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Trade Liberalization, Export and Product Innovation

Sizhong Sun

College of Business Law and Governance
James Cook University

sizhong.sun@jcu.edu.au

Introduction

- Arguably, innovation and export play an important role in a firm's profitability and growth.
- Researchers have explored innovation and export from different dimensions, both theoretically and empirically.
  - Melitz and Redding (2021) highlight four key mechanisms through which international trade affects innovation, namely market size, competition, comparative advantage and knowledge spillovers
  - Innovation can boost firms' export, both in terms of extensive and intensive margins (Cassiman et al., 2010, Becker and Egger, 2013)

Introduction

- Many of these studies explore international trade and innovation of forms other than product innovation.
- Relatively fewer studies specifically focus on firms' export and product innovation.
- This paper intends to investigate firms' decisions on export and product innovation both theoretically and empirically.

Introduction

- Theoretically, we model firms' behaviour in a multi-stage framework, where firms make optimal decisions on entry, exit, whether to innovate and export, the degree of product innovation, and prices in both the domestic and export markets which are monopolistically competitive.
- The model features a mixed static and dynamic decision making.
- Empirically , we bring the model to data of a sample of air-conditioner manufacturing firms in China from 2000 to 2007. In particular, utilizing an exogenous shock of China's WTO accession in December 2001, we examine how this affects firms' export and how the effect is transmitted to firms' optimal decision to innovate.

Introduction

- Identification Strategy:
- By imposing a theoretical model over data
- Utilize the structural relationship implied by the modelling;
- Utilize the variations in the sample (e.g. Das et al. 2007), for example:
  - Given an increase in marginal benefit of innovation (due to trade liberalization shock)
  - Firms that never innovates: It takes time to start innovation (R&D personnel recruitment and facilities set-up);
  - Firms that innovated previously: They can start new innovation more quickly by using existing facilities;
  - Hence, there exists variations of response by these two types of firms, which can be used for identification purpose.

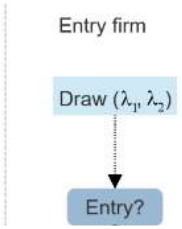
Introduction

- We find
- trade liberalization reduces the iceberg trade cost, ceteris paribus, which in turn promotes the value of export. The export promotion then improves firms' probability of product innovation through three channels, namely a contemporaneous static effect and two dynamic effects.
- Statically, trade liberalization promotes product innovation through a larger contemporaneous marginal benefit from a reduction of iceberg trade cost for exporting firms to innovate.
- Dynamically, export helps firms to move to a better state in the future, which in turn increase firms' probability to innovate. In addition, as firms innovate, they can save on innovation costs in the future, namely a benefit of option value.

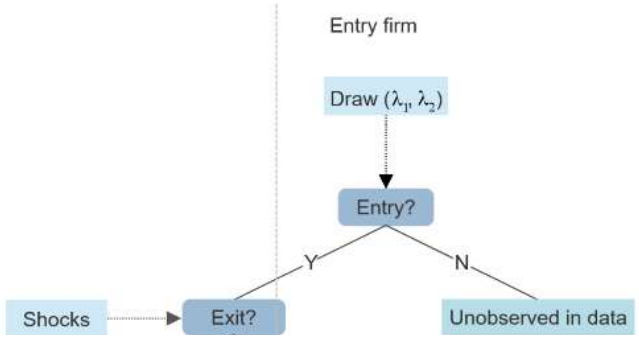
Introduction

- The study is linked to the studies of export and innovation:
- Theory: product cycle trade model (Krugman, 1979), Atkeson and Burstein (2010)
- Empirics: Empirical studies that examine the effect of export on product innovation cover different regions and generally discover a significantly positive effect:
  - Salomon and Shaver (2005), Ayllón and Radicic (2019), De Fuentes et al. (2021), Lileeva and Trefler (2010), Lin and Lin (2010), Bratti and Felice (2012), Damijan et al. (2010), Blyde et al. (2018)
  - China: Olabisi (2017), Dai et al. (2020)

