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Abstract

After joining the World Trade Organization (WTO), China witnessed a major inflow of Foreign Direct Investment (FDI). Many famous automobile firms of developed countries were attracted to invest in China to cooperate with domestic firms. This paper uses firm-level data of the Chinese automobile industry to analyze the determinants of, and the interrelationships between, innovation input and innovation output, and in particular whether FDI had any influence on these two aspects of innovation. A generalized tobit model will be estimated for both R&D and the share of innovative sales for 2002/2003 and 2005/2006. The findings show that FDI firms are less R&D intensive but, when they innovate in new products, they are more product innovative than domestic-funded firms.

Keywords: FDI, China, R&D, innovation, automobile industry

JEL codes: O14, L62, F21

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1. Introduction

After joining the World Trade Organization (WTO) China experienced a major inflow of Foreign Direct Investment (FDI). Many famous automobile firms of developed countries decided to set foot in China to cooperate with domestic firms. The question is whether FDI benefited the development of the Chinese automobile industry. On the one hand, foreign investors brought with them new technologies, methods of management and worldwide network linkages, but on the other hand they might have crowded out local producers of final and intermediate goods in the automobile industry.

The Chinese automobile industry grew rapidly after 2006 and became the third biggest producer in the world after the United Stated and Japan. But to ensure that this growth sustains, it is necessary for China to keep innovating. If China merely completes the process of introducing, assimilating, and imitating, it is likely to remain a junior partner among the major world players. To go on innovating China needs to invest in Research and Development (R&D). FDI could play an important role in this regards. But it is a priori unclear whether the effect of FDI on R&D and innovation is stimulating. It is often voiced that China does not build up its own innovation ability in declining automobile markets, and that it simply imports technologies without developing the ability to innovate on its own. Instead, one of the primary motivations for China is to attract FDI from the developed countries so as to obtain advanced technology on which to build its own innovation capability. Given the inconclusiveness of the role of FDI on R&D and innovation so far, we revisit this issue using firm level data that were collected by the State Statistical Bureau of China.

The paper is organized as follows. In section 2 we review the evidence on the effects of FDI in China. In section 3 we lay out the model that we shall use in this paper. In section 4 we describe the data that will be used. In section 5 we analyse the results of the estimation and in section 6 we summarize and conclude.

2. Review of the literature

The presence of foreign multinational enterprises (MNEs) may exert a significant influence on the host country's own innovation. However, different theoretical models and empirical studies come up with different conclusions regarding the relationship between FDI and R&D. FDI can increase or decrease technological innovation depending on the specific context. Those in favour of FDI argue that when attracting a major FDI, developing countries are ready to give up part of their domestic market to improve their domestic firms' competitive advantage, because FDI can bring in directly or indirectly technology transfer. To compete with the foreign-funded firms domestic enterprises need to improve or update their production, management and marketing techniques. Firms have to increase R&D inputs in order to raise their technology level. Those against FDI argue that the FDI competes with domestic enterprises, decreases their profits and may even drive some of them out of the market. Furthermore, domestic enterprises may not have sufficient technological capacity to innovate or do R&D on their own. Kokko (1994) pointed to a positive effect of FDI if the difference in technology between the MNEs and the host countries is not very large.

In recent years, the relationship between FDI and domestic innovation in China has received a lot of attention. The conclusions are mixed. He (2000), Chen (2001) and Huang (2003) find that FDI had a negative effect. Jiang et al. (2005), Xi and Yan (2005) and Wang, Li and Feng (2006) find that FDI helped China to improve its technological innovation capability. In the Chinese electronics industry, Hu and Jefferson (2002) find a significant drop in productivity rather than a positive spillover effect of FDI on domestic firms. Fu (2008) investigates the impact of FDI on the development of regional innovation capabilities using a panel dataset of Chinese firms. She finds that FDI had a significant positive impact on the overall regional innovation capacity and on the innovation efficiency in the host region. She concludes that the type and quality of FDI inflows and the strength of local absorptive capacity and of complementary assets in the host regions are crucial for FDI to serve as a driver of knowledge-based development. Fu and Gong (2008) explore the drivers of technology upgrading in emerging economies using Chinese firm-level panel data from 2001-2005 period. R&D activities of foreign firms exert a significant depressive effect on technical change of local firms over the sample period. It is the indigenous R&D activities at the industry level that push up Chinese firms to the technology frontier. A similar conclusion is reached by Huang and Sharif (2009), who find that FDI from Hong Kong, Macao and Taiwan do not raise the productivity of firms in Guangdong province and that these foreign-funded firms perform less R&D and are less innovative than domestic firms.

