A bargaining theory of trade invoicing and pricing

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[1] The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

Motivation

- In which currency do exporter set the price of their goods?
- Who bears the exchange rate risk, and whether exchange rate movements affect relative prices (and competitiveness).
  - Producer currency pricing (PCP). The import price in local currency varies with the exchange rate.
  - Local currency pricing (LCP). The import price in local currency is constant.
- Choice affected by aggregate, sectoral, and idiosyncratic factors.

Determinants of invoicing

- Aggregate factors: use a currency with low transaction costs (Devereux and Shi 2005, Portes and Rey 2001); low macroeconomic shocks (Devereux, Engel and Storgaard 2004); hedging benefits (imported inputs Novy 2006).
- Sectoral factors: follow the invoicing of competitors ("coalescing" effect, Goldberg and Tille 2008); advantage for the currency of exporters with a large market share (Bacchetta and van Wincoop 2005, Auer and Schoenle 2012).
- Idiosyncratic factors:role of individual transactions' characteristics (Goldberg and Tille 2011); parallel with flexible price pass-through (Gopinath, Itskhoki and Rigobon, 2010).
- Limitation of literature: models consider unilateral invoicing by exporter, but evidence of bargaining between exporters and importers (Friberg and Wilander 2008, Ito et al. 2010).

Our contribution

- Develop a model of pricing and invoicing with bargaining between individual exporters and importers (Nash solution).
  - Concave valuation of payoffs. Heterogeneity of marginal valuations for agents of different sizes.
  - First model with heterogeneity and uncertainty. IO literature only has some aspects (Chipty and Snyder 1999, DeGraba 2005, Horn and Wolinsky 1988, Inderst and Wey 2001, Normann et al. 2003).
- Illustrate through two specific cases: fragmentation (number of exporters and importers) and heterogeneity (relative size among exporter and importer).
- We show that:
  - Effective bargaining weight is affected by the size of the parties, and their sensitivity to risk.
  - Higher power of importers lowers prices, and leads to more exchange rate pass-through (less concern for risk when marginal valuation is low).
  - Impact on aggregate outcomes (average price and invoicing).

Structure of the model and pricing

- One period bargaining game between X exporters (indexed by x) and M importers (indexed by m).
- Importer m purchases Q_{xm} units from exporter x, resells them at a price Z_m in her currency (quantity can be affected by import price with elasticity ρ). Average cost of production C_{xm} for x, in her currency (allows for decreasing returns). In equilibrium all exporters sell to all importers.
- Bargaining over the price between the exporter and the importer: P^m_{xm} in importer currency, $P^x_{xm} = P^m_{xm} S$ in exporter currency, S is the exchange rate.
- Two component: preset price ex ante, p^f_{xm} (in logs), extent of importer currency use (LCP pricing) β_{xm}:

$$P^m_{xm} = \exp\left[p^f_{xm} - (1 - \beta_{xm})\, s\right]$$

Importer's payoff

- Expected concave valuation of profits from transactions with all exporters:

$$U_m = \frac{1}{1-\gamma_M} E\left(\sum_{i=1}^{X}\left(Z_m - P_{im}^m\right) Q_{im}\right)^{1-\gamma_M}$$

- Surplus from the transaction with x ("X except x" denotes transactions with all exporters except x):

$$\Theta_{xm}^m = U_m\left(\text{all exporters } X\right) - U_m\left(X \text{ except } x\right)$$

- Similar payoff for exporters, with CRRA utility (curvature γ_X) and surplus: $\Theta_{xm}^x = U_x\left(\text{all importers } M\right) - U_x\left(M \text{ except } m\right)$.

