A Macroeconomic Perspective on Taxing Multinational Enterprises

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November 3, 2022

Motivation

MNEs shift large portions of their profits to tax havens, reducing tax revenues in their home countries by hundreds of billions of dollars each year

- Tørsløv et al. (2022): **36% of MNEs profits** shifted to tax havens
- OECD: **$240 bn. (10%)** of global corporate tax revenues lost annually

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In October 2021, 190 countries representing **90% of global GDP** signed onto historic policy framework designed by OECD/G20 to address profit shifting

- Pillar 1: Sales-based allocation of profit taxation rights
- Pillar 2: Global minimum corporate income tax at 15%

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This paper:

- How does profit shifting affect MNEs' production decisions at the micro level?
- What are the aggregate consequences of these micro effects?
- How will the OECD/G20 framework affect the global economy?

Overview

What we do

1. Develop theory of profit shifting and intangible investment
2. Embed theory in multi-country general equilibrium model with heterogeneous firms
3. Calibrate to data on profit shifting under current international tax regime
4. Counterfactual analysis: shutting down profit shifting, OECD/G20 proposal

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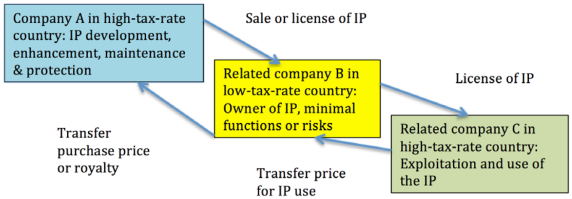
What we find

1. At the MNE level, profit shifting increases intangible investment, leading to higher output and greater profits
2. In equilibrium, profit shifting by MNEs from high-tax countries increases output everywhere these MNEs operate
3. The OECD/G20 plan will largely eliminate profit shifting, but this will come at a substantial macroeconomic cost

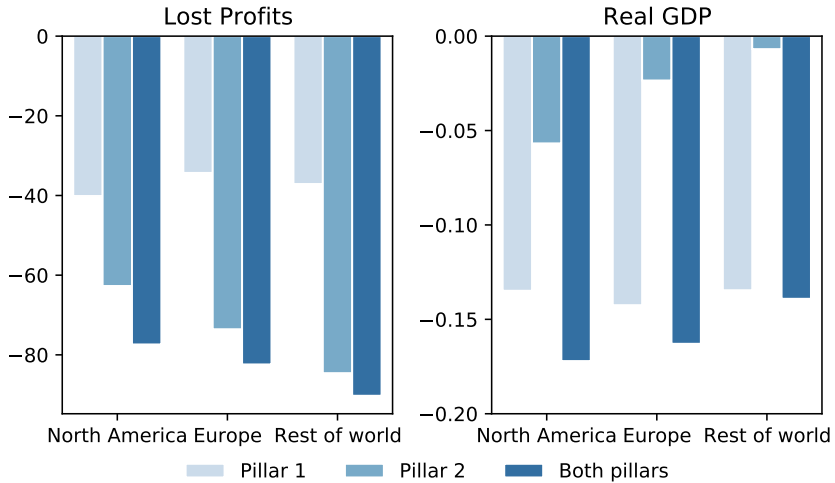
Our theory of profit shifting in brief



"95 percent of Apple's R&D… is conducted in the United States… [During] 2009 to 2012, ASI [Apple Ireland] paid… $5 billion to [Apple USA] as its share of the R&D costs. Over that same time period, ASI received profits of $74 billion. The difference between ASI's costs and the profits, almost $70 billion, is how much taxable income [should] have flowed to the United States."
— U.S. Senator Carl Levin, May 21, 2013

- MNEs shift profits by transferring **nonrival** IP to tax-haven affiliates
- Tax-haven affiliates charge parent (and other affiliates) licensing fees to use IP
- Transfer occurs at below market-value price, violating **arm's length principle**
- Empirical evidence
  - Delis et al. (2021): R&D-intensive firms shift profits
  - Accoto et al. (2021): Firms that shift profits import IP services
- **End result:** raise after-tax return on intangible investment.

Preview of the OECD/G20 plan's consequences



Contributions to the literature

1. **Profit shifting:** Guvenen et al. (2022), Tørsløv et al. (2022), Delis et al. (2021), Accoto et al. (2021)

   → **Model profit shifting's real effects**

2. **Macroeconomics of intangible capital:** Corrado et al. (2009), McGrattan and Prescott (2010), O'Mahony et al. (2018), Koh et al. (2020) and Peters and Taylor (2017) Ewens et al. (2019)

   → **Model transfer pricing and profit shifting of intangible income**

3. **Macro public finance:** Harberger (1962), Auerbach (1983), Barro and Furman (2018), Kaymak and Schott (2018), Bhandari and McGrattan (2020)

   → **Aggregate implications of profit shifting for corporate tax reform**

4. **MNEs:** Helpman et al. (2004), Antrás and Yeaple (2014), Garetto et al. (2019), McGrattan and Waddle (2020)

   → **Model where heterogeneous firms decide intangible investment, profit shifting, and foreign affiliate locations simultaneously**

Outline

1. Theory of profit shifting and intangible investment
2. Quantitative model
3. Taking the model to the data
4. Inspecting the economic mechanism
5. The effects of OECD/G20 plan

THEORY OF PROFIT SHIFTING AND INTANGIBLES

Environment

- MNE with its parent division in i operates in K locations.
- Location $k \in \{1, ..., K\}$:
  - Population: N_k
  - Productivity: A_k
  - Corporate profit tax rate: τ_k
  - Prices: p_k, w_k
- Technology:

$$F(z, l_k) = A_k \left(N_k \boldsymbol{z}\right)^{\phi} l_k^{\gamma}$$

  - $\boldsymbol{z}$ is **non-rival**, intangible capital
  - l_k is labor input
  - DRS: $(\gamma + \phi) < 1$

