Technology and Capital Adjustment Costs: A Micro Evidence of Automobile Electronics in the Auto-Parts Suppliers

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Slides

1. Automobile electronics: the ABC
2. Motivation
   - General purpose technology（ GPT)
   - Investment-specific technology shock
   - Cooper and Haltiwanger(2006)
3. What this paper does
   - Data
   - Estimation
   - Main results
4. Further work

1.“Automobile Electronics” the ABC

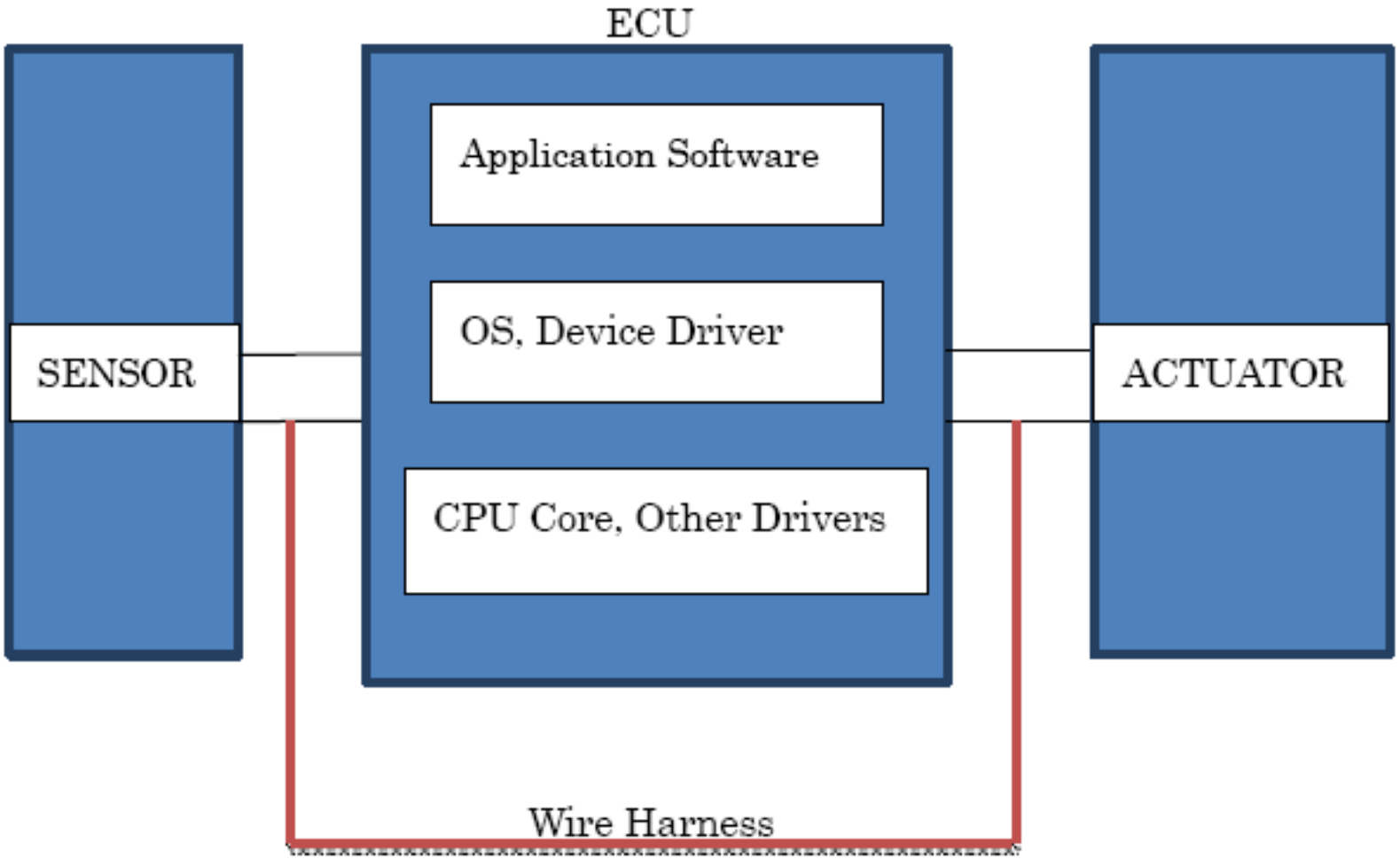


Figure 2: Automobile Electronics; Source: Figure 2-1 in Tokuda and Saeki (2007b).

Seven Products

- Electronically-controlled fuel injection device （ PET)
- Electric power steering（ EPS ）
- Anti-lock brake system (ABS)
- Airbag
- Navigation system
- Wire harness
- Lithium-ion battery

2.General Purpose Technology (GPT)

- David(1990): “general purpose engines” “occupy key positions in a web of strongly complementary technical relationships that give rise to *network externality effects* of various kinds, and so make issues of compatibility standardization important for business strategy and public policy.”

General Purpose Technology (GPT)

- Bresnahan and Trajtenberg(1996): Some characteristics
  - the emergence of an extended trajectory of incremental technical improvement;
  - the gradual and protracted process of diffusion into widespread use;
  - the confluence with other streams of technological innovation.

Investment-Specific Technology Shock

- Justiniano and Primiceri(2008): following CEE(2005)

$$K_t = (1-\delta)K_{t-1} + \mu_t \left[1 - \varphi\left(\frac{I_t}{I_{t-1}}\right) \right] I_t$$

  - A shock to the relative price of investment in terms of consumption good or
  - A shock to the production technology of capital goods (Greenwood, Hercowitz and Krusell, 1997).