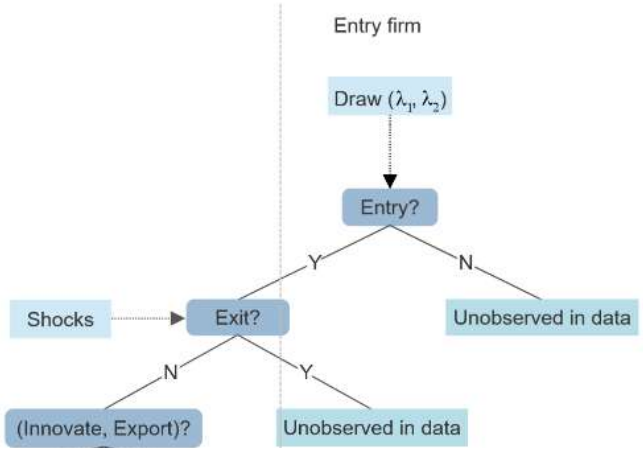
Analytical Framework-Economic Model



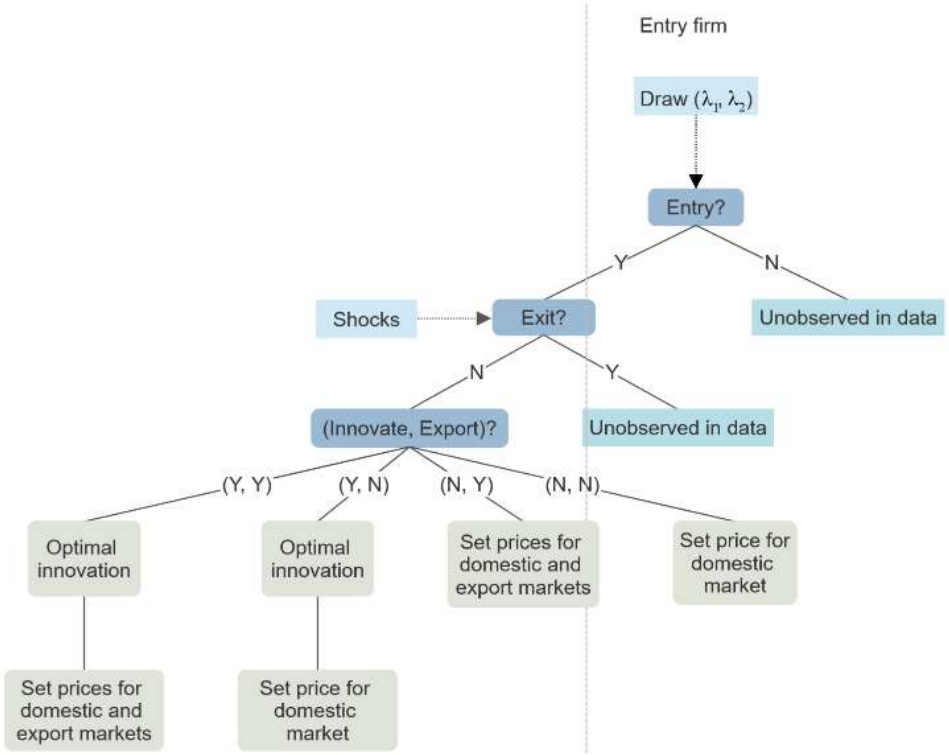
Analytical Framework-Economic Model



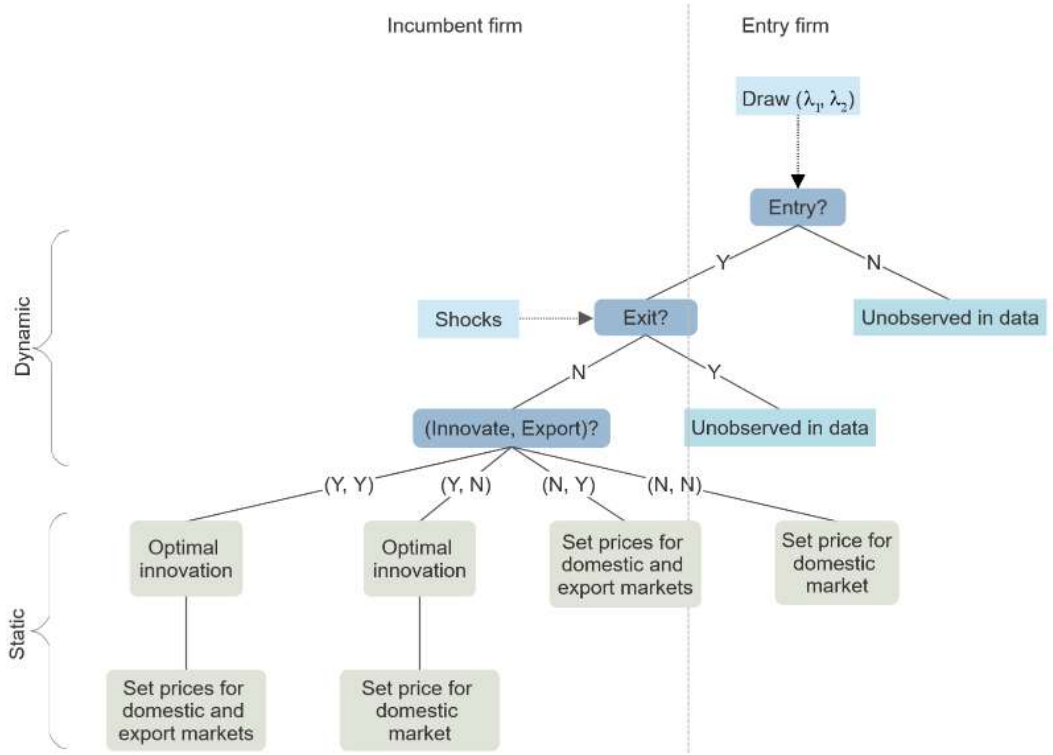
Analytical Framework-Economic Model



Analytical Framework-Economic Model



Analytical Framework-Economic Model



Analytical Framework-Economic Model

- Firms have perfect information in the current period, including the shocks at stage two. However, their information on the states in the future is imperfect, and as such they form belief on the transition of the states in making dynamic decisions.
- The ***equilibrium*** is a set of optimal decisions on entry, exit, whether to innovation and export, optimal level of product innovation, and prices in domestic and export markets, together with cut-off capabilities, that clear the markets and firms' belief is correct.

Analytical Framework-Economic Model

- Demand
- $q = Ap^{1/\rho - 1}$
- $q \equiv \left[q_o^{\rho} + (\zeta q_n)^{\rho}\right]^{1/\rho}$
- $\tilde{q} = \tilde{A}\tilde{p}^{1/\tilde{\rho} - 1}$
- $\tilde{q} \equiv \left[\tilde{q}_o^{\rho} + (\zeta \tilde{q}_n)^{\rho}\right]^{1/\rho}$

Analytical Framework-Economic Model

- Production:
- A fixed production cost:
- Firms can then combine one unit of labour with m units of intermediate inputs to produce s units of existing products, where $s = \lambda_1 \psi$.
- To produce new products, firms need to pay an additional fixed cost of innovation (*fn*), and combine one unit of labour with *m* units of intermediate inputs to produce $\lambda_2 s$
- marginal cost of production can be written as $c = \frac{(\lambda_2+\eta)(w+m)}{\lambda_2(1+\zeta^{\rho}\eta^{\rho})^{1/\rho}s}$, where $\eta \equiv \frac{q_n}{q_o}$

Analytical Framework-Economic Model

- Firms' per-period profit from the domestic market is then $\pi = (p - c)q - f - \left[f_n + f_n^e\left(1 - \chi_{1,-1}\right)\right]\chi_1$
- To export, firms need to pay a fixed and entry export costs (f_e and f_e^e respectively) and an iceberg trade cost (τ).
- Export profit can then be written as $\tilde{\pi} = (\tilde{p} - \tau c)\tilde{q} - \left[f_e + f_e^e\left(1 - \chi_{2,-1}\right)\right]$
- At stage five, firms set optimal prices as a markup over marginal cost of production, namely $p = \frac{c}{\rho}$ and $\tilde{p} = \frac{\tau c}{\tilde{\rho}}$
- At stage four, firms' optimal level of product innovation, should they decide to innovate, is $\eta = \lambda_2^{\frac{1}{1-\rho}}\zeta^{\frac{\rho}{1-\rho}}$.