Accounting profits

Free Transfer (FT): z transferred at no cost across locations:

$$\pi_i = p_i \left(A_i \left(N_i z \right)^{\phi} l_i^{\gamma} \right) - w_i l_i - p_i z$$

$$\pi_k = p_k \left(A_k \left(N_k z \right)^{\phi} l_k^{\gamma} \right) - w_k l_k, \quad \forall k \neq i$$

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Transfer pricing (TP): parent division retains legal ownership of z and licenses the rights to use it to its foreign affiliates.

$$\pi_i^{TP} = \pi_i + \sum_{k \neq i} q_k z$$
$$\pi_k^{TP} = \pi_k - q_k z \quad \forall k \neq i$$

where

$$q_k \equiv \underbrace{\phi p_k N_k \left(A_k \left(N_k z \right)^{\phi - 1} l_k^{\gamma} \right)}_{\text{Marginal revenue product of } z}$$

Accounting profits

Profit Shifting (PS):

$$\pi_i^{PS} = \pi_i + z\left[\varphi\lambda\sum_k q_k - \lambda q_i + (1-\lambda)\sum_{k\neq i} q_k - \mathcal{C}(\lambda)\sum_k q_k\right]$$

$$\pi_{i^*}^{PS} = \pi_{i^*} + z\left[\lambda\sum_{k\neq i^*} q_k - (1-\lambda)q_{i^*} - \varphi\lambda\sum_k q_k\right]$$

$$\pi_k^{PS} = \pi_k - q_k z \quad \forall k \neq i, i^*$$

where

- $\lambda \in [0,1]$ a fraction of intangible capital z transferred to the tax haven
- $\mathcal{C}(\lambda)$ is the cost of shifting the fraction λ
- $\varphi \leq 1$ is a markdown below the competitive price of z
- i^* is the tax haven, i.e., $\tau_{i^*} = \min\{\tau_1, ..., \tau_K\}$

Profit maximization

MNE's problem: choose z, $\{l_k\}_{k=1}^K$, and λ to maximize after-tax global profits:

$$\Pi^j \equiv \max_{z,\{l_k\}_{k=1}^K,\lambda} \sum_{k=1}^{K} (1-\tau_k)\pi_k^j$$

- $j \in \{FT, TP, PS\}$ denotes the scenario
- z^{FT}, z^{TP}, z^{PS} denote optimal choices of z in each scenario
- MNE only chooses λ in for scenario $j = PS$

Optimal profit shifting

Assumption

Let $\mathcal{C}(\lambda) \equiv \lambda - (1-\lambda)\log(1-\lambda)$, *implying* $\mathcal{C}'(\lambda) = -\log(1-\lambda)$, $\mathcal{C}(0) = 0$, $\mathcal{C}(1) = 1$, *and* $\lambda \in [0,1]$.

The share of shifted intangible capital:

$$\lambda = 1 - \exp\left(-\frac{(1-\varphi)(\tau_i - \tau_{i^*})}{1-\tau_i}\right)$$

Lemma

The share of shifted intangible capital λ *is:*

1. *Decreasing in* φ.
2. *Decreasing in* τ_{i^*} *with elasticity given by*

$$\varepsilon^{\lambda}_{\tau_{i^*}} = -\frac{1-\lambda}{\lambda}\left(\frac{1-\varphi}{1-\tau_i}\right)\tau_{i^*}$$

Profit shifting and optimal intangible investment

Proposition

1. *If* $\tau_i = \max\{\tau_k\}_{k=1}^K$ *then* $z^{TP} < z^{FT}$.
2. $z^{PS} > z^{TP} \iff \varphi < 1$ *and* $z^{PS} = z^{TP} \iff \varphi = 1$.
3. z^{PS} *is decreasing in* φ.
4. z^{PS} *is decreasing in* τ_{i^*}.

We show

$$z^{TP} = \left(\frac{\sum_{k=1}^K \phi \Lambda_k}{p_i} \right)^{\frac{1-\gamma}{1-\phi-\gamma}} < \left(\frac{\sum_{k=1}^K (1-\tau_k)\phi \Lambda_k}{(1-\tau_i)p_i} \right)^{\frac{1-\gamma}{1-\phi-\gamma}} = z^{FT}$$

where Λ_k is a function of A_k, p_k, N_k, w_k. Then z^{PS} is

$$z^{PS} = z^{TP} \underbrace{\left((1 - \mathcal{C}(\lambda)) + \frac{\lambda(1-\varphi)(\tau_i - \tau_{i^*})}{(1-\tau_i)} \right)^{\frac{1-\gamma}{1-\phi-\gamma}}}_{>1}$$

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with the following elasticities:

$$\varepsilon_{\tau_{i^*}}^{z^{TP}} = 0$$

and

$$\varepsilon_{\tau_{i^*}}^{z^{PS}} = \frac{1-\gamma}{1-\phi+\gamma}\left(\frac{-\tau_{i^*}}{\tau_i - \tau_{i^*}}\right)\frac{1}{\left[1+\frac{1-\mathcal{C}(\lambda)}{\mathcal{C}'(\lambda)}\right]} < 0$$

Effects of OECD/G20 pillar 1 (sales-based profit allocation)

The MNE's tax base in jurisdiction k as:

$$T_k = \underbrace{\pi_k^r}_{\text{Routine profit}} + (1-\boldsymbol{\theta}) \times \underbrace{\pi_k^R}_{\text{Residual profit}} + \boldsymbol{\theta} \times \underbrace{\frac{\boldsymbol{p_k y_k}}{\sum_k \boldsymbol{p_k y_k}}}_{\text{Sales share of } k} \times \underbrace{\prod^R}_{\text{Global residual profit}}$$

where:

- $\pi_k^r = \boldsymbol{\mu} p_k y_k$
- $\pi_k^R = \pi_k^{PS} - \pi_k^r$
- $\prod^R = \sum_k \pi_k^R$

with two policy parameters:

- $\boldsymbol{\mu}$ is the routine profit margin
- $\boldsymbol{\theta}$ is the fraction of global residual profits reallocated according to sales shares

Effects of OECD/G20 pillar 1 (sales-based profit allocation)

Proposition

1. $\hat{\lambda} < \lambda$ *and* $\hat{z}^{PS} < z^{PS}$.
2. $\hat{\lambda}$ *and* $\hat{z}^{PS}$ *are decreasing in* θ.
3. *The economy is less responsive to changes in* τ_{i^*}*:*

$$\left|\varepsilon^{\hat{z}^{PS}}_{\tau_{i^*}}\right| < \left|\varepsilon^{z^{PS}}_{\tau_{i^*}}\right|$$

$$\lambda = 1 - \exp\left(-\frac{(1-\varphi)(\tau_i - \tau_{i^*})}{1-\tau_i}\right)$$

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$$\left|\varepsilon^{\hat{z}^{PS}}_{\tau_{i^*}}\right| < \left|\varepsilon^{z^{PS}}_{\tau_{i^*}}\right|$$

$$\hat{\lambda} = 1 - \exp\left(-\frac{(1-\varphi)(1-\boldsymbol{\theta})(\tau_i - \tau_{i^*})}{1-((1-\boldsymbol{\theta})\tau_i + \boldsymbol{\theta}\widehat{\boldsymbol{\tau}})}\right).$$

where

$$\widehat{\tau} \equiv \sum_j \tau_j \cdot \frac{p_j y_j}{\sum_k p_k y_k}.$$

QUANTITATIVE MODEL

Model environment

- Synthesis of Helpman, Melitz, and Yeaple (2004) and McGrattan and Prescott (2010), plus **transfer pricing** and **profit shifting**
- I productive regions
  - Representative consumer, gov't, and measure of firms
  - Differ in size, TFP, trade/FDI openness, corporate taxes
- 1 unproductive region ("tax haven")
  - Gov't earns revenue by taxing profits of foreign MNEs' affiliates
- Firms in productive regions:
  - Heterogeneous in productivity, compete monopolistically a là Melitz
  - Choose whether to export and/or establish foreign affiliates
  - Parent division invests in nonrival intangible capital, foreign affiliates pay licensing fees
  - Shift profits to lowest-tax productive region and/or tax haven as in theory

Firm's problem

Each firm ω in region i chooses:

- Markets:
  - export destinations J_X, subject to fixed cost κ_i^X.
  - foreign affiliates J_F, subject to fixed cost κ_i^F.
- R&D and employment:
  - intangible capital investment z
  - local factors ℓ_j
- Profit shifting:
  - the share of intangible capital λ to shift

to maximize after-tax global profit:

$$\max_{J_X, J_F, z, \lambda, \ell} \left\{ (1-\tau_i) \left[\pi_i^{PS}(\omega) - \sum_{j \in J_X} W_i \kappa_{ij}^X - \sum_{j \in J_F} W_i \kappa_{ij}^F \right] + \sum_{j \in J_F} (1-\tau_j) \pi_{ij}^{PS}(\omega) \right\}$$

Measuring profit shifting in the model

- Profits shifted out of region i by firm ω from region j:

$$\tilde{\pi}_{ij}(\omega) = \pi_{ij}^{TP}(\omega) - \pi_{ij}^{PS}(\omega)$$

  - $\pi_{ij}^{PS}(\omega)$: profit booked in region j by firm ω based in region i
  - $\pi_{ij}^{TP}(\omega)$: the same object for TP scenario

- **Total profits shifted** out of region j:

$$\tilde{\Pi}_j = \sum_{i=1}^{I} \int_{\Omega_i} \tilde{\pi}_{ij}(\omega)\, d\omega.$$

- These measures can be defined in GE or PE:
  - PE: Hold fixed all Q's and P's and measure profits if shifting was not allowed
  - GE: Allow firms to re-optimize and re-clear all markets

TAKING THE MODEL TO THE DATA

Calibration

Aggregate countries into 5 regions:

- High-tax regions: North America (NA), Europe (EU), Rest of the World (RW)
- Tax havens identified by Tørsløv et al. (2022) split into
  - Low tax (LT): Belgium, Switzerland, Netherlands, Ireland etc.
  - Tax haven (TH): Antigua, Aruba, the Bahamas, Barbados etc.

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Identification of key parameters:

- TFP (A_i) and prod. dispersion (σ_a): GDP and firm size dist.
- Intangible share (ϕ): Foreign MNEs' intangible share
- Trade costs (κ^X, ξ): Num. exporters, trade flows
- FDI costs (κ^F, σ): Num. MNEs, foreign MNEs' VA shares
- Corporate tax rates (τ): data on effective tax rates
- Profit shifting costs (φ_i): Lost profit estimates from Tørsløv et al. (2022)
  - Measured in PE, consistent with empirical methodology
  - **Lost profits/GDP:** 0.6% for NA, 1.4% for EU, 0.7% for RoW.