3. Econometric model

We measure and try to identify the determinants of innovation in the Chinese automobile industry, once on the input side by way of R&D expenditures, once on the output side of innovation by way of the share in total sales due to new or substantially improved products. The input indicator can be seen as a predictor of future innovation and the output indicator as an indicator of past innovation efforts. In the literature on the knowledge production function, the output measure of knowledge or innovation is generally the number of patents (see Griliches, 1990 for a review). With the advent of the Oslo Manual (OECD, 1992) innovation surveys were launched in many countries containing a new measure of innovation output, the share in total sales due to new or subtantially improved products (also sometimes called the share of innovative sales). We shall use this measure in our analysis (for a comparison of the two measures of innovation output, see Crépon, Duguet and Mairesse, 1998).

Given the large number of zero observations for both R&D and the share of innovative sales, we estimate a generalized tobit model, also known as tobit type II model. This model estimates both the propensity to do R&D, resp. innovate, and, in the case of R&D performers, resp. innovators, the R&D, resp. innovation, intensity. The generalized tobit model consists of two parts. A first equation determines the level of the latent variable (y_{1i}^*)

$$y_{1i}^* = x_{1i}b_1 + u_{1i} \qquad (1)$$

that selects the R&D performers (resp. innovators) ($y_{1i} = 1$) and the non R&D performers (resp.) non-innovators ($y_{1i} = 0$) depending on whether its value falls above or below a given threshold, that in all generality we can set equal to zero

$$y_{1i} = \begin{cases} =1 & if \quad y_{1i}^{*} > 0 \\ =0 & if \quad y_{1i}^{*} \leq 0 \end{cases}.$$

A second equation determines the level of a latent variable (y_{2i}^{*}) that corresponds to the observed intensity of R&D (resp. innovation) (y_{2i}) for R&D performers (resp. innovators) and is equal to zero for non R&D performers (resp. non-innovators)

$$y_{2i}^{*} = x_{2i}b_2 + u_{2i} \tag{2}$$

with

$$y_{2i} = \begin{cases} = y_{2i}^{*}......if...y_{1i}^{*} > 0 \\ = 0........if...y_{1i}^{*} \leq 0 \end{cases}.$$

x_{ki} (k=1,2) are the explanatory variables in both equations, b_i their respective coefficients, and u_{1i} and u_{2i} are the error terms in both equations that are assumed to follow a bivariate normal distribution with correlation coefficient ρ and standard errors 1 (for reasons of identification) and σ_2 respectively.[1] We estimate the model by maximum likelihood (see Mohnen, Mairesse, Dagenais, 2007).

To say it more concretely, we observe and try to explain whether a firm has R&D expenditures and if so, how much R&D is does, and likewise whether a firm has introduced new products and, if so, what its share in total sales due to the new products is.

The first explanatory variable that we shall consider is firm ownership. Existing studies are inconclusive as to whether or not the nationality of ownership of a firm has an impact on its R&D. Caves et al. (1980, p.193) suggest that foreign activity reduces the rate of R&D activity in Canada. Haddad and Harrison (1993), based on Moroccan company-level data, prove that FDI with higher technology will not necessarily raise domestic R&D capacity. Aitken and Harrison

[1] The time subscript has been deleted to simplify notation.

