



# Exporting and Innovations: Evidence from German manufacturing firms

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# Outline of this talk

- Introduction
- Theoretical considerations
- Data
- Empirical strategies
- Empirical results
- Conclusions
- Appendices



# Introduction

- Exporting-innovation link as a main channel through which trade promotes economic growth
- Two broad branches of previous studies
  - Causal effect of innovation on exports based on trade version of product life cycle theory
  - Innovation activity endogenously determined by the inherent features of international markets



## Introduction (cont'd)

- Restrict my attention to the empirical test for the second perspective
  - Previous literature mostly focuses on the first strand
  - Uses indirect innovation measure such as R&D expenditure and the number of patents
  - There is little work to explore how various exporter types affect firms' innovative activities
- Start with questions:
  - Does exporting improve innovation activities of firms?
  - How does the heterogeneity of exporters affect on innovative activities and innovation performance?



# Theoretical considerations

- Two channels for exporting to affect firms' innovative activity
  - Fiercer competition in international markets
  - Easier for exporters to absorb new technology and knowledge than for domestic counterparts

- Innovation production function:

$$E( I_i ) = f_i( S_i, X_i, EX_i )$$

- *S*: past research or knowledge stock
- *X*: firm-specific characteristics or market environment that could affect the firm innovation decisions
- *EX*: firm export activity (and exporter types)



# Data

- Survey data on innovation activities of German manufacturing firms
  - carried out by the Center for European Economic Research (ZEW) in Germany
- Includes detailed questions on innovation activities such as product and process innovations
  - For example, the survey of the product innovation includes a question “Did you introduce into the market any new or significantly improved products during the last 3 years?”
  - Thus, the innovative activities of each firm are directly presented in dummies
- Provides information on firms’ general characteristics
  - Sales, exports, R&D, the proportion of educated workers, and industry sector



## Data (cont'd)

- Although this type of innovation measure has some drawbacks of its lack of information on the technological qualities and economic values of new products or processes and its dependency on subjective judgments of respondents, it also has clear advantages over other innovation measures, commonly used by economists, such as R&D expenditure or fraction of employees in R&D departments, and patent counts
- For example, many innovations take place outside formal R&D operations and R&D activities may oftentimes not lead to innovation. Furthermore, the R&D measures tend to underestimate innovation activities of small firms
- Patent counts may also distort firms' innovative activities. Many patents, for example, may never be commercially applied and that many innovations with economic value are not patented
- The innovation measure by the survey captures innovations that rise in non-R&D branches and without being patented



# Empirical strategies

- Cross-sectional model

- Construct a cross-sectional dataset with 1,025 firms, using 2002, 2000, 1999, and 1997 surveys

- Econometric specification

$$Innovation_{iT} = g( S_{iT-1}, XFIRMS_{iT-1}, XMARKETS_{iT-1}, XEXPORT_{iT-1}, \epsilon_{iT} )$$

- Exporter and non-exporter

- Type 1 exporter: firms that exported in the preceding year
- Type 2 exporter: firms that have any export experiences

- Exporter types

- Entrants: firms that started exporting in the last 3 years
- Incumbents: firms that continuously exported during the last 6 years
- Leavers: firms that stopped exporting in the last 3 years



## Empirical strategies (cont'd)

- Other control variables
  - *S*: measured by using the traditional proxy, R&D expenditure (*RnD*), and the proportions of high and professional workers (*HiEduT*, *HiEduSC*, and *ProEdu*)
  - Firm & market characteristic variables: sales (size), production technology (*LaborInt*, *Mcost*), and Gini coefficients (*Gini*)
  - Industry and Area dummies
- Dependent variable: product and process innovation indicators (*ProdInn* and *ProcInn*)
- Estimate the exporting effects on innovation within the linear probability model and probit family framework

# Empirical results I

## ■ Does exporting enhance innovative activities?

Product innovation of exporters (entire industry)

