Inward FDI Subsidy and Technology Adoption

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Issues in inward FDI policy

- **Issue.1: way and reason**

  Policy maker tries to attract foreign affiliates.

  How ? → Inward FDI subsidy in the broadest sense.

  Why ? → foreign affiliates transfer tech to local suppliers and strengthen industrial clusters.

  Many empirical papers support this.

- **Issue.2: key performance indicator (KPI)**

  the total amount of FDI will be adopted as the numerical target.

  Ex. the Council for Promotion of Foreign Direct Invmt in Japan
  → targets to double the Inward FDI stock in Japan by 2030

Reform of China's FDI Policy *cf Inada (2022)

- Before joining the WTO
  - all foreign firms are welcome.
  - main interest of Govt.: the total amount of FDI.
- After joining the WTO
  - selecting foreign Invmt (ex. industry, tech).
  - main interest of Govt.: the quality of FDI.

  *strictly speaking, this trend appeared before jointing the WTO.
- That is... Govt. provides
  selective subsidies to firms that invest in tech.

Research question

- **Question.1**: condition of achievement

  Under what circumstances would the scenario the policy maker aiming for be achieved ?

  Should Govt. select foreign affiliates for subsidy ?

- **Question.2**: KPI for inward FDI

  How should we set KPI for inward FDI, when we expect tech transfer?

- **Question.3**: justification of the policy

  Should we pay a subsidy to attract Inward FDI ?

  *Normative Question

Our approach.1: key measurements

- **measurement of tech transfer at industry level**

  $\rightarrow$ the average productivity of local suppliers

- **measurement of FDI**

  we focus on Invmt aspects (not founding aspects), especially,

  - (a) Invmt to set up a business office

    *entry cost: infrastructure development, regulatory costs

  - (b) tech Invmt

    *costs of tech partnership: quality control of intermediate goods, technical guidance

Our approach.2: theoretical model

transaction relationship

/	local suppliers H	local suppliers L
foreign affiliates H	transactions **with** tech adoption	No transactions
foreign affiliates L	No transactions	transactions **without** tech adoption

*tech adoption:intentional tech transfer that is costly to both parties

ex. tech partnerships, tech guidance, quality control

two types of inward FDI fixed subsidy

1. subsidy provided to all foreign affiliates (H&L).
2. subsidy targeted to foreign affiliates (H) *selective subsidy.

Answer to question.1

- Question.1: Under what circumstances would the scenario the policy maker aiming for be achieved ?
- If Govt. provides subsidy selectively to foreign affiliates H, tech transfer to local suppliers H is accelerated (the average productivity of local suppliers $\uparrow$) and furthermore, industrial cluster of local supplier H is strengthened.
- In other hands, if subsidies are non-selectively provided, the effect is rather counterproductive.

Answers to question.2 and.3

question.2: How should we set KPI for inward FDI, when we expect tech transfer?

- KPI should be set as "the quality of FDI" which is defined by presence of high-tech Invmts.
- This is because

  "the quality of FDI" is often positively correlated with the average productivity of local suppliers.

question.3: Do the inward subsidies raise welfare ?

- selective subsidy improve welfare.
- non-selective subsidy could worsen social welfare if the entry of local firms H is endogenous.

this paper's position in theoretical literature

paper	selection of foreign affiliate	FDI subsidy	vertical linkage	tech-adoption
Helpman et.al. (2004)	○	×	×	×
Chor (2009)	○	○	×	×
Rodr'iguez-clare (1996)	×	×	○	×
Bustos (2011)	×	×	×	○
This paper	○	○	○	○

This paper reveals the need to select foreign affiliates
to facilitates tech-transfer by constructing a unified model
that integrates these elements. ← contribution of this paper.

Overview of the model setup

- Govt. in home country attracts firms in foreign country.

  $\rightarrow$ we focus only on home market.

- Final goods are two-industry: consisting of homogeneous (numeraire) and differentiated goods

- Home and foreign firms don't compete in the differentiated good sector (market segmentation).

  $\rightarrow$ we should focus only on foreign firm's behavior.

- Two types of model

  model 1: the No.of local suppliers of both types are exogenous.

  model 2: the No.of local suppliers of H is endogenous while the one of L is exogenous.

Household: utility and consumption

- utility of household in home country (like the chor model)

$$U = q_O + \frac{1}{\mu} Q_C^{\mu}, \quad 0 < \mu < 1$$

- consumption of homogeneous good (q_O) and the differentiated good (Q_C)
- subscript C: consumer goods
- subscript j: firm's foreign entry mode (j= X, L, H)
- budget constraint:

$$q_O + P_C Q_C = wL - T.$$

T: lump-sum tax, L: labor force. w, L: exogenous.

demand function for the differentiated goods

- CES-aggregator: $Q_C^{\rho} \stackrel{\text{def}}{=} \int_{\omega\in\Omega} q_{Cj}^{\rho}(\omega)d\omega, \quad 0 < \mu < \rho < 1.$
- P_C is consumer price index: $P_C^{1-\sigma} \stackrel{\text{def}}{=} \int_{\omega\in\Omega_H} p_{Cj}^{1-\sigma}(\omega)d\omega.$
- the demand for any variety is given by

$$q_{Cj} = A_C {p_{Cj}}^{-\sigma}, \quad \sigma = 1/(1-\rho) > 1.$$

- A_C is aggregate demand factor in home market and defined by

$$A_C = P_C^{(\rho-\mu)/[(1-\mu)(1-\rho)]}$$

- $dA_C/dP_C > 0$ from $\mu < \rho$. $\rightarrow A_C$: the looseness of Comp

behavior of local suppliers: monopolistic Comp

- profit

$$\pi_{Mj} = p_{Mj} q^S_{Mj} - (w l_{Mj} + w f_{Mj})$$

  p_{Mj}: price of intermediate good, q^S_{Mj}: output, l_{Mj}: variable labor input, f_{Mj}: fixed labor input.

- subscript M: intermediate goods
- production function : $q^S_{Mj} = \lambda_j l_{Mj}$, *$\lambda_j$: TFP
- tech partnership: $\lambda_H > \lambda_L$, $f_{MH} > f_{ML}$
- optimal pricing: $p_{Mj} = w/(\nu\lambda_j)$, $p_{ML} > p_{MH}$ holds.
- CES-aggregator: $\int_{\omega\in\Omega} {q^s_{Mj}}^{\nu}(\omega) d\omega, \quad 0 < \nu < 1.$
- **intermediate price index**: $P_{Mj} = N_{Mj}^{1-\epsilon} p_{Mj}$, $\epsilon = 1/(1-\nu)$

  *N_{Mj}: the No.of local suppliers

tech and marginal cost of foreign firms

- Leontief production function: $q_{Cj} = \phi \min\{l_j/\phi_W, q_{Mj}/\phi_M\}$,
  *ϕ: TFP. This differ across firms. firm heterogeneity.
- cost minimization $\rightarrow$ variable cost: $(P_{lj}/\phi)q_{Cj}$
  , where $P_{lj} \stackrel{\text{def}}{=} \phi_W w + \phi_M P_{Mj}$ for $j = L, J$
- subscript l: input combination of labor and intermediate goods.
- P_{lj} is "the standardized marginal cost". *$\phi = 1$
- **forward linkage effect**: $N_{Mj} \uparrow \rightarrow P_{Mj} \downarrow \rightarrow P_{lj} \downarrow \rightarrow q_{Mj} \uparrow$
- This captures "the love of variety for inputs":
  industrial cluster $\uparrow \rightarrow$ specialization of supplier $\uparrow$.

profit of foreign firms

- Exporters' profits in home market

$$\pi_{CX} = p_{CX} q_{CX} - \tau P_{IX} q_{CX}/\phi - w^* f_X, \tag{5}$$

τ (> 1): transport cost, f_X: fixed trade cost.