(1999), based on firm-level panel data from Venezuela, found that the impact of FDI on R&D of domestic enterprises is negative. We classify firms into three groups: domestic-owned firms, foreign-funded firms and firms from Hongkong, Macao and Taiwan (HMT). Domestic-funded firms are the reference group and dummy variables are created for the other two groups. The intensity of foreign ownership is measured by the intensity of FDI capital over total capital.

Innovation is also postulated to be a function of firm size. According to Schumpeter's hypothesis we expect large firms to be more innovative than small firms, because large firms have easier access to finance, can spread the fixed costs of innovation over a larger volume of sales and may benefit from economies of scope and complementarities between R&D and other manufacturing activities. Firm size is measured by the total number of employees. In the selection equation, instead of using the continuous variable for size we classify firms into three groups: a firm is a large-scale firm if the number of employees is greater than or equal to 2000, middle-scale if the number of employees is between 300 and 2000, and small-scale otherwise. The small-scale firm is the reference group.

There is probably a strong link between R&D, which can be seen as an innovation input, and the share of innovative sales as a measure of innovation output. The endogeneity of R&D should be accounted for (as emphasized in Crépon et al, 1998). The predicted incidence of R&D will be used in the incidence of innovation output equation and the predicted intensity of R&D in the intensity of innovation output equation. The standard errors of the estimates will be corrected for the fact that the R&D variables are generated regressors.

Table 4 Explanatory variables introduced in the two generalized tobit models

Variables	Explanation of variables	R&D		New products	
		Propensity	Intensity	Propensity	Intensity
D-R&D	Dummy equal to 1 if the firm has R&D inputs			★	
R&D	R&D inputs / total capital				★
D-FDIF	Dummy equal to 1 if FDI is more than 25%	★		★	
D-HMTDIF	Dummy equal to 1 if HMTFDI is more than 25%	★		★	
FDI*	Foreign capital / total capital		★		★
HMTFDI*	HMT capital / total capital		★		★
L-SIZE	Dummy equal to 1 if the number of employees is greater than or equal to 2000	★		★	
M-SIZE	Dummy equal to 1 if the number of employees is between 300 and 2000	★		★	
SIZE	Number of employees		★		
MSHARE	Sales / total sales in the same (4-digital code) industry	★	★	★	★
D-IND	Dummies for the sub-industries (cars, vehicle rebuilding, trams, bodies and trailers, parts and accessories), the repair and maintenance sub-industry being the reference group	★	★	★	★
D-AREA	Dummies for geographical areas (East and Middle), West being the reference group	★	★	★	★

* Zero values are replaced by 0.00001 when taking logs.

Schumpeter's hypothesis is also sometimes cast in terms of market power. Firms with a large market share are more innovative than those with a smaller market share because they have more to lose by not innovating. We measure market share by the firm's sales as a percentage of the total sales in the 4-digit industry it belongs to. Of course, this measure only captures the domestic market share, but in the case of the Chinese automobile industry this seems to be the relevant market share to consider.

Since the innovative environment differs across industries and space, we let innovative activity also vary with industries and geographical location. The reference industry is the car maintenance and repair sub-industry, and binary variables corresponding to each of other five categories (cars, vehicle rebuilding, trams, bodies and trailers, and parts and accessories) have been constructed. The geographical reference area is the West, and binary variables have been constructed for the Middle and the East.

4. Data and descriptive statistics

The paper uses data of the Chinese automobile industry from 2002 to 2006. The year 2004 is excluded because of missing data. To minimize the influence of outliers, we cleaned the data by excluding firms that at one point in the sample had less than 5 million RMB in sales, or non-positive data on the number of employees, assets, sales, costs, salaries (incl. social welfare benefits). Further we restricted ourselves to firms with positive value-added, more than 10 employees, and less than a 50 percent share of R&D in total sales. Finally, we eliminated several firms of Xizang Province. After the process of cleaning the data, the sample encompassed 3244 firms in 2002 and up to 6795 in 2006 (see table 1).