Optimization

- Determination of the two components p^f_{xm} and β_{xm}. Nash solution maximizing a joint surplus (Chipty and Snyder 1999, Dowbson and Waterson 1997, and Horn and Wolinsky 1988) . δ is the formal bargaining weight of the importer:

$$\Theta^{joint}_{xm} = \left[\Theta^m_{xm}\right]^{\delta} \left[\Theta^x_{xm}\right]^{1-\delta}$$

- Two optimality conditions with respect to the preset price and invoicing:

$$\begin{aligned} 0 &= \delta \frac{\partial \Theta^m_{xm}}{\partial p^f_{xm}} \Theta^x_{xm} + (1-\delta) \frac{\partial \Theta^x_{xm}}{\partial p^f_{xm}} \Theta^m_{xm} \\ 0 &= \delta \frac{\partial \Theta^m_{xm}}{\partial \beta_{xm}} \Theta^x_{xm} + (1-\delta) \frac{\partial \Theta^x_{xm}}{\partial \beta_{xm}} \Theta^m_{xm} \end{aligned}$$

- Exact expressions are complex and highly non-linear.

Solution approach

- Solve for the steady state allocation (for simplicity $\bar{s} = 0$). Only the condition for the preset price matters, and gives $\bar{P}_{xm}$.
- Take quadratic expansions around the steady state. Focus on the condition for invoicing which gives β_{xm}.
  - Not affected by the log deviation of the preset price ($p^f_{xm} - \ln \bar{P}_{xm}$), not proportional to the variance of shocks (as long as it is nonzero). Similar to zero-order portfolio shares.
  - $p^f_{xm} - \ln \bar{P}_{xm}$ is second-order (proportional to the variance of shocks) and can be set arbitrarily small.

Steady state price

- The condition for the preset price gives:

$$\tilde{\delta}_{xm}\left(\bar{P}_{xm}-\frac{\rho}{\rho-1}\bar{Z}_m\right)\left(\bar{P}_{xm}-\overline{C}_{xm}\right)$$
$$=\quad\left(1-\tilde{\delta}_{xm}\right)\left(\bar{P}_{xm}-\frac{\rho}{\rho-1}\overline{MC}_{xm}\right)\left(\bar{Z}_m-\bar{P}_{xm}\right)$$

- $\bar{P}_{xm}$ is between the average cost $\overline{C}_{xm}$ and the final price $\bar{Z}_m$. With inelastic demand ($\rho=0$): $\bar{P}_{xm}=\tilde{\delta}_{xm}\overline{C}_{xm}+\left(1-\tilde{\delta}_{xm}\right)\bar{Z}_m$
- $\tilde{\delta}_{xm}$ is the "effective bargaining weight" of the importer m (vis-à-vis x). It exceeds the formal weight δ when the importer is large (ss. market share of exporter's profits), insensitive to risk (low γ_M), the exporter is small (ss. share of importer's profits accounted by exporter's goods), or risk sensitive (large γ_X)

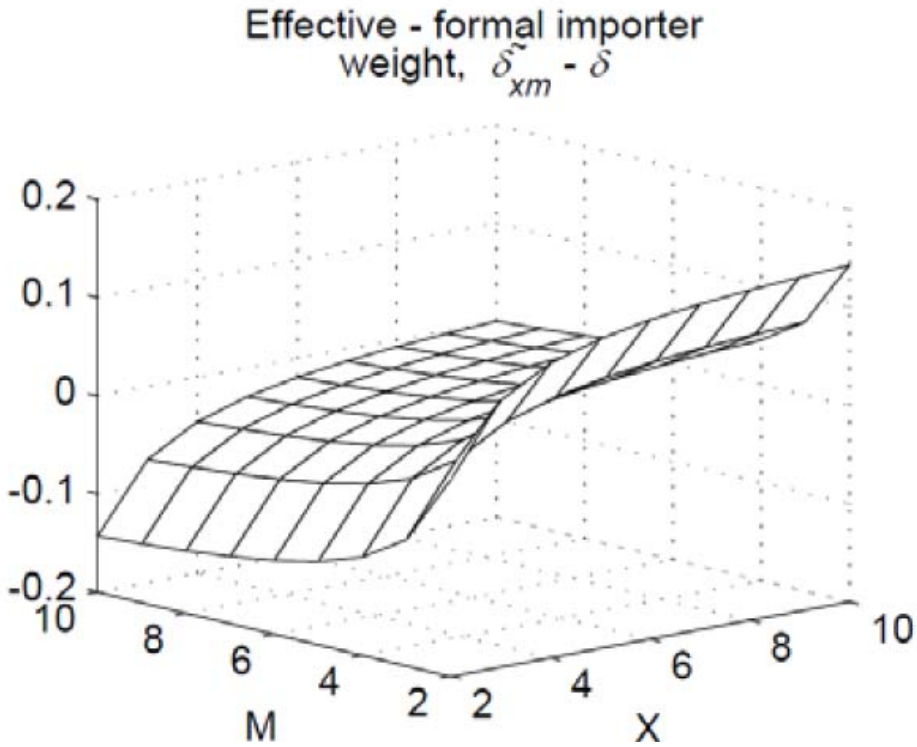
Optimal invoicing condition and illustration