- Profit of foreign affiliates of type L is given by

$$\pi_{CL} = p_{CL} q_{CL} - P_{IL} q_{CL}/\phi - [w f_E - s_E(w f_E - w^* f_X)], \tag{6}$$

f_E: entry costs, s_E: subsidy rate for entry ($0 \leq s_E < 1$).

- Profit of foreign affiliates of type H is given by

$$\begin{aligned}\pi_{CH} = {} & p_{CH} q_{CH} - P_{IH} q_{CH}/\phi \\ & - [w(f_E + f_T) - s_E(w f_E - w^* f_X) - w s_T(f_T - f_E)],\end{aligned} \tag{7}$$

f_T: cost of tech partner ship, s_T: subsidy rate for tech Invmt ($0 \leq s_T < 1$). f_T arises from local activities

$\rightarrow$ FDI (not R&D at headquarters).

Impact of FDI subsidy

- why are the upper limits of s_E and s_T one ?
- Impact of s_E on effective FDI entry cost, $wf_E - s_E(wf_E - w^* f_X)$

  If $s_E \to 1$, effective FDI entry cost $\to$ fixed export cost (f_X).

  $\to$ <u>All exporters will become FDI firms.</u>
- Impact of s_T on effective FDI tech Invmt cost,
  $wf_T - s_T w(f_T - f_E)$

  If $s_T \to 1$, effective FDI tech Invmt cost $\to$ FDI entry cost (f_E).

  $\to$ <u>All standard FDI firms will conduct tech upgrading.</u>

productivity cut-off

- exporters

$$\phi_X{}^{\sigma-1} = (\sigma\rho^{1-\sigma}/A_C)B_X, \quad B_X \stackrel{\text{def}}{=} \frac{w^* f_X}{(\tau P_{IX})^{1-\sigma}} \tag{8}$$

- type L

$$\phi_L{}^{\sigma-1} = (\sigma\rho^{1-\sigma}/A_C)B_L, \quad B_L \stackrel{\text{def}}{=} \frac{(1-s_E)(wf_E - w^* f_X)}{P_{IL}^{1-\sigma} - (\tau P_{IX})^{1-\sigma}} \tag{9}$$

- type H

$$\phi_H{}^{\sigma-1} = (\sigma\rho^{1-\sigma}/A_C)B_H, \quad B_H \stackrel{\text{def}}{=} \frac{w[f_T - s_T(f_T - f_E)]}{P_{IH}^{1-\sigma} - P_{IL}^{1-\sigma}}. \tag{10}$$

- interpretation of B_L & B_H

  numerator: increase in fixed cost $\rightarrow$ demerit of switching
  denominator: decrease in marginal cost $\rightarrow$ merit of switching

- assumption: $B_H > B_L > B_X > 0$ to certify $\phi_H > \phi_L > \phi_X > 0$.

productivity distribution and the No.of firms

- We assume productivity distribution to be Pareto distribution.
- The cumulative density function is given by

$$G(\phi) = 1 - (b/\phi)^k, \quad k > 2,\ b > 0.$$

- This distribution derives the No. of firms as follows

$$N_X = b^k(\phi_X^{-k} - \phi_L^{-k})N_E$$

$$N_L = b^k(\phi_L^{-k} - \phi_H^{-k})N_E$$

$$N_H = b^k\phi_H^{-k}N_E$$

$$N_L + N_H = b^k\phi_L^{-k}N_E$$

- N_E is the No.of foreign entrants.

  $\rightarrow$ N_E is exogenous by assumption of small open economy.

average productivity of local suppliers ($\tilde{\lambda}$)

- definition: total output of local suppliers (Q_M^S)

  $Q_M^S = \Sigma_j Q_{Mj}^S \rightarrow Q_M^S = \Sigma_j \lambda_j l_{Mj} N_{Mj}$.

- definition: average labor productivity of local suppliers ($\tilde{\lambda}$) by output and input

  $Q_M^S = \tilde{\lambda} \Sigma_j l_{Mj} N_{Mj}$.

- average productivity of local supplier $\tilde{\lambda}$ can be represented by only aggregate demand:

$$1/\tilde{\lambda} = \left(\frac{Q_{MH}}{Q_M}\right)(1/\lambda_H) + \left(\frac{Q_{ML}}{Q_M}\right)(1/\lambda_L). \qquad (12)$$

  $\rightarrow$ $\underline{\tilde{\lambda} \text{ is increasing in } Q_H/Q_L}$.

total amount and the quality of FDI (FDI_Q)

- aggregate amount of FDI : $FDI_A = wf_E N_L + w(f_E + f_T)N_H$.
- intensive term of FDI: $FDI_I = wf_T N_H$
- extensive term: $FDI_E = wf_E(N_L + N_H)$.
- the quality of FDI : $FDI_Q = FDI_I/FDI_A$

  *presence of tech Invmts in the amount of FDI.
- (FDI_Q and N_H/N_L)

$$FDI_Q = \frac{f_E/f_T}{1 + (f_E/f_T)(N_L/N_H)}. \tag{13}$$

$\rightarrow$ the quality of FDI is increasing in N_H/N_L.

average productivity of local suppliers & the quality of FDI

Proposition (1)

If P_{IH}/P_{IL} is fixed, FDI_Q and $\tilde{\lambda}$ are positively correlated.

- The mechanism behind the result is as follows.
- 1. FDI_Q is decreasing in ϕ_H/ϕ_L.
- 2. $\tilde{\lambda}$ is decreasing in ϕ_H/ϕ_L if P_{IH}/P_{IL} is fixed.
- Implication

  FDI_Q can be a key performance indicator (KPI) for FDI subsidy, if Govt. wants to induce tech transfer.

tech transfer from first backward linkage effect

- market clearing condition of intermediate good j:

$$N_{Mj} q_{Mj}^{S} = Q_{Mj} \tag{2}$$

- This determines q_{Mj}^{S} under exogenous N_{Mj}.
- **first backward linkage effect**

  demand of foreign affiliates $\uparrow \rightarrow$ output of each supplier $\uparrow$.

- Implication

  In the exogenous model, subsidy rate changes average productivity of local suppliers ($\tilde{\lambda}$) from a channel of q_{Mj}^{S}: first backward linkage effect.

tax, FDI, and welfare

- relationship between the amount of FDI and lump-sum tax

$$T = s_E \left(\frac{wf_E - w^* f_x}{wf_E} \right) FDI_E + s_T \left(\frac{f_T - f_E}{f_E} \right) FDI_I. \quad (14)$$

  subsidy rate $\uparrow \rightarrow FDI_E \uparrow$ or $FDI_I \uparrow$

- welfare (indirect utility)

$$U = wL - \left[s_E \left(\frac{wf_E - w^* f_x}{wf_L} \right) FDI_E + s_T \left(\frac{f_T - f_E}{f_E} \right) FDI_I \right] + (1/\mu - 1) P_C{}^{-\mu/(1-\mu)}. \quad (15)$$

- Implication

  subsidy rate $\uparrow \rightarrow T \uparrow \rightarrow q_O \downarrow$.