	Dependent variable: ProdInn							
	Exporter=Type1-Exporter				Exporter=Type2-Exporter			
	Probit	LP	Probit	LP	Probit	LP	Probit	LP
Size	.2644**	.0831**	.1854*	.0488*	.2851**	.0903**	.2066*	.0555*
Size <sup>2</sup>	-.0124	-.0037	-.0120	-.0030	-.0134	-.0041	-.0132	-.0034
LaborInt	.1224	.0344	.1368	.0346	.1190	.0344	.1332	.0344
Mcost	-.3252	-.1065	-.1529	-.0479	-.2915	-.0975	-.1195	-.0392
RnD	.1177**	.0314**	.0592**	.0158**	.1199**	.0323**	.0610**	.0165**
HiEduT	.8132	.2117	.4821	.1091	.9032	.2428	.5707	.1329
HiEduSC	2.211	.8235 <sup>+</sup>	2.651	.8823 <sup>+</sup>	2.328	.8677 <sup>+</sup>	2.742 <sup>+</sup>	.9213 <sup>+</sup>
ProEdu	1.375**	.4116**	1.182**	.3094**	1.360**	.4128**	1.177**	.3093**
Gini	-14.418	-3.212	-10.015	-1.596	-13.927	-3.093	-9.621	-1.499
Area	-.2103 <sup>+</sup>	-.0676*	-.1998 <sup>+</sup>	-.0521 <sup>+</sup>	-.1849 <sup>+</sup>	-.0602 <sup>+</sup>	-.1705	-.0451
Exporter	.4538**	.1620**	.3721**	.1146**	.3197**	.1170**	.2212 <sup>+</sup>	.0689 <sup>+</sup>
[Marginal effect]	[.1763]		[.1446]		[.1243]		[.0859]	
ProdInn(-1)	-	-	.8378**	.3078**	-	-	.8571**	.3157**
ProcInn(-1)	-	-	.3456**	.0980**	-	-	.3341**	.0952*
Log-likelihood	-542.65	-	-485.42	-	-547.22	-	-488.88	-
(Pseudo) R <sup>2</sup>	.2201	.2611	.3024	.3633	.2135	.2531	.2974	.3582
Observations	1025	1025	1025	1025	1025	1025	1025	1025

\*\* , \* , and + indicate significance at 1% , 5% , and 10% , respectively.

# Empirical results I (cont'd)

Process innovation of exporters (entire industry)

	Dependent variable: ProcInn							
	Exporter=Type1-Exporter				Exporter=Type2-Exporter			
	Probit	LP	Probit	LP	Probit	LP	Probit	LP
Size	.1469*	.0452*	.0854	.0193	.1775*	.0555*	.1182	.0297
Size <sup>2</sup>	.0137	.0052	.0136	.0053	.0115	.0046	.0110	.0046
LaborInt	.1132	.0363	.1394	.0386	.1103	.0361	.1354	.0383
Mcost	-.8355**	-.2616**	-.7345**	-.2008*	-.7830**	-.2499**	-.6706*	-.1881*
RnD	.0232	.0084	-.0079	-.0022	.0267 <sup>+</sup>	.0097 <sup>+</sup>	-.0043	-.0011
HiEduT	.3069	.0903	.0886	.0147	.3991	.1254	.1806	.0454
HiEduSC	.8131	.2557	1.062	.2789	.9709	.3086	1.227	.3323
ProEdu	.7031*	.2259*	.5359	.1605	.6955*	.2282*	.5229	.1609
Gini	12.356	3.378	19.702	4.954	12.572	3.489	19.879	5.066
Area	-.1833 <sup>+</sup>	-.0587 <sup>+</sup>	-.1604	-.0457	-.1518	-.0489	-.1256	-.0354
Exporter	.4843**	.1535**	.4619**	.1247**	.2927*	.0891*	.2405*	.0540
[Marginal effect]	[.1826]		[.1730]		[.1120]		[.0918]	
ProdInn(-1)	-	-	.2401 <sup>+</sup>	.0673	-	-	.2620 <sup>+</sup>	.0776 <sup>+</sup>
ProcInn(-1)	-	-	.7717**	.2560**	-	-	.7564**	.2534**
Log-likelihood	-588.75	-	-540.29	-	-594.71	-	-545.84	-
(Pseudo) R <sup>2</sup>	.1605	.1996	.2296	.2737	.1520	.1901	.2217	.2664
Observations	1025	1025	1025	1025	1025	1025	1025	1025

\*\* , \* , and + indicate significance at 1% , 5% , and 10% , respectively.

