International Trade and Domestic Production Network

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Section 1

Introduction

Motivation

- Recent development on the importance of a network structure in macro models
- No theoretical trade model explicitly recognizes a domestic inter-firm production network, (not industry-level IO structure)
- It is possible that many firms are indeed connected to foreign markets via indirect trade
    - e.g. Toyota and its suppliers in the domestic market
- This research investigates the importance and implications of indirect exporters both theoretically and empirically

Why networks?

- Many "non-exporters" indeed export their value-added to foreign markets through direct exporters (regardless of their intention)
- It is important to capture the distance to foreign markets in terms of supply chains
- Trade statistics are gross values, not net values
- We need to modify trade models
    - The effect of trade liberalizations on firm inequality is altered

Firm-level trade data

- Recent surge of research using firm-level trade data
  - Trade and labor adjustments
  - Trade and innovation
  - FTA and resource reallocation between firms
- We need to capture firm-level "value-added" trade (customs records cannot reveal this information)
- Extreme example: wholesalers or product carry trade
- Service sectors play an important role in trade

Melitz effect dampened?

- A driver of the Melitz effect (resource reallocation towards productive firms) is the relative advantage of exporters compared to non-exporters
- With domestic production network:
  - Size and employment differences get amplified
  - "Non-exporters" can export value-added indirectly via exporters –> distinction between exporters and non-exporters gets fuzzy
- This will dampen the Melitz effect (productivity gain via reallocation)?

Empirical results

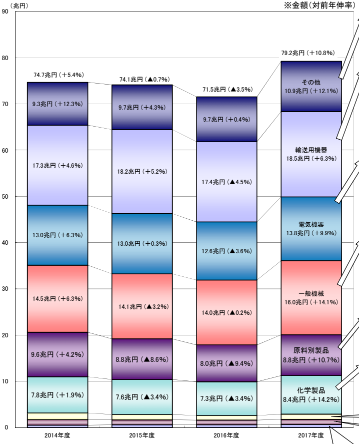
- Only 1.7% of firms directly export, but 21.3% is 1st-order indirect exporters
- On average, direct exporters have 35 suppliers whereas non-exporters have 4.6 suppliers
- More than half of firms have potential access to foreign markets within two transactions
- There is a strict ordering of size in the degree of indirect exporting
- There exists many indirect exporters even in construction or service sectors
- The upstream propagation elasticity is around 2~3% in terms of sales

Related literature

- Trade
  - Tintelnot, Kikkawa, Mogstad, and Dhyne (2018)
  - Melitz (2003), Chaney (2008), Caliendo and Parro (2015), Autor, Dorn, and Hanson (2013)
  - WIOD (World Input-Output Database), value-added trade
- Networks
  - Lim (2018)
  - Carvalho (2010, 2014), Bernard et al. (2015), Atalay (2014), Baqaee (2015), Oberfield (2012), Acemoglu, Akcigit, and Kerr (2015)

Japanese exports

品目別輸出額の推移（年度ベース）



（注）2016年度以前は確定値、2017年度は確報値。

（上段：金額、下段：対前年伸率）

＜その他＞

科学光学機器	2.4兆円 ＋12.6%	中　国	0.89兆円 ＋14.8%	米　国	0.33兆円 ＋13.4%	韓　国	0.28兆円 ＋20.7%
写真用・映画用材料	0.5兆円 ＋8.7%	米　国	0.10兆円 ＋5.8%	中　国	0.09兆円 ＋21.9%	台　湾	0.09兆円 ＋2.6%

＜輸送用機器＞

自動車	12.1兆円 ＋7.0%	米　国	4.61兆円 ＋5.7%	オーストラリア	0.83兆円 ＋17.1%	中　国	0.59兆円 ＋11.8%
自動車の部分品	3.9兆円 ＋8.3%	米　国	0.95兆円 ＋5.9%	中　国	0.81兆円 ＋11.3%	タ　イ	0.29兆円 ＋1.5%
船　舶	1.3兆円 ＋2.1%	パナマ	0.52兆円 ▲3.5%	シンガポール	0.20兆円 ＋51.5%	マーシャル	0.14兆円 ▲6.3%
航空機類	0.5兆円 ▲10.4%	米　国	0.40兆円 ▲9.6%	仏領ギアナ	0.03兆円 ＋5.3%	ドイツ	0.01兆円 ▲18.8%

＜電気機器＞

半導体等電子部品	4.0兆円 ＋9.7%	中　国	1.06兆円 ＋12.4%	台　湾	0.69兆円 ＋9.1%	香　港	0.64兆円 ＋6.0%
電気回路等の機器	2.1兆円 ＋13.2%	中　国	0.64兆円 ＋23.7%	米　国	0.21兆円 ▲1.0%	香　港	0.21兆円 ＋3.0%
電気計測機器	1.6兆円 ＋11.5%	中　国	0.33兆円 ＋20.2%	米　国	0.31兆円 ＋2.1%	韓　国	0.17兆円 ＋23.7%

＜一般機械＞

原動機	2.8兆円 ＋12.7%	米　国	0.86兆円 ＋12.7%	中　国	0.43兆円 ＋23.5%	タ　イ	0.18兆円 ＋9.9%
半導体等製造装置	2.6兆円 ＋22.1%	韓　国	0.81兆円 ＋52.0%	中　国	0.80兆円 ＋45.7%	台　湾	0.43兆円 ▲27.9%
ポンプ・遠心分離機	1.3兆円 ＋3.0%	中　国	0.26兆円 ＋17.9%	米　国	0.23兆円 ＋4.6%	韓　国	0.10兆円 ＋8.6%