  If consumer price index $\uparrow \rightarrow$, then $Q_C \downarrow \rightarrow$ welfare $\downarrow$.

  $\rightarrow$ consumer price index $\downarrow$ is necessary condition for welfare $\uparrow$.

comparative statistics: eq (8)–(11)

- hat notation as $\hat{X} = dX/X$.
- productivity cut-offs

$$\hat{\phi}_X = -\eta \hat{P}_C, \tag{17}$$

$$\hat{\phi}_L = -\eta \hat{P}_C - B_{LL} B_{IL} \hat{N}_{ML} - \frac{B_{SE}}{\sigma - 1} \hat{s}_E, \tag{18}$$

$$\hat{\phi}_H = -\eta \hat{P}_C - B_{IL}(B_{HH} \hat{N}_{MH} - B_{HL} \hat{N}_{ML}) - \frac{B_{ST}}{\sigma - 1} \hat{s}_T, \tag{19}$$

- consumer price index

$$\hat{P}_C = \frac{\Omega}{\sigma - 1} \Sigma_{j \in \{X,L,H\}} J_{\phi j} \hat{\phi}_j - \Sigma_{j \in \{L,H\}} J_{Ij} B_{Ij} \hat{N}_{Mj}, \tag{20}$$

- all co-efficient are positive

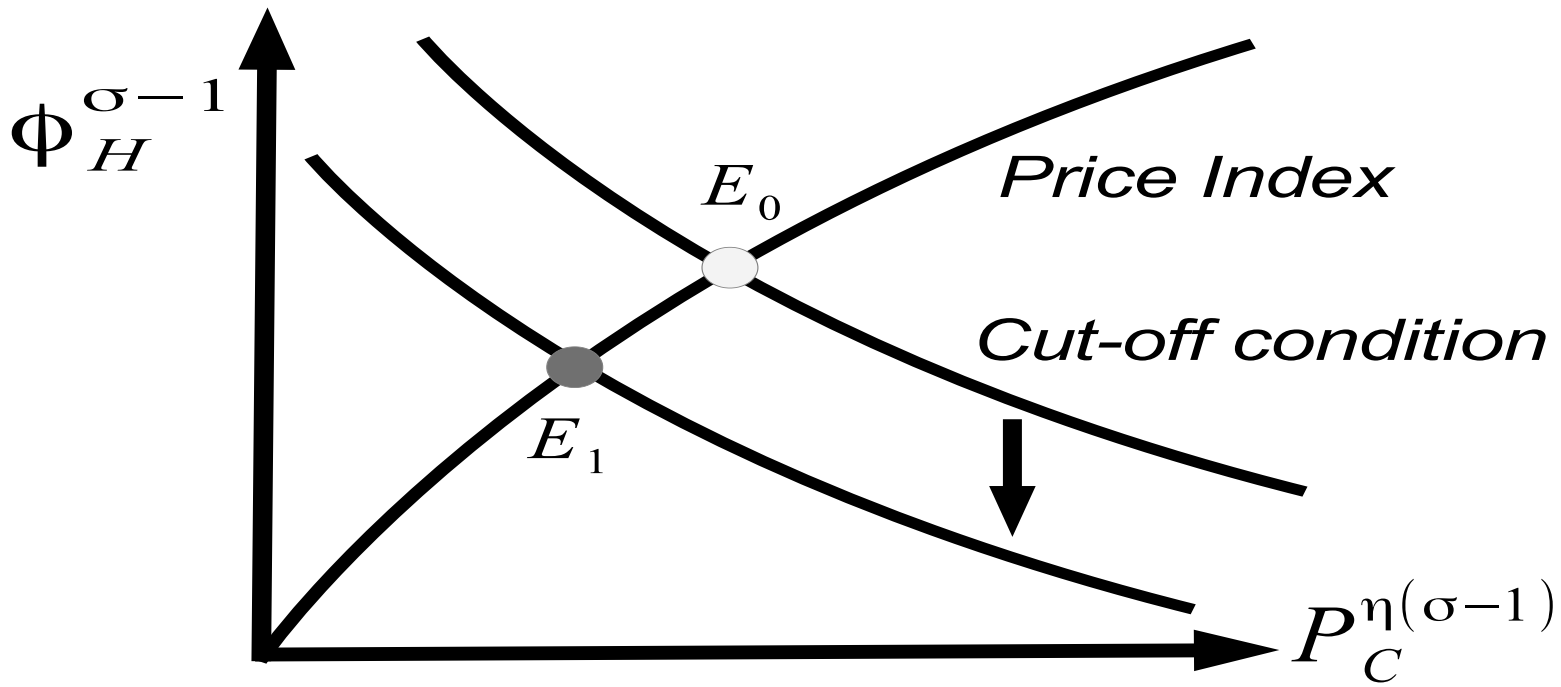
Lemma 1 and Proposition 2: regular case

effect / subsidy (entry)	s_T (N_{MH})	s_E (N_{ML})
ϕ_X	$+$	$+$
ϕ_L	$+$	$-$
ϕ_H	$-$	$+$
P_C	$-$	$-$
$\tilde{\lambda}$	$+$	$-$
FDI_Q	$+$	$-$
Q_C	$+$	$+$

From a channel of Q_C, welfare improves.

If subsidy rate is sufficiently low, welfare may improve.

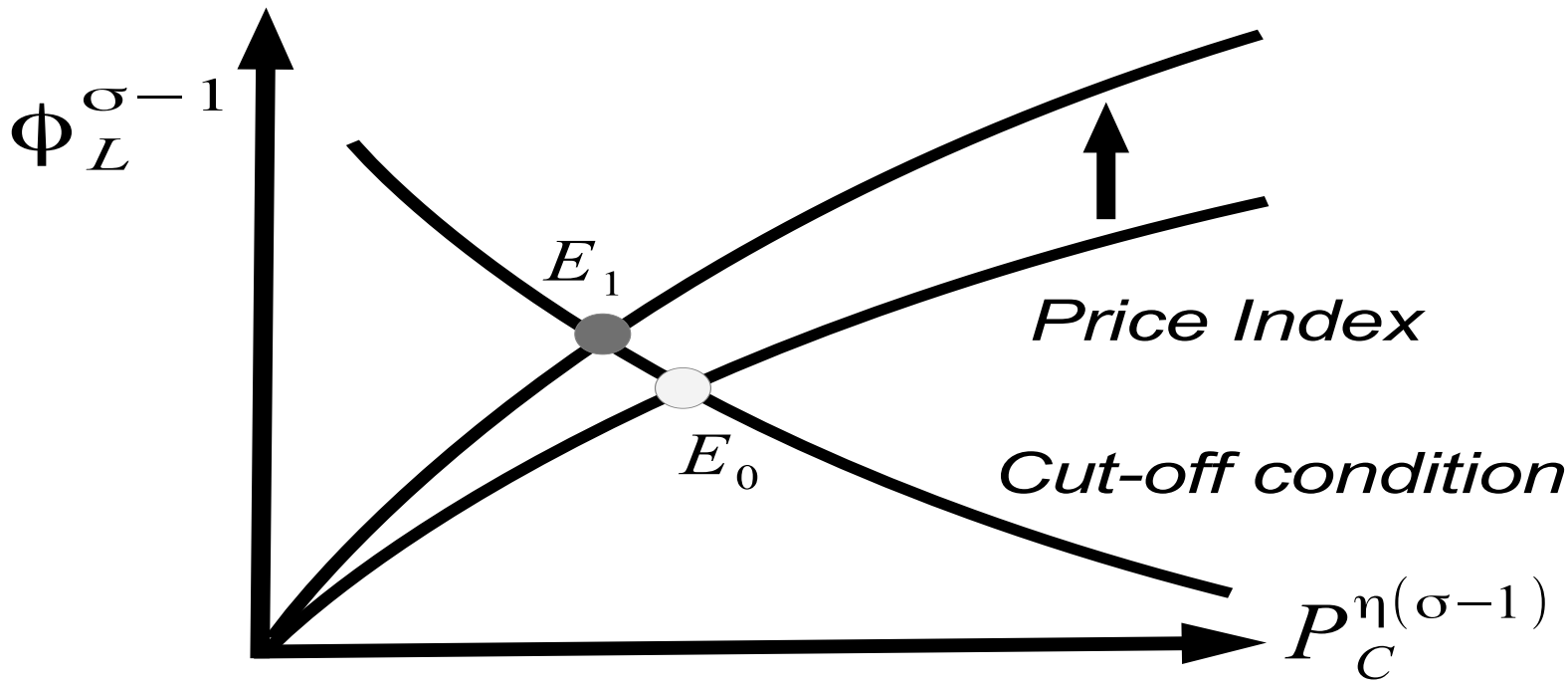
Intuition 1-1: impacts of s_T in model.1