# Empirical results I (cont'd)

Multinomial probit regression: innovation of exporters (entire industry)

	Dependent variable: InnoCate								
	Exporter=Type1-Exporter				Exporter=Type2-Exporter				
	0	1	2	3	0	1	2	3	
Size		.1332	-.1698	.3591**		.1352	-.1587	.4067**	
Size <sup>2</sup>		.0015	.0701**	.0064		.0023	.0700**	.0029	
LaborInt		-.0415	-.1405	.2059		-.0445	-.1418	.1973	
Mcost		.2215	-.4569	-1.072*		.2409	-.4283	-.9809*	
RnD		.1650**	-.0212	.1352**		.1656**	-.0204	.1401**	
HiEduT		.5424	-2.857	1.098		.6022	-2.756	1.253 <sup>+</sup>	
HiEduSC		1.368	-11.781 <sup>+</sup>	2.689		1.434	-11.588 <sup>+</sup>	2.924	
ProEdu		1.409*	.2046	1.823**		1.379*	.1804	1.782**	
Gini		-29.857	57.340	1.542		-29.406	57.159	2.088	
Area		-.0786	.1633	-.3794*		-.0633	.1865	-.3238*	
Exporter		.3434*	.3917	.8606**		.3050 <sup>+</sup>	.2849	.5486**	
[Marginal effect]	[-.1873**]	[-.0137]	[.0001]	[.2009**]	[-.1317**]	[.0097]	[.0005]	[.1215**]	
Log-likelihood		-1004.3002				-1011.8608			
Observations		1025				1025			

1) InnoCate=0 if both=0, InnoCate=1 if only ProdInn=1, InnoCate=2 if only Proclnn=1, and InnoCate=3 if both=1.

2) Base outcome is “no innovations”, which InnoCate=0.

3) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.

## Empirical results II

- Does exporter type matter? Entrants, incumbents, and leavers

Innovation by exporter type (entire industry)

	Dependent variable: ProdInn		Dependent variable: ProcInn	
	Probit	LP	Probit	LP
Size	.2724**	.0855**	.1555*	.0481*
Size <sup>2</sup>	-.0137	-.0042	.0122	.0047
LaborInt	.1059	.0308	.1042	.0327
Mcost	-.3549	-.1125	-.8639*	-.2684**
RnD	.1199**	.0312**	.0229	.0082
HiEduT	.7662	.2050	.2757	.0790
HiEduSC	2.086	.7752 <sup>+</sup>	.6477	.2141
ProEdu	1.423**	.4240**	.7471*	.2389*
Gini	-12.651	-2.446	14.245	4.099
Area	-.1823	-.0577 <sup>+</sup>	-.1591	-.0506
Entrant	.7855**	.2577**	.6874**	.2337**
[Marginal effect]	[.2529]		[.2679]	
Incumbent	.3799**	.1410**	.4124**	.1327**
[Marginal effect]	[.1461]		[.1581]	
Leaver	-.4479 <sup>+</sup>	-.1416 <sup>+</sup>	-.7462*	-.1825**
[Marginal effect]	[-.1766]		[-.2508]	
Log-likelihood	-536.76	-	-581.87	-
(Pseudo) R <sup>2</sup>	.2286	.2705	.1703	.2102
Observations	1025	1025	1025	1025

\*\* , \* , and + indicate significance at 1% , 5% , and 10% , respectively.

## Empirical results II (cont'd)

Multinomial probit regression: innovation of exporter type (entire industry)

	Dependent variable: InnoCate			
	0	1	2	3
Size		.1342	-.1674	.3769**
Size <sup>2</sup>		.0008	.0681**	.0036
LaborInt		-.0562	-.1468	.1769
Mcost		.1869	-.5132	-1.159**
RnD		.1667**	-.0227	.1379**
HiEduT		.4761	-2.932	1.017
HiEduSC		1.251	-11.777 <sup>+</sup>	2.417
ProEdu		1.451**	.2512	1.914**
Gini		-28.104	60.119	4.772
Area		-.0587	.1621	-.3377*
Entrant		.6692*	.4814	1.279**
[Marginal effect]	[-.2494**]	[-.0273]	[-.0112]	[.2879**]
Incumbent		.3240 <sup>+</sup>	.4237 <sup>+</sup>	.7062**
[Marginal effect]	[-.1601**]	[-.0059]	[.0041]	[.1620**]
Leaver		-.2172	-.3750	-1.493*
[Marginal effect]	[.2286*]	[.0736]	[.0037]	[-.3059**]
Log-likelihood		-994.8493		
Observations		1025		

1) InnoCate=0 if both=0, InnoCate=1 if only ProdInn=1, InnoCate=2 if only ProcInn=1, and InnoCate=3 if both=1.