Analytical Framework-Economic Model

- firms' optimal per-period profit from domestic and export markets at stage four are:
- $\pi(\chi_1 = 0) = (1-\rho)\rho^{\frac{\rho}{1-\rho}} A (w+m)^{\frac{\rho}{\rho-1}} \psi^{\frac{\rho}{1-\rho}} \lambda_1^{\frac{\rho}{1-\rho}} - f$
- $\pi(\chi_1 = 1) = (1-\rho)\rho^{\frac{\rho}{1-\rho}} A (w+m)^{\frac{\rho}{\rho-1}} \psi^{\frac{\rho}{1-\rho}} \left(1 + \lambda_2^{\frac{\rho}{1-\rho}} \zeta^{\frac{\rho}{1-\rho}}\right) \lambda_1^{\frac{\rho}{1-\rho}} - f - - \left[f_n + f_n^e \left(1 - \chi_{1,-1}\right)\right]$
- $\tilde{\pi}(\chi_1 = 0) = (1-\tilde{\rho})\tilde{\rho}^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \tau^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} \tilde{A} (w+m)^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} \psi^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \lambda_1^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} - \left[f_e + f_e^e \left(1 - \chi_{2,-1}\right)\right]$
- $\tilde{\pi}(\chi_1 = 1) = (1-\tilde{\rho})\rho^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \tau^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} \tilde{A} (w+m)^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} \psi^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \left(1 + \lambda_2^{\frac{\rho}{1-\rho}} \zeta^{\frac{\rho}{1-\rho}}\right)^{\frac{\tilde{\rho}}{\tilde{\rho}-1}\frac{1-\rho}{\rho}} \lambda_1^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} - \left[f_e + f_e^e \left(1 - \chi_{2,-1}\right)\right]$,

Analytical Framework-Economic Model

- At stage three, if a firm decides to innovate and/or export, it needs to pay entry costs, which are waived if it innovates and exports in the previous period, due to re-utilizing facilities in the past period.
- In addition, decisions at stage three affect the evolution of state variable ($\frac{\psi}{w+m}$). Therefore, the stage three decisions are dynamic.
- In making decisions, firms form belief on the evolution of state variables.

Analytical Framework-Economic Model

- **Firms' *belief***.
- For the future shocks, which affect A and $\tilde{A}$, firms understand that there is a probability of $1-\sigma$ $(0<\sigma<1)$ that negative shocks will occur, resulting in exit in the next period. Conditional on staying in the market, firms forecast A and $\tilde{A}$ of next period by this period's A and $\tilde{A}$ (akin to an adaptive expectation).
- For the state variable ($\frac{\psi}{w+m}$), firms understand that it follows a discrete-state Markov chain, conditional on entry and stay in the market, where the transition probability depends on today's decisions of whether to innovate and export. Firms estimate the transition probability matrixes from the past experience and other available information. In equilibrium, firms' estimates of the transition probability are correct.

Analytical Framework-Economic Model

- Given firms' belief, we can obtain their value functions.
- The value of choosing $(\chi_1, \chi_2) = (0,0)$, normalized by the fixed cost of production, is $v_{(0,0)} \equiv \frac{1}{f}\check{v}_{(0,0)} = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\frac{1}{f}A(w+m)^{\frac{\rho}{\rho-1}}\psi^{\frac{\rho}{1-\rho}}\lambda_1^{\frac{\rho}{1-\rho}} - 1 + \delta\sigma E v_{(0,0)}$

Analytical Framework-Economic Model

- At stage two, if the realized shock is negative (namely it reduces the per-period profit) and sufficiently large such that the value of staying in the market is less than its liquidation value, the firm exits.
- At stage one, firms' value functions depend on their capability endowments. If the realized capability endowments are such that the value functions are negative, firms do not enter the market.
- The stage two decision results in an endogenous sample attrition, while the stage one problem leads to an endogenous sample selection.

Analytical Framework-Estimation Strategy

- In step one, we first estimate the CES preference parameters, ρ and $\tilde{\rho}$
- $TVC = \rho R + \tilde{\rho}\tilde{R} + \varepsilon_1$
- In step two, we then proceed to estimate the impact of trade liberalization (the WTO accession) on the iceberg trade cost.
- Firms' optimal per-period domestic sales and export revenues are $R = \rho^{\frac{\rho}{1-\rho}} A c^{\frac{\rho}{\rho-1}}$ and $\tilde{R} = \tilde{\rho}^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \tilde{A} c^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} \tau^{\frac{\tilde{\rho}}{\tilde{\rho}-1}}$
- Hence, $\frac{\tilde{\rho}\tilde{R}^{\frac{\tilde{\rho}-1}{\tilde{\rho}}} Y^{\frac{\rho-1}{\rho}}}{\rho R^{\frac{\rho-1}{\rho}} \tilde{Y}^{\frac{\tilde{\rho}-1}{\tilde{\rho}}}} = \frac{\tilde{P}^{\frac{\tilde{\rho}-1}{\tilde{\rho}}}}{P^{\frac{\rho-1}{\rho}}} \tau$