support effect: $s_T \uparrow$ shifts CO curve $\downarrow$.

selective subsidy reinforces the benefits of switching from L to H.

Intuition 1-2: impacts of s_T in model.1



Comp effect: $\phi_H \downarrow$ ($N_H \uparrow$) shifts PI curve $\uparrow$.

rivals $\uparrow \rightarrow$ tougher Comp$\rightarrow$ demand for you $\downarrow \rightarrow$ survival hurdles $\uparrow$.

calibration(setting parameter)

Many parameters common or close to the ones of Chor (2009).

- source of elasticity: $\mu = 0.5$, $\rho = \nu = 0.74 \rightarrow \sigma = \epsilon = 3.8462$
- productivity distribution (Pareto): $k = 3.4$, $b = 0.04$
- trade cost: $\tau = 1.3$, $f_X = 40$
- costs of FDI: $f_E = 250$, $f_T = 400$
- labor force and nominal wage: $L = 3$, $w = w^* = 1$
- the No. of foreign entrants and local suppliers : $N_E = 10^5$, $N_{ML} = 1.6 \times 10^{-4}$, $N_{MH} = 1.3 \times 10^{-4}$.
- labor productivity: $\lambda_X = 1$, $\lambda_L = 1.1$, $\lambda_H = 1.5$
- input coefficient: $\phi = 1$, $\phi_M = 2.3 \times 10^{-2}$
- fixed costs of local suppliers: $f_{ML} = 3.5$, $f_{MH} = 11$

replication of possible real economy

variable / type	economy	type X	type L	type H
$q_O/(P_C Q_C)$	3.75	none	none	none
$FDI_A/(P_C Q_C)$	0.02	none	none	none
share of No.	none	0.83	0.13	0.03
No.of N_j / No.of N_{Mj}	none	1.59	0.31	0.09
profit rate	none	0.12	0.16	0.24
value added rate	none	0.70	0.70	0.74
labor share	none	0.82	0.76	0.66
share of parts cost in VC	none	0.40	0.39	0.34