2) Base outcome is “no innovations”, which InnoCate=0.

3) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.

# Empirical results III

- How different between hi-tech and low-tech industries?

## Innovation of exporters (hi-tech vs. low-tech)

	Dependent variable: ProdInn				Dependent variable: ProcInn			
	Hi-tech		Low-tech		Hi-tech		Low-tech	
	Probit	LP	Probit	LP	Probit	LP	Probit	LP
Size	.2133**	.0578**	.2035**	.0712**	.2710**	.0915**	.2292**	.0747**
LaborInt	-.0003	-.0160	.1735	.0601	.4147*	.1399*	-.0558	-.0205
Mcost	.3812	.0894	-.5589	-.1848	-.3289	-.1084	-1.090**	-.3411**
RnD	.0814**	.0218**	.1985**	.0507**	.0066	.0027	.0588*	.0205*
HiEduT	1.584*	.3993*	.0586	.0390	.7739	.2471	.3102	.0806
HiEduSC	1.137	.5659	2.232	.8331	.9158	.3246	.7105	.1806
ProEdu	1.183*	.2972*	1.433**	.5103**	.5684	.1834	.7814 <sup>+</sup>	.2521 <sup>+</sup>
Gini	-25.040	-4.350	-5.394	-2.757	1.662	1.001	24.185	7.375
Area	-.0870	-.0170	-.2395 <sup>+</sup>	-.0899 <sup>+</sup>	.1678	.0515	-.3323*	-.1064*
Exporter	.6032**	.2194**	.2187	.0809 <sup>+</sup>	.4028*	.1285*	.2605 <sup>+</sup>	.0740 <sup>+</sup>
[Marginal effect]	[.2093]		[.0868]		[.1561]		[.0972]	
Log-likelihood	-205.73	-	-331.87	-	-264.21	-	-325.13	-
(Pseudo) R <sup>2</sup>	.2501	.2813	.1579	.1940	.1624	.2044	.1513	.1848
Observations	456	456	569	569	456	456	569	569

1) Exporter=Type 2-Exporter

2) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.

# Empirical results III (cont'd)

Innovation by exporter type (hi-tech vs. low-tech)

	Dependent variable: ProdInn				Dependent variable: ProcInn			
	Hi-tech		Low-tech		Hi-tech		Low-tech	
	Probit	LP	Probit	LP	Probit	LP	Probit	LP
Size	.1989**	.0534**	.1932**	.0666**	.2538**	.0846**	.2112**	.0676**
LaborInt	.0161	-.0112	.1564	.0551	.4388*	.1488*	-.0679	-.0267
Mcost	.3845	.0869	-.6613 <sup>+</sup>	-.2089 <sup>+</sup>	-.3817	-.1122	-1.194**	-.3694**
RnD	.0821**	.0213**	.1963**	.0488**	.0017	.0011	.0527*	.0183 <sup>+</sup>
HiEduT	1.476 <sup>+</sup>	.3688*	-.0871	-.0060	.6925	.2086	.1375	.0206
HiEduSC	.8515	.4704	1.855	.7100	.4847	.2060	.3626	.0730
ProEdu	1.117*	.2747*	1.591**	.5540**	.5272	.1595	.9272*	.2936*
Gini	-23.316	-3.785	-4.633	-2.186	4.171	1.717	25.529	8.049
Area	-.1026	-.0188	-.2294 <sup>+</sup>	-.0819 <sup>+</sup>	.1495	.0460	-.3264*	-.1047*
Entrant	.8945*	.2942**	.7705**	.2540**	.6726*	.2311*	.6981**	.2329**
[Marginal effect]	[.1919]		[.2880]		[.2575]		[.2700]	
Incumbent	.6686**	.2357**	.2454 <sup>+</sup>	.0942 <sup>+</sup>	.5706**	.1902**	.3513*	.1089*
[Marginal effect]	[.2236]		[.0976]		[.2197]		[.1322]	
Leaver	-.0824	-.0359	-.5990 <sup>+</sup>	-.1901*	-.7174	-.1470 <sup>+</sup>	-.7205 <sup>+</sup>	-.2024**
[Marginal effect]	[-.0261]		[-.2250]		[-.2570]		[-.2304]	
Log-likelihood	-202.30	-	-324.52	-	-258.50	-	-317.58	-
(Pseudo) R <sup>2</sup>	.2626	.2959	.1765	.2154	.1805	.2238	.1710	.2077
Observations	456	456	569	569	456	456	569	569