Cooper and Haltiwanger(2006)

- "On the *Nature* of Capital Adjustment Costs"
  - Convex or non-convex
  - Irreversibility
- Functional forms

Convex or Non-Convex

- Convex： Hayashi(1982)

$$C(I,K)=\frac{\gamma}{2}\left(\frac{I}{K}\right)^2 K$$

- Non-convex: fixed costs
  - Plant restructuring, worker retraining or organizational restructuring.
    - Indivisibilities in capital; increasing returns to the installation of new capital; increasing returns to retraining and restructuring of production activities.
  - Opportunity costs $(1-\lambda)\Pi$
  - Proportional to size FK

Irreversibility

- Transaction costs: differentials between buying and selling price of capital

$$p(I) = \begin{cases} p_b \equiv 1 & \text{if } I > 0 \\ p_s & \text{if } I < 0 \end{cases}$$

  - The transaction costs are probably caused by capital specificity or asymmetric information between buyers and sellers
  - Discrete choices with inaction between (s, S) bounds.

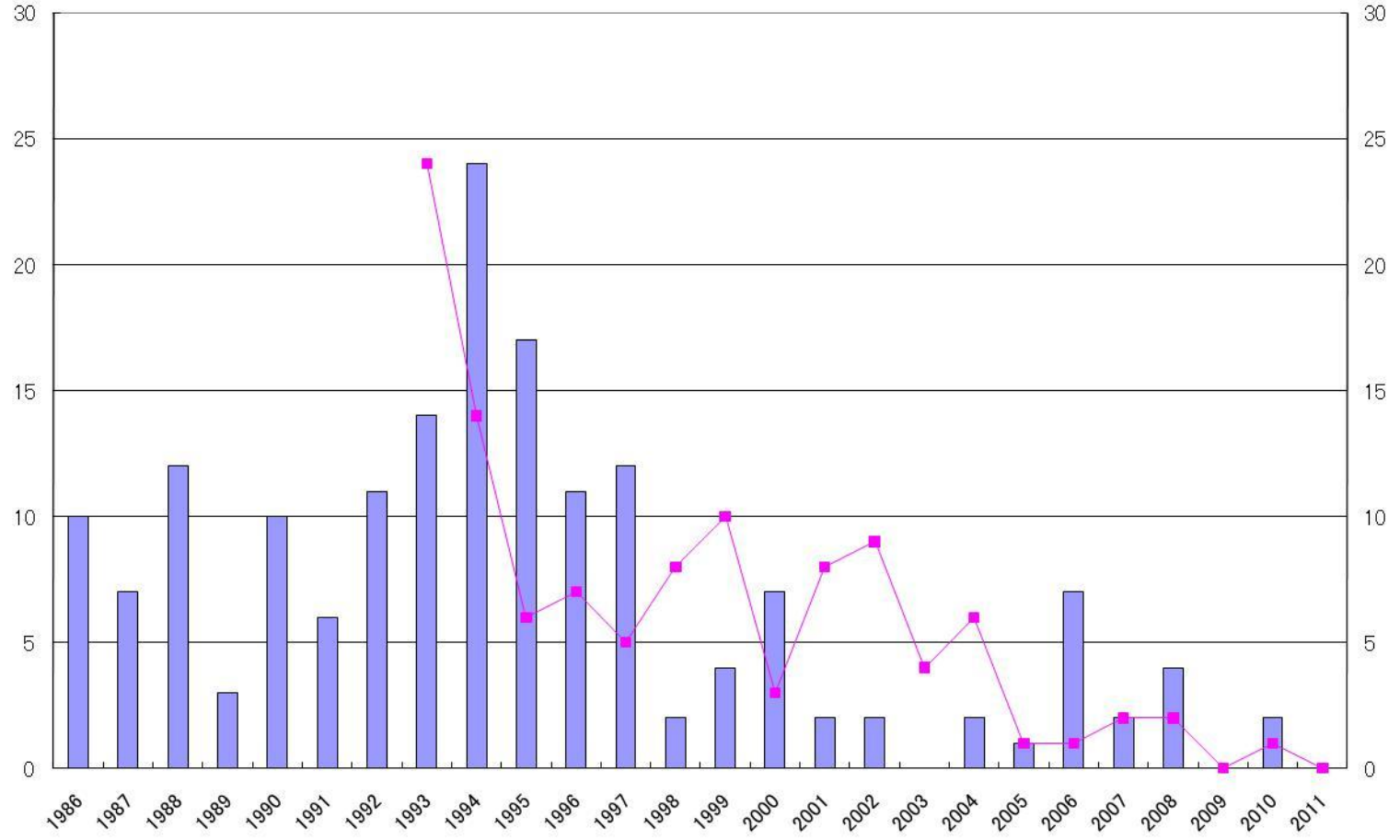
3.What This Paper Does

1. Identification of auto electronics technologies
2. Quantitative evaluation of changes in the nature of capital adjustment costs associated w/ auto electronics technologies

Identification of Auto Electronics Technologies

- Data: *Patent Gazettes* of the Japan Patent Office, in the *Industrial Property Digital Library*
  - The number of patent grants related to auto electronics.
- Key words in Japanese
  - Electronically-controlled fuel injection device（PET)
  - Electric power steering（EPS）
  - Anti-lock brake system (ABS)
  - Airbag
  - Navigation system
  - Wire harness
  - Lithium-ion battery

PET “1986-97”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Data

- *Census of Manufactures* (METI, Japan)
  - Plant level data
  - Auto-parts suppliers
    - Automotive body and concomitant(#3012)
    - Automotive component and accessory(#3013)
  - Perpetual inventory method applied with depreciation rate 0.073 for 1986-92 or 0.096 for 93-07.
  - Capital retirement: market-book value ratios.