Analytical Framework-Estimation Strategy

- Therefore, we can use the following specification to identify the effect of WTO accession:
- $lny = \alpha_0 + \alpha_1 dWTO + \varepsilon_2$
- $lny = ln\left(\frac{\tilde{\rho}\tilde{R}^{\frac{\tilde{\rho}-1}{\tilde{\rho}}}Y^{\frac{\rho-1}{\rho}}}{\rho R^{\frac{\rho-1}{\rho}}\tilde{Y}^{\frac{\tilde{\rho}-1}{\tilde{\rho}}}}\right)$
- The parameter α_1 measures change of iceberg trade cost after WTO accession
- To account for the estimation errors brought in from step one, we compute the bootstrap standard errors where we randomly re-sample (with placement) not just the data, but also from the distribution of the estimates of ρ and $\tilde{\rho}$ in step one.

Analytical Framework-Estimation Strategy

- In order to estimate the dynamic decisions on whether to innovate and export, we need to have the probability of exit and transition probability of state variable $\left(\frac{\psi}{w+m}\right)$.
- We nonparametrically estimate them as the relative frequency in step three
- the exit probability $(1-\sigma)$, it is the number of exit firms divided by total number of firms in the sample, where a firm exits if it appears in the current year, but not in the next year

Analytical Framework-Estimation Strategy

- The state variable $\left(\frac{\psi}{w+m}\right)$ contains ψ and $(w+m)$
- $(w+m)$ equals total wage and intermediate inputs divided by number of workers
- For ψ, we first assume it depends on firm size (total number of workers) and capital intensity (fixed assets per worker)
- We then utilize the principal component analysis to extract the principal component from data of firm size and capital intensity. Divided by $(w+m)$, we further discretise it into four equal intervals
- That is, $\left(\frac{\psi}{w+m}\right) \in \{1,2,3,4\}$ where 1, 2, 3 and 4 represent < 25%, 25-50%, 50-75% and >75% respectively
- Conditional on (χ_1, χ_2), the transition probability from one state to another is estimated as the share of firms that move from one state in the current year to another in the next year

Analytical Framework-Estimation Strategy

- Step four estimates firms' decisions on whether to innovate and export, which is a dynamic discrete choice model
- Parameterization:
- $\hat{\lambda}_1 \equiv \frac{1}{f} A \lambda_1^{\frac{\rho}{1-\rho}} \sim e^{N\left[-\frac{1}{2}ln2, ln2\right]}$, $\hat{\lambda}_2 \equiv \lambda_2^{\frac{\rho}{1-\rho}} \zeta^{\frac{\rho}{1-\rho}} \sim e^{N\left[-\frac{1}{2}ln2, ln2\right]}$, $\tau^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} f^{\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}} \tilde{A} A^{-\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}} \equiv e^{\beta_0}$, $\frac{f_e}{f} \equiv e^{\beta_1} + \varepsilon_3$, $\frac{f_n}{f} \equiv e^{\beta_2} + \varepsilon_4$, $\frac{f_e^e}{f} \equiv e^{\beta_3 + \beta_4 IsBig} + \varepsilon_5$, and $\frac{f_e^n}{f} \equiv e^{\beta_5 + \beta_6 IsBig} + \varepsilon_6$, where $\varepsilon_i \sim N[0,1]$, $i = 3,4,5,6$; $IsBig \in \{0,1\}$ is a dummy variable, taking value 1 if a firm is big; and $\beta \equiv (\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6)'$ is the vector of parameters that we will estimate from data. Note $\hat{\lambda}_1$ and $\hat{\lambda}_2$ are log-normally distributed with mean and variance of 1.