\*\* , \* , and + indicate significance at 1%, 5%, and 10%, respectively.



## Empirical results IV

- Investigate the return on innovation by exporter types.
  - Focus on comparing the difference of the innovation return between entrants and incumbents.
  - If incumbents' innovation return is bigger than entrants', then incumbents' innovative activity is more efficient and therefore we conclude that there exists the learning-by-exporting effect.
- What are the dependent variables?
  - SaleNIP: the share of new or improved product sales in total sales
  - CostRe: the average cost reduction in % (productivity growth rate) by means of process innovation
- Dependent variables are interval variables, use the mid-point OLS, interval regression, and ordered probit models.

# Empirical results IV (cont'd)

Return on product innovation by exporter type (coefficients)

	Dependent variable: SaleNIP								
	Type1-Exporter			Type2-Exporter			Exporter type		
	mOLS	IntReg	OProbit	mOLS	IntReg	OProbit	mOLS	IntReg	Oprobit
Size	.0533**	.0518**	.3148**	.0564**	.0549**	.3339**	.0541**	.0526**	.3227**
Size <sup>2</sup>	-.0053**	-.0052**	-.0287**	-.0055**	-.0053**	-.0301**	-.0054**	-.0052**	-.0295**
LaborInt	.0309	.0299	.1585	.0310	.0299	.1584	.0301	.0291	.1513
Mcost	-.0310	-.0301	-.1837	-.0271	-.0261	-.1572	-.0312	-.0302	-.1880
RnD	.0182**	.0181**	.0853**	.0186**	.0185**	.0871**	.0181**	.0179**	.0854**
HiEduT	.1097	.1095	.5401	.1216	.1213	.5986	.1156	.1149	.5637
HiEduSC	.7675*	.7294*	3.607**	.7817*	.7442*	3.680**	.7401*	.7021*	3.465**
ProEdu	.1880**	.1837**	1.053**	.1867**	.1825**	1.046**	.1960**	.1915**	1.101**
Gini	-4.441 <sup>+</sup>	-4.377 <sup>+</sup>	-15.010	-4.420 <sup>+</sup>	-4.361 <sup>+</sup>	-14.571	-4.181	-4.131	-13.389
Area	-.0709**	-.0681**	-.3033**	-.0682**	-.0654**	-.2868**	-.0647**	-.0622**	-.2721**
Exporter Entrant	.0600**	.0584**	.3967**	.0411*	.0397*	.2944**	-	-	-
Incumbent	-	-	-	-	-	-	.1215**	.1189**	.6526**
Leaver	-	-	-	-	-	-	.0475*	.0460*	.3156**
Observations	956			956			956		

- 1) mOLS, Intreg, and OProbit indicate mid-point OLS, interval regression, and ordered probit regression, respectively.  
 2) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.

Return on product innovation (marginal effects after ordered probit regression)

	x=SaleNIP								
	0	1	2	3	4	5	6	7	8
Type 1-Exporter	-.1567**	-.0005	.0011	.0042*	.0066**	.0270**	.0514**	.0308**	.0360**
Type 2-Exporter	-.1165**	-.0004	.0007	.0029 <sup>+</sup>	.0048*	.0198*	.0382**	.0232**	.0273**
Entrant	-.2318**	-.0058*	-.0109*	-.0059	-.0011	.0184**	.0721**	.0612**	.1040**
Incumbent	-.1243**	-.0008*	-.0000	.0025*	.0046*	.0204**	.0411**	.0256**	.0308**
Leaver	.0947	.0002	-.0011	-.0029	-.0044	-.0169	-.0311	-.0182	-.0203

- 1) SaleNIP takes value 0 if  $x=0$ , 1 if  $0 \leq x < .05$ , 2 if  $.05 \leq x < .1$ , 3 if  $.1 \leq x < .15$ , 4 if  $.15 \leq x < .2$ , 5 if  $.2 \leq x < .3$ , 6 if  $.3 \leq x < .5$ , 7 if  $.5 \leq x < .75$ , and 8 if  $.75 \leq x < 1$ .  
 2) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.