Fig.1: Impacts of s_T on productivity cut-offs in model 1

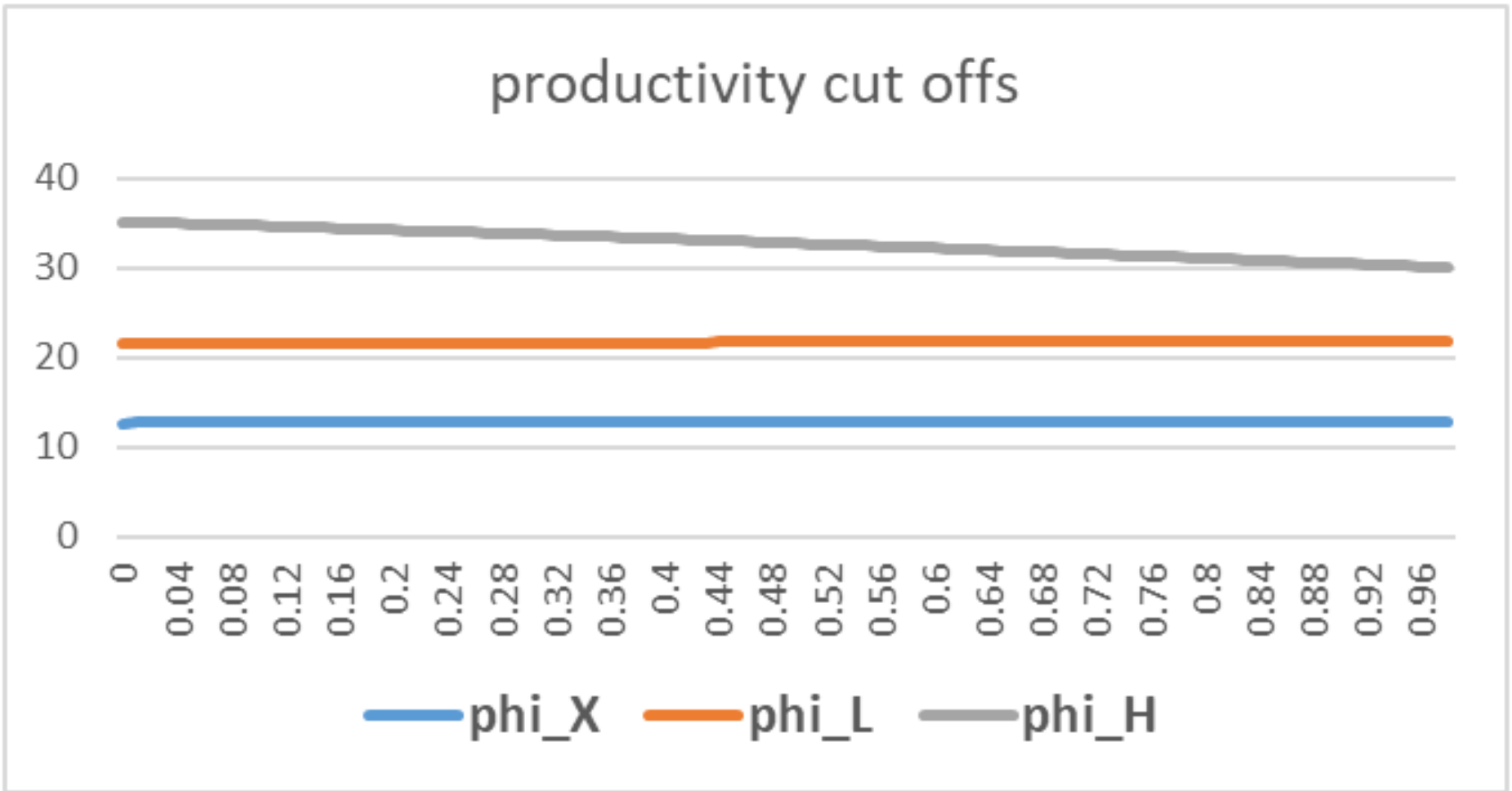


Fig.2: Impacts of s_T on FDI in model 1

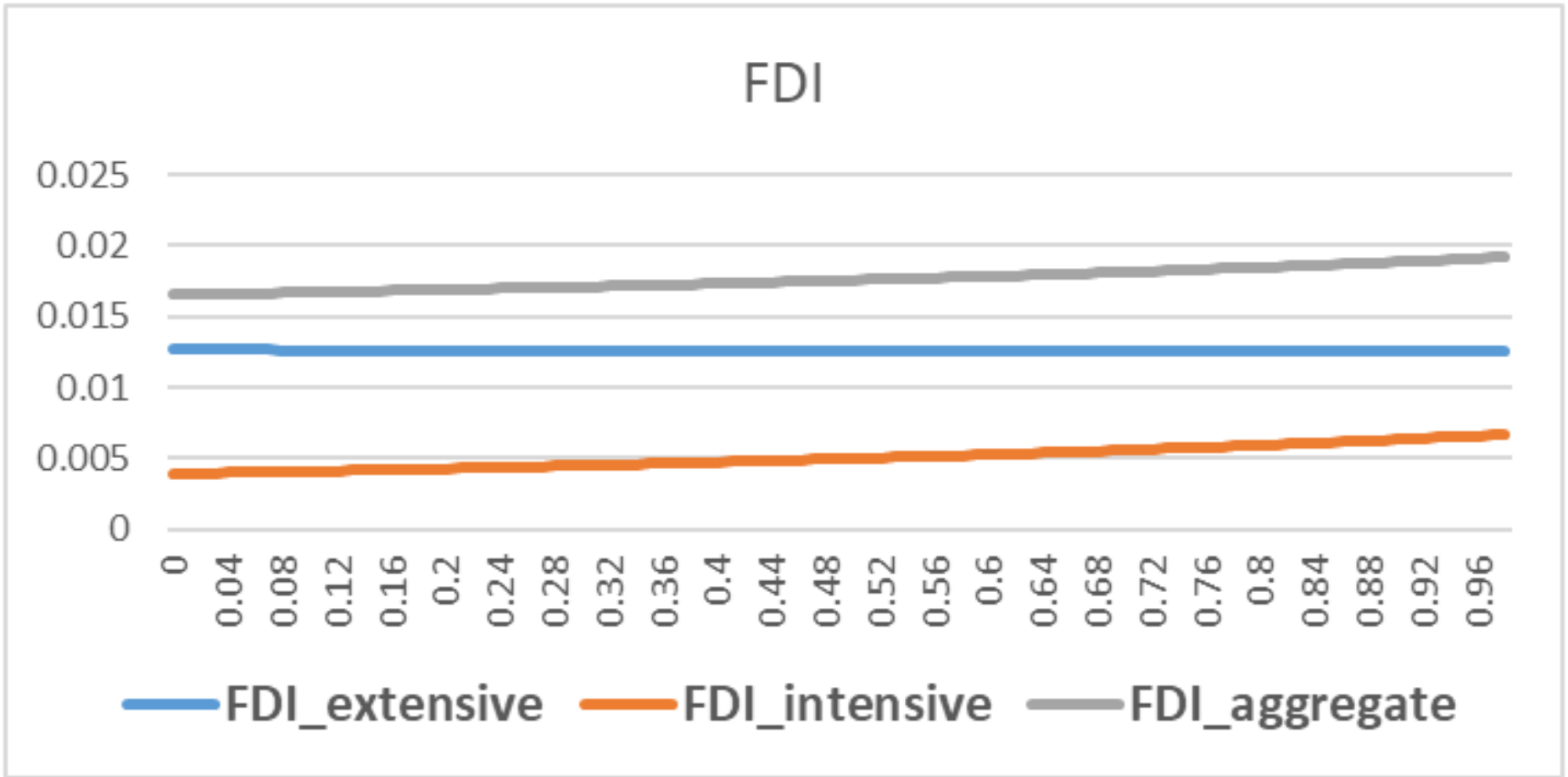


Fig.3: Impacts of s_T on outputs of local suppliers in model 1

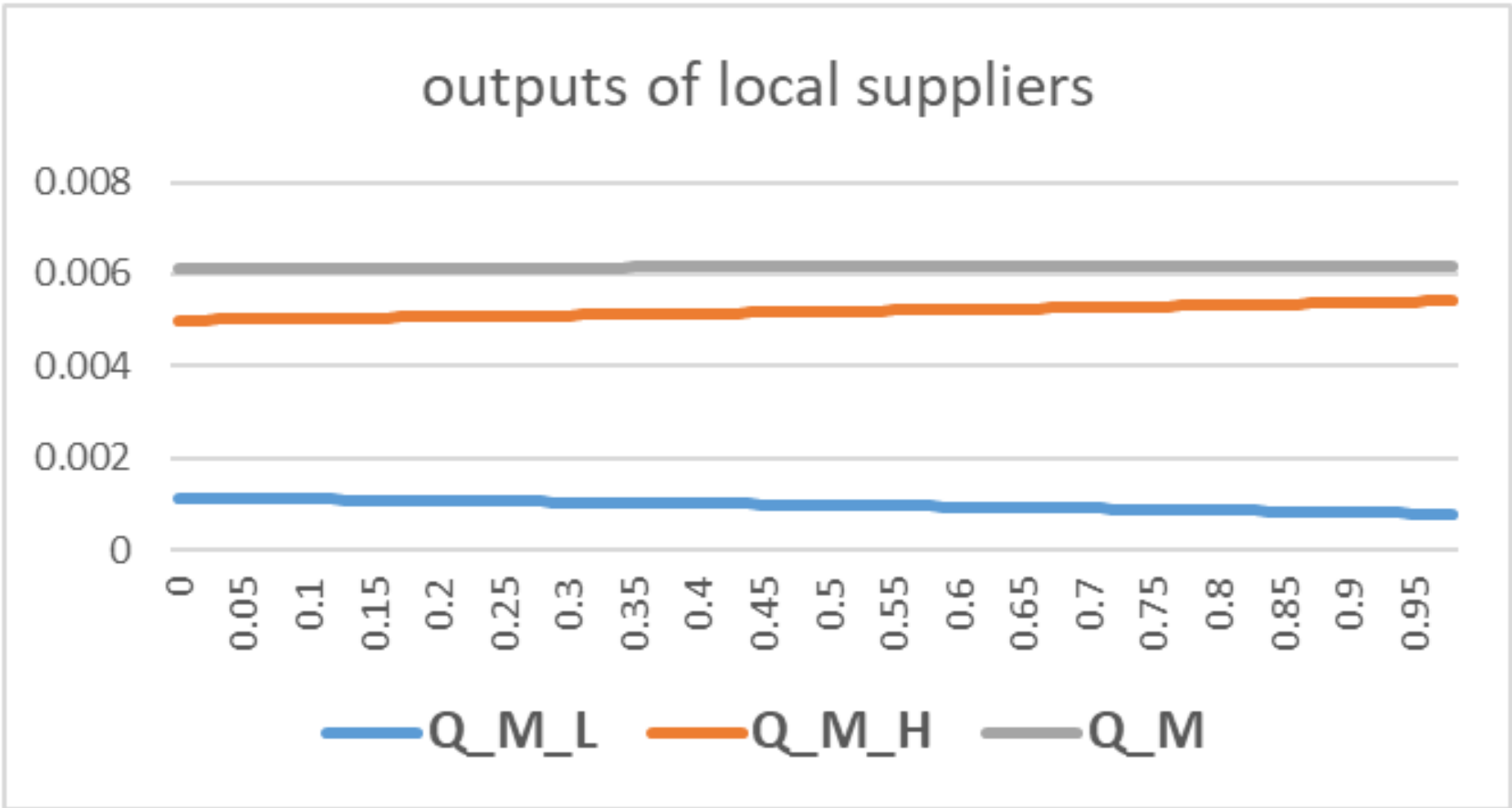
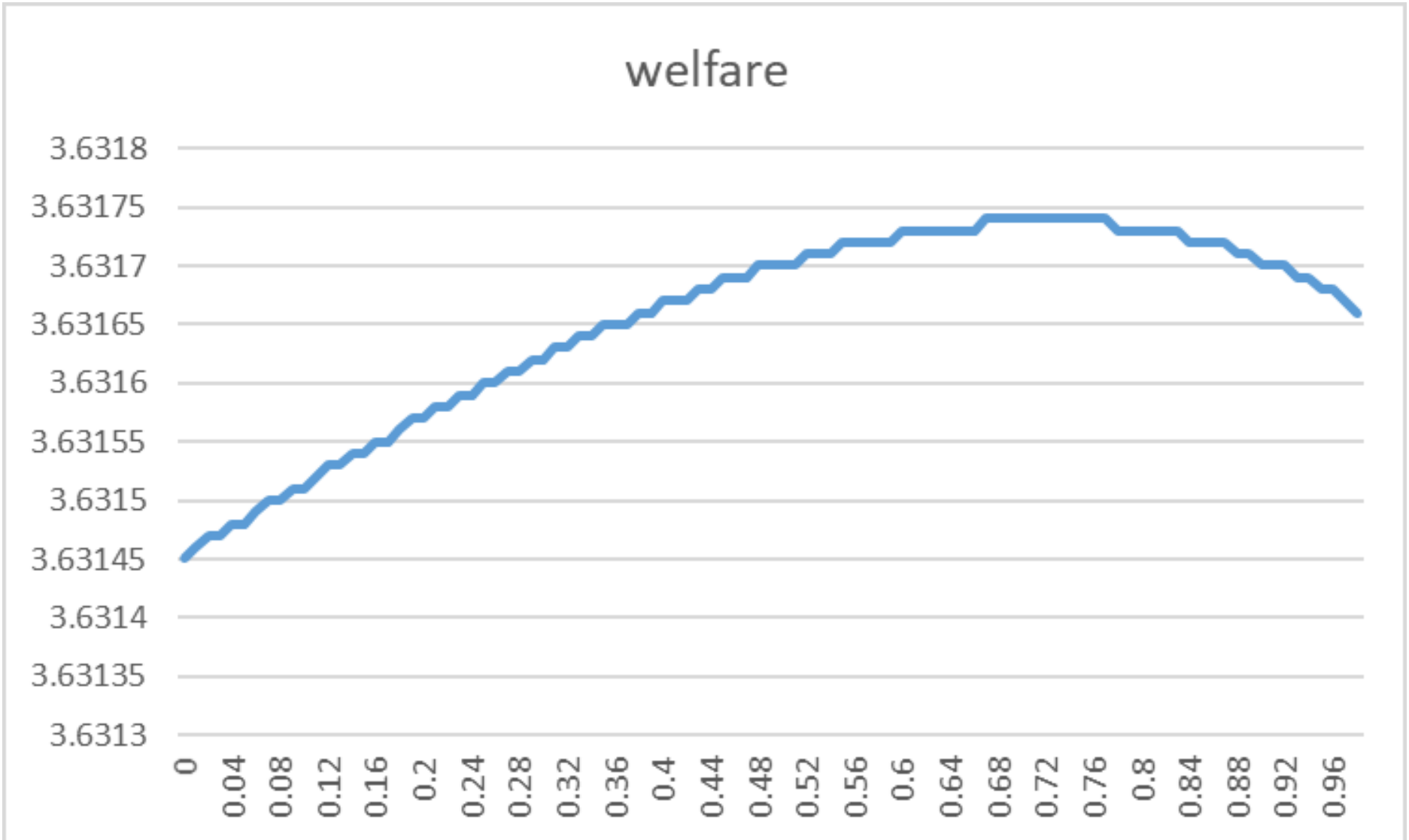


Fig.4: An impact of s_T on welfare in model 1



endogenous entry model

- the No.of local suppliers H (N_{MH}) : endogenous entry
- the No.of local suppliers L (N_{ML}) : exogenous entry
- What kind of economy can this model setting capture the economy?
- Lets assume local suppliers H as a division of firm.
- In the short run, it would be easier for firms to initiate and dissolve tech partnership than to enter and exit the market

