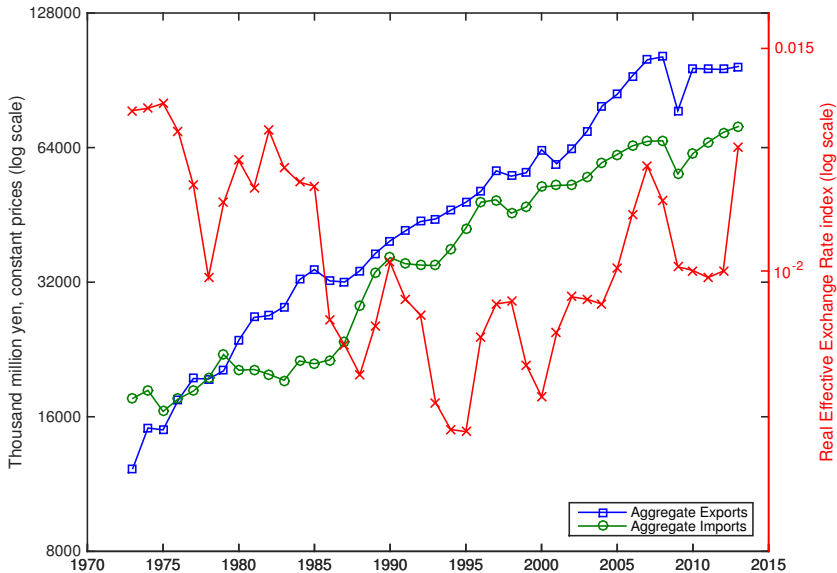


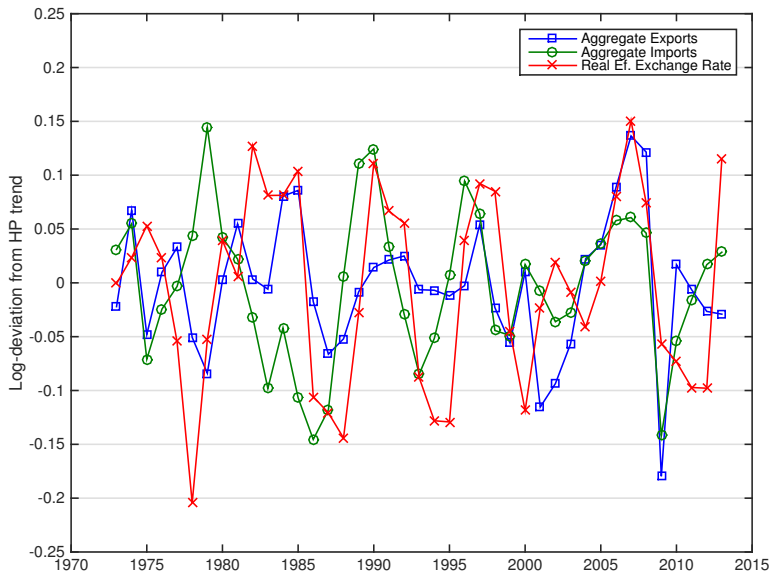
# Dynamics of Firms and Trade in General Equilibrium

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**Figure 1a.** Aggregate exchange rate disconnect (levels)



**Figure 1b.** Aggregate exchange rate disconnect (HP filtered)



$$\text{Corr}(\text{Exp}, \text{REER}) = 0.47^{***} \\ (0.11)$$

$$\text{Corr}(\text{Imp}, \text{REER}) = 0.19 \\ (0.16)$$

**Table 1.** Exports regression, Kaigin panel

	(1) All Sample	(2) High Profitability	(3) Low Profitability	(4) Big Employment	(5) Small Employment	(6) Big Sales	(7) Small Sales
log RER	0.374 (0.049)***	0.284 (0.110)**	0.393 (0.054)***	0.338 (0.061)***	0.406 (0.068)***	0.389 (0.063)***	0.369 (0.065)***
log Y*	0.398 (0.055)***	0.315 (0.125)**	0.417 (0.061)***	0.305 (0.072)***	0.424 (0.076)***	0.594 (0.073)***	0.316 (0.073)***
log Agg TFP	0.378 (0.080)***	1.537 (0.181)***	0.106 -0.089	0.389 (0.104)***	0.301 (0.111)***	0.588 (0.105)***	0.3 (0.106)***
log Firm TFP	2.112 (0.079)***	2.158 (0.169)***	2.091 (0.089)***	2.721 (0.121)***	1.898 (0.101)***	1.726 (0.111)***	2.253 (0.102)***
Cons	6.289 (1.596)***	7.744 (3.611)**	5.963 (1.771)***	10.412 (2.083)***	4.803 (2.190)**	2.55 -2.109	7.79 (2.107)***
F-stat	325.8	118.6	228.2	250.2	152.5	171.7	196.2
Adj. R-sq.	0.042	0.122	0.029	0.171	0.002	0.126	0.022
# Obs.	9,997	2,034	7,963	3,549	6,448	3,089	6,908

Size differentiation is done by 75th percentile. \*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ .

In Kaigin data, the average total sales of exporters is twice as large as non-exporters → Consistent with Melitz (2003)

But

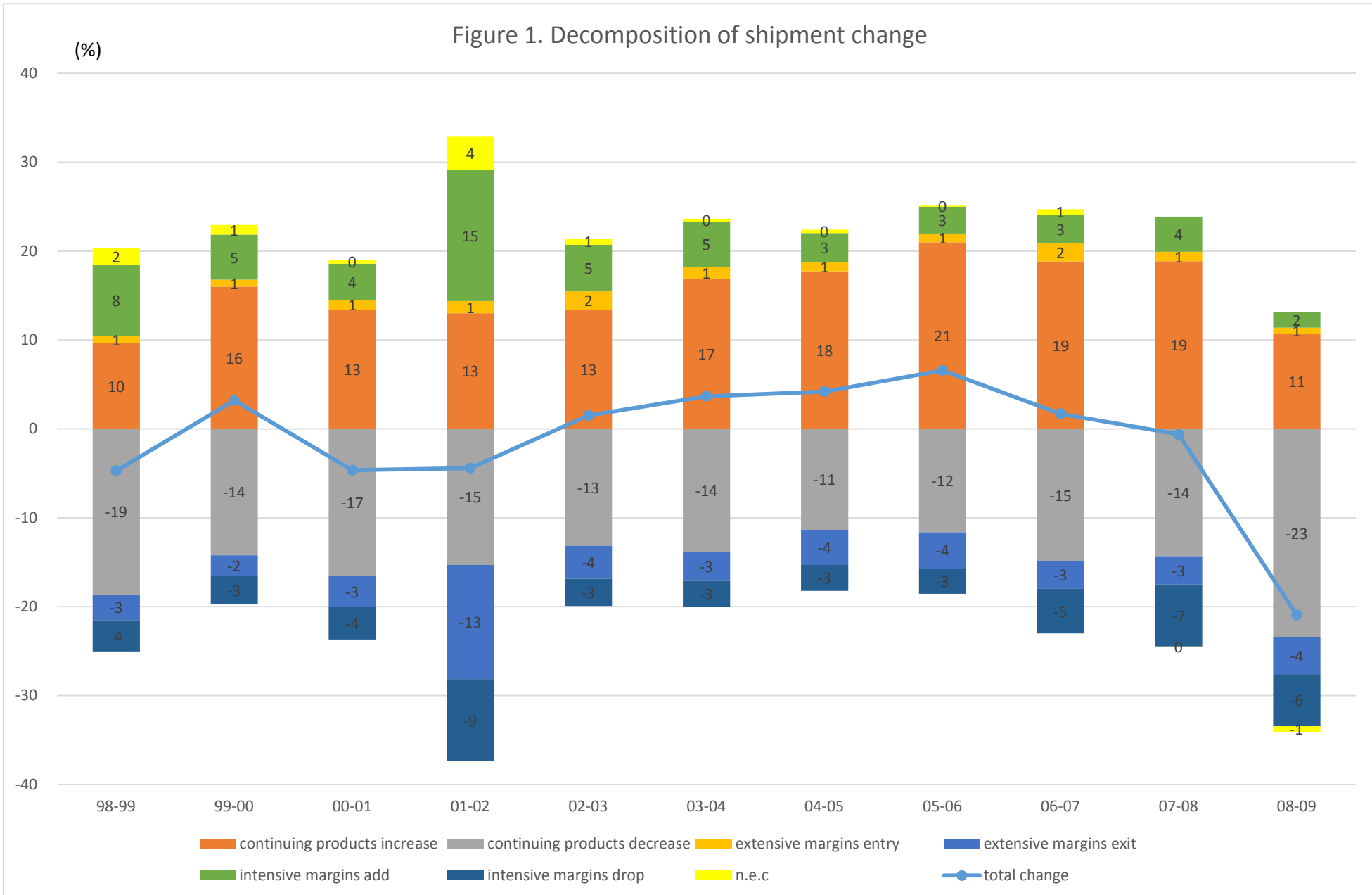
Correlation between firm size and export dummy is weak 0.09

Correlation between firm size and export share of exporters is even weaker 0.03

Many firms have negative profit, 8% in total and 11% among exporters

→ We consider heterogeneous productivity of each product and each firm produces multiple products

Figure 1. Decomposition of shipment change



# Small Open Economy Model

A continuum of home firm  $h \in \mathcal{H}_t$ . Firm  $h$  produces  $I_{ht}$  number of differentiated products for home and export market

$$q_{hit}^H = a_{hit} Z_t \left( \frac{l_{hit}^H}{\gamma_L} \right)^{\gamma_L} \left( \frac{m_{hit}^{*H}}{\mathbf{1} - \gamma_L} \right)^{1-\gamma_L}, \text{ for } i = 1, 2, \dots, I_{ht}$$

$$q_{hit}^F = a_{hit} Z_t \left[ \left( \frac{l_{hit}^F}{\gamma_L} \right)^{\gamma_L} \left( \frac{m_{hit}^{*F}}{\mathbf{1} - \gamma_L} \right)^{1-\gamma_L} - \phi \right], \text{ for } i = 1, 2, \dots, I_{ht}$$