Table 1 Data cleaning: Chinese Automobile Industry, firm-level data, 2002-2003, 2005-2006

Process of cleaning data	2002	2003	2005	2006
Number of firms in the original database	4632	5182	7371	8233
Less than 5 million RMB in sales	3675	4454	6918	7820
Non-positive number of employees, total assets, sales, costs (incl. administration costs), salaries (incl. social welfare benefits)	3323	4064	6270	6974
Non-positive value-added, more than 10 employees, less than 50 percent share of R&D in total sales	3244	4000	6114	6796
Deleting Xizang Province (Tibet)	3244	4000	6112	6795

As table 2 shows, our sample is composed to roughly 80% of domestic-owned firms and to 10%-15% of foreign-funded firms other than firms from HMT (Hong-Kong, Macao, Taiwan). The percentage of firms with new products and the share of new products in total sales were always the highest in foreign-funded firms and the smallest in HMT firms.[2] The percentage of firms with R&D activities was always higher in foreign-funded firms than in domestic or HMT firms, but the intensity of R&D was lower in foreign-funded firms. Their R&D/sales ratio was on average lower than 1.5. Thus it already appears from a cursive glance at table 2 that foreign-funded firms tend to be more innovative in new products and rely on R&D conducted abroad. HMT firms, while always less innovative in new products than domestic firms, are sometimes more R&D intensive than domestic firms.

[2] Foreign-funded enterprises include joint-venture enterprises, cooperative enterprises, enterprises with sole funds and share-holding corporations Ltd. Joint-venture enterprises and cooperative enterprises are charged with the amount of investment by the contract. According to Chinese legislative regulations, when a share-holding corporation Ltd. registers with agencies of the Administration for Industry & Commerce, it is classified as a foreign-funded firm only if the foreign equity stake is at or above 25 percent. More detailed discussion of the classification of foreign-funded firms in China can be found in Huang, 2003, p.4 and p.35.

Table 2 Innovation indicators by type of ownership, Chinese automobile industry, firm-level data, 2002-2006

year	Funding	Number of firms	Distribution (%)	Firms with new products （%）	Share of new products in total sales （%）	Share of new products in total sales in firms with new products (%）	Firms with R&D （%）	R&D/ sales （%）	R&D/ sales in firms with R&D （%）
2002	Domestic	2674	82.43	16.83	23.27	49.08	26.55	1.25	1.64
	HMT	227	7.00	9.25	11.29	31.39	22.47	0.76	1.08
	Foreign	343	10.57	19.83	50.78	68.92	41.40	0.88	1.04
	Total	3244	100	16.62	30.55	56.20	27.84	1.12	1.43
2003	Domestic	3278	81.95	15.77	24.39	50.64	26.24	0.71	0.94
	HMT	267	6.68	9.74	23.45	38.46	24.34	0.83	1.21
	Foreign	455	11.38	19.34	52.02	77.57	39.78	0.70	0.85
	Total	4000	100	15.78	36.37	63.80	27.65	0.71	0.91
2005	Domestic	4877	79.79	15.32	27.26	47.12	16.69	1.04	1.60
	HMT	394	6.45	14.21	21.28	44.92	18.27	1.10	2.12
	Foreign	841	13.76	20.69	43.42	71.91	31.39	0.93	1.26
	Total	6112	100	15.98	34.03	58.15	18.82	0.99	1.45
2006	Domestic	5352	78.76	16.01	26.80	45.57	18.14	1.14	1.71
	HMT	446	6.56	13.45	15.92	38.64	18.83	0.72	1.46
	Foreign	997	14.67	21.97	46.54	68.37	30.39	0.79	1.08
	Total	6795	100	16.72	36.34	57.85	19.99	0.95	1.36

* HMT: Hong-Kong, Macao, Taiwan

As table 3 shows, most of the firms in our sample produce car accessories (around 75% to 80%). The percentage of firms with new products and with R&D inputs is the highest in the cars sub-industry. If we exclude the tram sub-industry, which has very few firms in our sample, the percentage of innovators and their innovation intensity, both in terms of new products and in terms of R&D, are substantially smaller in the other subsectors. Many firms in vehicle rebuilding are R&D performers, but with a relatively lower R&D intensity compared for instance to the firms that produce parts and accessories, which are sometimes even more R&D intensive than the cars manufacturers.