equilibrium and comparative statistics

- free-entry condition: $\pi_{MH} = 0$.
  $\rightarrow q^S_{MH} = \lambda_H(\nu/1-\nu)F_{MH}$.
- market clearing: $N_{MH}q^S_{MH} = Q_{MH}$. $\rightarrow N_{MH}$ is determined.
- comparative statistics: effective supply $=$ effective demand

$$(1-\sigma B_{IH})\hat{N}_{MH} = (\sigma-1)\eta\hat{P}_C - \Omega\hat{\phi}_H. \tag{21}$$

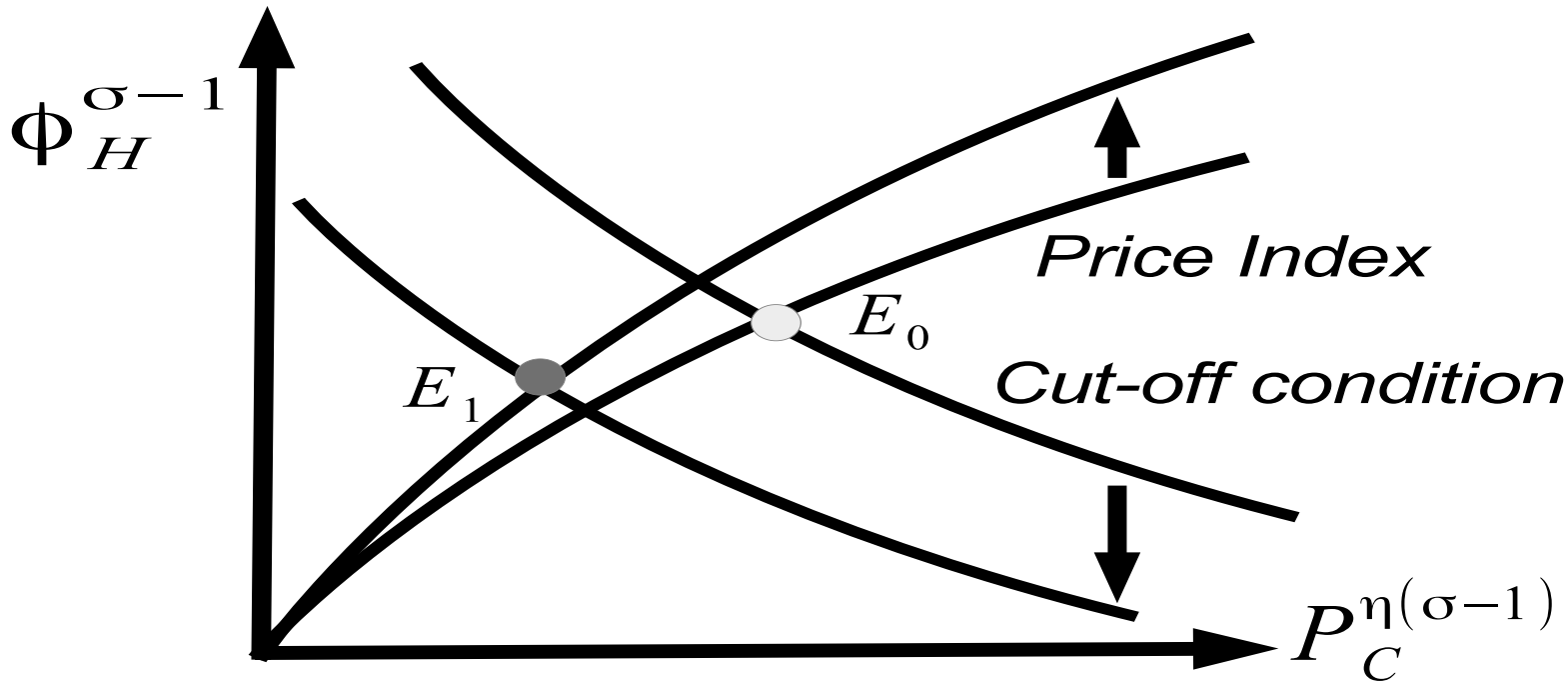
- a channel of **second backward linkage effects** opens up
  demand of foreign affiliates H $\uparrow \rightarrow$ entry of local firm H $\uparrow$.
- furthermore, this generates forward linkage effect
  $\rightarrow$ demand of foreign affiliates H $\uparrow$ *positive feed back.