Analytical Framework-Estimation Strategy

- The choice value functions:
  - $v_{(0,0)} = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{\psi}{w+m}\right)^{\frac{\rho}{1-\rho}}\hat{\lambda}_1 - 1 + \delta\sigma Ev_{(0,0)}$,
  - $v_{(0,1)} = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{\psi}{w+m}\right)^{\frac{\rho}{1-\rho}}\hat{\lambda}_1 + (1-\tilde{\rho})\tilde{\rho}^{\frac{\tilde{\rho}}{1-\tilde{\rho}}}e^{\beta_0}\left(\frac{\psi}{w+m}\right)^{\frac{\tilde{\rho}}{1-\tilde{\rho}}}\hat{\lambda}_1^{\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}} - 1 - \left\{e^{\beta_1} + \varepsilon_3 + \left(e^{\beta_3+\beta_4 IsBig} + \varepsilon_5\right)\left(1-\chi_{2,-1}\right)\right\} + \delta\sigma Ev_{(0,1)}$,
  - $v_{(1,0)} = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{\psi}{w+m}\right)^{\frac{\rho}{1-\rho}}\hat{\lambda}_1\left(1+\hat{\lambda}_2\right) - 1 - \left\{e^{\beta_2} + \varepsilon_4 + \left(e^{\beta_5+\beta_6 IsBig} + \varepsilon_6\right)\left(1-\chi_{1,-1}\right)\right\} + \delta\sigma Ev_{(1,0)}$,
  - $v_{(1,1)} = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{\psi}{w+m}\right)^{\frac{\rho}{1-\rho}}\hat{\lambda}_1\left(1+\hat{\lambda}_2\right) + (1-\tilde{\rho})\tilde{\rho}^{\frac{\tilde{\rho}}{1-\tilde{\rho}}}e^{\beta_0}\left(\frac{\psi}{w+m}\right)^{\frac{\tilde{\rho}}{1-\tilde{\rho}}}\hat{\lambda}_1^{\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}}\left(1+\hat{\lambda}_2\right)^{\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}} - 1 - \left\{e^{\beta_1} + \varepsilon_3 + \left(e^{\beta_3+\beta_4 IsBig} + \varepsilon_5\right)\left(1-\chi_{2,-1}\right)\right\} - \left\{e^{\beta_2} + \varepsilon_4 + \left(e^{\beta_5+\beta_6 IsBig} + \varepsilon_6\right)\left(1-\chi_{1,-1}\right)\right\} + \delta\sigma Ev_{(1,1)}$

Analytical Framework-Estimation Strategy

- The known parameters in the value functions, from estimations in the previous steps, are $(\rho, \tilde{\rho}, \sigma, \Sigma)$ where Σ represents the set of conditional transition probability matrix of discretised $\left(\frac{\psi}{w+m}\right)$, and we set the discount rate $(1-\delta)$ to 0.05
- In step four, first, we draw $D = 1000$ $\hat{\lambda}_1$ and $\hat{\lambda}_2$ from the standard log-normal distributions and $D = 1000$ ε_3, ε_4, ε_5 and ε_6 from the standard normal distributions.
- Conditional on $(\rho, \tilde{\rho}, \sigma, \Sigma, \delta)$, one can compute the choice values for each pair of (λ_1, λ_2) with a guess of β, namely $\left(v^d_{(0,0)}, v^d_{(0,1)}, v^d_{(1,0)}, v^d_{(1,1)}\right)$, $d = 1, \ldots, D$, where we utilize a nested fixed-point algorithm in the computation (Rust, 1987).

Analytical Framework-Estimation Strategy

- Then, we can simulate the four choice probabilities, conditional on firm entry at stage one and stay at stage two.
- For example $\widehat{Pr}(\chi_1 = 1, \chi_2 = 1|entry, stay) = \frac{1}{\sum_{d=1}^{D} 1\left(v^d_{(0,0)} \geq 0\right)} \sum_{d=1}^{D} \frac{1}{1+exp\left(v^d_{(0,0)} - v^d_{(1,1)}\right)+exp\left(v^d_{(0,1)} - v^d_{(1,1)}\right)+exp\left(v^d_{(1,0)} - v^d_{(1,1)}\right)}$ where $\widehat{Pr}$ represents the McFadden kernel smoothed probability simulator.
- $E[\chi_1\chi_2|entry, stay] = Pr(\chi_{1it} = 1, \chi_{2it} = 1|entry, stay)$
- A natural estimator is to choose parameters β to minimize the sum of squared errors between $\chi_1\chi_2$ and $\widehat{Pr}(\chi_1 = 1, \chi_2 = 1|entry, stay)$. That is:
  - $\hat{\beta} = argmin\, Q \equiv \frac{1}{2n}\sum_{i,t}\left[\chi_{1it}\chi_{2it} - \widehat{Pr}(\chi_{1it} = 1, \chi_{2it} = 1|entry, stay)\right]^2$

Data and Variables

- The data are a set of air-conditioner manufacturing firms in China, sourced from the National Bureau of Statistics (NBS), China.
- It covers 184 firms in 2000, 232 firms in 2001, 254 firms in 2002, 237 firms in 2003, 201 firms in 2005, 191 firms in 2006, and 206 firms in 2007, where years 2000 and 2001 are pre-WTO accession periods.