Calibration: Region-specific target moments

Region	North America	Europe	Low-tax	RoW	Tax haven
Population (NA = 100)	100	92	11	1,323	–
Real GDP (NA = 100)	100	80.78	14.57	297.10	–
Corporate tax rate (%)	**22.5**	**17.3**	**11.4**	**17.4**	**3.3**
Foreign MNEs' VA share (%)	**11.12**	**19.82**	**28.73**	**9.55**	–
Total lost profits ($B)	143	216	–	257	–
Lost profits to TH (%)	66.4	44.5	–	71.1	–
Imports from… (% GDP)					
North America	–	1.28	1.77	1.74	–
Europe	1.70	–	12.39	3.78	–
Low tax	0.35	2.98	–	0.59	–
Row	6.15	7.96	6.78	–	–

Validation

Compare **semi-elasticity** of profit shifting in simulated firm-level data to empirical estimates

$$\log \pi_i^{k,PS}(\omega) = \beta_0 + \beta_\ell \log \ell_i^k(\omega) + \beta_z \log z^k(\omega) - \beta_\tau \hat{\tau}_i^k + \epsilon_i^k(\omega)$$

- $\hat{\tau}_i^k$: tax differential between an MNE's home region and LT or TH.
- β_τ: Percentage change in reported profit in response to a one-percentage-point change in the tax differential between the home country and a tax haven
- k: the index of the counterfactual economy

Study	**Data source**	β_τ
Johansson et al. (2017)	ORBIS, 2000-2010	1.11
Heckemeyer and Overesch (2017)	Meta: 27 studies, 203 estimates	0.79
Beer et al. (2020)	Meta: 38 studies, 402 estimates	0.98
This paper	Simulated model data	**0.87**

QUANTITATIVE EXPERIMENTS

Inspecting the mechanism: intuition (NA only)

Effect of transfer pricing (FT → TP)

- Partial equilibrium:
  - Domestic MNEs: after-tax marginal revenue product of $z \downarrow \rightarrow z \downarrow \rightarrow$ output $\downarrow$
  - Non MNEs: no direct effect
  - Corporate tax base $\uparrow/\downarrow$
- General equilibrium
  - Reallocation effect: Wages $\downarrow \rightarrow$ non MNEs z, $Y \uparrow$
  - FDI effect: Wages $\downarrow \rightarrow$ foreign MNEs z, $Y \uparrow$
  - Corporate tax base $\uparrow$

Effect of profit shifting (TP → PS)

- Opposite direction for all effects
- Allowing MNEs to shift profits undoes adverse effects of transfer pricing regulations

Inspecting the Mechanism: Macro Effects

Region	Lost profits (% GDP)	Corp. tax rev. (% chg.)	Value added (% chg.)	Tech. capital (% chg.)		
				Total	Non MNEs	Domestic MNEs
(a) Effects of transfer pricing (no transfer pricing vs. no shifting)						
North America	0.00	4.32	-0.16	**-0.54**	**0.58**	**-1.34**
Low tax	0.00	-2.17	-0.25	**0.74**	**-0.75**	**2.28**
(b) Effects of profit shifting (no shifting vs. baseline)						
North America	0.68	-3.82	0.08	0.21	-0.11	0.45
Low tax	-4.37	23.52	-0.04	-0.55	-0.60	-0.49

Wages

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Inspecting the Mechanism: VA decomposition

Region	Value added (% chg.)			
	Total	Non MNEs	Domestic MNEs	Foreign MNEs
(a) Effects of transfer pricing (no transfer pricing vs. no shifting)				
North America	**-0.16**	**0.36**	**-0.85**	**0.35**
Low tax	**-0.25**	**-0.72**	**1.10**	**-0.56**
(b) Effects of profit shifting (no shifting vs. baseline)				
North America	0.08	-0.00	0.15	0.15
Low tax	-0.04	-0.33	-0.29	0.64

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North America	**0.08**	**-0.03**	**0.15**	**0.15**
Low tax	**-0.04**	**-0.33**	**-0.29**	**0.64**

OECD/G20 plan details

Pillar 1: sales-based profit allocation

- Allocate rights to tax **25%** of an MNE's global residual profits based on countries' shares of its global sales.
- Residual profits defined as reported profits above pre-determined share of revenues
- Independent of a physical presence; export destinations without foreign affiliates get a cut

Pillar 2: global minimum corporate income tax at **15%**

- If firm based in i reports profits in j with $\tau_j < \underline{\tau}$, then these profits are taxed in i at rate $\underline{\tau} - \tau_j$.
- Additional revenue for i is

$$\tilde{R}_i = \sum_{j=1}^{I} \int_{\Omega_i} \max\left[\left(\underline{\tau} - \tau_j\right), 0\right] \pi_{ij}^{PS}(\omega) \; d\omega$$

OECD Reform Proposal: Macro Effects

Region	Lost profits (benchmark = 1)	Corp. tax rev. (% chg.)	Value added (% chg.)	Tech. capital (% chg.)		
				Total	Non MNEs	Domestic MNEs
(a) Pillar 1: Profit reallocation						
North America	0.60	2.54	-0.13	**-0.40**	**0.15**	**-0.80**
Low tax	0.69	-11.40	-0.13	0.79	0.23	1.35
(b) Pillar 2: Global minimum tax rate						
North America	0.37	3.24	-0.06	**-0.15**	**0.08**	**-0.31**
Low tax	0.49	-9.70	0.02	0.32	0.36	0.28
(c) Pillars 1 & 2 together						
North America	0.23	4.36	-0.17	**-0.48**	**0.17**	**-0.94**
Low tax	0.33	-16.46	-0.13	1.00	0.48	1.51

Notes: For the low-tax region, lost profits are negative in both the benchmark equilibrium and in the policy counterfactuals, i.e., profits are shifted inward to the low-tax region.

Wages

OECD Reform Proposal: Macro Effects

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Low tax	0.69	-11.40	-0.13	0.79	0.23	1.35
(b) Pillar 2: Global minimum tax rate						
North America	**0.37**	**3.24**	**-0.06**	-0.15	0.08	-0.31
Low tax	0.49	-9.70	0.02	0.32	0.36	0.28
(c) Pillars 1 & 2 together						
North America	**0.23**	**4.36**	**-0.17**	-0.48	0.17	-0.94
Low tax	0.33	-16.46	-0.13	1.00	0.48	1.51

Notes: For the low-tax region, lost profits are negative in both the benchmark equilibrium and in the policy counterfactuals, i.e., profits are shifted inward to the low-tax region.