Lemma 2 and Proposition 3: regular case

effect / subsidy	s_T	s_E
N_{MH}: new!	$+$	$-$
ϕ_X	$+$	$-$ or $+$?
ϕ_L	$+$	$-$
ϕ_H	$-$	$+$
P_C	$-$	$+$ or $-$?
$\tilde{\lambda}$	$+$	$-$
FDI_Q	$+$	$-$
Q_C	$+$	$-$

$s_T \uparrow$ ($s_E \uparrow$) $\rightarrow$ local industrial cluster with high-tech $\uparrow$ ($\downarrow$).

Intuition 3-1: impacts of s_T in model.2

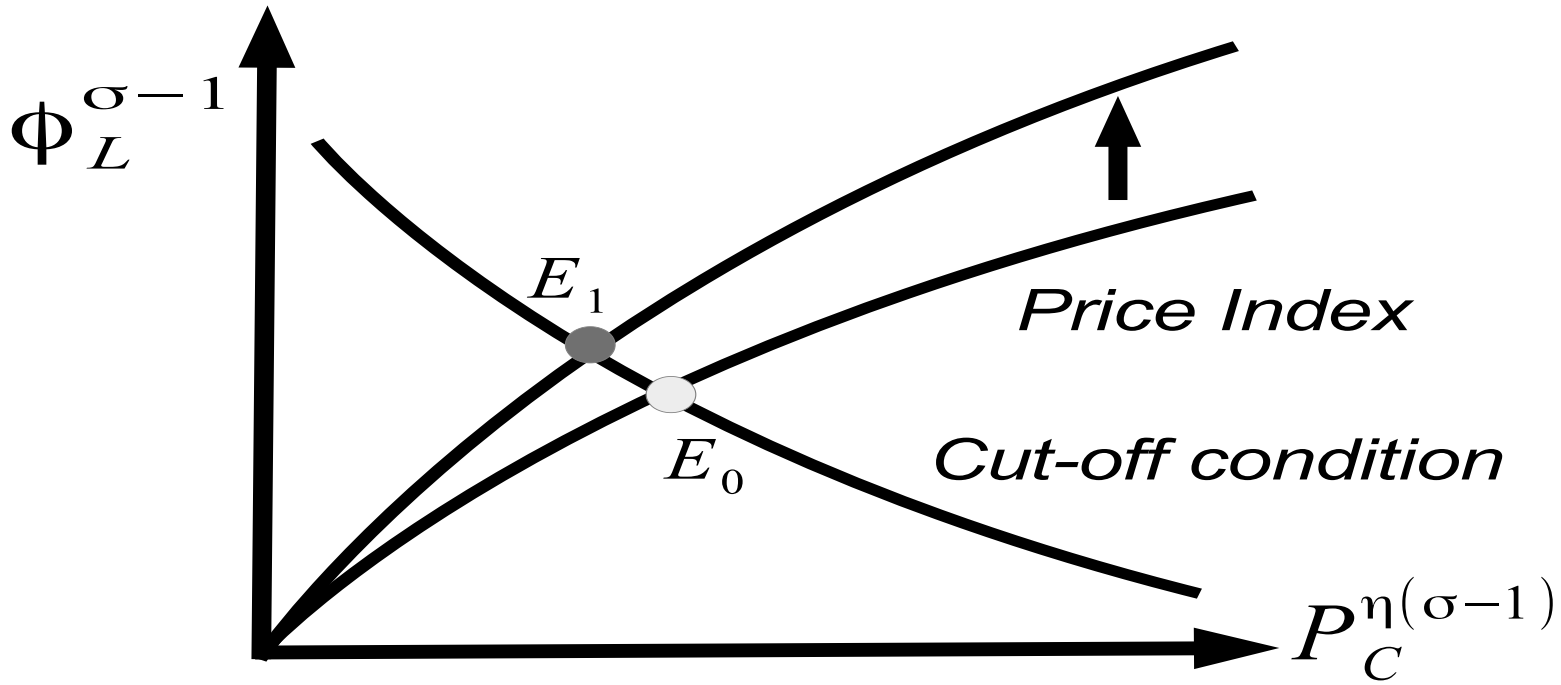


support effect: $s_T \uparrow$ shifts CO curve $\downarrow$.

direct forward linkage effect: $N_{MH} \uparrow$ ($P_{IH} \downarrow$) shifts CO curve $\downarrow$.

indirect forward linkage effect: $N_{MH} \uparrow$ ($P_{IH} \downarrow$) shifts PI curve $\uparrow$.

Intuition 3-2: impacts of s_T in model.2



Comp effect : $\phi_H \downarrow$ ($N_H \uparrow$) shifts PI curve $\uparrow$. more rivals...

indirect forward linkage effect: $N_{MH} \uparrow$ ($P_{IH} \downarrow$) shifts PI curve $\uparrow$.
*This makes Comp tougher across all types.