＜原料別製品＞

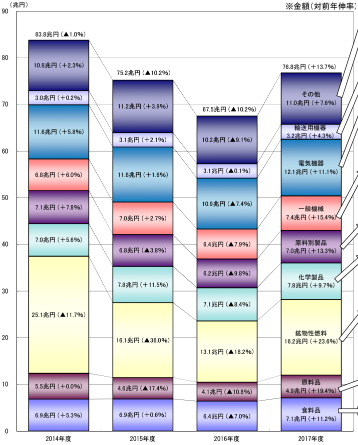
鉄　鋼	3.3兆円 ＋12.9%	中　国	0.55兆円 ＋14.7%	タ　イ	0.45兆円 ＋16.5%	韓　国	0.45兆円 ＋7.7%
非鉄金属	1.4兆円 ＋13.8%	中　国	0.41兆円 ＋25.1%	台　湾	0.24兆円 ＋7.9%	タ　イ	0.13兆円 ＋13.1%

＜化学製品＞

プラスチック	2.5兆円 ＋8.4%	中　国	0.82兆円 ＋13.7%	韓　国	0.32兆円 ▲1.1%	台　湾	0.26兆円 ＋1.9%
有機化合物	2.0兆円 ＋12.9%	中　国	0.73兆円 ＋19.8%	韓　国	0.32兆円 ＋4.7%	米　国	0.19兆円 ▲0.3%

Japanese imports

品目別輸入額の推移（年度ベース）



（上段：金額、下段：対前年伸率）

＜その他＞

衣類・同付属品	3.1兆円 ＋4.1%	中　国	1.91兆円 ＋1.4%	ベトナム	0.39兆円 ＋11.6%	インドネシア	0.11兆円 ＋12.1%
科学光学機器	1.8兆円 ＋11.7%	米　国	0.44兆円 ＋11.6%	中　国	0.33兆円 ＋7.3%	アイルランド	0.15兆円 ＋8.1%

＜輸送用機器＞

自動車	1.4兆円 ＋16.1%	ドイツ	0.68兆円 ＋24.0%	英　国	0.13兆円 ＋18.9%	米　国	0.10兆円 ＋10.7%

＜電気機器＞

通信機	3.1兆円 ＋12.6%	中　国	2.32兆円 ＋6.3%	タ　イ	0.20兆円 ＋165.1%	ベトナム	0.16兆円 ＋65.8%
半導体等電子部品	2.8兆円 ＋10.6%	台　湾	1.16兆円 ＋18.9%	中　国	0.47兆円 ▲6.2%	米　国	0.29兆円 ▲16.7%
音響・映像機器（含部品）	1.2兆円 ＋9.2%	中　国	0.67兆円 ＋10.5%	米　国	0.11兆円 ＋2.6%	タ　イ	0.09兆円 ＋17.8%

＜一般機械＞

電算機類（含周辺機器）	2.0兆円 ＋15.0%	中　国	1.51兆円 ＋15.0%	米　国	0.10兆円 ＋18.8%	タ　イ	0.10兆円 ＋11.1%
原動機	1.3兆円 ＋11.9%	米　国	0.64兆円 ＋11.8%	中　国	0.14兆円 ＋1.1%	英　国	0.09兆円 ＋36.0%

＜原料別製品＞

非鉄金属	1.8兆円 ＋26.8%	南アフリカ	0.27兆円 ＋8.9%	ロシア	0.24兆円 ＋43.6%	中　国	0.21兆円 ＋23.8%

＜化学製品＞

医薬品	2.7兆円 ＋1.2%	ドイツ	0.46兆円 ＋6.9%	米　国	0.40兆円 ▲4.3%	スイス	0.31兆円 ＋4.6%
有機化合物	1.8兆円 ＋12.4%	中　国	0.36兆円 ＋20.5%	米　国	0.29兆円 ＋12.0%	韓　国	0.14兆円 ＋4.3%

＜鉱物性燃料＞

原粗油	7.3兆円 ＋17.8%	サウジアラビア	2.89兆円 ＋25.5%	アラブ首長国連邦	1.82兆円 ＋21.1%	カタール	0.54兆円 ▲1.3%
液化天然ガス	4.1兆円 ＋22.1%	オーストラリア	1.32兆円 ＋38.8%	マレーシア	0.69兆円 ＋15.9%	カタール	0.46兆円 ＋7.5%
石　炭	2.5兆円 ＋32.9%	オーストラリア	1.59兆円 ＋29.2%	インドネシア	0.33兆円 ＋26.9%	ロシア	0.23兆円 ＋29.9%

＜原料品＞

非鉄金属鉱	1.5兆円 ＋20.6%	チ　リ	0.42兆円 ＋33.8%	インドネシア	0.23兆円 ＋18.3%	ペルー	0.18兆円 ＋56.7%

＜食料品＞

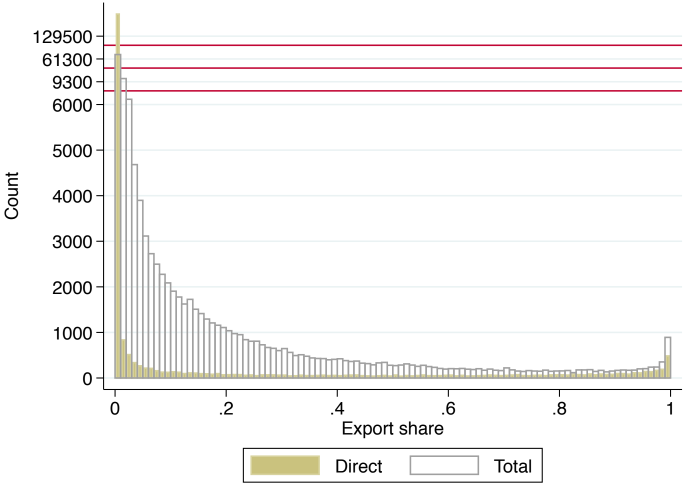
魚介類	1.7兆円 ＋12.4%	中　国	0.30兆円 ＋10.2%	米　国	0.16兆円 ＋26.2%	チ　リ	0.15兆円 ＋14.4%