- The quadratic approximation of the first-order condition with respect to the invoicing share gives a complex relation, with following features:
  - Invoicing share β_{xm} linked to comovements of the exchange rate with prices ($E\hat{z}_m\hat{s}/E\hat{s}^2$), costs ($E\hat{w}_x\hat{s}/E\hat{s}^2$) and quantities ($E\hat{q}_{xm}\hat{s}/E\hat{s}^2$, coalescing motive, only with decreasing returns to scale).
  - The variables for the *xm* pair are affected by other *xj* and *im* pairs when payoffs are concave ($\gamma_M > 0$, $\gamma_X > 0$), as outcome with other partners affect marginal valuations.
- Illustrate through two numerical examples:
  - Fragmentation: all exporters are identical, all importers are also. Focus on the number of agents.
  - Heterogeneity: 2 exporters and 2 importers. Focus on the relative size of the two agents within a group.

Fragmentation case

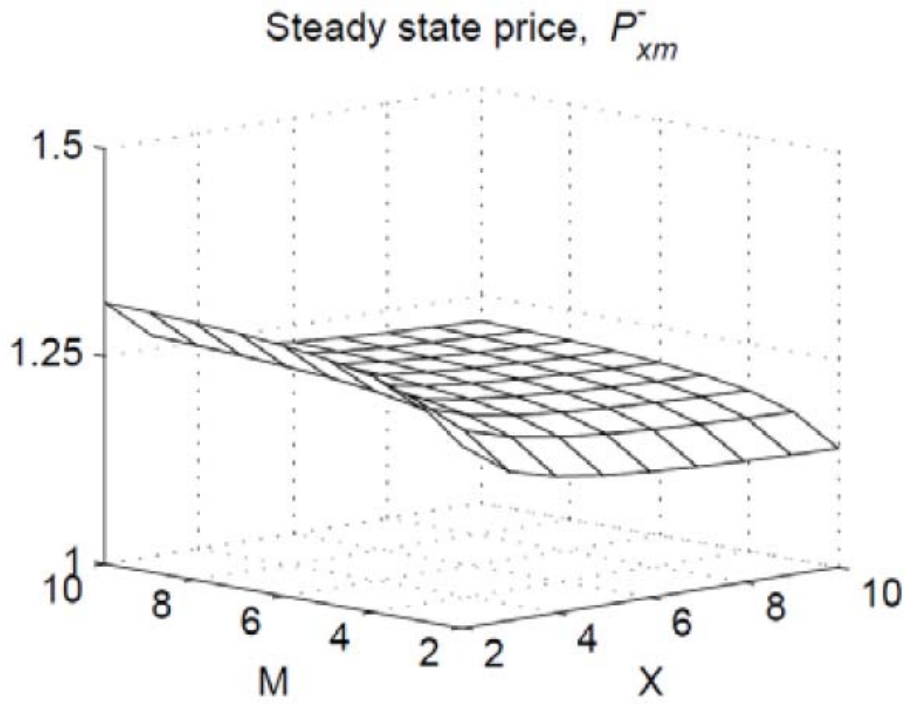
- Effective importer's bargaining weight increases with the number of exporters and decreases with the number of importers.
- A higher bargaining weight lowers prices. This raises the payoff of importers, and thus lowers their marginal valuation. Importers are then less sensitive to ex-post fluctuations, and take a larger exposure to exchange rate movements (low value of β_{xj}).
- Patterns are amplified by concavity of payoffs, muted by higher price elasticity of demand.