Summary Statistics of Overall Sample

Average Investment Rate	0.1699
Inaction Rate	0.069
Fraction of Obs. w/ Negative Investment	0.0536
Positive Spike Rate: >0.2	0.2937
Negative Spike Rate: <-0.2	0.00395
Serial Correlation	0.0305
Correlation w/ Profitability	0.1376

Auto Electronics Dummy Vars.

Overall sample of plants: 33092

- PET: commodity“Parts, attachments and accessories of internal combustion engines for motor vehicles” ; 6733 samples.
- EPS: “Parts of driving, transmission and operating units”; 4912.
- ABS: “Parts of suspension and brake systems”; 2031.
- Airbag: “Parts of chassis and bodies”; 5086.
- Navigation: “Radio applied equipment”;17.
- Wire harness: “Parts, attachments and accessories of auxiliary equipment for internal combustion engines” ; 108 .
- Lithium ion battery: “Lithium ion batteries” ; 0.

η Correlation w/ Productivity

PET	EPS	ABS	AB	NAV	WH	LIB
-0.0797 *(-8.67)*	0.0366 (3.65)	0.0567 (4.26)	-0.0011 (-0.11)	0.3004 (1.47)	0.0746 (0.99)	---

System GMM

Sectoral Cases

QE of the Nature of Capital Adjustment Costs Associated w/ Auto Electronics Technologies

- Tracing Cooper and Haltiwanger(2006)
- Numerical solution to the Bellman Eq. for dynamic discrete-choices, both for overall and sectoral samples

$$V(A,K) = \max\left[V^b(A,K), V^S(A,K), V^i(A,K)\right]$$

$$V^b(A,K) = \max \Pi(A,K)\lambda - FK - p_b I - \frac{\gamma}{2}\left(\frac{I}{K}\right)^2 K + \beta E_{A'|A} V(A', K(1-\delta)+I)$$

$$V^S(A,K) = \max \Pi(A,K)\lambda - FK + p_s R - \frac{\gamma}{2}\left(\frac{R}{K}\right)^2 K + \beta E_{A'|A} V(A', K(1-\delta)-R)$$

$$V^i(A,K) = \Pi(A,K) + \beta E_{A'|A} V(A', K(1-\delta)).$$

Estimation

1. Profit functions via system GMM
2. The Bellman equations via simulated method of moments (SMM)

Profit Functions

- System GMM (Blundell and Bond, 1998)

$$\Pi(A_{it}, K_{it}) = A_{it} K_{it}^{\theta}$$

$$\log A_{it} \equiv a_{it} = b_t + \varepsilon_{it}$$

$$b_t = \mu_b + \rho_b b_{t-1} + \eta_{bt}$$

$$\varepsilon_{it} = \rho_\varepsilon \varepsilon_{it-1} + \eta_{it}$$

$$\log \Pi_{it} \equiv \pi_{it} = \rho_\varepsilon \pi_{it-1} + \theta k_{it} - \rho_\varepsilon \theta k_{t-1} + b_t - \rho_\varepsilon b_{t-1} + \eta_{it}$$

where instruments:

- GMM type $(\pi_{t-2}, k_{it-1}, k_{it-2})$
- Simultaneity: real land capital at t and (t-1).

System GMM

	Coef.	S.E.(z-stat)
π_{it-1}	0.689	0.039(17.78)
k_{it}	0.60	0.13(4.73)
k_{it-1}	-0.43	0.15(-2.91)

- Aggregate common shock controlled by logged real GDP & logged material inputs price and wage at t and (t-1), as well as year-dummies.
- Arellano-Bond test for AR(1) of error term accepts no serial correlation.
- Hansen J-test cannot reject exogeneity of instruments.
- The estimated AR(1) processes approximated by first-order Markov chain via Rouwenhorst (1995) method for highly persistent processes. η Correlation w/ Productivity

$$a_{it} = b_t + \varepsilon_{it}, b_t = \hat{\mu}_b + \hat{\rho}_b b_{t-1} + \hat{\eta}_{bt}, \varepsilon_{it} = \hat{\rho}_\varepsilon \varepsilon_{it-1} + \hat{\eta}_{it}$$

The Bellman Equations

- SMM (Fackler and Tastan, 2008)
  - Find a parameter vector $\Theta = (F, \lambda, p_s, \gamma)$ minimizing the distance between empirical and simulated moments

$$\min_{\Theta} J(\Theta) = [\Psi^d - \Psi^s(\Theta)]' W [\Psi^d - \Psi^s(\Theta)]$$

  - Procedure:

1. Given Θ ,value function iteration.
2. Resulting policy function generates a panel data set.
3. The panel obtains $\Psi^s(\Theta)$
4. Minimization w.r.t. Θ.

Overall Sample

	Coef.	ASE(t-stat)
F	0.0103	0.000095(108.25)
γ	0.0586	0.003168(18.48)
p_s	1.0012	0.003806(263.05)
λ	1.1457	0.003094(370.25)

- Convex adjustment cost is significant.
- Fixed costs are there, since significant F and λ (though >1).
- Irreversibility is none, since $p_s=1$.

