1. Estimation Framework

Our estimation procedure is based on Eaton et al. (2011). We proceed to (1) respecify the entry and sales conditions for simulation, (2) simulate artificial firms under a particular set of parameter values, (3) construct a set of four moments, and (4) search for the optimal set of structural parameters by the simulated method of moments. Throughout this section, we denote home country \( i \), by \( J \) (Japan) and an artificial firm \( s \) by \( s = 1, 2, ..., S \).

1.1 Respecification for Simulation

Substituting the price index in equation (2.5) into equation (9), and rearranging gives:

\[
\bar{c}_n(j) = \left( \frac{\eta_n(j)}{\sigma \epsilon_n j} \right)^{1/(\sigma - 1)} \left( \frac{x_n}{\kappa_1 \psi_n} \right)^{1/\sigma}
\]

Repeating equation (B1) into equation (10), we arrive at:

\[
X_n(\alpha, \eta) = a_n(j) \eta_n(j)^{\theta - (\sigma - 1)} \kappa_0 \pi_n X_n
\]

where:

\[
\pi_n = \phi_n(\sigma \epsilon_n j)^{-\theta (\sigma - 1)}.
\]

From this point, we focus on a country pair between a host country \( i \) and a home country \( J \), where \( J \) denotes Japan. We proceed to express equations (1.1) and (1.2) in terms of a standard unit cost. Rearranging equation (11) gives

\[
z_f(j) = T_f \vartheta u(j)^{-1/\sigma}.
\]

Substituting this expression into equation (1), we obtain

\[
c_{nj}(j) = \left( \frac{u(j)}{\phi_{nj}} \right)^{1/\sigma}.
\]

The threshold unit cost for entry is then given by:

\[
\bar{c}_{nj}(j) = \left( \frac{u(j)}{\phi_{nj}} \right)^{1/\sigma}
\]

Using equations (B1) and (B3), we can rewrite the entry condition as follows:

\[
u(j) \leq \bar{u}(j)
\]

where:

\[
\bar{u}(j) = \eta_n(j)^{\theta - (\sigma - 1)} \frac{X_n \pi_n j}{\kappa_1 \sigma \epsilon_n j}
\]

We can also express the sales condition in terms of the standardized unit cost. Replacing the unit cost for firm \( j \) and the threshold unit cost in equation (10), we obtain:

\[
X_{nj}(j) = \frac{a_n(j)}{\eta_n(j)} \sigma \epsilon_n j \left( \frac{u(j)}{\bar{u}(j)} \right)^{\sigma - 1} \theta
\]

Finally, we parameterize the entry and sales conditions by connecting the conditions with actual data on aggregate multinational production. We first express the total number of firm entries to market \( n \) from Japan as:

\[
N_{nj} = \int [\mu_n(\bar{c}_{nj}(\eta))] g_2(\eta) d\eta
\]

Substituting \( \mu_n(c) = \Phi_{nj}(\bar{c}_{nj}(j)) \theta \) and equation (B1) into equation (B7), we obtain:

\[
N_{nj} = \frac{X_n \pi_n j}{\kappa_2 \sigma \epsilon_n j}
\]

Replacing equation (1.8) into (1.5) gives:

\[
\bar{u}(j) = \eta_n(j)^{\theta - (\sigma - 1)} \frac{N_{nj}}{\kappa_2}
\]

This expression corresponds to equation (12).

We then proceed to connect the sales condition with data by replacing \( X_n \pi_n j \) in equation (1.8) with data. Integrating equation (1.3) across the joint density \( g(\alpha, \eta) \), total sales by firms from Japan in country \( n \) are given by:

\[
X_{nj} = \int [a_n(j) \eta_n(j)^{\theta - (\sigma - 1)} \kappa_0 \pi_n X_n g(\alpha, \eta)] d\alpha d\eta
\]

Rearranging gives \( X_{nj} = \pi_n X_n \kappa_2 \). Substituting this expression in equation (B8), we obtain:

\[
\sigma \epsilon_n j = \frac{X_n \kappa_2}{\kappa_1 N_{nj}}
\]

Replacing equation (1.11) into equation (1.6) gives:
where $X_{njf}(j) = \frac{\alpha_n(j) \bar{\eta}_n(s) \kappa_2(\bar{u}(j))^{\sigma-1}}{\eta_n(j) \alpha_n(s)}$. This expression corresponds to equation (13).