（注）2016年度以前は確定値、2017年度は確報値。

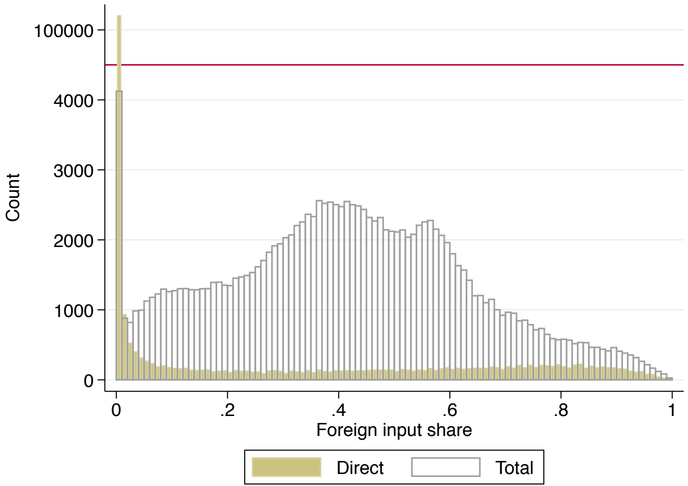
Tintelnot et al. (2018)

- They also investigate the interplay between international trade and domestic production network
- Firm-to-firm transactions data (for VAT purpose) in Belgium
- It is revealed that many small firms are also connected to foreign markets via supply chains
- Indirect exports and indirect imports show different patterns

Indirect export shares



Indirect import shares



Section 2

Model

Overview

- Melitz-type export model with domestic production networks
- Preferences and production are both CES
- Continuum of firms –> computational simplicity
- Exogenous networks
- Labor is the only factor of production (L is supplied inelastically)
- Wage is normalized to be one
- Consider autarky first, then opening up for trade

Households

- Utility of the representative household is given by

$$U = \left[\int_{\Omega} x_H(\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right]^{\frac{\sigma}{\sigma-1}}$$

  where $x_H(\omega)$ is the household's consumption of a variety ω, Ω is the set of available goods, and σ is the elasticity of substitution across varieties.
- Demand for a variety ω is

$$x_H(\omega) = \Delta_H p_H(\omega)^{-\sigma}$$

  where $\Delta_H \equiv U P_H^{\sigma}$ is a household demand shifter which is determined in a general equilibrium
- The associated ideal price index is given by

$$P_H = \left[\int_{\Omega} p_H(\omega)^{1-\sigma} \, d\omega \right]^{\frac{1}{1-\sigma}}$$

Firms

- Each firm produces its output by combining labor and intermediate inputs produced by other firms
- Firms are indexed by their fundamental productivity ϕ
- The cumulative distribution function of productivity is denoted by G_ϕ with density g_ϕ and support $S_\phi \subseteq \mathbb{R}_+$
- Firm-to-firm trade is characterized by a matching function $m\left(\phi, \phi^{'}\right)$
    - Every ϕ-firm can purchase inputs from a $\phi^{'}$-firm with a probability $m\left(\phi, \phi^{'}\right)$
    - This matching function specifies the extensive margin of domestic production networks

Production

- Firm ϕ produces its output $X(\phi)$ according to the following CES production function:

$$X(\phi) = \left[[\phi l(\phi)]^{\frac{\sigma-1}{\sigma}} + \int_{S_\phi} m\left(\phi, \phi'\right) \left[\alpha x\left(\phi, \phi'\right)\right]^{\frac{\sigma-1}{\sigma}} dG_\phi\left(\phi'\right) \right]^{\frac{\sigma}{\sigma-}}$$

where $l(\phi)$ is the quantity of labor demanded and $x\left(\phi, \phi'\right)$ is the quantity of intermediate inputs sourced from ϕ'-firms

- The share of intermediate goods relative to labor inputs is controlled by α. For aggregate variables to be finite, it is assumed that $\alpha < 1$.
- The fundamental productivity ϕ can be considered as labor productivity

Marginal cost

- The marginal cost of a ϕ-firm is given by:

$$\eta(\phi) = \left[\phi^{\sigma-1} + \alpha^{\sigma-1}\int_{S_\phi} m\left(\phi,\phi'\right)\left[p\left(\phi,\phi'\right)\right]^{1-\sigma} dG_\phi\left(\phi'\right)\right]^{\frac{1}{1-\sigma}} \quad (1)$$

where $p\left(\phi,\phi'\right)$ is the price of intermediate inputs charged by ϕ'-firms

- It is clear that the marginal cost is decreasing in ϕ and increasing in $p\left(\phi,\phi'\right)$. If a firm has access to low-cost suppliers, it will be reflected in the lower marginal cost

Market structure

- Since each buyer faces a continuum of sellers, monopolistic competition is assumed
- Each seller does not have any marketing power since they face many other competitors though the mass can be very small. Hence, the profit-maximizing prices charged by a ϕ-firm is given by

$$p_H(\phi) = p\left(\phi', \phi\right) = \mu\eta(\phi) \;\; \forall\phi' \tag{2}$$

where $\mu = \frac{\sigma}{\sigma-1}$ is the standard CES markup.