Moments	Overall Sample	Simulation
Serial correlation	0.1331	0.2304
Correlation w/ prof.	0.1127	0.0234
Positive spike rate	0.2934	0.1368
Negative spike rate	0.0055	0.0086
Inaction rate	0.0843	0.0900

Specifications

Coef. ASE(t-stat)	Full Specification	λ=1	F=0
F	0.0103 0.000095(108.25)	-0.0006 0.000017(-37.95)	---
γ	0.0586 0.003168(18.48)	0.0811 0.000224(361.07)	0.0581 0.000000(inf.)
p_s	1.0012 0.003806(263.05)	1.0150 0.000231(4392.14)	0.7744 0.000000(inf.)
λ	1.1457 0.003094(370.25)	---	1.0308 0.000000(inf.)
Objective Function Estimate	0.1359	0.2671	0.3832

Sectoral Cases

- Summary Statistics

	Overall	PET_EPS_ABS _AB_WH_LI_NV	EPS_ABS	EPS_ABS_WH	AB_LI_NV
Average Inv. Rate	0.1699	0.194	0.182	0.181	0.182
Inaction Rate	0.069	0.058	0.049	0.048	0.066
Negative Inv.	0.0536	0.064	0.069	0.069	0.079
Positive Spike	0.2937	0.325	0.303	0.304	0.3004
Negative Spike	0.00395	0.008	0.0103	0.011	0.0104
Serial Corr.	0.0305	0.059	0.0104	0.0105	0.0421
Corr. w/ Prof.	0.1376	0.122	0.184	0.183	0.109

η Correlation w/ Productivity

Sectoral Cases

- System GMM

Price competitive

	Overall Sample	PET_EPS_ABS _AB_WH_LI_NV	EPS_ABS	EPS_ABS_WH	AB_LI_NV
π_{it-1}	0.689(17.78)	0.62(8.94)	0.43(1.20)	0.43(0.94)	0.599(4.29)
k_{it}	0.60(4.73)	0.48(2.76)	0.81(2.31)	0.81(1.75)	0.25(0.82)
k_{it-1}	-0.43(-2.91)	-0.22(-1.22)	-0.398(-1.83)	-0.41(-1.45)	0.038(0.14)

Sectoral Cases

Coef. ASE(t-stat)	Overall Sample # of sample 41377	PET_EPS_ABS _AB_WH_LI_NV # 12278	EPS_ABS # 4229	EPS_ABS_WH # 4280	AB_LI_NV # 3554
F	0.0103 0.000095(108.25)	0.0179 0.000060(300.68)	0.0090 0.000094(96.65)	0.0081 0.001203(6.74)	0.0217 0.0028(7.73)
γ	0.0586 0.003168(18.48)	0.0441 0.002559(17.24)	0.0700 0.007381(9.48)	0.0633 0.071006(0.89)	0.0531 0.000000(inf.)
p_s	1.0012 0.003806(263.05)	0.9732 0.005112(190.39)	1.0006 0.003213(311.40)	1.0010 0.003614(277.02)	0.8451 0.000000(inf.)
λ	1.1457 0.003094(370.25)	1.3499 0.004774(282.75)	1.1694 0.024153(48.41)	1.1541 0.000602(1916.76)	1.1025 0.003773(292.18)
Specifications: •Full •λ=1 •F=0	Obj. fun. est. 0.1359 0.2671 0.3832	 0.0895 6.9743 11.2029	 0.2733 0.4651 0.4364	 0.2631 0.3318 0.4365	 0.4226 9.6937 0.4232

Main Results

- For the overall auto-parts suppliers, there are significant adjustment costs, except for irreversibility.
- Concerning the auto-electronics parts, esp. EPS and ABS suppliers look price-rivalries, so that correlation with profitability is relatively high and idiosyncratic shocks are subordinated.
- For auto-electronics cases, in spite of 'partial' sets of the overall case, clearly similar features to overall case.
  - Comparing EPS_ABS or EPS_ABS_WH w/ PET_EPS_ABS_AB_WH_LI_NV or AB_LI_NV, no changes in the adjustment costs in a response to "auto-electronics"
  - Meaning smooth adjustments to the auto-electronics by the Japanese auto-part suppliers