# Empirical results IV (cont'd)

Return on process innovation by exporter type (coefficients)

	Dependent variable: CostRe								
	Type1-Exporter			Type2-Exporter			Exporter type		
	mOLS	IntReg	OProbit	mOLS	IntReg	OProbit	mOLS	IntReg	Oprobit
Size	.0057**	.0053**	.2688**	.0061**	.0057**	.2867**	.0059**	.0055**	.2716**
Size <sup>2</sup>	-.0003	-.0002	-.0173	-.0003	-.0002	-.0184	-.0003	-.0003	-.0182
LaborInt	.0035	.0035	.0731	.0036	.0036	.0748	.0034	.0034	.0720
Mcost	-.0093	-.0089	-.4768 <sup>+</sup>	-.0086	-.0083	-.4455	-.0091	-.0087	-.4724
RnD	.0007	.0007	.0264 <sup>+</sup>	.0008	.0007	.0282 <sup>+</sup>	.0007	.0007	.0259 <sup>+</sup>
HiEduT	-.0146	-.0133	-.1785	-.0122	-.0111	-.1226	-.0145	-.0133	-.1863
HiEduSC	.0076	.0067	.4755	.0099	.0087	.5609	.0053	.0047	.4078
ProEdu	-.0059	-.0047	-.3131	-.0061	-.0049	-.3459	-.0053	-.0042	-.2781
Gini	-.5558	-.5369	-11.987	-.5390	-.5224	-11.241	-.4920	-.4802	-10.101
Area	.0025	.0022	.0287	.0029	.0026	.0390	.0030	.0026	.0332
Exporter	.0115**	.0103**	.4130**	.0088**	.0077**	.3324*	-	-	-
Entrant	-	-	-	-	-	-	.0155 <sup>+</sup>	.0134 <sup>+</sup>	-.6423*
Incumbent	-	-	-	-	-	-	.0103**	.0093**	.4242**
Leaver	-	-	-	-	-	-	-.0042	-.0040	.3846
Observations	910			910			910		

- 1) mOLS, Intreg, and OProbit indicate mid-point OLS, interval regression, and ordered probit regression, respectively.  
 2) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.

Return on process innovation (marginal effects after ordered probit regression)

	x=CostRe					
	0	1	2	3	4	5
Type 1-Exporter	-.1206**	.0355**	.0403**	.0290**	.0080**	.0078**
Type 2-Exporter	-.0974**	.0286*	.0325*	.0233**	.0065*	.0063*
Entrant	-.1469*	.0329*	.0462*	.0402 <sup>+</sup>	.0129	.0148
Incumbent	-.1161**	.0330**	.0386**	.0285**	.0081*	.0080*
Leaver	.0723	-.0222	-.0244	-.0169	-.0046	-.0043

- 1) CostRe takes value 0 if  $x=0$ , 1 if  $0 \leq x < .05$ , 2 if  $.05 \leq x < .1$ , 3 if  $.1 \leq x < .15$ , 4 if  $.15 \leq x < .2$ , and 5 if  $.2 \leq x < .3$ .  
 2) \*\*, \*, and + indicate significance at 1%, 5%, and 10%, respectively.