Network variables

- Define firms' "network productivity" as follows

$$\Phi\left(\phi\right) \equiv \eta\left(\phi\right)^{1-\sigma}$$

- We obtain the following equation to determine firms' network productivity

$$\Phi\left(\phi\right) = \phi^{\sigma-1} + \left(\frac{\alpha}{\mu}\right)^{\sigma-1} \int_{S_\phi} m\left(\phi, \phi^{'}\right) \Phi\left(\phi^{'}\right) dG_\phi\left(\phi^{'}\right)$$

- The above integral equation is classified as an inhomogenous Fredholm equation of the second kind, where $m\left(\phi, \phi^{'}\right)$ is the kernel.
- Since $\left(\frac{\alpha}{\mu}\right)^{\sigma-1} < 1$ and $m\left(\phi, \phi^{'}\right) \leq 1$ for all firm pairs, contraction mapping can be applied to the integral equation
- Solving for $\Phi\left(\phi\right)$ is easy in Matlab (standard iteration process)

Two extreme cases

1. No network: $m\left(\phi, \phi^{'}\right) = 0$ for all $\phi, \phi^{'}$ pairs –> Melitz (2003)

$$\Phi\left(\phi\right) = \phi^{\sigma-1}$$

2. Lattice network: $m\left(\phi, \phi^{'}\right) = 1$ for all $\phi, \phi^{'}$ pairs

$$\Phi\left(\phi\right) = \phi^{\sigma-1} + C$$

Numerical example

- Log-normal distribution for the fundamental productivity ϕ with a mean μ and variance σ^2

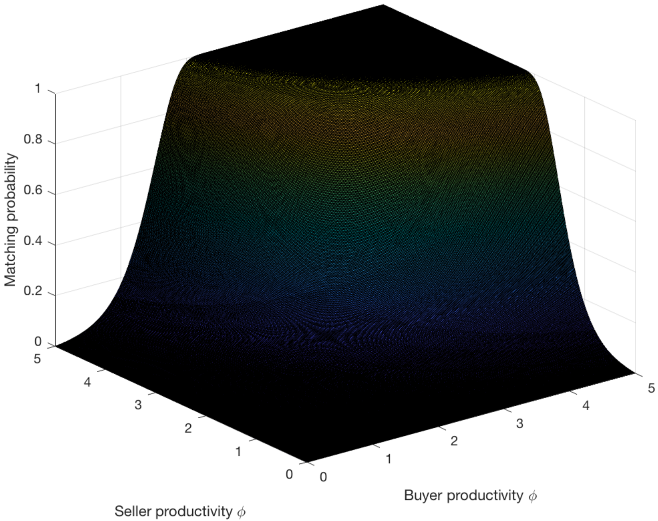
$$g_\phi(\phi) = \frac{1}{\phi\sigma\sqrt{2\pi}} \exp\left[-\frac{(\ln\phi - \mu)^2}{2\sigma^2}\right] \text{ for } \phi \in (0, \infty)$$

- Gompertz distribution for the matching function with a scale parameter $b > 0$ and shape parameter $s > 0$

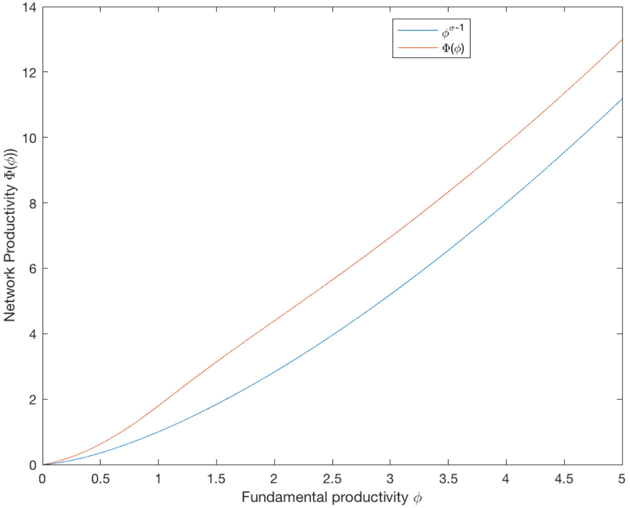
$$m\left(\phi, \phi'\right) = 1 - \exp\left[-b\left[\exp\left(s \times \phi \times \phi'\right) - 1\right]\right] \text{ for } \phi, \phi' \in [0, \infty)$$

- Gompertz is heavily used in survival analysis, and the sign of the elasticity gradient of the distribution is variable when $s \in (0, 1)$

Matching function



Network productivity



Numerical example 2

- Pareto distribution for the fundamental productivity ϕ with a shape parameter θ

$$g_{\phi}(\phi) = \theta\phi^{-(\phi+1)} \text{ for } \phi \in [1, \infty)$$

- CDF of "Bivariate Pareto distribution" for the matching function with two parameters λ_c and λ_s

$$m\left(\phi, \phi^{'}\right) = 1 - \phi^{-\lambda_c}\phi^{'-\lambda_s} \text{ for } \phi, \phi^{'} \in [1, \infty)$$

- In this special case, we obtain an analytical expression for $\Phi(\phi)$

$$\Phi(\phi) = \phi^{\sigma-1} - c_1\phi^{-\lambda_c} + c_2$$

where c_1 and c_2 are constants determined by parameters

- We have $\Phi'(\phi) > 0$

Determining constants

- c_1 and c_2 are the solution for the following linear equations

$$\begin{bmatrix} c_1 \\ c_2 \end{bmatrix} = \left(\boldsymbol{I} - \left(\frac{\alpha}{\mu}\right)^{\sigma-1} \begin{bmatrix} \frac{\theta}{\theta+\lambda_c+\lambda_s} & \frac{\theta}{\theta+\lambda_s} \\ \frac{\theta}{\theta+\lambda_c} & 1 \end{bmatrix} \right)^{-1} \times \left(\frac{\alpha}{\mu}\right)^{\sigma-1} \begin{bmatrix} \frac{\theta}{\theta-(\sigma-1)+\lambda_s} \\ \frac{\theta}{\theta-(\sigma-1)} \end{bmatrix}$$

Network demand

- Network demand is defined as follows

$$\Delta(\phi) = \mu^{-\sigma} + \mu^{-\sigma}\alpha^{\sigma-1}\int_{S_\phi} m\left(\phi', \phi\right)\Delta\left(\phi'\right) dG_\phi\left(\phi'\right)$$