4.Further Work

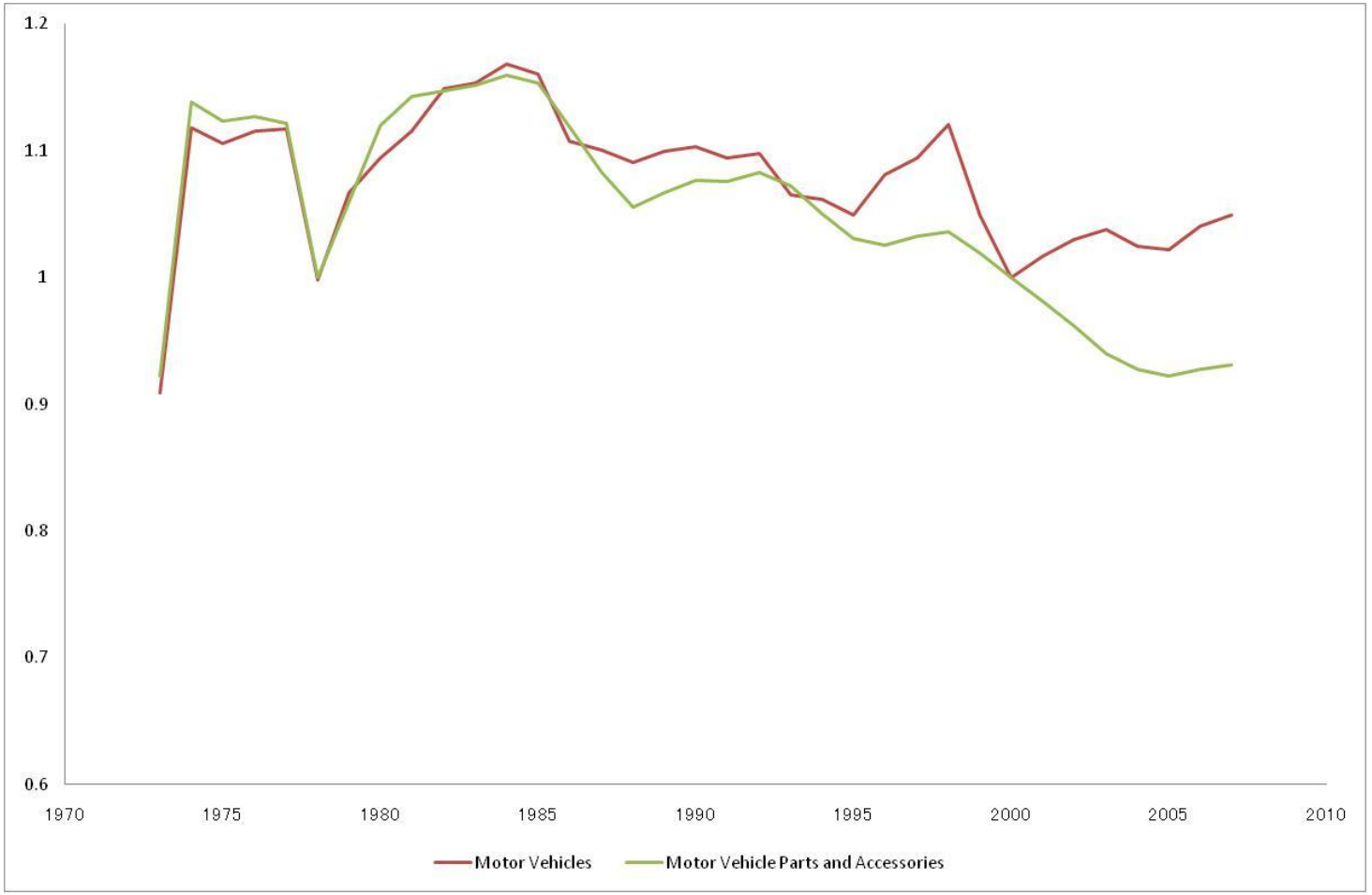
- We are revising this paper, in search for robustness of SMM estimates.
  - Our current optimization algorithm is ‘local’ even though too much time-consuming
  - So need ‘global’ search in the SMM optimization

Supplements

General Purpose Technology (GPT)

- Jovanovic and Rousseau(2002)
  - Learning by doing
  - An increase in the parameter indicating higher learning $p = (\frac{K}{B})^{-\beta}$
  - Speed β in the long run, raises growth but
  - In the transition, decreases convergence speed
    - A reduction of new capital price causes free riding and delayed diffusion lags.

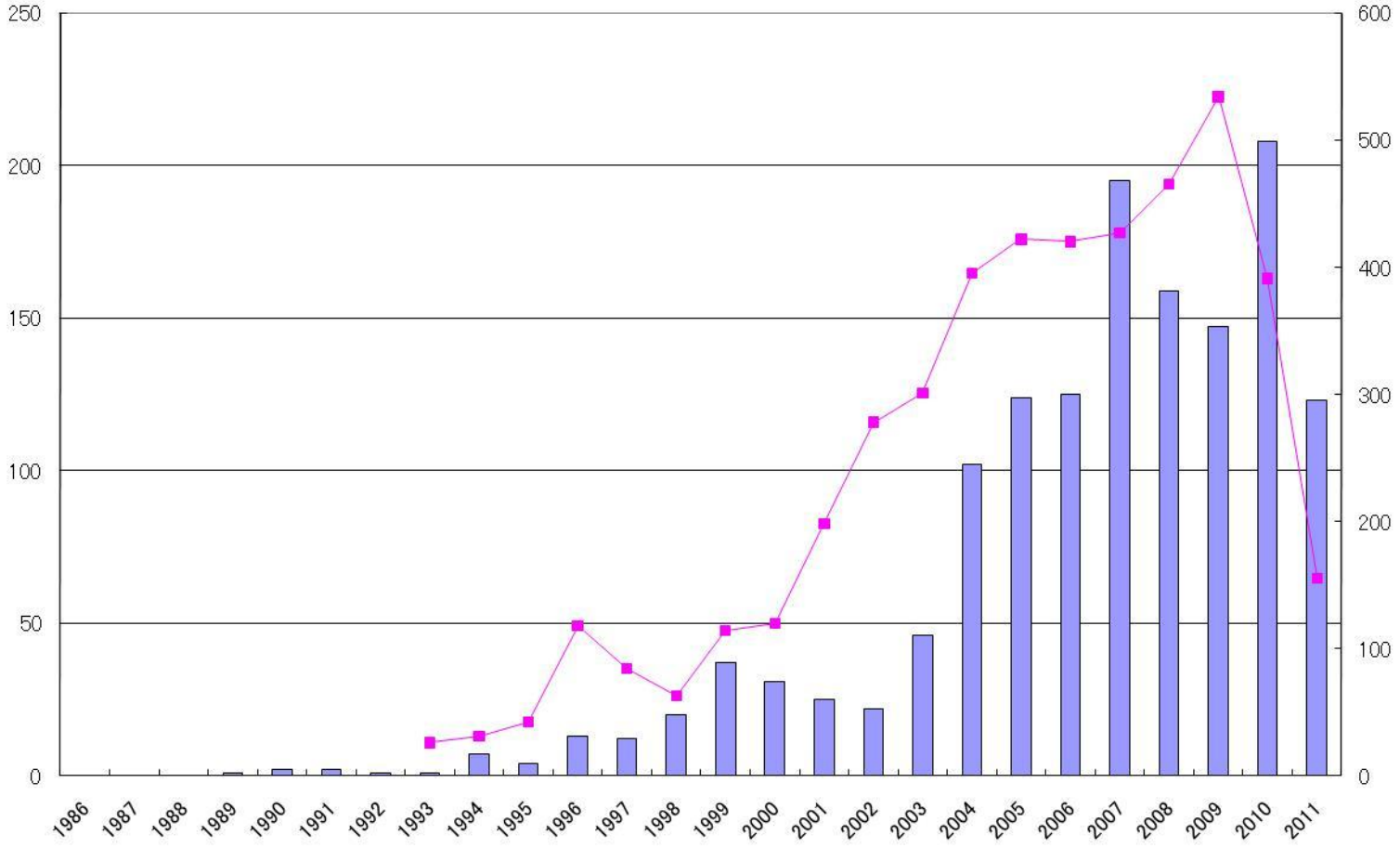
General Purpose Technology (GPT)