A.  

1.2 Simulation of Multinational Firms

We use the entry and sales conditions in equations (12) and (13) to simulate individual multinational activities. An artificial producer $s$ is generated from its efficiency draw, $u(s)$, sales shock, $\alpha_n(s)$, and entry shock $\eta_n(s)$. These simulated draws are generated from the stochastic distributions as dictated by the four structural parameters in $\Theta$: heterogeneity in observed sales $\tilde{\theta}$, variances in sales $\sigma_a$ and entry shocks $\sigma_\eta$, and correlation between these shocks $\rho$. With aggregate data on the number of Japanese firms investing in country $n$, $N_{njf}$, and their aggregate sales $X_{njf}$ in that country and $\Theta$, we can produce an artificial dataset of heterogeneous multinationals on the location and sales of their foreign affiliates.

To simulate the total number $S$ of firms, we first fix $\Theta$ and construct realizations for standardized unit cost, $\bar{u}(s)$, for each firm $s$. Demand and entry shocks, $\alpha_n(s)$ and $\eta_n(s)$, are generated from a joint lognormal distribution for each firm $s$ across country $n$. These realizations of stochastic components are fixed throughout the estimation. We then compute the entry hurdle condition (12) for each artificial firm across each market and define an indicator variable $Z$ of whether each firm establishes local production in each market $n$:

$$Z_{nj}(s) = \begin{cases} 1 & \text{if } u(s) \leq \bar{\eta}_n(s) \\ 0 & \text{otherwise} \end{cases}$$

(1.13)

When the entry indicator is equal to one, a simulated firm from country $J$ (Japan) enters the market. Conditional on entry, we compute its sales in market $n$ according to the sales condition (13). We then construct the matrix of sales for each artificial firm across each market that indicates where each artificial firm sets up a foreign affiliate and how much sales it generates in that country.

1.3 Moments

With an artificial dataset of individual multinational entry and sales, we construct a vector of moments. Each moment is defined as the share of multinational parent firms that fall into a set of mutually exclusive bins. We denote $N^k$ as the number of actual firms achieving an outcome $k$ in the actual data, and $N^k$ as the number of simulated firms achieving the same outcome. For each moment, the number of simulated firms falling into each outcome is weighted as follows:

$$N^k = \frac{1}{2 \sum s \bar{u}(s)Z_{nj}(s)}$$

(1.14)

where $\bar{u}(s)$ is the importance weight of each simulated firm. We define a vector of deviations between actual and artificial moments for outcome $k$:

$$\gamma(\Theta) = m^k - \bar{m}^k(\Theta)$$

(1.15)

Following the theoretical implications of the model, we choose four moment conditions: pecking order strings, affiliate sales distributions across markets, parent sales distribution in Japan, and multinational production intensity. Corresponding to these moments, we also construct a vector of moments from the actual data on Japanese multinational firms. As described in empirical regularities of Japanese firms, we seek to capture these characteristics for simulated multinationals. Given that $N$ is the number of foreign markets penetrated by Japanese firms, each

---

1 We assume that $\alpha_n(s)$ and $\eta_n(s)$ have a joint bivariate lognormal distribution:

$$\begin{bmatrix} \ln \alpha_n(s) \\ \ln \eta_n(s) \end{bmatrix} \sim \mathcal{N} \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_a^2 & \rho_{\alpha \eta} \sigma_a \sigma_\eta \\ \rho_{\alpha \eta} \sigma_a \sigma_\eta & \sigma_\eta^2 \end{bmatrix} \right)$$