Figure 1: Pricing and invoicing, fragmentation case



M denotes the number of (identical) importers. X denotes the number of (identical) exporters.
Parameters: $\delta = 0.5$, $\gamma_X = 2$, $\gamma_M = 2$, $\rho = 2$, $\lambda = 1$, $W_x = 1$, $Q^{set} = 10$, $\zeta_x = 0$, $E(q^{set}\, s)/(Es^2) = 0$, $E(w_x\, s)/(Es^2) = 0$, $E(z\, s)/(Es^2) = 0$.

Figure 1: Pricing and invoicing, fragmentation case



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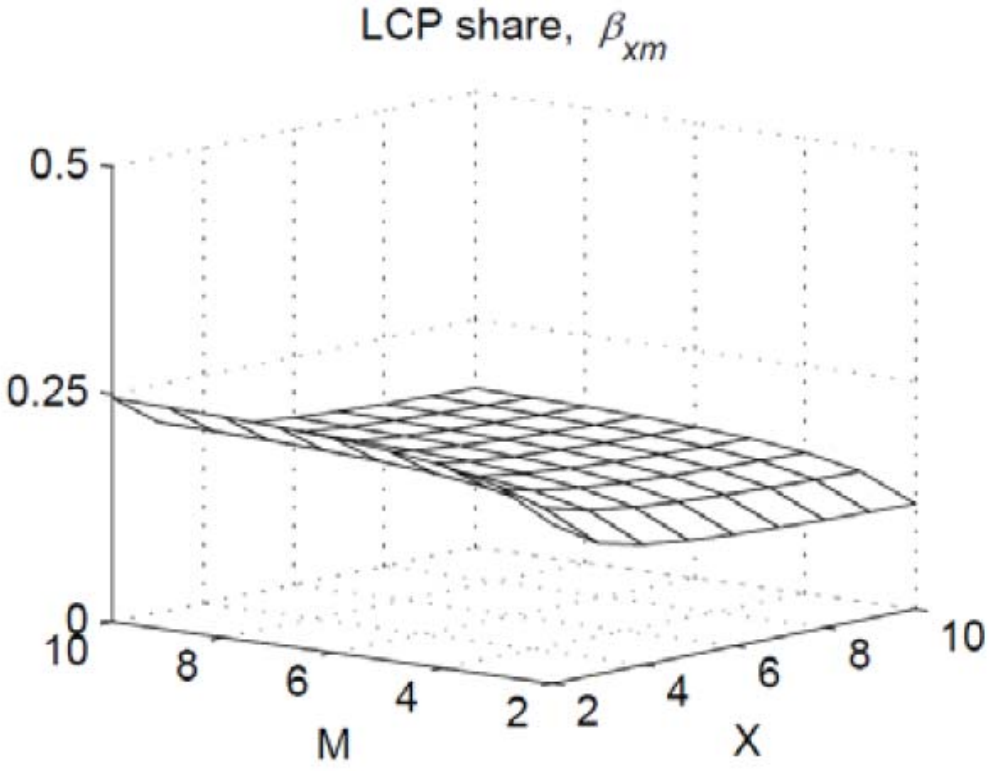


M denotes the number of (identical) importers. X denotes the number of (identical) exporters.