- Due to the limited identification, heterogeneity in a preference parameter is not allowed
- Unique solution is guaranteed
- In the earlier examples, $\frac{d\Delta}{d\phi} > 0$

Firm size and profit

- Firm ϕ's total revenue, variable profit, and labor demand are respectively given by the following

$$R(\phi) = \mu \Delta_H \Delta(\phi) \Phi(\phi)$$
$$\pi(\phi) = (\mu - 1) \Delta_H \Delta(\phi) \Phi(\phi) - f$$
$$l(\phi) = \Delta_H \Delta(\phi) \phi^{\sigma-1}$$

- Total output is given by

$$X(\phi) = \Delta_H \Delta(\phi) \Phi(\phi)^{\frac{\sigma}{\sigma-1}}$$

- In the numerical example (Pareto case), for $\phi^{'} > \phi$,

$$\frac{l\left(\phi^{'}\right)}{l(\phi)} = \frac{\Delta\left(\phi^{'}\right)}{\Delta(\phi)} \left(\frac{\phi^{'}}{\phi}\right)^{\sigma-1} > \left(\frac{\phi^{'}}{\phi}\right)^{\sigma-1}$$

Fixed and entry costs

- f : per-period fixed cost for domestic sales (in units of labor)
- f_e : sunk cost for entry
- δ : exogenous death shock rate
- If a firm pays f_e , it can draw a productivity from an exogenous distribution $f(\phi)$
- If the operating profit $\pi(\phi) - f$ is negative, the firm immediately exits the market –> $g(\phi)$ is a truncated distribution of $f(\phi)$
- Let ϕ^* be the cutoff firm –> S_ϕ is then $[\phi^*, \infty)$

Aggregate variables

- Define the average network productivity $\tilde{\Phi}$ as

$$\tilde{\Phi}(\phi^*) = \left[\int_{\phi^*}^{\infty} \Phi(\phi)\, g(\phi)\, d\phi\right]^{\frac{1}{\sigma-1}}$$

- Define the average "size" measure $\tilde{\chi}$ as

$$\tilde{\chi}(\phi^*) = \int_{\phi^*}^{\infty} \Delta(\phi)\, \Phi(\phi)\, g(\phi)\, d\phi$$

- Let M be the mass of operating firms
- Aggregate revenue and profit are

$$R = M\mu\Delta_H\tilde{\chi}(\phi^*)$$
$$\Pi = (\mu - 1)\, M\mu\Delta_H\tilde{\chi}(\phi^*) - fM$$

Zero cutoff profit condition

- By definition, $\pi(\phi^*) = 0$ or

$$(\mu - 1)\Delta_H \Delta(\phi^*)\Phi(\phi^*) = f$$

- The average profit $\bar{\pi} = \frac{\Pi}{M}$ is then

$$\bar{\pi} = f\left[\frac{\tilde{\chi}(\phi^*)}{\Delta(\phi^*)\Phi(\phi^*)} - 1\right]$$

- $\bar{\pi}$ is decreasing in ϕ^*? –> ZCP condition
  - This depends on $m\left(\phi, \phi^{'}\right)$ and $g(\phi)$

Free entry condition

- Each firm's value function is

$$v(\phi) = \max\left\{0, \frac{1}{\delta}\pi(\phi)\right\}$$

- The net value of entry is

$$v_e = p_{in}\bar{v} - f_e = \frac{1 - F(\phi^*)}{\delta}\bar{\pi} - f_e$$

- Hence, the free entry (FE) condition is

$$\bar{\pi} = \frac{\delta f_e}{1 - F(\phi^*)}$$

which is increasing in ϕ^*

Stationary equilibrium

- Under certain conditions with $m\left(\phi, \phi^{'}\right)$ and $g\left(\phi\right)$, a unique solution for $(\bar{\pi}, \phi^{*})$ can be characterized

Labor Market clearing

- L_p : labor used for production
- L_e : labor used for entry investment
- Labor market clearing:

$$\int_{S_\phi} l(\phi)\, dG_\phi(\phi) = L - L_e$$

Stability conditions

- Firm inflow = firm outflow: $p_{in} M_e = \delta M$
- With FE condition,

$$L_e = M_e f_e = \frac{\delta M}{p_{in}} f_e = M \bar{\pi} = \Pi$$

Household demand and welfare

- The demand shifter is

$$\Delta_h = \frac{L}{\int_{s_\phi} \Delta(\phi)\, \phi^{\sigma-1} dG_\phi(\phi)}$$

- Price index is

$$P_H = \mu M^{\frac{1}{1-\sigma}} \left[\int_{\phi^*}^{\infty} \Phi(\phi)\, dG(\phi) \right]^{\frac{1}{1-\sigma}} = \mu M^{\frac{1}{1-\sigma}} \tilde{\Phi}^{-1}$$

- Household welfare is

$$U = \mu^{-\sigma} M^{\frac{1}{\sigma-1}} \frac{\tilde{\Phi}^{\sigma}}{\int_{\phi^*}^{\infty} \Delta(\phi)\, \phi^{\sigma-1} g(\phi)\, d\phi}$$

Exporting

- Now, consider that domestic firms have an option of exporting their products to a foreign country.
- Two symmetric countries
- Cross-border firm-to-firm trade is not allowed
  - Home firms can export only to the consumers in the foreign country, not to the foreign firms, and they cannot import any foreign inputs
- To export, firms must incur a standard iceberg trade cost $\tau > 1$ and a fixed cost f_x in terms of labor a la Melitz (2003).

