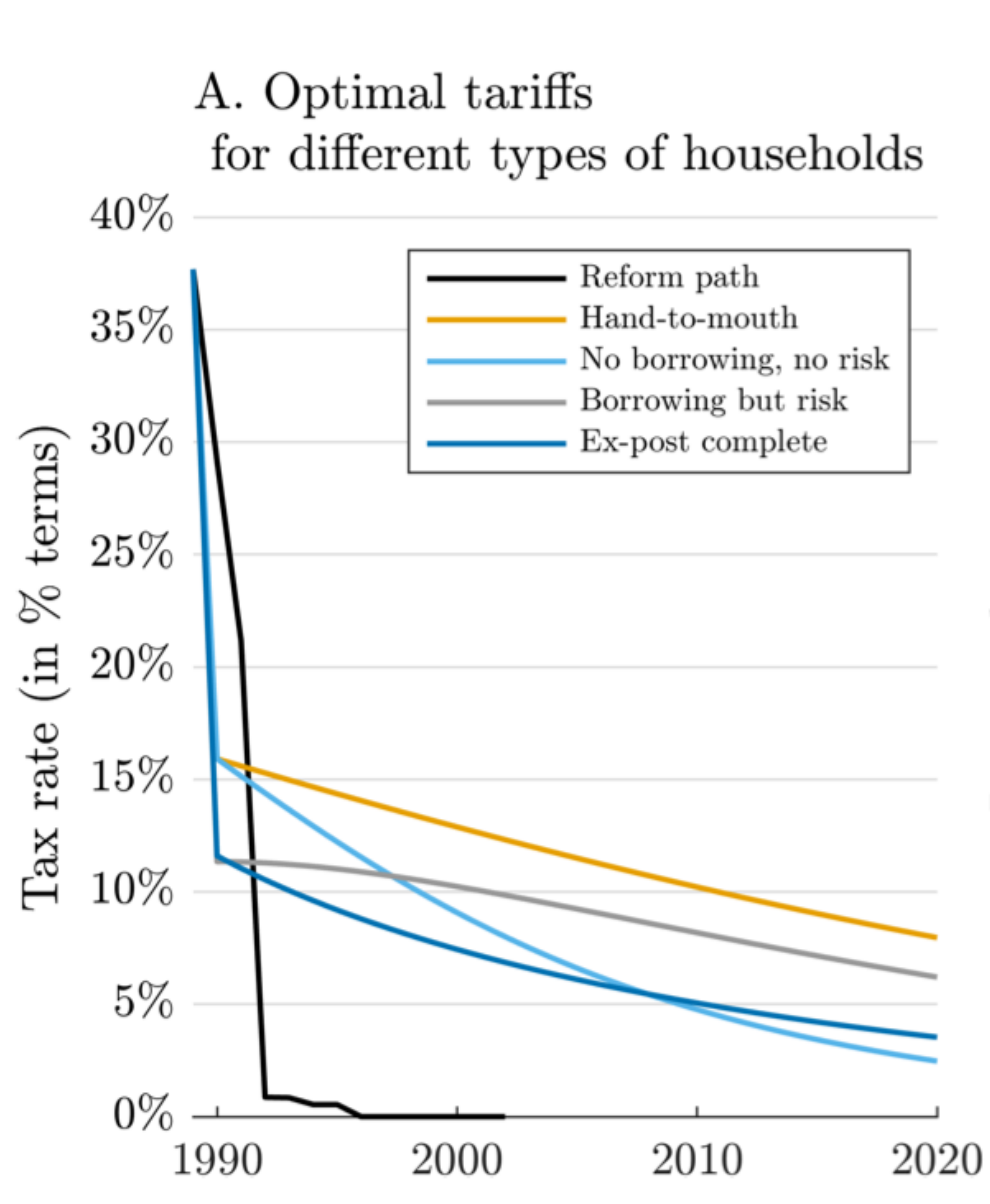
- In 1990, Colombia embarked in ambitious reform program, dropping effective tariffs from 75% to 25% in 2 years
- Swift rise in import penetration from 10 to 15% of GDP
- **Goldberg-Pavcnik (2005):** a 10 pp drop in tariffs leads to a 1% decline in wages of workers in that industry.



COLOMBIA'S TRADE LIBERALIZATION

- Output is CES of islands with $\sigma = 2$ (Broda and Weinstein et al. 2006)
- 25 disrupted islands. Island $x \in \mathscr{D}$ represents the share $s_{i(x)}$ of varieties in 2-digit industry $i(x)$ being outcompeted by imports after the liberalization.
- We assume that for these islands, $(1 + \tau_{x,0})/A_x = \bar{w}$ before reform
- $s_{i(x)}, \alpha$ jointly calibrated to match:
  1. Rise in imports by 2-digit industry $\Rightarrow s_{i(x)}$
  2. income decline associated with drop in protection $\Rightarrow \alpha = 3\,\%$
- Remaining parameters: $r = \rho = 5\,\%$; inverse IES of 2

COLOMBIA'S TRADE LIBERALIZATION



- **Summary of findings**:
  - Optimal reform requires gradual tariff decline, with 5-10% tariffs by 2010
  - Similar results with endogenous effort or with reforms to income tax/saftey net
  - Sudden reform reduces welfare of disrupted households by 16%, gradual reform by 11%

CONCLUDING REMARKS

Question 1: Should gradualism be encouraged via temporary taxes?

Yes. **Positive optimal tax in short run and zero tax in long run**

Question 2: Does society benefit from more gradual technological advances?

Not in our calibration for China Shock and the automation of routine jobs (taxes yield revenue, slow technological progress does not)

Some **additional insights**:

- When losers from trade and technology concentrated and hard to identify, better to assist them by distorting technology than by reforming income tax / safety net
- Endogenous effort: protect in short run and commit to subsidy in medium run to preserve incentives for reallocation