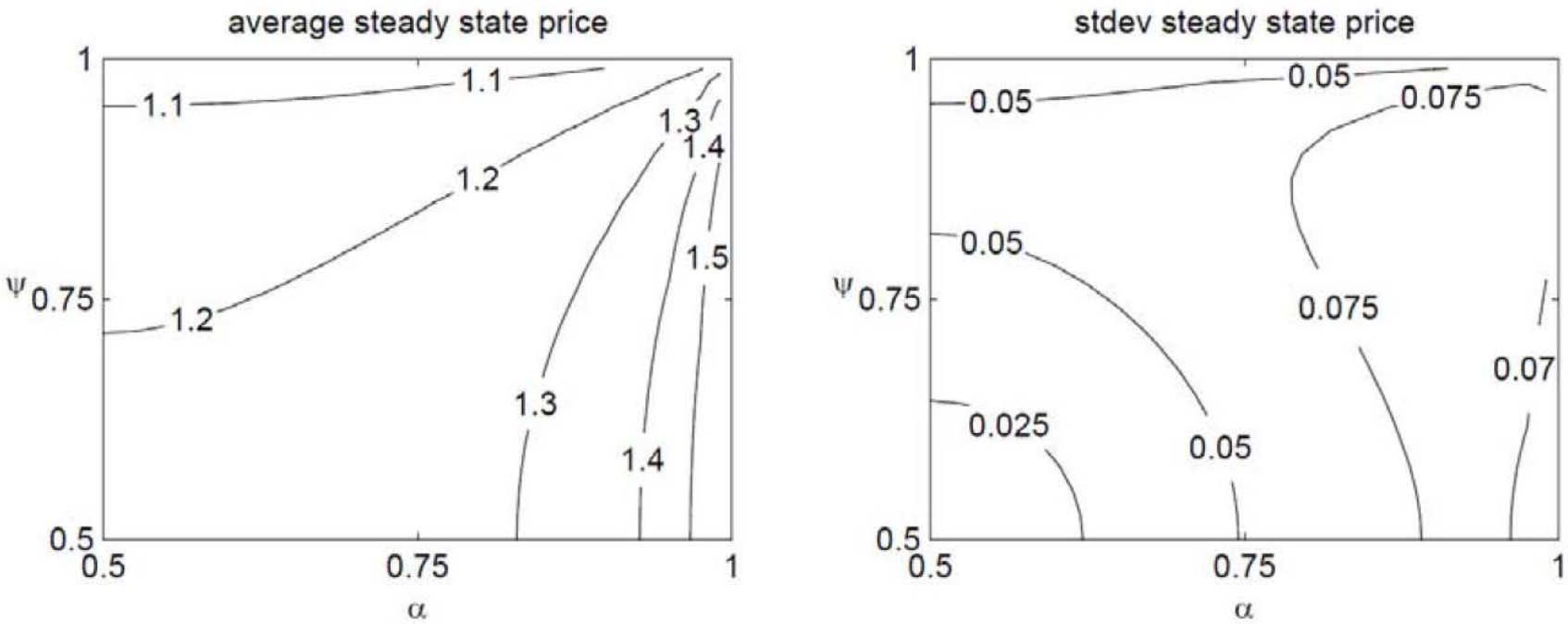
Heterogeneity case

- Consider that exporter 1 and importer 1 are the larger ones. Size parameters: $\alpha \geq 0.5$ for exporters and $\psi \geq 0.5$ for importer. Exogenous quantity in the steady state is:

$\bar{Q}^{set}_{X1M1} = \alpha\psi\bar{Q}^{set}$	$\bar{Q}^{set}_{X1M2} = \alpha\left(1-\psi\right)\bar{Q}^{set}$
$\bar{Q}^{set}_{X2M1} = \left(1-\alpha\right)\psi\bar{Q}^{set}$	$\bar{Q}^{set}_{X2M2} = \left(1-\alpha\right)\left(1-\psi\right)\bar{Q}^{set}$