Export profit and cutoff

- The net export profit of a firm ϕ is

$$\pi_x(\phi) = (\mu - 1)\,\Delta_F \tau^{1-\sigma} \Phi(\phi) - f_x$$

- The export cutoff productivity denoted by ϕ_X satisfies

$$\Phi(\phi_X) = \frac{f_x \tau^{\sigma-1}}{(\mu - 1)\,\Delta_F}$$

- Assume $\tau^{\sigma-1} f_x > f$
- As we expect, ϕ_X is increasing in the fixed cost f_x and iceberg cost τ and decreasing in the foreign demand shifter Δ_F.

Indirect exporters

- Only the most productive firms will directly export to the foreign market. Yet, there are many other firms whose value-added is indirectly exported via direct exporters
- The share of direct exporters (degree 0 indirect exporters) is given by

$$s_X^{(0)} = \int_{\phi_X}^{\infty} dG_\phi(\phi)$$

- The share of first-degree indirect exporters is

$$s_X^{(1)} = \int_0^{\infty} \int_{\phi_X}^{\infty} m\left(\phi, \phi'\right) dG_\phi(\phi)\, dG_\phi\left(\phi'\right)$$

Higher-degree indirect exporters

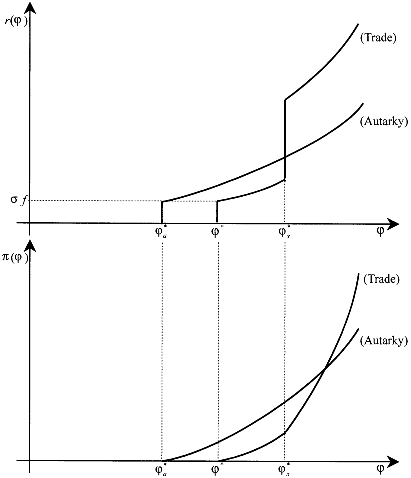
- Define an indirect matching functions recursively as follows

$$m^{(d)} = \int_{S_\phi} m^{(d-1)}\left(\phi, \phi''\right) m\left(\phi'', \phi'\right) dG_\phi\left(\phi''\right)$$

- Then, the share of higher-degree indirect exporters is given by

$$s_X^{(n)} = \int_0^\infty \int_{\phi_X}^\infty m^{(n)}\left(\phi, \phi'\right) dG_\phi\left(\phi\right) dG_\phi\left(\phi'\right)$$

Melitz Effect



Dampened Melitz effects

- Opening up for trade induces ϕ^* to be higher
- Due to CES, no effect of import competition on markup
- Reallocation occurs since firms compete for the same factor input (labor)
- Increased labor usage of exporters propagates to indirect exporters with domestic production network
- Compared to no network case, this will dampen the Melitz effect (ϕ^* does not rise as much)
- With network, two competing forces
  - amplified employment size differences
  - propagation of increased demand from exporters to non-exporters

Section 3

Empirical Evidence

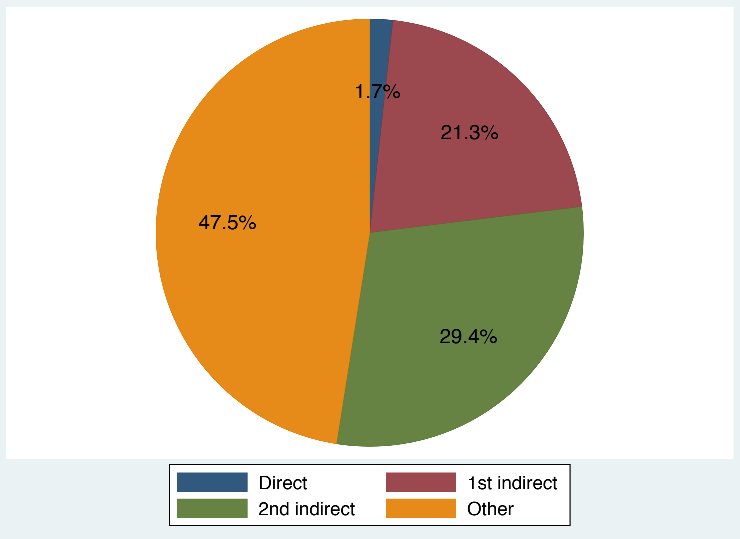
Data

- Tokyo Shoko Research (TSR)
  - about a million firms information (address, industry classification, sales, # of employees etc.)
  - supplier and customer information for each firm up to 24 partners
  - by combining self- and other-reported data, we can capture the transaction network quite well
  - years: 2006, 2011, 2012, 2014
  - 2014 data include export and import flag for each firm
- Kikatsu
  - Panel data of firm information for relatively large firms (around 30,000 firms per year)
  - Firm-level export and import values

Indirect exporters

- Direct exporters (D): Firms that directly export to foreign markets
- 1st-degree indirect exporters (1E): Firms that do not export but at least one of their customers exports
- 2nd-degree indirect exporters (2E): Firms that are not in the above two groups but one of their customers' customers exports
- Other firms (O): Other firms who need at least three downstream links to reach an exporter