Data and Variables

Table 1. Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
R	1,505	423421.6	2127498	2.198614	3.33E+07
EX	1,505	160880.6	1032184	0	2.21E+07
TW	1,505	14575.22	78529.26	6.595843	2306854
M	1,505	464875.1	2312630	23	4.01E+07
TL	1,505	0.612936	2.195058	0.008	41
VNP	1,505	251432.1	2093122	0	4.17E+07
kl	1,505	114810.3	238748.2	0	3781611
wm	1,505	461799.2	595295.2	4600.29	7517665
χ_1	1,505	0.18804			
χ_2	1,505	0.352824			

Note: R: domestic sales revenue; EX: export revenue; TW: total wage; M: intermediate inputs; TL: the number of workers; VNP: value of new products; kl: fixed assets annual net average per worker; wm: TVC per worker; χ_1: whether a firm innovates; and χ_2: whether a firm exports.
Source: NBS, China, 2000-2007.

Data and Variables

Table 2. Probabilities of Innovation and Export, conditional on Previous Period's Experience				
	[1]		[2]	
	$\chi_1 = 0$	$\chi_1 = 1$	$\chi_2 = 0$	$\chi_2 = 1$
$\chi_{-1} = 0$	0.887976	0.112024	0.780833	0.219167
$\chi_{-1} = 1$	0.198795	0.801205	0.121311	0.878689
Note: For [1], the rows correspond to $\chi_{-1} = \chi_{1,-1}$; For [2], the rows correspond to $\chi_{-1} = \chi_{2,-1}$.				

Data and Variables

Table 3. Probabilities of Innovation/Export, conditional on Contemporaneous Export/Innovation						
	[1] $Pr(\chi_1 \mid \chi_2)$				[2] $Pr(\chi_2 \mid \chi_1)$	
	$\chi_1 = 0$	$\chi_1 = 1$			$\chi_2 = 0$	$\chi_2 = 1$
$\chi_2 = 0$	0.870637	0.129363		$\chi_1 = 0$	0.693944	0.306056
$\chi_2 = 1$	0.704331	0.295669		$\chi_1 = 1$	0.44523	0.55477

Results

- The estimates of the CES preference parameters as $\hat{\rho} = 0.7516836$ in the domestic market and $\hat{\tilde{\rho}} = 0.9163455$
- Therefore, the elasticity of substitution in the domestic market is 4.03, lower than that in the export market (11.95)
- In the sample, 24.86% firm-year observations do not appear in the next year

Results

- The effect of WTO accession

Table 4. The Impact of Trade Liberalization on the Iceberg Trade Cost			
	[1]	[2]	[3]
$1(t = 2001)$			-0.0263
			(0.0877)
$1(t = 2002)$			-0.0559
			(0.0907)
$1(t = 2003)$			-0.186*
			(0.110)
$1(t = 2005)$			-0.221**
			(0.0986)
$1(t = 2006)$			-0.273***
			(0.100)
$1(t = 2007)$			-0.266***
			(0.102)
constant	1.163***	1.170***	1.212***
	(0.150)	(0.153)	(0.155)
dWTO	-0.135***	-0.184***	
	(0.0496)	(0.0499)	
N	374	374	374

Note: In [1], dWTO = 1 if post-WTO accession (year > 2001); In [2], dWTO = 1 if year > 2002, namely one year lagged; 1() is the indicator function; Bootstrap standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: The authors' estimation with data from NBS, China.

Results

- The transition probability matrixes ($\hat{\Sigma}$)
- Export and innovation have a dynamic benefit of helping firms move to a better state, namely $\hat{\Sigma}(\chi_1 = 1, \chi_2 = 1)$, $\hat{\Sigma}(\chi_1 = 1, \chi_2 = 0)$ and $\hat{\Sigma}(\chi_1 = 0, \chi_2 = 1)$ first-order stochastically dominate $\hat{\Sigma}(\chi_1 = 0, \chi_2 = 0)$