# Conclusions

- What are the sources of innovative propensity of exporters?
- Conscious self-selection rather than natural self-selection into export markets
  - 70% of entrants innovated in product in the previous period
  - 60% of entrants innovated in process in the previous period
- Being exporters is the fruit of conscious effort, not an accidental event or a stroke of fortune
  - Firms that make a decision to enter international markets could be consciously innovative
  - Once they start exporting, then the nature of export markets reinforces their innovation propensity
- Exit from export markets weakens incentives to innovation



## Conclusions (cont'd)

- Features of industry could affect exporters' innovative activities
  - Hi-tech entrants, incumbents, and low-tech entrants are equally innovative on product and process
  - Low-tech incumbents are relatively less innovative
  - This fact might be related with different product and technology cycles between hi-tech and low-tech industries
- No clear evidence of learning-by-exporting effect
  - Sales contribution of innovative products is bigger for entrants than for incumbents
  - In terms of productivity growth rate, entrants' process innovation is more efficient

# Appendix I

## Classification of German manufacturing industry

NC13 Code	Explanation	Number of Observations	%
2	Food products and tobacco	59	5.76
3	Textiles, clothing and leather products	57	5.56
4	Wood, paper, printing	97	9.46
5	Petroleum refining, coke manufacture, chemical industry	74	7.22
6	Rubber and plastics products	95	9.27
7	Glass, ceramics, other non-metallic mineral products	64	6.24
8	Manufacture of primary metals and fabricated metal products	155	15.12
9	Machinery, weapons and ammunition, domestic appliance	170	16.59
10	Office machinery and computers, electrical machinery and apparatus	86	8.39
11	Medical, precision and optical instruments	77	7.51
12	Motor vehicles and parts, other transportation equipment, aircraft and spacecraft	49	4.78
13	Furniture, jewelry, games and toys, musical instruments, sports equipment	42	4.10

\* The gray area indicates “hi-tech industry group”

# Appendix II

## Definition of variables

Variable	Definition	Source
ProdInn	Any new or improved products during the last 3 years: Yes=1, No=0 (2002 group: 2001-1999, 2000 group: 1999-1997)	ZEW
ProcInn	Any process innovation during the last 3 years: Yes=1, No=0 (2002 group: 2001-1999, 2000 group: 1999-1997)	ZEW
InnoCate	0 if ProdInn=0 and ProcInn=0, 1 if ProdInn=1 and ProcInn=0 2 if ProdInn=0 and ProcInn=1, 3 if ProdInn=1 and ProcInn=1	ZEW
SaleNIP	Proportion of sales from new or improved products to the total sales; in intervals	ZEW
CostRe	Reduction of average costs by means of process innovations in %; in intervals	ZEW
ProdInn(-1)	Any new or improved products in the previous survey period: Yes=1, No=0 (2002 group: 1998-1996, 2000 group: 1996-1994)	ZEW
ProcInn(-1)	Any process innovations in the previous survey period: Yes=1, No=0: (2002 group: 1998-1996, 2000 group: 1996-1994)	ZEW
Type1- Exporter	Export in the previous year : Yes=1, No=0 (2002 group: in 1998, 2000 group: in 1996)	ZEW
Type2- Exporter	Any export experience: Yes=1, No=0	ZEW
Entrant	Starting to export in the previous survey period: Yes=1, No=0 (For 2002 group, export in 1998, but no export in t<1998 or export in 1998-97, but no export in t<1997 or export in 1998-96, but no export in t<1996, Similarly for 2000 group)	ZEW
Incumbent	Continuously export during the past 5 and more years: Yes=1, No=0	ZEW
Leaver	Exit from export markets during the past 3 years: Yes=1, No=0 (For 2002 group, no export in 1998 and export in t<1998 or no export in 1998-97 and export in t<1997 or no export in 1998-96 and export in t<1996, Similarly for 2000 group)	ZEW

## Appendix II (cont'd)

Size	Total sales in the previous year (2002 group: in 1998, 2000 group: in 1996)	ZEW
LaborInt	Log of the number of full-time workers/sales in the previous year (2002 group: in 1998, 2000 group: in 1996)	ZEW
Mcost	Material cost-sales ratio in the previous year; in intervals (2002 group: in 1998, 2000 group: in 1996)	ZEW
Gini	Gini coefficient in the previous year, measure for domestic market structure (2002 group: in 1998, 2000 group: in 1996)	Suedekum (2006)
RnD	Total R&D expenditure-sales ratio in the previous year, multiplied by 100 (2002 group: in 1998, 2000 group: in 1996)	ZEW
HiEduT	Proportion of all employees who have a university degree or other higher education qualification in science or technology; in intervals (2002 group: in 1998, 2000 group: in 1996)	ZEW
HiEduSC	Proportion of all employees who have a university degree or other higher education qualification in economics, law, and other social sciences; in intervals (2002 group: in 1998, 2000 group: in 1996)	ZEW
ProEdu	Proportion of all employees who have successfully completed vocational school; in intervals (2002 group: in 1998, 2000 group: in 1996)	ZEW
Year	Year group dummy: 2002=1, 2000=0	ZEW
NC13	Industry dummies	ZEW
Area	Area dummy: Western Germany=1, Eastern Germany=0	ZEW