Home output for home and export markets are produced as

$$Q_t^H = \left[ \int_{h \in \mathcal{H}_t} \left( \sum_{i=1}^{I_{ht}} q_{hit}^H \frac{\theta-1}{\theta} \right) dh \right]^{\frac{\theta}{\theta-1}}$$
$$Q_t^F = \left[ \int_{h \in \mathcal{H}_t} \left( \sum_{i=1}^{I_{ht}} q_{hit}^F \frac{\theta-1}{\theta} \right) dh \right]^{\frac{\theta}{\theta-1}}$$

A new entrant who pays a sunk cost  $\kappa_{Et}$  at date  $t$  draws an opportunity of producing a new products from date  $t+1$  with probability  $\lambda_E$ . The productivity of the new product is distributed as

$$\text{Prob}(a_{hit} \leq a) = F(a) = 1 - a^{-\alpha}, \text{ for } a \in [1, \infty)$$

where  $\alpha > 1$  and  $\alpha > \theta - 1$ .

A firm must pay the fixed maintenance cost  $\kappa$  for each product in order to produce and maintain its productivity

$$a_{hit+1} = \begin{cases} a_{hit}, & \text{with probability } 1 - \delta \\ 0, & \text{with probability } \delta \end{cases}$$

In addition, each maintained product yields an opportunity to produce another new product with probability  $\lambda\delta < \delta$  with the same Pareto distribution.



Each firm can produce many products. Each product multiplies and dies like "amoeba."

Home final goods market

$$Q_t^H = C_t + \kappa_{Et}N_{Et} + \kappa N_t$$

$N_{Et}$  is measure of entering firms,  $N_t$  is measure of differentiated products maintained, and

$$\kappa_{Et} = \kappa_E \left( \frac{N_{Et}}{N_E} \right)^\eta, \quad \eta > 0 \quad (1)$$

The representative household supplies labor  $L_t$ , consumes final goods  $C_t$  and holds home and foreign real bonds  $D_t$  and  $D_t^*$  to maximize its expected utility

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left( \ln C_t - \psi_0 \frac{L_t^{1+1/\psi}}{1+1/\psi} + \xi_t^* \ln D_t^* \right)$$

subject to the budget constraint

$$\begin{aligned} & C_t + \kappa_E N_{Et} + \kappa N_t + D_t + \epsilon_t D_t^* \\ &= w_{Lt} L_t + \Pi_t + R_{t-1} D_{t-1} + \epsilon_t R_{t-1}^* D_{t-1}^* \end{aligned}$$

$\xi_t^*$  : utility (liquidity) shock to foreign bond holding

Foreigners do not hold home bond  $\rightarrow D_t = 0$

Foreign bond holding of home household

$$D_t^* = R_{t-1}^* D_{t-1}^* + p_t^F Q_t^F - M_t^{*H}$$

where  $M_t^{*H}$  is total import of intermediate input

Foreign aggregate demand for home exports are given by

$$Q_t^F = (p_t^F)^{-\varphi} Y_t^*$$

where  $Y_t^*$  is an exogenous foreign demand

# Competitive Equilibrium

All firms choose to pay the fixed maintenance cost

$$N_{t+1} = (1 - \delta + \delta\lambda) N_t + \lambda_E N_{Et} \quad (2)$$

Price of differentiated goods is a mark-up over the unit cost and the price index of home final goods at home is

$$1 = p_t^H = \left[ \int_{h \in \mathcal{H}_t} \left( \sum_{i=1}^{I_{ht}} p_{hit}^H \right)^{1-\theta} dh \right]^{\frac{1}{1-\theta}} = \frac{\theta}{\theta-1} \frac{w_t}{\bar{a} N_t^{\frac{1}{\theta-1}} Z_t} \quad (3)$$

$$w_t = (w_{Lt})^{\gamma_L} \epsilon_t^{1-\gamma_L}, \quad \bar{a} \equiv \left[ \int_1^\infty a^{\theta-1} dF(a) \right]^{\frac{1}{\theta-1}} = \left( \frac{\alpha}{\alpha + 1 - \theta} \right)^{\frac{1}{\theta-1}}$$

Only products with higher than  $\underline{a}_t$  productivity is exported.

$$\underline{a}_t = \left[ \frac{\alpha (\theta - 1) \phi \bar{a} Z_t N_t^{\frac{\theta}{\theta-1}}}{\alpha + 1 - \theta \quad \epsilon_t^\varphi Y_t^*} \right]^{\frac{\theta-1}{\alpha(\theta-1) + (\alpha+1-\theta)(1-\varphi)}} \quad (4)$$