Wages

OECD Reform Proposal: VA decomposition

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North America	**-0.13**	**-0.01**	**-0.30**	**-0.05**
Low tax	-0.13	-0.10	0.36	-0.56
(b) Pillar 2: Global minimum tax rate				
North America	**-0.06**	**0.01**	**-0.10**	**-0.13**
Low tax	0.02	0.23	0.19	-0.46
(c) Pillars 1 & 2 together				
North America	**-0.17**	**-0.02**	**-0.36**	**-0.11**
Low tax	-0.13	0.07	0.50	-0.98

OECD Reform Proposal: Macro Effects

Region	Lost profits (benchmark = 1)	Corp. tax rev. (% chg.)	Value added (% chg.)	Tech. capital (% chg.)		
				Total	Non MNEs	Domestic MNEs
(a) Pillar 1: Profit reallocation						
North America	0.60	2.54	-0.13	-0.40	0.15	-0.80
Low tax	0.69	-11.40	-0.13	**0.79**	**0.23**	**1.35**
(b) Pillar 2: Global minimum tax rate						
North America	0.37	3.24	-0.06	-0.15	0.08	-0.31
Low tax	0.49	-9.70	0.02	**0.32**	**0.36**	**0.28**
(c) Pillars 1 & 2 together						
North America	0.23	4.36	-0.17	-0.48	0.17	-0.94
Low tax	0.33	-16.46	-0.13	**1.00**	**0.48**	**1.51**

Notes: For the low-tax region, lost profits are negative in both the benchmark equilibrium and in the policy counterfactuals, i.e., profits are shifted inward to the low-tax region.

Wages

OECD Reform Proposal: Macro Effects

Region	Lost profits (benchmark = 1)	Corp. tax rev. (% chg.)	Value added (% chg.)	Tech. capital (% chg.)		
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North America	0.23	4.36	-0.17	-0.48	0.17	-0.94
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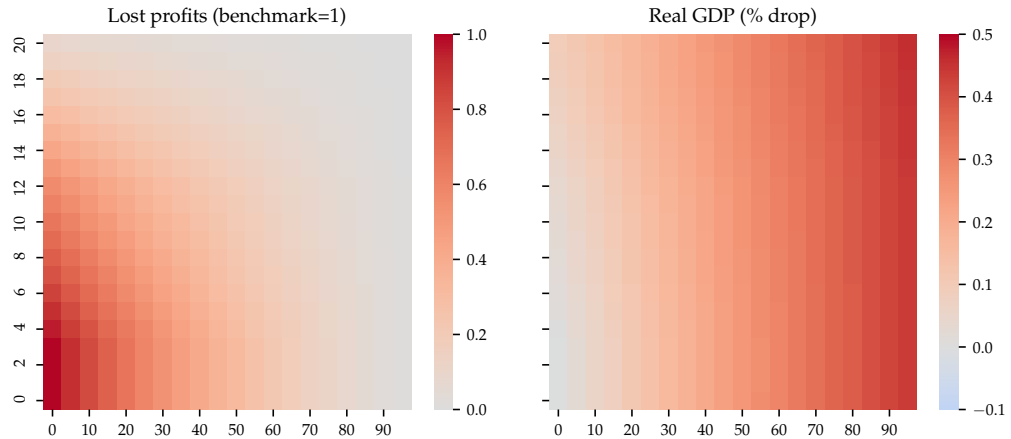
Notes: For the low-tax region, lost profits are negative in both the benchmark equilibrium and in the policy counterfactuals, i.e., profits are shifted inward to the low-tax region.

Wages

OECD Reform Proposal: VA decomposition

Region	Value added (% chg.)			
	Total	Non MNEs	Domestic MNEs	Foreign MNEs
(a) Pillar 1: Profit reallocation				
North America	-0.13	-0.01	-0.30	-0.05
Low tax	**-0.13**	**-0.10**	**0.36**	**-0.56**
(b) Pillar 2: Global minimum tax rate				
North America	-0.06	0.01	-0.10	-0.13
Low tax	**0.02**	**0.23**	**0.19**	**-0.46**
(c) Pillars 1 & 2 together				
North America	-0.17	-0.02	-0.36	-0.11
Low tax	**-0.13**	**0.07**	**0.50**	**-0.98**

OECD/G20 plan: varying the sizes of the pillars (NA only)



Note: X-axis in each plot represents the reallocation share for pillar 1. Y-axis in each plot represents the global minimum corporate income tax rate for pillar 2.

Summary

1. **Methodology**: We develop a theory in which MNEs can shift profits by transferring IP to tax havens and integrate it into a quantitative GE model

2. **Theoretical insight**: profit shifting erodes high-tax countries' tax bases, but also incentivizes their MNEs to invest more heavily in intangible capital

3. **Quantification**: OECD/G20 reform designed to address profit shifting will materially reduce global GDP despite small number of firms targeted
   - Similar magnitude to welfare effects of major trade liberalizations
     - U.S. gained 0.06% from NAFTA (Caliendo and Parro, 2014)
     - OECD gained 0.15% from China trade (di Giovanni et al., 2014)

Future work

Limitations:

- Static model: corporate tax distortions are purely intratemporal
- Abstract from financial forms of profit shifting (e.g. manipulation of debt and interest payments), some details of OECD reform

Pipeline:

- **Dyrda, Hong, and Steinberg (2022a)**: International tax competition with intangible capital and profit shifting
- **Dyrda, Hong, and Steinberg (2022b)**: Optimal Taxation of Multinational Enterprises: A Cooperative Ramsey Approach