- 1) The education variables take the value of mid-point in each interval:  $x=0$ ,  $0 \leq x < .5$ ,  $.5 \leq x < .1$ ,  $.1 \leq x < .15$ ,  $.15 \leq x < .2$ ,  $.2 \leq x < .3$ , 6 if  $.3 \leq x < .5$ ,  $.5 \leq x < .75$ , and  $.75 \leq x < 1$ ,  $x=1$ .
- 2) Mcost takes the value of mid-point in each interval:  $0 \leq x < .05$ ,  $.05 \leq x < .1$ ,  $.1 \leq x < .15$ ,  $.15 \leq x < .2$ ,  $.2 \leq x < .3$ ,  $.3 \leq x < .4$ ,  $.4 \leq x < .5$ ,  $.5 \leq x < .7$ ,  $x \geq .7$ .

# Appendix III

Characteristics of variables (entire industry)

Variables	Observations	Mean	Std.Dev.	Min	Max
ProdInn	1025	.5843902	.4930674	0	1
ProcInn	1025	.4331707	.4957556	0	1
InnoCate	1025	1.450732	1.316127	0	3
ProdInn(-1)	1025	.635122	.4816309	0	1
ProcInn(-1)	1025	.5365854	.4989031	0	1
Type1-Exporter	1025	.7141463	.4520406	0	1
Type2-Exporter	1025	.7580488	.428474	0	1
Entrant	1025	.0682927	.2523706	0	1
Incumbent	1025	.6087805	.4882616	0	1
Leaver	1025	.035122	.1841779	0	1
Size	1025	2.625245	1.748731	-1.733573	7.987213
LaborInt	1025	1.561755	.5578196	.5108251	3.577176
Mcost	1025	.4351951	.1792855	.025	.75
Gini	1025	.4301268	.1549669	.15	.77
RnD	1025	1.750627	3.299715	0	15
HiEduT	1025	.0785122	.1113597	0	.875
HiEduSC	1025	.0230976	.0348517	0	.4
ProEdu	1025	.0951707	.1301004	0	1

# Appendix IV

Characteristics of variables (hi-tech vs. low-tech)

Variables	Hi-tech industry					Low-tech industry				
	Obs.	Mean	Std.Dev	Min	Max	Obs.	Mean	Std.Dev	Min	Max
ProdInn	456	.7105	.4540	0	1	569	.4833	.5001	0	1
ProcInn	456	.4737	.4999	0	1	569	.4007	.4904	0	1
Type1-Exporter	456	.7939	.4050	0	1	569	.6502	.4773	0	1
Type2-Exporter	456	.8355	.3711	0	1	569	.6959	.4604	0	1
Entrant	456	.0483	.2145	0	1	569	.0843	.2781	0	1
Incumbent	456	.7149	.4520	0	1	569	.5237	.4998	0	1
Leaver	456	.0307	.1726	0	1	569	.0387	.1929	0	1
Size	456	2.8599	1.8145	-1.734	7.987	569	2.4372	1.6721	-1.593	7.319
LaborInt	456	1.5192	.5301	.5108	3.5772	569	1.5959	.5773	.5108	3.1561
Mcost	456	.4425	.1722	.025	.75	569	.4293	.1847	.025	.75
Gini	456	.4562	.1510	.32	.7	569	.4092	.1551	.15	.77
RnD	456	2.8785	4.0156	0	15	569	.8467	2.2073	0	15
HiEduT	456	.1151	.1328	0	.875	569	.0491	.0792	0	.875
HiEduSC	456	.0258	.0341	0	.25	569	.0208	.0352	0	.4
ProEdu	456	.1077	.1330	0	1	569	.0851	.1268	0	1

\* Hi-tech industry consists of NC13 code 5, 9, 10, 11, 12.