The input composite market equilibrium is

$$X_t = \left( \frac{L_t}{\gamma_L} \right)^{\gamma_L} \left( \frac{M_t^{*H}}{\mathbf{1} - \gamma_L} \right)^{1-\gamma_L} = \frac{\mathbf{1}}{\gamma_L(\psi_0 C_t)^\psi} \left( \frac{w_t^{1-\gamma_L+\psi}}{\epsilon_t^{(1-\gamma_L)(1+\psi)}} \right)^{\frac{1}{\gamma_L}} \quad (5)$$

$$= X_t^H + \phi \frac{\theta\alpha + 1 - \theta}{\alpha + 1 - \theta} \underline{a}_t^{-\alpha} N_t \quad (6)$$

Free entry condition is

$$\kappa_{Et} = \lambda_E E_t (\Lambda_{t,t+1} \bar{V}_{t+1}) : \text{free entry} \quad (7)$$

where the value function of the average product

$$\bar{V}_t = \bar{\pi}_t - \kappa + (\mathbf{1} - \delta + \delta\lambda) E_t (\Lambda_{t,t+1} \bar{V}_{t+1}) \quad (8)$$

where  $\Lambda_{t,t+1} = \beta C_t / C_{t+1}$  and

$$\bar{\pi}_t = w_t \left[ \frac{X_t}{(\theta - \mathbf{1}) N_t} - \frac{\theta}{\theta - \mathbf{1}} \phi \underline{a}_t^{-\alpha} \right] \quad (9)$$

The final goods market clearing implies

$$C_t + \kappa_{Et} N_{Et} + \kappa N_t = \bar{a} N_t^{\frac{1}{\theta-1}} Z_t X_t^H \quad (10)$$

Net foreign assets evolve as

$$\epsilon_t D_t^* = \epsilon_t R_{t-1}^* D_{t-1}^* + \underline{a}_t^{\frac{(\alpha+1-\theta)(1-\varphi)}{\theta-1}} \epsilon_t^\varphi Y_t^* - (1 - \gamma_L) w_t X_t \quad (11)$$

Home demand for home bond and foreign bond imply

$$1 = R_t E_t(\Lambda_{t,t+1}) \quad (12)$$

$$\epsilon_t - R_t^* E_t(\Lambda_{t,t+1} \epsilon_{t+1}) = \xi_t^* \frac{C_t}{D_t^*} \quad (13)$$

(1 – 13) determine  $w_t, \underline{a}_t, X_t, X_t^H, C_t, \epsilon_t, R_t, \bar{V}_t, \bar{\pi}_t, \kappa_{Et}, N_{Et}, N_{t+1}$  and  $D_t^*$  as a function of the state variables  $\mathcal{M}_t = (N_t, D_{t-1}^*, Z_t, \xi_t^*, Y_t^*, R_t^*)$

**Table 2a.** Baseline parameterization

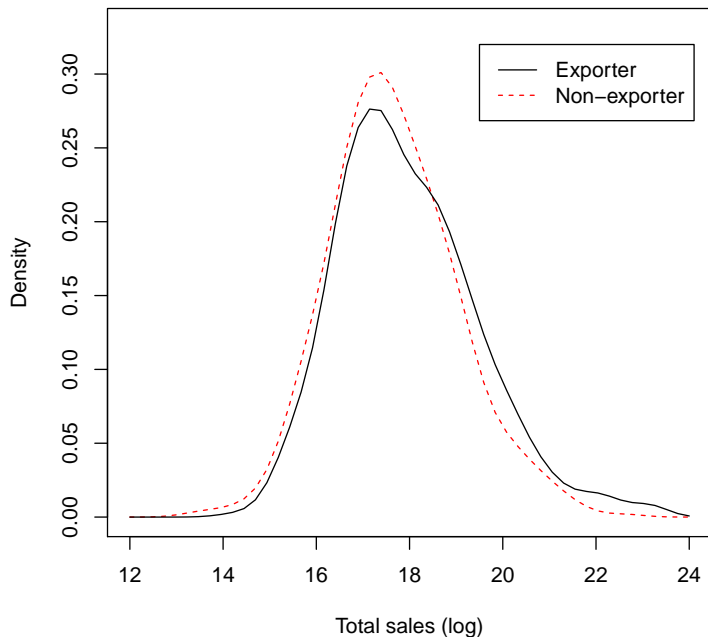
$\beta$	Discount factor	0.92
$\theta$	Elasticity of substitution between products	4.19
$\psi$	Frisch elasticity of labor supply	6.02
$\psi_0$	Labor disutility	12.84
$\gamma_L$	Labor share	0.85
$\alpha$	Productivity distribution shape parameter	3.64
$\varphi$	Elasticity of foreign demand	0.75
$\phi$	Export cost	3.14
$\kappa$	Maintenance cost	16.57
$\kappa_E$	Entry cost	89.26
$\eta$	Elasticity of entry cost	0.1
$\delta$	Probability of losing product	0.12
$\lambda$	Probability of drawing new product for incumbent	0.49
$\lambda_E$	Probability of producing new product for entrant	0.41
$\sigma$	Std. dev. of noise for sales	1.67
$Z$	Steady state aggregate productivity	1
$Y^*$	Steady state foreign demand	$10^6$
$G/C$	Steady state govt. expenditure / cons.	0.28
$\xi^*$	Steady state liquidity shock	0.01
$R^*$	Steady state foreign interest rate	1.05