Investment-Specific Technology Shock

- Hornstein and Krusell(1996): investment-specific technological change in a vintage capital model where new technologies with less learning or less experience are introduced at fast rate.
  - Since learning or experience does matter with productivity, the investment-specific technology shock can then reduce measured productivity growth.

EPS “1999-07”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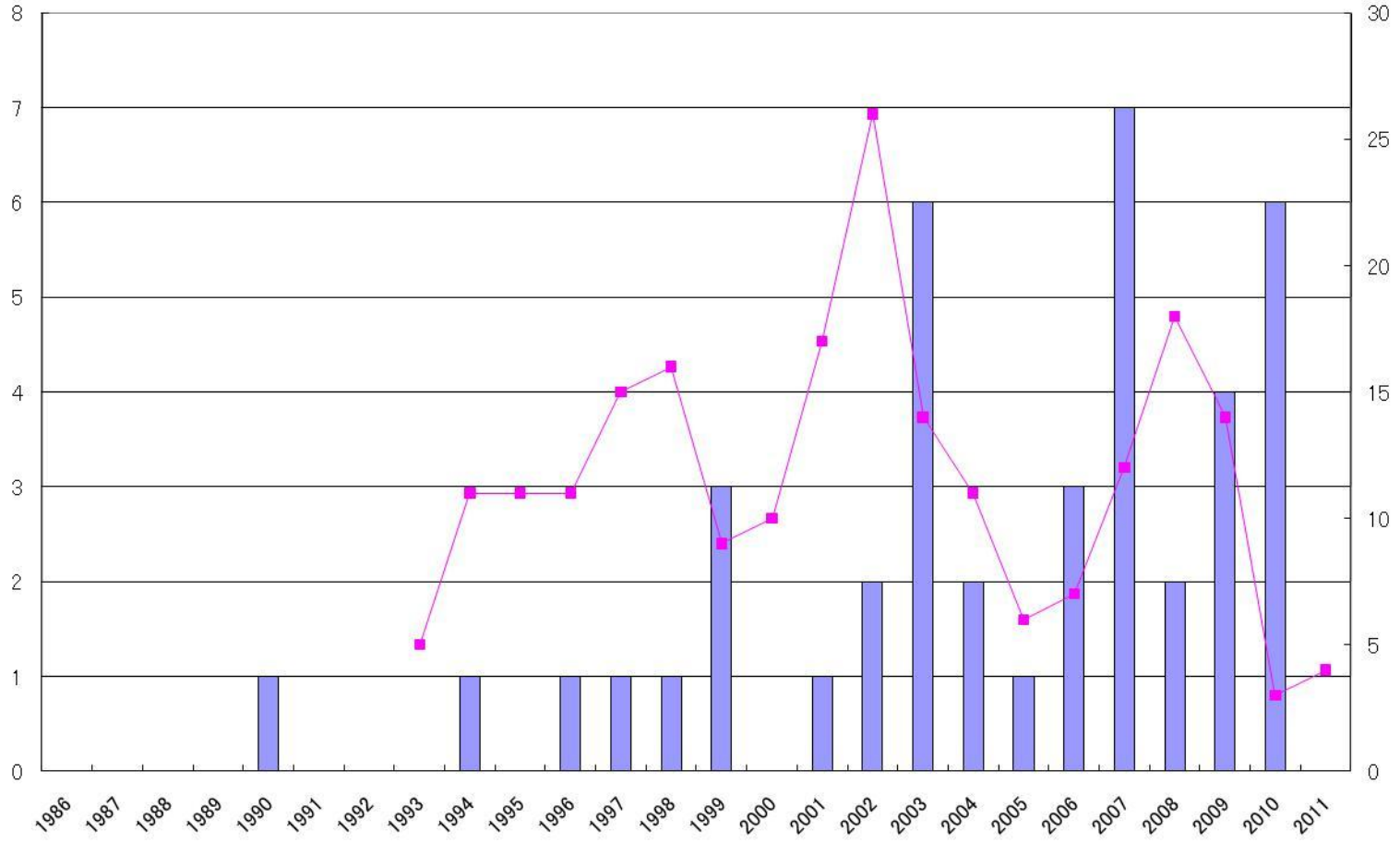