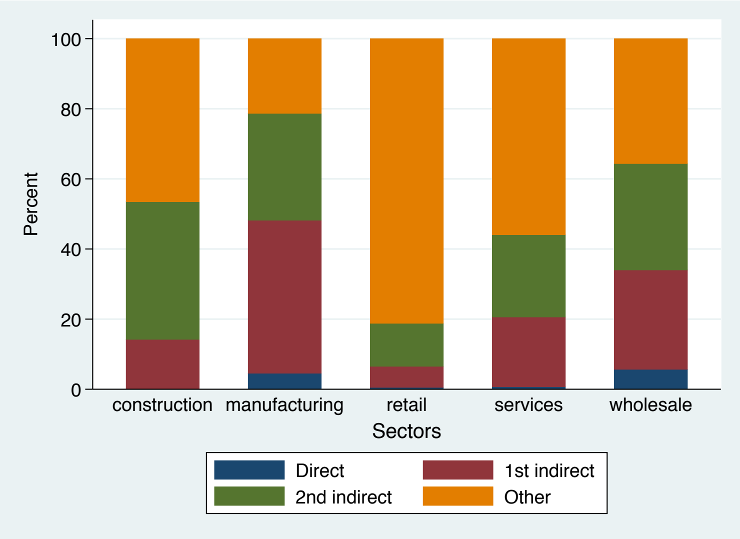
Share of indirect exporters



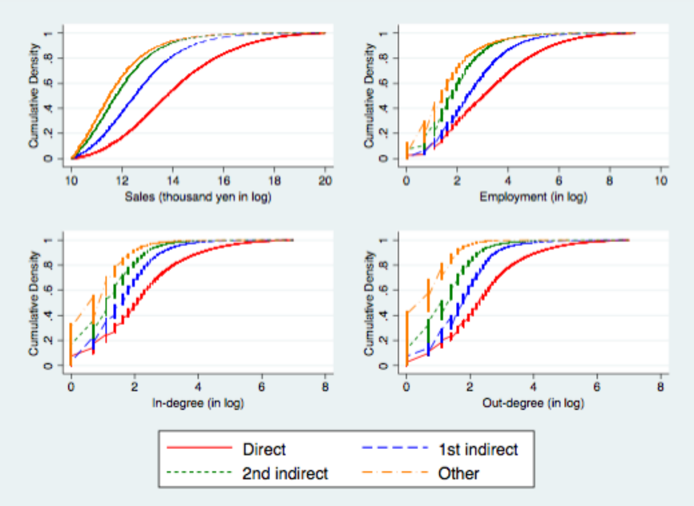
Share of indirect exporters (by sectors)

	# of firms	#of D	# of 1E	# of 2E	# of O
manufacturing	159117 (16%)	7238 (42%)	69537 (33%)	48392 (17%)	33950 (7%)
construction	327667 (33%)	210 (1%)	46349 (22%)	128709 (44%)	152399 (33%)
wholesale	128093 (13%)	7253 (42%)	36310 (17%)	38863 (13%)	45667 (10%)
retail	114225 (12%)	587 (3%)	6869 (3%)	14000 (5%)	92769 (20%)
services	255661 (26%)	1838 (11%)	50819 (11%)	60016 (21%)	142988 (31%)
All	984763 (100%)	17126 (100%)	209884 (100%)	289980 (100%)	467773 (100%)

Share of indirect exporters (by sectors)



Empirical CDF by exporter types



Estimation of propagation effects

- Analyze the sales growth rates of direct and indirect exporters in years 2005 and 2010 separately
- 2005: Increased exports due to Yen depreciation
- Simple DID regression analysis
- Three types of direct exporters:
  - Direct exporters (any firm whose export volume is positive)
  - Net exporters (firms that export but do not import)
  - Intense exporters (firms whose export sales is more than 10% of total sales)

Number of firms in each export groups

	direct	1st-degree	2nd-degree
exporter	3,701	88,090	137,839
net exporter	1,141	36,962	136,378
intense exporter	1,212	49,900	120,818

Upstream propagation (2005)

	(1) sales growth	(2) sales growth	(3) sales growth	(4) sales growth	(5) sales growth	(6) sales growth	(7) sales growth	(8) sales growth	(9) sales growth	(10) sales growth
1E	0.021***		0.026***	0.023***					0.014***	0.009***
	(0.001)		(0.001)	(0.002)					(0.002)	(0.002)
2E		0.004***	0.012***	0.010***						
		(0.001)	(0.001)	(0.001)						
1NE					0.028***	0.025***			0.007***	
					(0.002)	(0.002)			(0.002)	
2NE					0.015***	0.012***				
					(0.001)	(0.001)				
1IE							0.032***	0.030***		0.015***
							(0.002)	(0.002)		(0.002)
2IE							0.015***	0.014***		
							(0.001)	(0.001)		
in-degree				-0.003***		-0.003***		-0.003***	-0.003***	-0.003***
				(0.001)		(0.001)		(0.001)	(0.001)	(0.001)
out-degree				0.006***		0.006***		0.006***	0.007***	0.007***
				(0.001)		(0.001)		(0.001)	(0.001)	(0.001)
employment	0.019***	0.019***	0.018***	0.016***	0.018***	0.016***	0.018***	0.016***	0.016***	0.016***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
age	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.022***	0.022***	0.020***	0.028***	0.021***	0.029***	0.021***	0.030***	0.032***	0.032***
	(0.006)	(0.006)	(0.006)	(0.008)	(0.006)	(0.008)	(0.006)	(0.008)	(0.008)	(0.008)
2-digit JSIC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	462,083	462,083	462,083	285,910	462,083	285,910	462,083	285,910	285,910	285,910
R-squared	0.019	0.019	0.020	0.022	0.020	0.022	0.020	0.023	0.022	0.022

Sectoral heterogeneity of propagation effects (2005)

	exporters		net exporters		intense exporters	
	(1) sales growth	(2) sales growth	(3) sales growth	(4) sales growth	(5) sales growth	(6) sales growth
1E	0.025***		0.026**		0.027***	
	(0.007)		(0.011)		(0.009)	
1E×manufacturing	-0.010		-0.007		-0.006	
	(0.007)		(0.011)		(0.009)	
1E×construction	-0.001		-0.002		0.001	
	(0.007)		(0.012)		(0.010)	
1E×wholesale	0.006		0.007		0.015*	
	(0.007)		(0.011)		(0.009)	
1E×services	-0.012*		-0.016		-0.014	
	(0.007)		(0.011)		(0.009)	
2E		0.007		0.011**		0.010**
		(0.004)		(0.005)		(0.005)
2E×manufacturing		-0.011**		-0.008		-0.011**
		(0.005)		(0.005)		(0.005)
2E×construction		0.002		0.001		0.005
		(0.005)		(0.005)		(0.005)
2E×wholesale		-0.004		0.006		0.001
		(0.005)		(0.005)		(0.006)
2E×services		-0.001		-0.002		0.000
		(0.005)		(0.005)		(0.005)
employment	0.019***	0.019***	0.019***	0.019***	0.019***	0.019***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
age	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.023***	0.024***	0.023***	0.023***	0.023***	0.023***
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
2-digit JSIC FE	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	462,083	462,083	462,083	462,083	462,083	462,083
R-squared	0.019	0.019	0.019	0.019	0.019	0.019