**Table 2b.** Steady state moments (aggregate and cross-sectional)

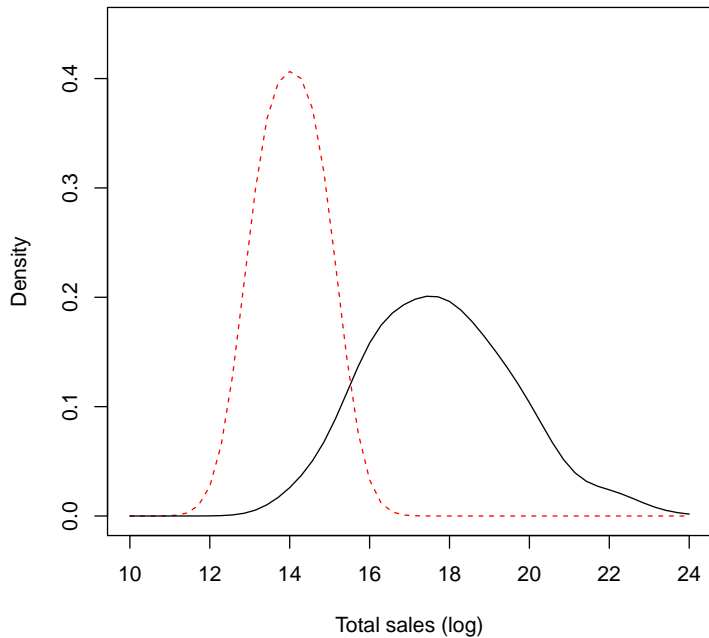
	Data	Model
$C/Y$	0.56	0.66
$\epsilon D^*/Y$	0.20	0.19
$Exp/Y$	0.12	0.12
$N_E/N$	0.10	0.15
Mean $\log Rev$	17.77	17.77
SD $\log Rev$	1.42	1.84
Mean $\log Dom$	17.65	17.66
SD $\log Dom$	1.41	1.84
Mean $\log Exp$	16.03	15.58
SD $\log Exp$	2.09	1.85
Mean $PR$	0.03	0.15
SD $PR$	0.06	0.15
$\#Exp/N$	0.39	1.00
Corr $PR, \log Rev$	0.07	0.71
Corr $ES, \log Rev$	0.17	0.32



**Figure 3a.** Cross sectional distribution of total sales by export status: Kaigin data



**Figure 3b.** Cross sectional distribution of total sales by export status: Model



**Table 3a.** Calibration of stochastic processes

	Efficient	Subjective
Standard deviation		
$\sigma_Z$ (%)	0.87	0.59
$\sigma_{Y^*}$ (%)	1.35	5.46
$\sigma_G$ (%)	0.83	0.61
$\sigma_{\xi^*}$ (%)	22.05	79.16
Autocorrelation		
$\rho_Z$	0.55	0.73
$\rho_{Y^*}$	0.94	0.84
$\rho_G$	0.95	0.95
$\rho_{\xi^*}$	0.95	0.27