Fig.5: Impacts of s_T on the No.of local suppliers in model 2

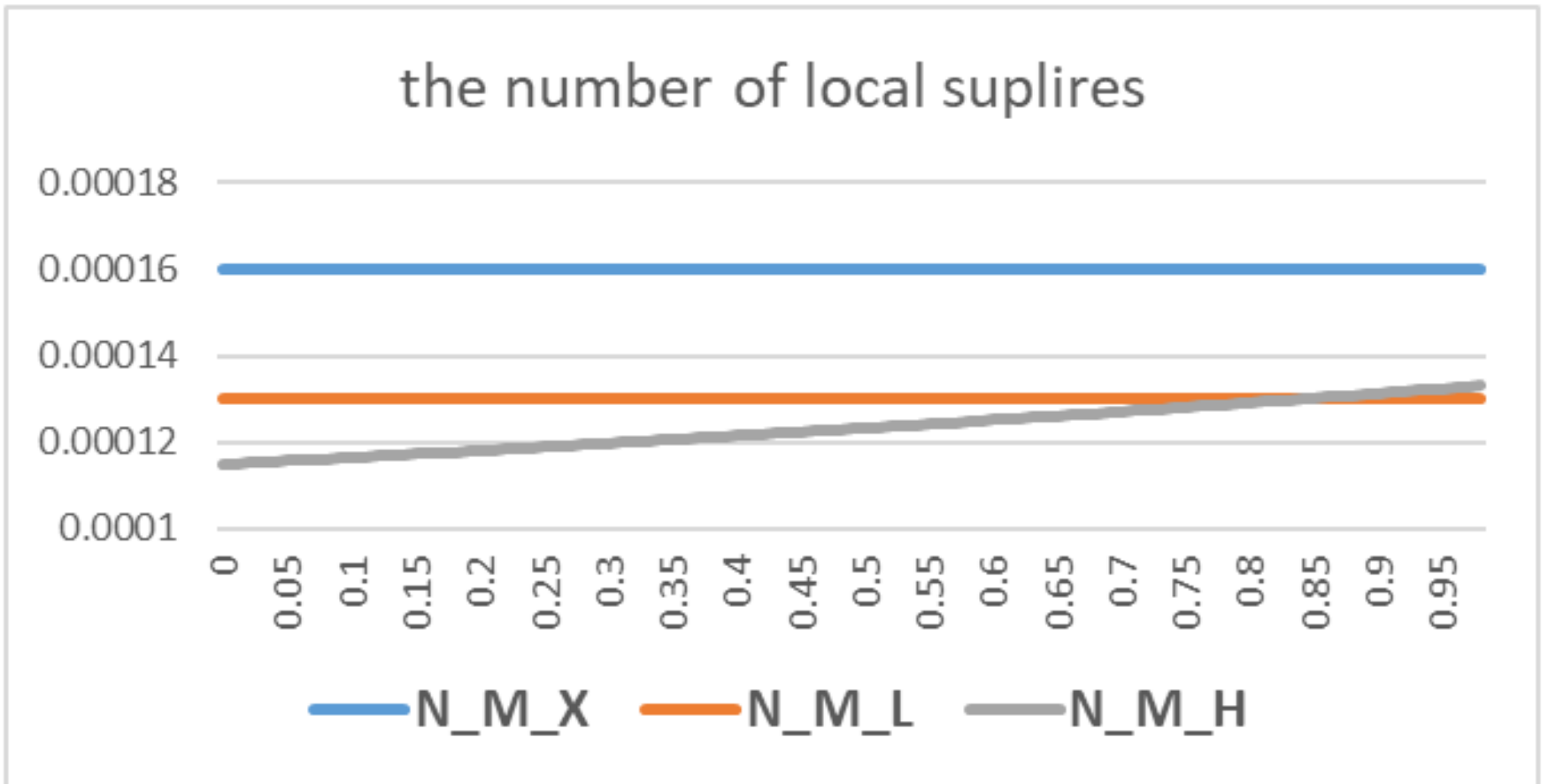
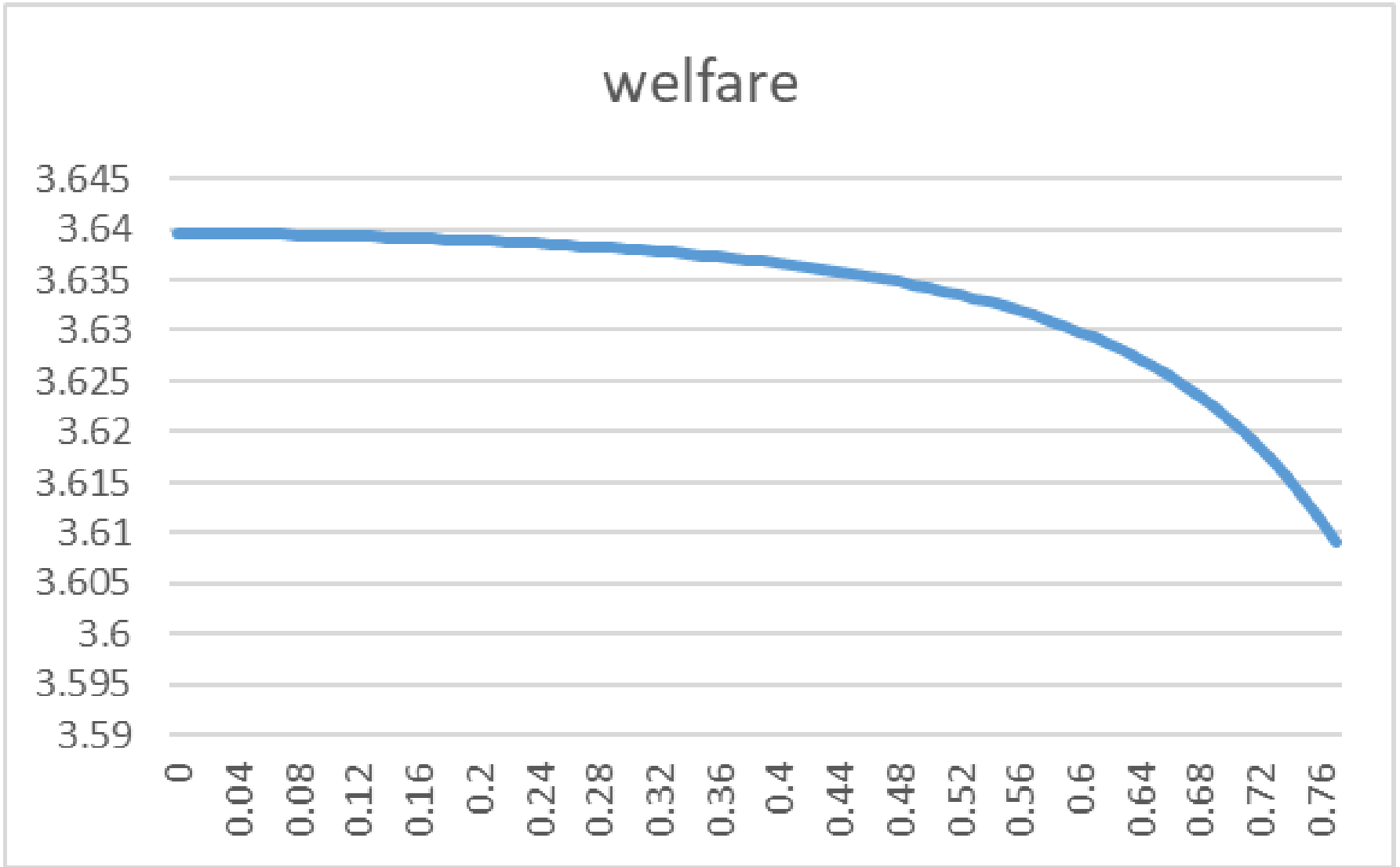


Fig.6: Impacts of s_E on welfare in model 2



Concluding Remarks

- Selected subsidy induces tech transfer from foreign affiliates to one type of local suppliers and strengthens the industrial cluster.

  *If human capital becomes a bottleneck, selection of foreign affiliates could select local suppliers.

- Non selected subsidy has the opposite effects.

- Govt. should use the quality of FDI as KPI because it can be often positive correlated with the average productivity of local suppliers

- Selected subsidy will improves welfare while non-selected subsidy could worsen welfare.

Thank you for your attention !

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