To draw these realizations of random shocks, we use the Choleski decomposition factor to construct $\ln \alpha$ and $\ln \eta$ with:

$$\begin{bmatrix} \ln \alpha_n(s) \\ \ln \eta_n(s) \end{bmatrix} \sim \begin{bmatrix} \sigma_a \sqrt{1 - \rho^2} & \rho_{\alpha \eta} \sigma_a \\ 0 & \sigma_\eta \end{bmatrix} \begin{bmatrix} \alpha_n(s) \\ \eta_n(s) \end{bmatrix}$$

To avoid drawing the firms that end up not selling anywhere, productivity draws are bounded to the firms that sell in Japan and at least one foreign market. In doing so, we use the importance sampling from $u(s) = \nu(s)\bar{u}_J(s)$, where random realizations of $\nu(s)$ are independently drawn from a uniform distribution over interval $[0,1]$ and $\bar{u}_J(s)$ is the firm-specific hurdle for entering the Japanese market and at least one foreign market. As this measure serves as a sampling weight, we ensure that all draws are to be $u(s) \leq \bar{u}_J(s)$, which corrects an upward bias in generating more efficient firms.
moment is defined as follows.

**Pecking order string:** We compute the share of multinationals entering each possible combination of the five most popular countries for Japanese multinationals: China, the United States, Thailand, Taiwan, and Indonesia in 2006. Determining the market popularity by the number of their foreign affiliates we set each string such that multinationals entering the most popular market (China) invest in less popular markets progressively. Then, we make another combination for that string such that multinationals entering the first (China) and third (Thailand) invest in less popular markets progressively. By adding up all possible combinations, we have $2^5$ moments.

**Sales distributions across foreign markets:** We calculate $q^\text{th}$ percentiles for multinational sales in each market $n$, for $q = 50$, 75, 100. For each set of firms that enter market $n$, we use these percentiles to set up sales intervals. We then calculate the share of multinationals that fall into each of these bins. The $q^\text{th}$ percentiles are calculated from the actual data and the simulated firms are set according to these bins. ($N \times 3$ moments).

**Distribution of multinational parent sales in Japan:** This moment links the level of sales in Japan to the set of firms that enter market $n$. We calculate $q \Sigma^3$ percentiles ($q = 50, 75, 100$) over domestic sales in Japan for each set of firms that enter market $n$. These intervals are calculated from the actual data. We then assign the firms that fall into these bins and calculate the share of multinationals ($N \times 3$ moments).

**Multinational production intensity:** We make two intervals for firms whose ratio of sales in market $n$ to sales in Japan is below and above the 50th percentile. Then, we compute the share of simulated firms that sell in each market $n$ and fall into either of these percentiles.

1.4 Simulated Method of Moments

Equation (C3) shows that an optimal set of parameters can be judged from the distance between actual and artificial moments, with the smaller distance indicating better parameters. To estimate the parameters, we employ simulated method of moments as introduced by McFadden (1989). This estimation method matches moments of simulated and real data, and searches for a set of parameters that minimizes the total distance between them. Under the true set of parameter values, $\Theta_0$, the following moment condition is assumed to hold:

$$E[y(\Theta_0)] = 0$$

An objective function is specified under the following weighted quadratic form:

$$\hat{\Theta} = \arg \min_\Theta [y(\Theta) \ W y(\Theta)]$$

where $\hat{\Theta}$ is a set of estimated parameters, and $W$ is assumed to be an identity matrix in practice.

To search for the parameters that best fit the model, we employ the Nelder-Mead simplex method (Nelder and Mead, 1965). To mitigate optimization errors, we introduce random variations to the starting values and repeat the minimization algorithm for a fixed set of artificial and real moments 1000 times. Finally, we take the optimal parameters that give the minimum distance.