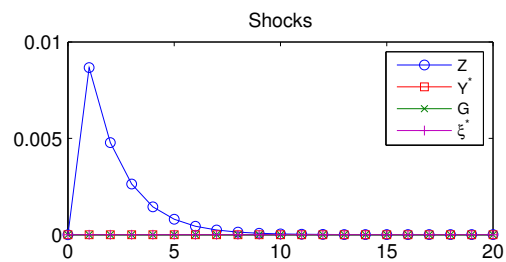
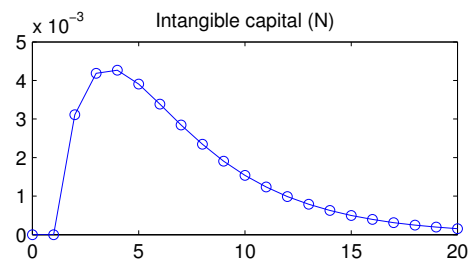
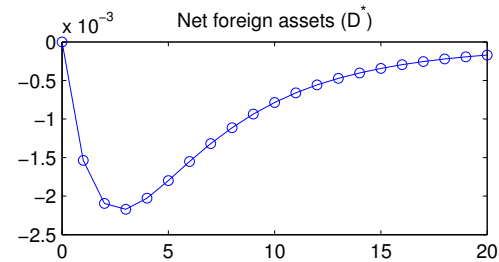
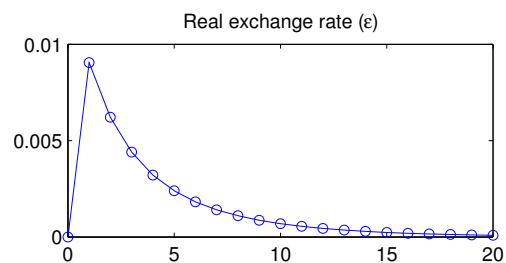
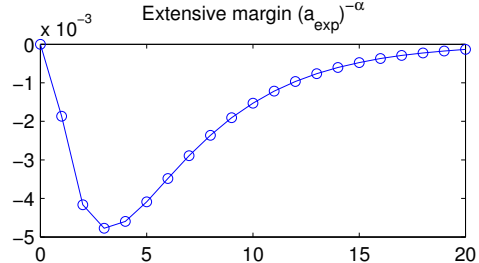
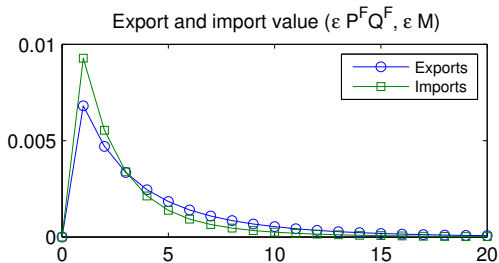
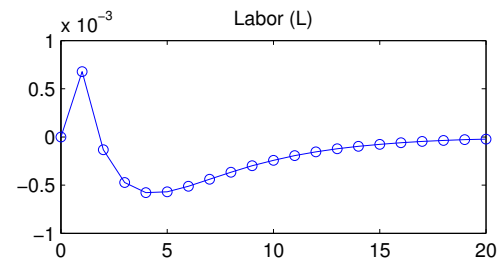
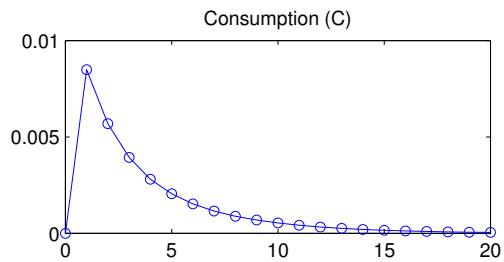
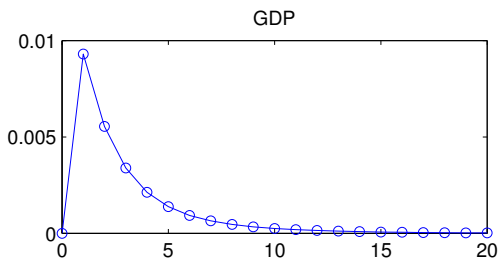
**Table 3b.** Sample and simulated moments

	Data	Efficient	Subjective
Standard deviation			
SD GDP (%)	0.88 (0.10)	0.93	0.96
SD Gov / SD GDP	0.63 (0.11)	0.83	0.59
SD Inv / SD GDP	3.13 (0.13)	2.80	2.47
SD Exp / SD GDP	4.63 (0.70)	2.41	4.24
SD RER (%)	3.52 (0.31)	3.07	3.57
Autocorrelation			
AC(1) GDP	0.55 (0.15)	0.34	0.40
AC(1) Gov	0.65 (0.07)	0.49	0.49
AC(1) Inv	0.58 (0.13)	0.30	0.23
AC(1) Exp	0.36 (0.18)	0.45	0.37
AC(1) RER	0.49 (0.06)	0.46	0.28
Correlation with GDP			
Corr Gov, GDP	0.08 (0.19)	0.12	0.08
Corr Inv, GDP	0.96 (0.01)	0.97	0.85
Corr Exp, GDP	0.55 (0.19)	0.08	0.53
Corr RER, GDP	0.42 (0.16)	-0.04	-0.59