Table 3 Innovation indicators by industry, Chinese automobile industry, firm-level data, 2002-2006

year	Funding	Number of firms	Distribution (%)	Firms with new products (%)	Share of new products in total sales (%)	Share of new products in total sales in firms with new products (%)	Firms with R&D (%)	R&D/ sales (%)	R&D/ sales in firms with R&D (%)
2002	Cars	161	4.96	42.86	45.92	63.63	59.63	1.67	1.73
	Veh. Rebuilding	230	7.09	27.83	23.95	50.33	50.43	0.51	0.59
	Trams	2	0.06	50.00	64.87	99.62	50.00	0.08	0.12
	Bodies/Trailers	88	2.71	11.36	13.38	68.18	20.45	0.10	0.28
	Parts/Accessories	2396	73.86	16.49	10.79	33.02	27.05	0.53	1.04
	Mainten./Repair	367	11.31	0.00	0	0	6.54	0.05	0.26
2003	Cars	180	4.50	46.67	51.16	72.86	64.44	0.83	0.88
	Veh. Rebuilding	291	7.28	27.15	30.24	45.23	45.36	0.31	0.38
	Trams	5	0.13	20.00	14.30	90.39	0	0	0
	Bodies/Trailers	107	2.68	14.02	12.24	55.40	21.50	0.22	0.58
	Parts/Accessories	3012	75.30	14.94	10.79	34.29	27.12	0.63	1.28
	Mainten./Repair	405	10.13	0.49	0.39	19.90	4.44	0.03	0.18
2005	Cars	212	3.47	48.11	52.85	66.34	59.43	1.46	1.63
	Veh. Rebuilding	363	5.94	30.03	26.72	45.44	36.09	0.70	1.08
	Trams	10	0.16	10.00	2.19	43.12	10.00	0.59	1.48
	Bodies/Trailers	169	2.77	12.43	9.29	35.72	11.24	0.23	1.04
	Parts/Accessories	4867	79.63	14.92	11.69	35.86	17.77	0.48	1.06
	Mainten./Repair	491	8.03	3.67	0.36	12.54	1.63	0.02	1.10
2006	Cars	224	3.30	50.00	54.58	63.60	62.05	1.22	1.35
	Veh. Rebuilding	367	5.40	28.88	26.94	42.04	41.96	0.65	0.88
	Trams	10	0.15	10.00	0.64	15.16	10.00	3.94	30.51
	Bodies/Trailers	188	2.77	9.57	19.10	55.12	14.89	0.16	0.67
	Parts/Accessories	5517	81.19	16.01	10.58	36.81	18.63	0.63	1.54
	Mainten./Repair	489	7.20	3.27	0.29	6.53	1.64	0	0.19

The 6 sub-industries correspond to the following codes in the 2002 Chinese industrial classification (GB/T 4754-2002): cars (3721), vehicle rebuilding (3722), trams (3723), trailers (3724), parts & accessories (3725), and repair and maintenance (3726).

We examine the growth of the Chinese automobile industry after China joined the WTO by distinguishing the 2002-2003 period, when growth was rapid, and the more stable period 2005-2006. We chose firms that were present in 2002 and 2003 and in 2005 and 2006. There were 2462 firms present in both 2002 and 2003, of which 1991 were domestic-funded and 289 were foreign-funded. Firms present in both 2005 and 2006 numbered 5097, of which 4027 were domestic-funded are 4027 and 711 were foreign-funded.