The search procedure above should provide the best fitting parameters. However, they may be subject to sampling errors of real Japanese multinationals and simulation errors of artificial multinationals. To address these issues, we compute bootstrapped standard errors for the initial optimal estimates. First, we resample Japanese multinational firms from the actual dataset with replacement. A dataset of simulated multinationals is also generated from a new set of idiosyncratic parameters $u^b(s), \alpha^b_n(s), \text{and } \eta^b_n(s)$. Then, we follow the simulated method of moments to estimate a new set of structural parameters, $\hat{\Theta}_0$. Repeating 25 times, we calculate:

$$V(\Theta) = \frac{1}{25} \sum_1^{25} (\hat{\Theta} - \hat{\Theta}_0)' (\hat{\Theta} - \hat{\Theta}_0)$$

(1.18)

where $\hat{\Theta}^*$ is the initial set of the best fitting structural parameters. Taking the square root of the diagonal elements, we obtain the bootstrapped standard errors. They serve to gauge the potential influence of sampling and simulation errors in the best fitting parameters.

2. The Price Index

Following Eaton et al. (2011), a representative consumer in market $n$ faces the following price index, $P_n$:

$$P_n = \tilde{m} \int \left( \sum_{i=1}^{N} \int_0^{\sigma_n(c)} \alpha_n(j) e^{-\sigma-1} d\mu_n(c) \right) g(\alpha, \eta) d\alpha d\eta$$

(2.1)

where $g(\alpha, \eta)$ is a joint density function from which we draw demand and entry shocks specific to individual producers, $\alpha_n(j)$ and $\eta_n(j)$. To solve for the price index, we first rewrite the integral over $\mu_n(c) = T_1(w_n d_n)^{-\theta} c^{-\theta}dc$ in equation (A1):

$$P_n = \tilde{m} \int \left( \alpha_n(j) \sum_{i=1}^{N} \Phi_n \int_0^{\sigma_n(c)} \theta c^{-\sigma-1} dc \right) g(\alpha, \eta) d\alpha d\eta$$

(2.2)

where $\Phi_n = T_1(w_n d_n)^{-\theta}$. Note that $d\mu_n(c) = \Phi_n \theta c^{-\theta-1} dc$.

From the laws of integration, we can solve for the integral over $c$: 
\[ P_n = \bar{m} \left[ \int \left( \alpha_n(j) \sum_{i=1}^{N} \Phi_{ni} \frac{\theta}{\theta - (\sigma - 1)} \tilde{c}_{ni}(\eta)^{\theta - (\sigma - 1)} \right) g(\alpha, \eta) d\alpha d\eta \right]^{-1/(\sigma - 1)} \]  

(2.3)

Substituting the threshold unit cost, \( \tilde{c}_{ni}(\eta) \), into equation (A3), and rearranging gives:

\[ P_n = \bar{m} \left[ \kappa_0 \int \left( \alpha_n(j) \sum_{i=1}^{N} \Phi_{ni} \left( \left( \eta_n(j) \frac{X_{ni}}{\sigma E_{ni}} \right)^{1/(\sigma - 1)} \frac{\theta_{ni}}{\bar{m}} \right)^{1 - (\sigma - 1)} \right) g(\alpha, \eta) d\alpha d\eta \right]^{-1/(\sigma - 1)} \]  

(2.4)

where \( \kappa_0 = \frac{\theta}{\theta - (\sigma - 1)} \).

By moving the price-index term to the left side, we obtain the following:

\[ P_n = \bar{m}(\kappa_1 \psi_n) \bar{X}_n \left( \frac{1}{\theta - (\sigma - 1)} \right) \]  

(2.5)

where:

\[ \kappa_1 = \kappa_0 \int \alpha_n(j) \eta_n(j) \frac{\theta - (\sigma - 1)}{\sigma - 1} g(\alpha, \eta) d\alpha d\eta \]

\[ \psi_n = \sum_{i=1}^{N} \Phi_{ni} \left( \frac{\sigma E_{ni}}{\sigma - 1} \right) \]

3.  