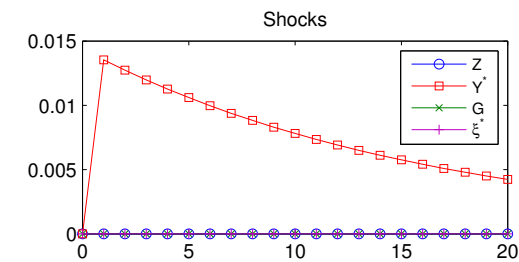
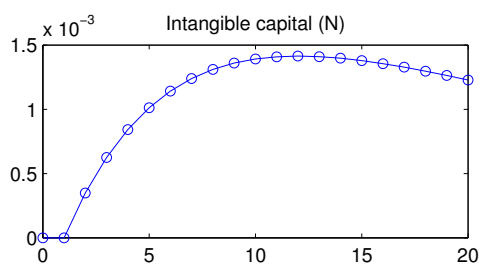
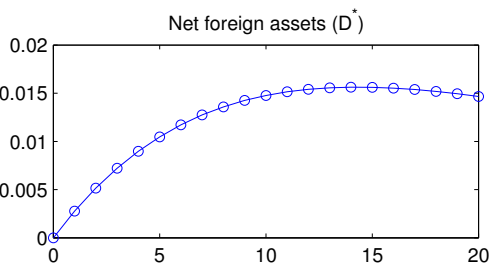
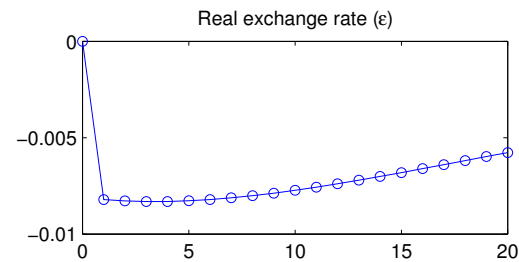
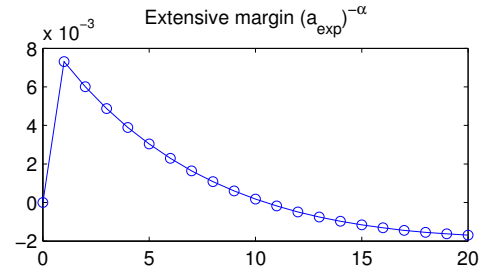
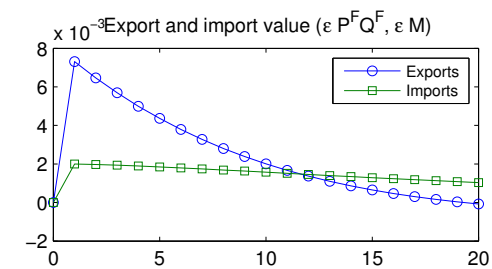
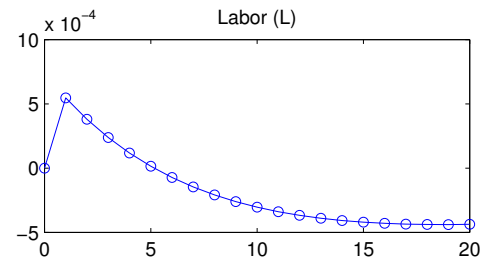
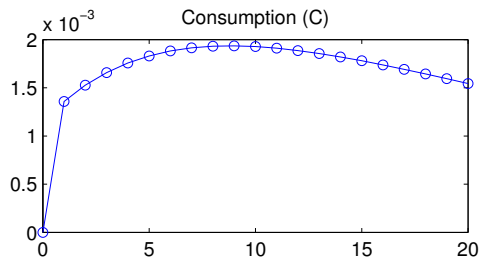
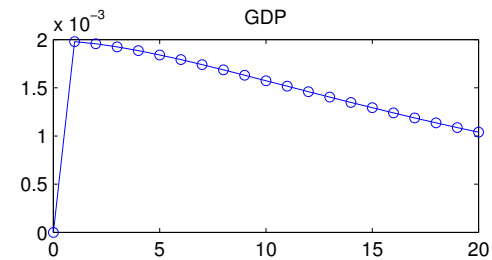
Data and output from the model are HP filtered.

HAC robust standard errors are shown in parenthesis.

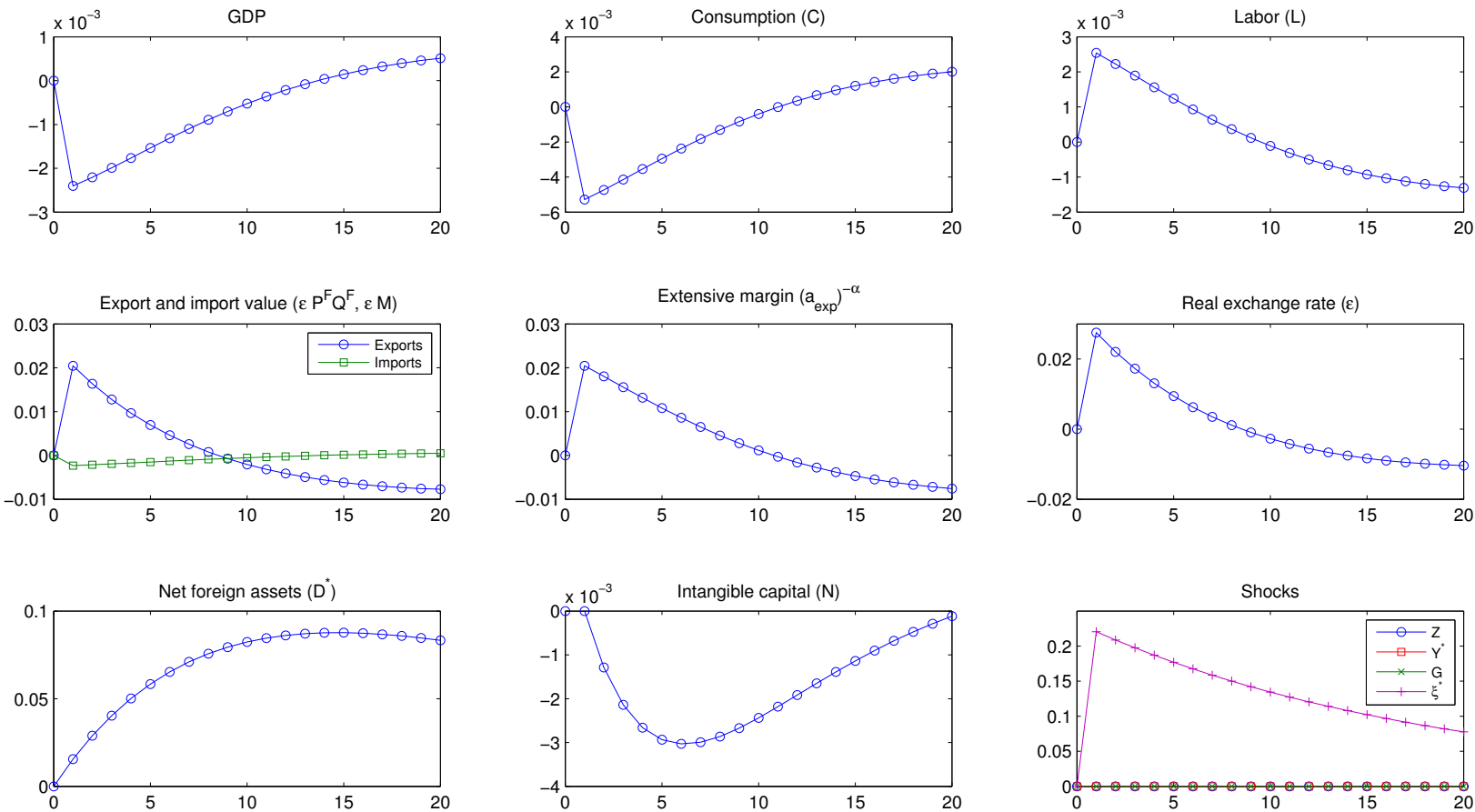
**Figure 4.** Impulse response to TFP shock  $Z$