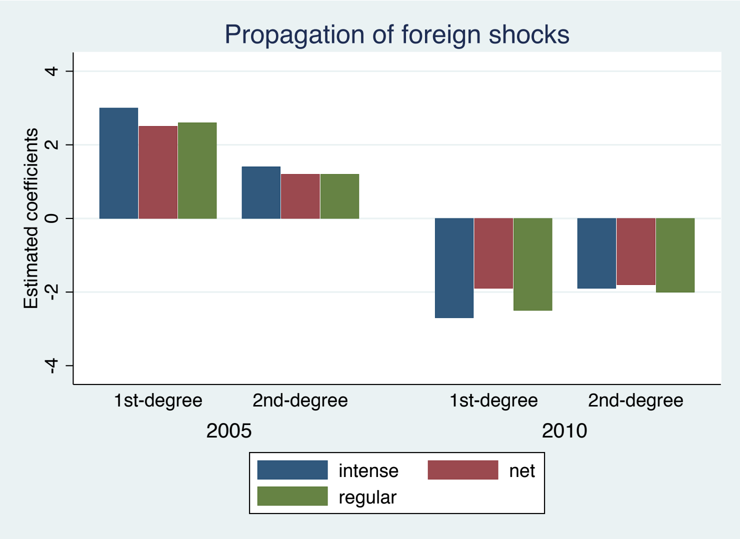
Differential sales growth of exporters (2010)

	(1) sales growth	(2) sales growth	(3) sales growth	(4) sales growth	(5) sales growth
exporter	-0.0346***		-0.0391***		-0.0280***
	(0.0043)		(0.0049)		(0.0053)
importer		-0.0094**	0.0088*		0.0098**
		(0.0041)	(0.0047)		(0.0047)
net exporter				-0.0343***	
				(0.0062)	
net importer				0.0115*	
				(0.0060)	
intense exporter					-0.0370***
					(0.0071)
log of employment	0.0266***	0.0273***	0.0267***	0.0273***	0.0264***
	(0.0025)	(0.0025)	(0.0025)	(0.0025)	(0.0025)
log of total asset	0.0006	-0.0014	0.0004	-0.0015	0.0010
	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
constant	-0.1794**	-0.1692**	-0.1806**	-0.1752**	-0.1833**
	(0.0733)	(0.0734)	(0.0733)	(0.0734)	(0.0733)
2-digit JSIC FE	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes
Observations	23,174	23,174	23,174	23,174	23,174
R-squared	0.1687	0.1666	0.1689	0.1677	0.1698

Upstream propagation (2010)

	(1) sales growth	(2) sales growth	(3) sales growth	(4) sales growth	(5) sales growth	(6) sales growth	(7) sales growth	(8) sales growth
1E	-0.016***		-0.027***	-0.025***				
	(0.001)		(0.001)	(0.002)				
2E		-0.012***	-0.020***	-0.020***				
		(0.001)	(0.001)	(0.001)				
1NE					-0.025***	-0.019***		
					(0.002)	(0.002)		
2NE					-0.021***	-0.018***		
					(0.001)	(0.001)		
1IE							-0.031***	-0.027***
							(0.002)	(0.002)
2IE							-0.021***	-0.019***
							(0.001)	(0.001)
in-degree				-0.010***		-0.010***		-0.010***
				(0.001)		(0.001)		(0.001)
out-degree				0.000		-0.001		-0.000
				(0.001)		(0.001)		(0.001)
employment	0.015***	0.015***	0.016***	0.019***	0.016***	0.019***	0.017***	0.019***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
age	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.041***	-0.038***	-0.036***	-0.043***	-0.038***	-0.046***	-0.038***	-0.046***
	(0.005)	(0.005)	(0.005)	(0.007)	(0.005)	(0.007)	(0.005)	(0.007)
2-digit JSIC FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	710,061	710,061	710,061	446,671	710,061	446,671	710,061	446,671
R-squared	0.012	0.012	0.012	0.014	0.012	0.014	0.013	0.014

Upstream propagation of foreign shocks



Conclusion

- Empirics
  - Only 1.7% of firms directly export, but 21.3% is 1st-order indirect exporters
  - More than half of firms have potential access to foreign markets within two transactions
  - There is a strict ordering of size in the degree of indirect exporting
  - There exists many indirect exporters even in construction or service sectors
  - The upstream propagation elasticity is around 2~3% in terms of sales
- Theory
  - Domestic production networks amplify the productivity difference –> more skewed size distribution
  - Melitz-type effects are dampened

Appendix: Network Demand

- The analytical expression for the network demand in special case (Pareto assumption) is

$$\Delta(\phi) = c_4 - c_3\phi^{-\lambda_s}$$

with

$$c_3 = \left(\frac{\lambda_s + \lambda_c + \theta}{\lambda_s + \lambda_c + \theta + \gamma\theta}\right)\left(\gamma\frac{\theta}{\theta + \lambda_c}\right)c_4$$

$$c_4 = \frac{1}{1-\gamma}\left(\mu^{-\sigma} - \gamma\frac{\theta}{\theta + \lambda_s}c_3\right)$$