ABS “2001-07”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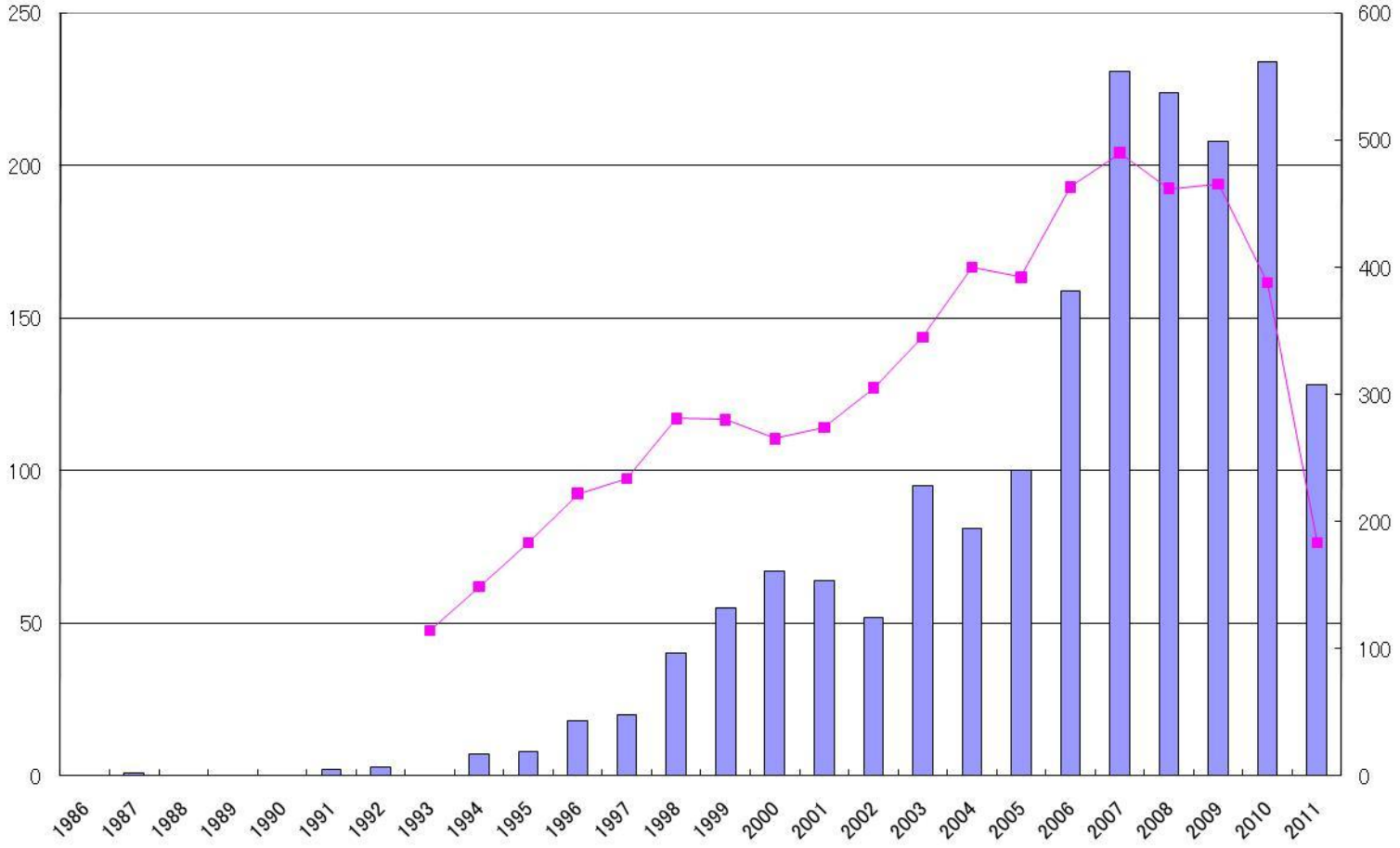
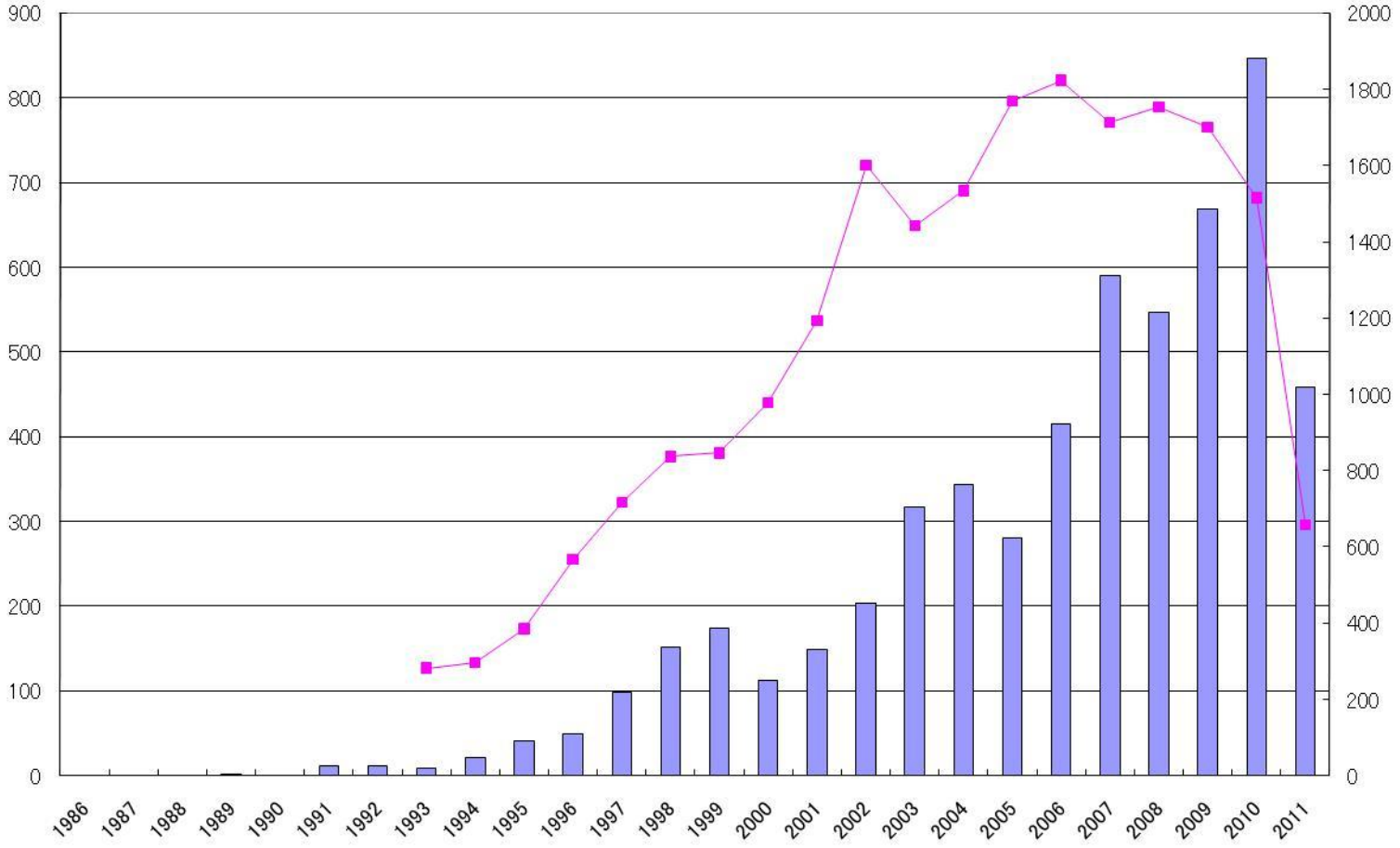
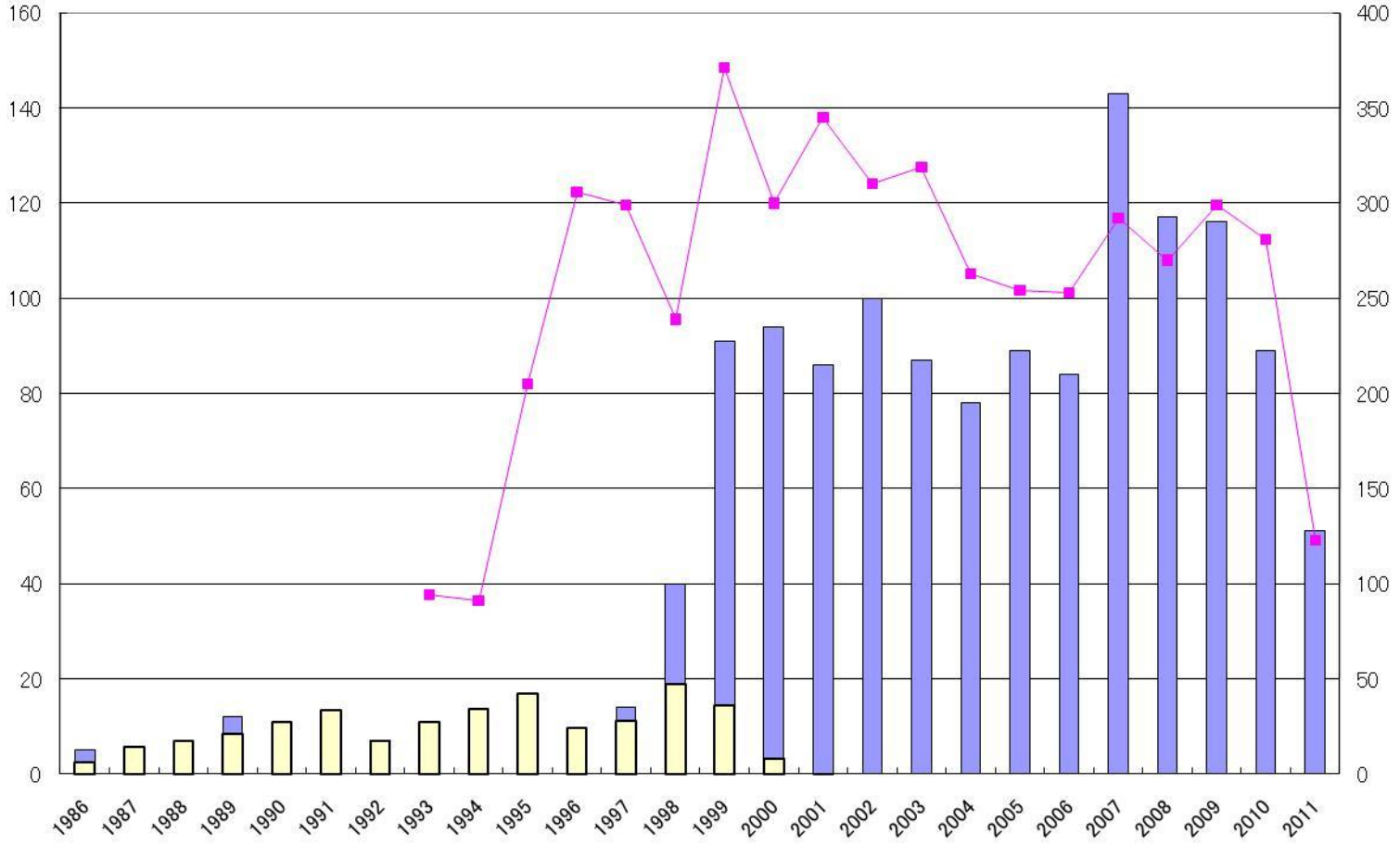
Airbag “1998-07”



Navigation “1997-07”



Wire Harness “1999-07”



Lithium Ion Battery “2000-07”