**Figure 5.** Impulse response to foreign demand shock  $Y^*$



**Figure 7.** Impulse response to liquidity shock  $\xi^*$



**Table 6.** Panel regression on simulated data: Profitability interaction

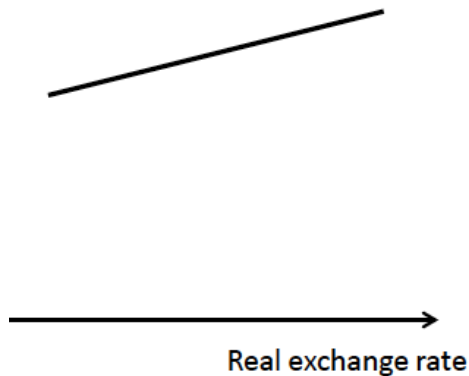
	Data	Model			
		(1)	(2)	(3)	(4)
log RER	0.527 (0.065)***	1.95 (-7.4, 11.07)	1.95 (-0.02, 3.8)	2.00 (0.11, 3.84)	1.65 (1.18, 2.21)
log RER $\times$ PR	-1.604 (0.954)*		-0.25 (-0.3, -0.23)	-1.81 (-4.11, 0.56)	-0.58 (-1.39, 0.27)
log Y*	0.383 (0.055)***	2.19 (-17.9, 23.33)	2.28 (-2.06, 6.61)	2.36 (-1.88, 6.69)	2.17 (0.9, 3.29)
log Y* $\times$ PR	-0.357 (0.155)**			-2.32 (-5.72, 1.25)	-0.83 (-2.03, 0.43)
log Agg TFP	-0.678 (0.103)***	-0.83 (-29.32, 24.36)	-2.32 (-8.62, 2.99)	-2.64 (-8.89, 2.21)	-1.16 (-2.77, -0.17)
log Agg TFP $\times$ PR	21.09 (1.436)***			7.76 (0.24, 16.04)	1.16 (-1.26, 3.96)
log Firm TFP	2.295 (0.084)***				0.98 (0.97, 0.99)
Cons	7.573 (1.626)***				
# Obs.	9,994	26,752 (10536, 38688)			

For the model, 95% bootstrap confidence intervals (with 1,000 simulations) are shown in parenthesis.

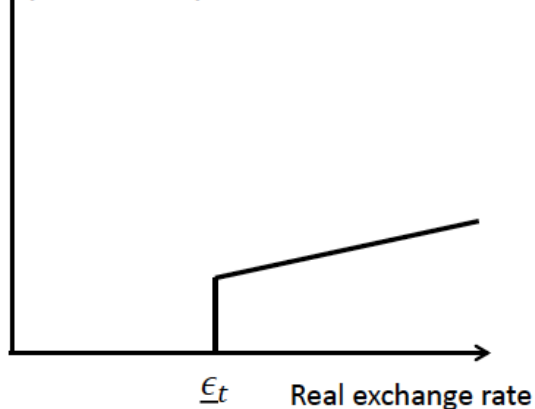


**Figure 8.** Response of exports to the exchange rate at extensive and intensive margins

export of high  
productive product      Figure 8a



export of marginally  
productive product      Figure 8b



aggregate export      Figure 8c