Table 5 R&D propensity

		2002		2005	
		Number of firms with R&D	Percentage of firms with R&D (%)	Number of firms with R&D	Percentage of firms with R&D (%)
Funding	Domestic-funded	556	27.93%	700	17.38%
	HMT-funded*	42	23.08%	62	17.27%
	Foreign-funded	129	44.64%	242	34.04%
Scale	Large	56	83.58%	87	80.56%
	Middle	313	49.53%	407	45.47%
	Small	358	20.31%	510	12.46%
	Total	727	29.53%	1004	19.70%

*HMT: Hong-Kong, Macao, Taiwan

Table 6 R&D intensity for firms with R&D

year	variables	mean	stdv	25%	50%	75%	95%
2002	R&D	0.009	0.014	0.002	0.004	0.011	0.034
	FDI	0.096	0.231	0	0	0	0.600
	HMTFDI	0.037	0.153	0	0	0	0.342
	Log(SIZE)	5.837	1.243	4.898	5.724	6.718	7.847
	MSHARE	0.004	0.016	0.000	0.001	0.002	0.020
2005	R&D	0.013	0.021	0.002	0.005	0.016	0.053
	FDI	0.155	0.308	0	0	0	1.000
	HMTFDI	0.045	0.177	0	0	0	0.488
	Log(SIZE)	5.794	1.243	4.875	5.677	6.564	7.919
	MSHARE	0.003	0.017	0.000	0.000	0.001	0.009

Table 5 shows that the percentage of firms with R&D inputs is higher in the group of large firms and of foreign-funded firms. On the whole, the percentage of firms with R&D decreased between 2002 and 2005. Table 6 indicates that the R&D intensity and the fractions of foreign capital and of HMT capital in total capital increased between 2002 and 2005 for firms with R&D inputs.

Table 7 Innovation propensity

		2003		2006	
		Number of firms with new products	Percentage of firms with new products (%)	Number of firms with new products	Percentage of firms with new products (%)
Funding	Domestic-funded	371	18.63	677	16.81
	HMT-funded	19	10.44	54	15.04
	Foreign-funded	62	21.45	160	22.50
Scale	Large	54	68.35	79	72.48
	Middle	236	34.96	370	38.14
	Small	162	9.48	442	11.00
R&D-doing	No	144	8.55	369	9.31
	Yes	308	39.59	522	45.99
Total		452	18.36	891	17.48

Table 8 Innovation intensity for firms with new products

year	variables	mean	stdv	25%	50%	75%	95%
2003	NEWP	0.392	0.286	0.142	0.347	0.601	1
	$R\&D_{-1}$	0.006	0.012	0	0	0.007	0.029
	FDI	0.074	0.195	0	0	0	0.503
	HMTDI	0.015	0.082	0	0	0	0.000
	SIZE	1034	1967	196	447	1037	3847
2006	NEWP	0.371	0.304	0.104	0.279	0.584	1
	$R\&D_{-1}$	0.009	0.019	0	0.000	0.009	0.047
	FDI	0.100	0.240	0	0	0	0.663
	HMTDI	0.040	0.163	0	0	0	0.342
	SIZE	936	3578	125	300	749	2952

$R\&D_{-1}$ refers to 2002 (resp. 2005).

Table 7 reveals that there is clearly a higher percentage of firms with new products in foreign-funded firms, large firms, and in firms with R&D. Table 8 shows that between 2003 and 2006 the share in total sales of new products decreased from 39.2% to 37.1%, the R&D intensity in the preceding year increased from 0.6% to 0.9%, the FDI share in total capital climbed from 7.4% to 10% and the HMT-originating FDI in total capital went up from 1.5% to 4%. The compared averages in tables 4 to 7 do not correspond to the same firms and are therefore only indicative of changes over time. To disentangle the various determinants of the propensity and the intensity of doing R&D and of innovating in products we now revert to a multivariate analysis. What is also visible from these tables is that the sample means are often above the medians and influenced by some extreme values.