3.1 General Equilibrium Framework

Following the approach in EKK (2011), each country is endowed with an amount of labor, \( L_i \), which is mobile across sectors but not countries, and has a wage rate \( W_i \). Intermediates are a Cobb-Douglas combination of labor and intermediates with an input bundle of \( W_i^\beta P_i^{1-\beta} \). Final output is also non-traded and is a Cobb-Douglas combination of manufactures and labor, with manufactures having a share \( \gamma \).

Profits are earned by the country where the firm is headquartered in their country. This allows profits to be redistributed equally among the consumers of their country. Country \( i \)'s total GDP, \( Y_i^A \), is equal to its total wages generated from production in the country, \( W_i L_i \) and its total profits abroad \( \Pi_i \). Lastly, countries have FDI deficits \( D_i \), where some countries are net receivers of FDI and some are net providers. Net profits earned in destination \( n \) are gross profits \( X_n / \sigma \) minus total entry costs incurred there, where total profits are \( \Pi_n^D = \frac{\sigma - 1}{\sigma} X_n \). In equilibrium, firms or multinationals from country \( i \) earn a share \( \pi_{ni} \) from the total level of profits \( \Pi_n^D \) from each market:

\[ \Pi_i = \sum_{n=1}^{N} \pi_{ni} \Pi_n^D = \frac{\sigma - 1}{\sigma} Y_i \]  

(3.1)

Country \( i \)'s total GDP, \( Y_i^A \), is equal to its total wages generated from production in the country, \( W_i L_i \) and its total profits from abroad \( \Pi_i \):

\[ Y_i^A = W_i L_i + \Pi_i \]  

(3.2)

Total demand for manufacturing production in country \( i \), \( X_i \), must be equal to final demand and use of manufactures in intermediates:

\[ X_i = \gamma (Y_i^A) + \frac{(1 - \beta)(\sigma - 1)}{\sigma} X_i \]  

(3.3)

The first component is the share of manufacturing production from final demand and the second component is the share from its use as intermediates. Using the profit expression (3.1) and the income equation (3.2), the demand equation (3.3) can be respecified as:

\[ X_i = \gamma \left( W_i L_i + \frac{\sigma - 1}{\sigma} Y_i \right) + \frac{(1 - \beta)(\sigma - 1)}{\sigma} X_i \]  

(3.3)

Assuming that gross manufacturing production in market \( X_n \) is equal to gross manufacturing of all production with \( n \)'s technology \( Y_n \) plus an FDI sales deficit \( D_n \), we have:

\[ Y_i = \frac{\gamma \sigma (W_i L_i) + [-\beta \sigma + \beta - 1] D_n \theta}{\sigma \theta - \sigma \gamma + \gamma (\sigma - 1)(\sigma - 1) \beta} \]  

\[ X_n = \frac{\gamma \sigma (W_i L_i) + [-\beta \sigma + \beta - 1] D_n \theta}{\sigma \theta - \sigma \gamma + \gamma (\sigma - 1)(\sigma - 1) \beta} + D_n \]  

(3.4)

With \( \pi_{ni} = \frac{\Phi_{ni}(\sigma E_{ni})^{-\theta - (\sigma - 1)}}{\psi_n} \) from (B2) and \( \psi_n = \sum_{i=1}^{N} \Phi_{ni} (\sigma E_{ni})^{-\theta - (\sigma - 1)} \) from (2.5), we can write:

\[ \pi_{ni} = \frac{\tau_i (W_i^\beta P_i^{1-\beta} d_{ni})^{-\theta - (\sigma - 1)} (\sigma E_{ni})^{-\theta - (\sigma - 1)}}{\sum_{n=1}^{N} \tau_i (W_i^\beta P_i^{1-\beta} d_{ni})^{-\theta - (\sigma - 1)} (\sigma E_{ni})^{-\theta - (\sigma - 1)}} \]  