Results

Table 5. The Transition Probability Matrixes

	1	2	3	4	1	2	3	4
	$(\chi_1 = 0, \chi_2 = 0)$				$(\chi_1 = 0, \chi_2 = 1)$			
1	0.7113	0.2535	0.0282	0.0070	0.7	0.2667	0.0333	0
2	0.2035	0.5752	0.1947	0.0265	0.1136	0.5909	0.2955	0
3	0.0194	0.1748	0.7184	0.0874	0.0227	0.1136	0.7045	0.1591
4	0.0175	0.0526	0.1579	0.7719	0	0.0202	0.0808	0.8990
	$(\chi_1 = 1, \chi_2 = 0)$				$(\chi_1 = 1, \chi_2 = 1)$			
1	0.6429	0.3571	0	0	0.5	0.25	0	0.25
2	0	0.6190	0.3333	0.0476	0	0.6667	0.3333	0
3	0.0417	0.0833	0.6667	0.2083	0.0323	0.0323	0.8065	0.1290
4	0.0526	0	0.1579	0.7895	0	0	0.0227	0.9773

Note: Transition is from rows to columns. For example, with $(\chi_1 = 0, \chi_2 = 0)$, a firm at state 1 has a probability of 0.2535 to transition to state 2 in the next period.

Source: The authors' estimation with data from NBS, China.

Results

- The dynamic decisions on export and product innovation

Table 6. Estimation Results of the Dynamic Choices of Export and Product Innovation			
	Coef.	S.E.	t
β_0	-8.9705***	0.1367	-65.6280
β_1	0.4345	0.3621	1.2001
β_2	-1.7658***	0.5323	-3.3174
β_3	8.3171***	0.2412	34.4889
β_4	-2.3615***	0.3556	-6.6407
β_5	8.4302***	0.2693	31.2991
β_6	-1.404***	0.4116	-3.4114

Note: Standard errors are bootstrapped; *** p<0.01.
Source: The authors' estimation with data from NBS, China.

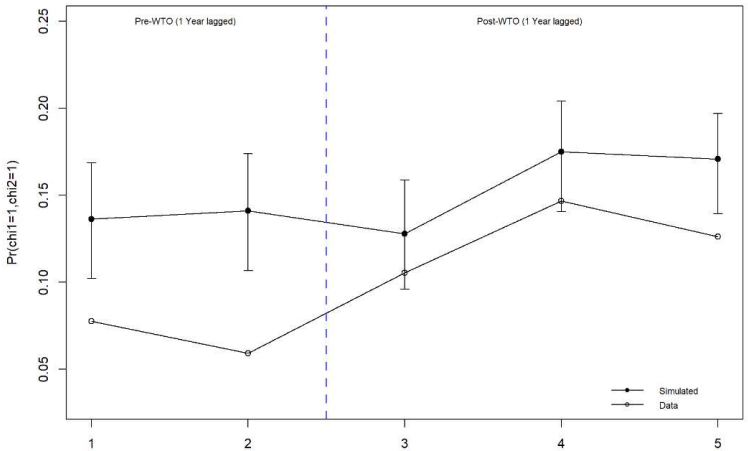
Results

- The parameter β_0, which contains the post-WTO iceberg trade cost ($\tau^{\frac{\tilde{\rho}}{\tilde{\rho}-1}} f^{\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}} \tilde{A} A^{-\frac{(1-\rho)\tilde{\rho}}{\rho(1-\tilde{\rho})}} \equiv e^{\beta_0}$), is estimated to be close to -8.9 (namely 0.000127), statistically significant at the five per cent level. Hence, with a 13.5% decrease of iceberg trade cost due to the WTO accession, the pre-WTO β_0 is -10.44926.
- The pattern of small fixed costs and large entry costs, which corroborates with the finding of Das, Roberts and Tybout (2007)

Results

- Counterfactual analysis

Figure 2. The Probabilities of Product Innovation and Export



Note: t = 1, year 2001; t = 2, year 2002; t = 3, year 2003; t = 4, year 2006; t = 5, year 2007; The error bars are bootstrap 99% confidence intervals.

Concluding Remarks

- This study explores firms' optimal decisions to export and conduct product innovation both theoretically and empirically.
- We find that China's WTO accession reduces the iceberg trade cost and subsequently promotes export. In turn, the export promotion improves firms' product innovation through one static channel and two dynamic channels.
- Trade liberalization is generally considered to be beneficial in the sense of promoting export and import, particularly for developing economies. In addition, our findings suggest that it can also promote innovation, both in the short and longer terms. Such an additional benefit is somewhat an intended consequence of trade liberalization.