Calibration Overview

Parameter	Description	Value(s)	Target/source
(a) Assigned parameters			
ϱ	EoS between products	5	Standard
N_j	Population	Varies	World Development Indicators
τ_j	Corporate income tax rate	Varies	Tørsløv, Wier, and Zucman (2022)
(b) Calibrated parameters			
ϕ	Technology capital share	0.11	MNEs' intangible income share
A_i	Total factor productivity	Varies	Real GDP
η_i	Productivity dispersion	Varies	Large firms' employment share
ψ_i	Utility weight on leisure	Varies	$L_i = N_i/3$
ξ_{ij}	Variable export cost	Varies	Bilateral imports/GDP
κ_i^X	Fixed export cost	Varies	Pct. of firms that export
σ_i	Variable FDI cost	Varies	Foreign MNEs' share of value added
κ_i^F	Fixed FDI cost	Varies	Avg. emp. of firms w/ foreign affiliates
ψ_{iLT}	Cost of shifting profits to LT	Varies	Total lost profits
ψ_{iTH}	Cost of shifting profits to TH	Varies	Share of profits shifted to TH
κ_i^{TH}	Fixed cost of TH affiliate	Varies	Avg. emp. of firms w/ TH affiliates

Calibration: Region-specific target moments

Region	North America	Europe	Low-tax	RoW	Tax haven
Population (NA = 100)	100	92	11	1,323	–
Real GDP (NA = 100)	100	80.78	14.57	297.10	–
Corporate tax rate (%)	**22.5**	**17.3**	**11.4**	**17.4**	**3.3**
Foreign MNEs' VA share (%)	**11.12**	**19.82**	**28.73**	**9.55**	–
Total lost profits ($B)	143	216	–	257	–
Lost profits to TH (%)	66.4	44.5	–	71.1	–
Imports from… (% GDP)					
North America	–	1.28	1.77	1.74	–
Europe	1.70	–	12.39	3.78	–
Low tax	0.35	2.98	–	0.59	–
Row	6.15	7.96	6.78	–	–

Calibration: Internally-calibrated parameter values

Region	North America	Europe	Low-tax	RoW	Tax haven
TFP (A_i)	1.00	0.89	1.58	0.20	–
Prod. dispersion (η_i)	4.28	4.31	4.83	4.12	–
Utility weight on leisure (ψ_i)	1.06	1.08	1.09	1.06	–
Fixed export cost (κ_i^X)	1.7e-3	3.5e-3	1.0e-3	1.4e-2	–
Variable FDI cost (σ_i)	0.47	0.56	0.52	0.53	–
Fixed FDI cost (κ_i^F)	1.80	1.59	0.46	8.75	–
Cost of shifting profits to LT (ψ_{iLT})	3.40	0.38	–	2.35	–
Cost of shifting profits to TH (ψ_{iTH})	2.25	1.25	–	1.76	–
Fixed FDI cost to TH (κ_i^{TH})	0.09	0.06	–	0.59	–
Variable trade cost from…					
North America	–	3.21	3.41	2.07	–
Europe	1.89	–	1.69	1.33	–
Low tax	2.04	1.59	–	1.56	–
RoW	2.26	2.59	3.01	–	–

Consumer's Problem

Consumers choose labor supply L and consumption C:

$$U(C_i, L_i) = \max_{C_i, L_i} \left[\log\left(\frac{C_i}{N_i}\right) + \psi \log\left(1 - \frac{L_i}{N_i}\right) \right]$$

s.t.

$$P_i C_i = W_i L_i + (1 - \tau_i) D_i$$

Final Goods Producer

The final goods producer of region i combines intermediate goods with a CES technology:

$$Q_j = \left[\sum_{i=1}^{J} \int_{\Omega_{ji}} q_{ji}(\omega)^{\frac{\varrho-1}{\varrho}} d\omega \right]^{\frac{\varrho}{\varrho-1}}$$

- Ω_{ji}: the set of goods from i available in j.
- q_{ji}: quantity of inputs
- ϱ: elas. of sub. between varieties

Demand curves:

$$p_{ji}(\omega) = P_i Q_i^{\frac{1}{\varrho}} q_{iji}(\omega)^{-\frac{1}{\varrho}}, \tag{1}$$

The price index is :

$$P_j = \left[\sum_{i=1}^{J} \int_{\Omega_{ji}} p_{ji}(\omega)^{1-\varrho} d\omega \right]^{\frac{1}{1-\varrho}}$$

Technology

Technology of firm ω in region

$$y_j(\omega) = \sigma_{ij} A_j a(\omega) \left(N_j z(\omega)\right)^{\gamma} \ell_j(\omega)^{\phi}. \tag{2}$$

where

- σ_{ij} is openness of j to FDI from i
- A_j is TFP in region j
- a is the firm-specific productivity
- N_j is population in region j
- z is firm's intangible capital
- ℓ_j is labor hired in j
- γ and ϕ are returns to scale parameters

Trade and Foreign Direct Investment

- Firms from region i can serve the domestic market freely.
- Two options for serving foreign markets:
  - Export domestically produced goods. Fixed cost: κ_{ijX}
  - Open a foreign affiliate and produce locally. Fixed cost: κ_{ijF}
- The firm's resource constraints

$$y_i = q_{ii} + \sum_{j \in J_X} \xi_{ij} q_{ij}^X \tag{3}$$

$$y_j = q_{ij}, \ \ j \in J_F \tag{4}$$

where

  - $J_X \subseteq J \setminus i$: set of foreign destinations to which the firm exports
  - $J_F \subseteq J \setminus i$: set of foreign destinations in which the firm operates a subsidiary

Scale Choice

We use non-exporting foreign affiliate as an example.