(3.6)

and the following price equation:
\[ P_n = \bar{m}k_1^{-1/\theta} \left[ \sum_{i=1}^{N} T_i (W_n^\theta P_n^{1-\theta} d_{ni})^{-(\sigma^2 - (\sigma-1))/(\sigma-1)} \right]^{-1/\theta} \left( \frac{X_n}{W_n^{\theta/2}} \right)^{(1/\theta) - 1/(\sigma-1)} \]  

Equilibrium in the world market for manufacturers, \( Y_i = \sum_{n=1}^{N} \pi_{ni} X_n \), sets up a system of equations where changes in real wages and price levels, \( W_n \) and \( P_n \), can be solved following an exogenous decrease in \( d_{ni} \) and/or \( E_{ni} \). As is the case for welfare gains from trade in the heterogeneous firm model, the reductions in FDI barriers would lead to welfare gains from a decline in price levels \( P_n \) (through better access to cheaper goods) and a rise in real wages \( W_n \) (through increased production from rising productivity).

Following Dekle, Eaton, and Kortum (2008), rather than estimating all the parameters embedded in the model, the equations can be respecified in terms of the counterfactuals and their rate of change. The merit of this method is that it requires no information on the initial level of technology, variable FDI barriers, and fixed costs to entry. Under this specification, the change of wages \( \hat{W}_n \) and the changes in manufacturing price indices \( \hat{P}_n \) around the world can be solved from exogenous changes in \( \hat{d}_{ni} \) or \( \hat{E}_{ni} \) (where the hat indicates the ratio of counterfactual to baseline).

Given \( \Theta, \sigma, \beta, \gamma \) and global FDI shares (not just for Japan), a simple iterative algorithm may be used to jointly solve for changes in wages and prices resulting from an exogenous decrease in FDI barriers.

D.2 Data for Counterfactuals

In addition to the benchmark parameters estimated in \( \Theta \), the counterfactual exercise requires additional parameters that need to be calibrated. We use Kang’s (2008) estimate of the elasticity of substitution for the Japanese manufacturing sector and set \( \sigma = 2.1 \). For labor shares \( \beta \), we take the averages reported in UNIDO across countries and set \( \beta = 0.24 \).

To construct a dataset on bilateral FDI activity, we rely on several data sources. We use the RIETI FDI Database for aggregate sales of foreign affiliates of Japanese multinationals in 2006. For other bilateral pairs, affiliate sales are estimated from the UNCTAD data on FDI stocks and flows for the period 1990-2006. In doing so, we first construct bilateral FDI stocks in 2006 for each country pair. Missing figures for bilateral FDI stocks are approximated by the cumulative stocks of FDI flows over 1990-2006. As FDI flows were negative for certain country pairs and periods, an estimate of FDI stocks in 2006 becomes negative for some country pairs. In this case, we replace zero FDI stocks. When the figures remain missing, we assume zero FDI stocks for the corresponding country pairs.

Furthermore, we estimate total FDI stocks in manufacturing sectors by multiplying the figures by 21%. This figure is an average share of manufacturing FDI as reported in the World Investment Report (2010). Finally, we multiply the FDI stocks by 2.0198 to convert into sales by foreign affiliates. This factor is based on the estimated relationship between FDI stocks and affiliate sales, as shown in the World Investment Report (2010).

We use the World Bank’s World Development Indicators for data on GDP and manufacturing value-added. To construct a measure of the production that employs domestic technology, we approximate domestic production from value-added. Following an estimate for the average ratio of total sales to value-added in UNIDO, value-added is converted into total sales by a multiplying factor of 2.745. Second, we subtract total sales of inward FDI from total domestic sales to discount the contribution of foreign technology. Lastly, FDI deficits are calculated by subtracting total sales of outward FDI from total sales of inward FDI.
References