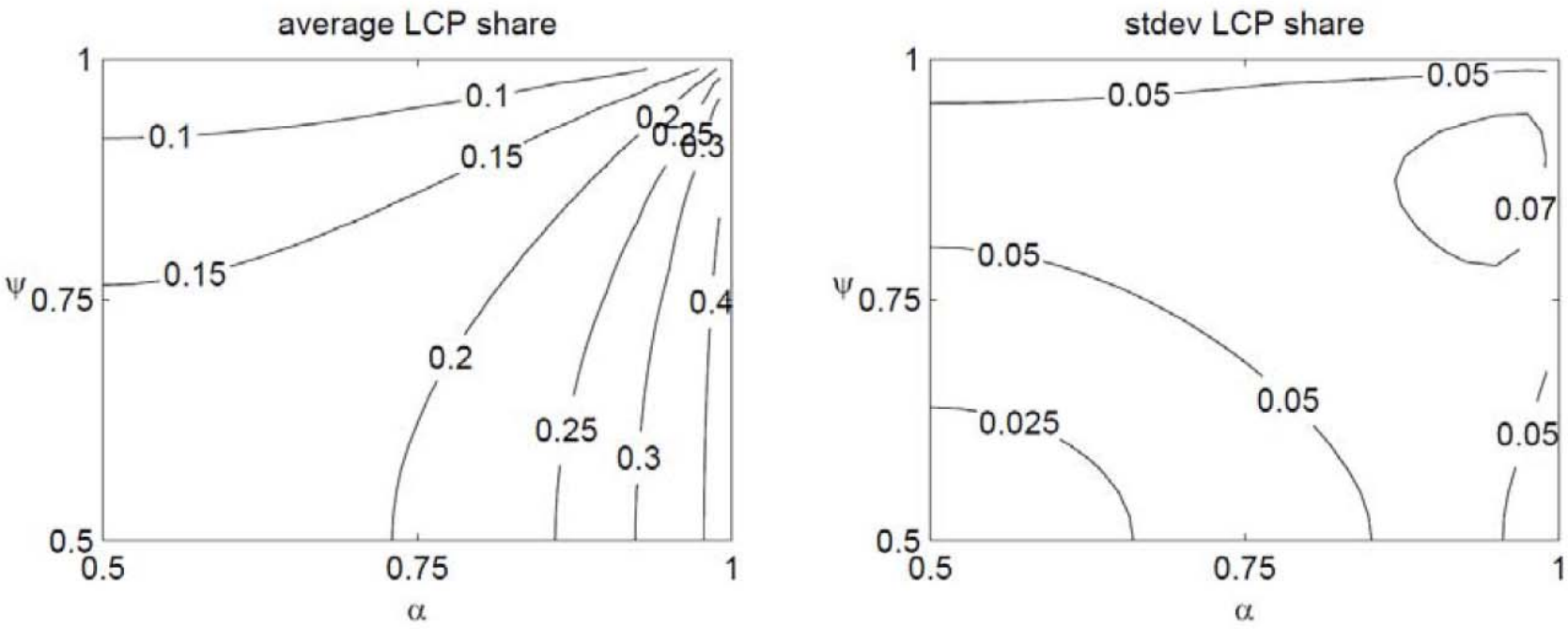
- Market structure (α and ψ) impacts the effective weight, steady state price and invoicing for each pair.
- Impact also on aggregate variables: average and standard deviation of price and invoicing (weighted by steady state transaction value) and correlation between transaction value and invoicing.
- Impact magnified by concavity of payoffs, muted by higher price elasticity of demand.

Figure 11: Average and standard deviation of steady state price $\bar{P}_{xm}$, heterogeneity case