Given z, an affiliate of firm $\omega \in \Omega_i$ in region j chooses labor input l to maximize profit:

$$\begin{aligned}\pi_{ij}^{F}(a,z) &= \max_{q,\ell} p_{ij}(q)q - W_i\ell \\ &= \max_{\ell} P_j Q_j^{\frac{1}{\varrho}} \left(\sigma_{ij}A_j a\right)^{\frac{\varrho-1}{\varrho}} \left(N_j z\right)^{\gamma\frac{\varrho-1}{\varrho}} \ell^{\phi\frac{\varrho-1}{\varrho}} - W_j\ell\end{aligned}$$

From the FOC, ℓ can be solved as:

$$\ell = \left\{ \left[\frac{\phi(\varrho-1)}{\varrho}\right]^{\varrho} \left(P_j/W_j\right)^{\varrho} Q_j \left(\sigma_{ij}A_j a\right)^{\varrho-1} \left(N_j z\right)^{\gamma(\varrho-1)} \right\}^{\frac{1}{\phi+\varrho-\phi\varrho}}$$

IP Choice

R&D technology: number of workers required to produce 1 unit of intangible capital in country j is B_j

Under free transferability, the optimal choice of z is

$$z = \left\{ \left(\frac{\phi + \varrho - \phi\varrho}{\gamma(\varrho - 1)} \right) \left[\frac{(1-\tau_i) W_i / A_i}{(1-\tau_i)\left(\bar{R}_{ii} - \bar{C}_{ii}\right) + \sum_{j \in J_F} (1-\tau_j)\left(\bar{R}_{ij} - \bar{C}_{ij}\right)} \right] \right\}^{\frac{\phi+\varrho-\phi\varrho}{\gamma\varrho+\phi\varrho-\gamma-\phi-\varrho}}$$

Within the square bracket (the exponent outside is negative):

- The numerator is the marginal cost of producing z.
- The denominator is the marginal benefit.
- Adding transfer pricing and profit shifting will change optimal z through the denominator.

Profit Shifting Choice

From the FOC, optimal λ can be solved as (independent of z):

$$\lambda = (\mathcal{C}')^{-1}\left[(1-\varphi)\frac{(\tau_i - \tau_{i^*})}{1-\tau_i}\right]$$

We can see that λ:

- decreases with the discount factor φ.
- decreases with lowest tax rate τ_{i^*}.

Firm's problem: free transfer of z

$$d_i^{FT}(\omega) = \max_{z,\ell,J_X,J_F,q} \Bigg\{ (1-\tau_i) \overbrace{\left[p_{ii}(q_{ii})q_{ii} + \sum_{j\in J_X} \left(p_{ij}^X(q_{ij}^X)q_{ij}^X - W_i\kappa_{ijX}\right) - W_i(\ell_i + z/A_i) - W_i \sum_{J\in J_F} \kappa_{ijF} \right]}^{\text{Domestic parent profits}} + \sum_{j\in J_F} (1-\tau_j) \underbrace{\left[p_{ij}(q_{ij})q_{ij} - W_j\ell_j\right]}_{\text{Foreign subsidiary profits}} \Bigg\} \tag{5}$$

subject to (1), (2), (3), and (4).

Simplify the notation:

$$\pi_i^D(a, z; J_X) = \max_{q_{ii}, \{q_{ij}^X\}_{j\in J_X}, \ell_i} \left\{ p_{ii}(q_{ii})q_{ii} + \sum_{j\in J_X} p_{ij}(q_{ij}^X)q_{ij}^X - W_i\ell_i \right\}$$

$$\text{s.t} \quad q_{ii} + \sum_{j\in J_X} \xi_{ij} q_{ij} = y_i = A_i a (N_i z)^\gamma \ell_i^\phi$$

and

Firm's problem: free transfer of z

Thus, the conglomerate's problem can be written more succinctly as

$$d_i^{FT}(\omega) = \Bigg\{(1-\tau_i)\Bigg[\pi_i^D(a,z;J_X) - W_i\Bigg(z/A_i + \sum_{J\in J_X}\kappa_{ijX} + \sum_{j\in J_F}\kappa_{ijF}\Bigg)\Bigg] + \sum_{j\in J_F}(1-\tau_j)\pi_{ij}^F(a,z)\Bigg\}$$

Firm's Problem: transfer pricing

Building upon $d^{FT}(a)$, the TP version of the problem can be written as

$$d_i^{TP}(\omega) = \max_{z, J_X, J_F} \Bigg\{ (1-\tau_i) \Bigg[\pi_i^D(a, z; J_X) - W_i \Bigg(z/A_i + \sum_{J \in J_X} \kappa_{ijX} + \sum_{j \in J_F} \kappa_{ijF} \Bigg) + \overbrace{\sum_{j \in J_F} \vartheta_{ij}(z) z}^{\text{Licensing fees}} \Bigg] + \sum_{j \in J_F} (1-\tau_j) \Bigg[\pi_{ij}^F(a, z) - \underbrace{\vartheta_{ij}(z) z}_{\text{Licensing fee}} \Bigg] \Bigg\}$$

Firm's Problem: profit shifting

$$
\begin{aligned}
d_i^{PS}(\omega) = \max_{z, J_X, J_F, \lambda_{LT}, \lambda_{TH}} \Bigg\{ & (1-\tau_i)\Bigg[\pi_i^D(a,z;J_X) - W_i\Bigg(z/A_i + \sum_{J\in J_X}\kappa_{ijX} + \sum_{j\in J_F}\kappa_{ijF}\Bigg) \\
& + \overbrace{\sum_{j\in J_F}(1-\lambda_{LT}-\lambda_{TH})\vartheta_{ij}(z)z}^{\text{Licensing fee receipts}} + \overbrace{(\varphi_i\lambda_{LT}+\varphi_i\lambda_{TH})\,v_i(z)z}^{\text{Proceeds from selling } z} \\
& - \overbrace{(\lambda_{LT}+\lambda_{TH})\vartheta_{ii}(z)z}^{\text{Licensing fee payments}} - \overbrace{W_i\kappa_{iTH}1(\lambda_{TH}>0)}^{\text{Tax haven affiliate cost}} - \overbrace{C(\lambda_{TH}+C(\lambda_{LT}))\nu_i(z)z}^{\text{Cost of shifting } z}\Bigg] \\
& + (1-\tau_{LT})1_{(LT\in J_F)}\Bigg[\pi_{i,LT}^F(a,z) + \overbrace{\sum_{j\in J_F\cup\{i\}\setminus\{LT\}}\lambda_{LT}\vartheta_{ij}(z)z}^{\text{Licensing fee receipts}} - \underbrace{\varphi_i\lambda_{LT}v_i(z)z}_{\text{Cost of buying } z} - \underbrace{\vartheta_{iLT}(z)z}_{\text{Licensing fee pay}}\Bigg] \\
& + (1-\tau_{TH})1_{(\lambda_{TH}>0)}\Bigg[\underbrace{\sum_{j\in J_F\cup\{i\}}\lambda_{TH}\vartheta_{ij}(z)z}_{\text{Licensing fee receipts}} - \underbrace{\varphi_i\lambda_{TH}v_i(z)z}_{\text{Cost of buying } z}\Bigg] \\
& + \sum_{j\in J_F\setminus\{LT\}}(1-\tau_j)\Bigg[\pi_{ij}^F(a,z) - \underbrace{\vartheta_{ij}(z)z}\Bigg]\Bigg\}
\end{aligned}
$$

Accounting Measures

Nominal GDP:

$$GDP_i = \sum_{j=1}^{I} \int_{\omega \in \Omega_j,\, i \in J_F(\omega)} p_{ji}(\omega) y_{ji}(\omega)\ d\omega.$$

Goods Trade:

$$EX_i^G = \sum_{j \neq i} \int_{\Omega_i} p_{ij}^X(\omega) \left(1 + \xi_{ij}\right) q_{ij}^X(\omega)\ d\omega,$$

$$IM_i^G = \sum_{j \neq i} \int_{\Omega_j} p_{ji}^X(\omega) \left(1 + \xi_{ji}\right) q_{ji}^X(\omega)\ d\omega.$$

Accounting Measures

Services Trade:

- high-tax regions

$$EX_i^S = \sum_{j \neq i} \int_{\Omega_i} \left[1 - \lambda_{LT}(\omega) - \lambda_{TH}(\omega)\right] \vartheta_{ij}(\omega) z(\omega) \; d\omega$$

$$IM_i^S = \sum_{j \neq i} \int_{\Omega_i} \left[\lambda_{LT}(\omega) + \lambda_{TH}(\omega)\right] \vartheta_{ij}(\omega) z(\omega) \; d\omega + \sum_{j \neq i} \int_{\Omega_j} \vartheta_{ji}(\omega) z(\omega) \; d\omega$$

- low-tax regions:

$$EX_{LT}^S = \sum_{j \neq i} \int_{\Omega_i} \left[1 - \lambda_{TH}(\omega)\right] \vartheta_{ij}(\omega) z(\omega) \; d\omega + \sum_{j \neq i} \int_{\Omega_j} \lambda_{LT} \vartheta_{ji}(\omega) z(\omega) \; d\omega$$

$$IM_{LT}^S = \sum_{j \neq i} \int_{\Omega_i} \lambda_{TH}(\omega) \vartheta_{ij}(\omega) z(\omega) \; d\omega + \sum_{j \neq i} \int_{\Omega_j} \left[1 - \lambda_{LT}(\omega)\right] \vartheta_{ji}(\omega) z(\omega) \; d\omega$$

- tax haven:

$$EX_{TH}^S = \sum_{j=1}^{I} \int_{\Omega_j} \lambda_{TH} \vartheta_{ji}(\omega) z(\omega) d\omega$$

Accounting Measures

Net factor receipts and payments:

$$NFR_i = \sum_{j \neq i} \int_{\Omega_i} \left(1 - \tau_j\right) \pi_{ij}^{PS}(\omega) \, d\omega$$

$$NFP_i = \sum_{j \neq i} \int_{\Omega_j} \left(1 - \tau_i\right) \pi_{ji}^{PS}(\omega) \, d\omega$$

Market Clearing

Labor market:

$$L_i = \overbrace{\sum_{j=1}^{I} \int_{\Omega_j} \ell_{ji}(\omega)\ d\omega}^{\text{goods production}} + \overbrace{\int_{\Omega_i} z(\omega)/A_i\ d\omega}^{z \text{ production}} + \overbrace{\int_{\Omega_i} \left(\sum_{j \in J_X(\omega)} \kappa_i^X + \sum_{j \in J_F(\omega)} \kappa_i^F + \lambda_{TH}(\omega) > 0 \kappa_i^{TH} \right)\ d\omega}^{\text{fixed costs}}$$
$$+ \underbrace{\int_{\Omega_i} \left(\mathcal{C}_{i,TH}(\lambda_{TH}) + \mathcal{C}_{i,LT}(\lambda_{LT}) \right) \nu(\omega) z(\omega)\ d\omega}_{\text{costs of shifting } z}$$

Government Budget Constraint:

$$T_i = \tau_i \sum_{j=1}^{I} \int_{\Omega_j} \pi_{ji}^{PS}(\omega)\ d\omega.$$

Balance of Payments:

$$EX_i^G + EX_i^S - IM_i^G - IM_i^S + NFR_i - NFP_i = 0.$$

Wages and Employment

return

Region	Wages	Employment
(a) Effects of transfer pricing		
North America	-0.02	-0.08
Europe	-0.06	0.05
Low tax	0.06	-0.04
Rest of world	-0.03	0.01
(b) Effects of profit shifting		
North America	0.02	0.10
Europe	-0.03	0.11
Low tax	0.18	-0.33
Rest of world	-0.03	0.06

Wages and Employment

return

Region	Wages	Employment
(c) Pillar 1: Profit reallocation		
North America	-0.03	-0.08
Europe	-0.01	-0.05
Low tax	-0.16	0.22
Rest of world	-0.00	-0.03
(d) Pillar 2: Global minimum tax rate		
North America	-0.02	-0.08
Europe	0.03	-0.10
Low tax	-0.07	0.16
Rest of world	0.03	-0.05
(e) Pillars 1 & 2 together		
North America	-0.04	-0.12
Europe	0.01	-0.11
Low tax	-0.20	0.30