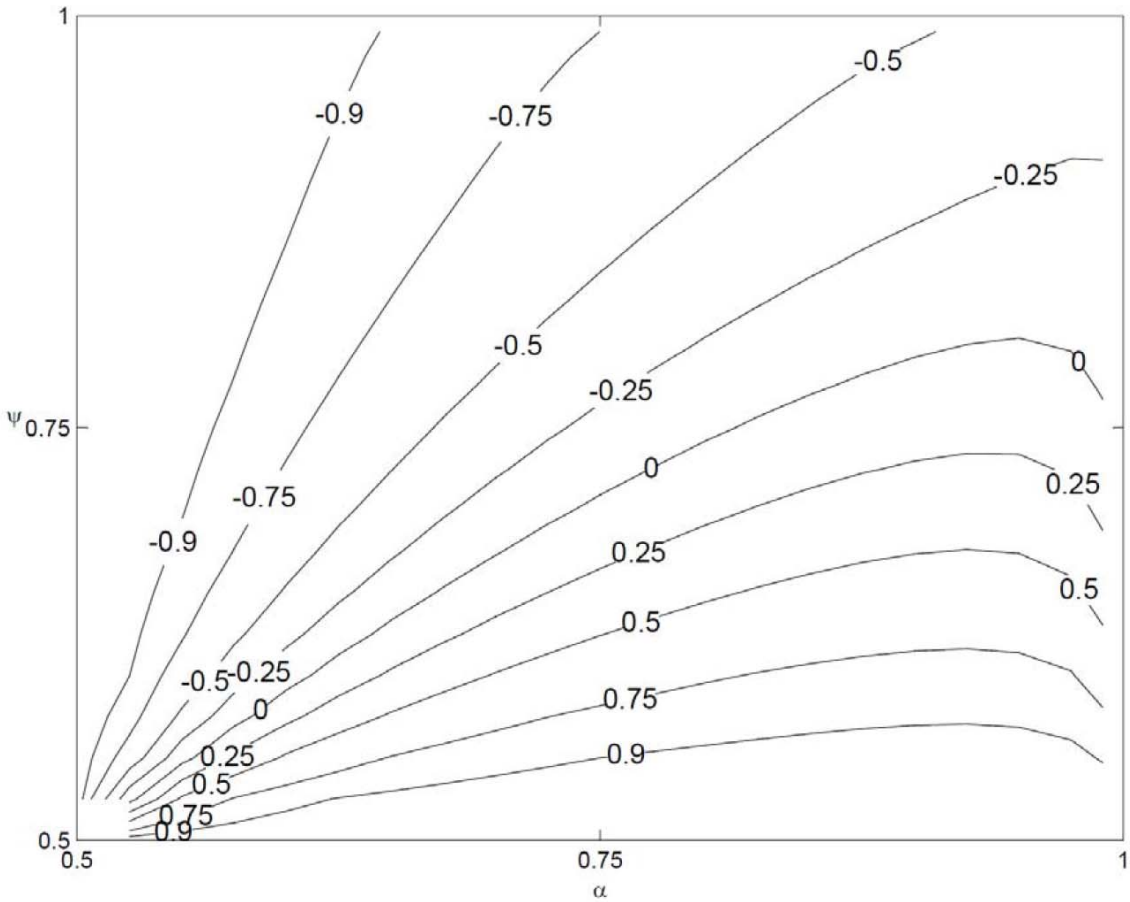
α denotes the size of the larger exporter. ψ denotes the size of the larger importer.
Parameters: $\delta = 0.5$, $\gamma_X = 2$, $\gamma_M = 2$, $\rho = 2$, $\lambda = 1$, $W_x = 1$, $Q^{set} = 10$, $\zeta_x = 0$, $E(q^{set}\, s)/(Es^2) = 0$, $E(w_x\, s)/(Es^2) = 0$, $E(z\, s)/(Es^2) = 0$.

Figure 11: Average and standard deviation of LCP share β_{xm}, heterogeneity case



α denotes the size of the larger exporter. ψ denotes the size of the larger importer.
Parameters: $\delta = 0.5$, $\gamma_X = 2$, $\gamma_M = 2$, $\rho = 2$, $\lambda = 1$, $W_x = 1$, $Q^{set} = 10$, $\zeta_x = 0$, $E(q^{set}\, s)/(Es^2) = 0$, $E(w_x\, s)/(Es^2) = 0$, $E(z\, s)/(Es^2) = 0$.

Figure 12: Correlation between transaction value $\overline{P}_{xm}\overline{Q}_{xm}$ and LCP share β_{xm}, heterogeneity case



α denotes the size of the larger exporter. ψ denotes the size of the larger importer.

Conclusion and further steps

- Novel model of international trade pricing and invoicing through bargaining, with heterogenous valuations and uncertainty.
- Market structure matters for specific exporter-importer pairs but also in aggregate.
- Need to think carefully of pricing process and market structure of specific industries.