5. Results

The innovation input and output models that estimate simultaneously the innovation propensity and intensity equations have been estimated separately for the rapid growth period 2002-2003 and the more stable period 2005-2006. Just after joining the WTO, the automobile industry grew rapidly, driven by a high domestic demand. After 2004, the development slowed down and development problems came up. Thus the industry had a different pace of development in 2002-

2003 and in 2005-2006. Therefore the two periods are estimated separately, but in each pair of years the data are pooled.

Table 9 reveals that the propensity to engage in R&D increases with size. Medium-sized firms have a higher propensity than small firms, and large firms have an even higher propensity than medium-sized firms. Firms with a higher market share have also a higher propensity to be R&D performers. These effects are significant for both time periods. FDI firms were not significantly more likely to be R&D performers than domestic-funded firms in 2002-2003. In 2005-2006 their effect is significant. FDI firms have a 1.7 percentage point higher propensity to do R&D. Hong Kong, Macao, and Taiwan-funded firms were never significantly more likely to be R&D performers than domestic-funded firms. The intensity of R&D decreases with firm size, whereas it increases with the market share. What is interesting to notice is that the elasticity of R&D/sales with respect to the perce, i.e. if foreign ownership increases by 10%, R&D/sales decreases by 1%. The elasticity is somewhat lower for capital funded by Hong Kong, Macao and Taiwan, and somewhat lower in 2005-2006 than in 2002-2003.

Table 9 Generalized Tobit estimation of R&D efforts in the Chinese automobile industry

	2002-2003 pooled data						2005-2006 pooled data					
	Propensity			Intensity: log(R&D/sales)			Propensity			Intensity: log(R&D/sales)		
	Coeffi-cient	P-value	Margin. effect	Coeffi-cient	P-value	Margin. effect*	Coeffi-cient	P-value	Margin. Effect	Coeffi-Cient	P-value	Margin. effect*
L-SIZE	0.431	0.001	0.119				0.493	0	0.107			
M-SIZE	0.316	0	0.087				0.411	0	0.089			
SIZE (in logs)				-0.431	0	-0.431				-0.222	0	-0.222
MSHARE (in logs)	0.295	0	0.081	0.645	0	0.499	0.316	0	0.069	0.394	0	0.374
DFDI	0.060	0.294	0.016				0.080	0.053	0.017			
DHMTFDI	0.015	0.836	0.004				-0.011	0.857	-0.002			
FDI (in logs)				-0.126	0	-0.126				-0.079	0	-0.079
HMTFDI (in logs)				-0.089	0	-0.089				-0.050	0	-0.050
Intercept	0.424	0.005		-2.048	0.001		0.125	0.4		-3.157	0	
ρ (Std. Err.)				0.386	(0.087)					0.051	(0.117)	
σ_2 (Std. Err.)				1.953	(0.058)					1.891	(0.028)	
Number of observations	7244			2009			12907			2508		

N.B. Sub-industry, region and year dummies are controlled for but not reported.

*: marginal effect conditional on doing R&D

Table 10 Generalized Tobit estimation of innovation in new products in the Chinese automobile industry

	2002-2003 pooled data						2005-2006 pooled data					
	Propensity			Intensity: log(share in sales of new-to-firm products)			Propensity			Intensity: log(share in sales of new-to-firm products)		
	Coeffi-cient	P-value	Margin. effect	Coeffi-cient	P-value	Margin. effect*	Coeffi-cient	P-value	Margin. Effect	Coeffi-Cient	P-value	Margin. effect*
Predicted R&D probability	0.197	0.776	0.039				0.665	0.058	0.141			
Predicted log of R&D intensity				0.433	0.001	0.433				0.282	0.062	0.282
L-SIZE	0.725	0.029	0.143				0.602	0.004	0.128			
M-SIZE	0.498	0.028	0.098				0.232	0.125	0.049			
MSHARE (in logs)	0.148	0.468	0.029	-0.105	0.190	-0.546	-0.041	0.710	-0.009	0.786	0.034	-0.125
DFDI	-0.161	0.042	-0.032				-0.089	0.091	-0.019			
DHMTFDI	-0.342	0.001	-0.068				-0.054	0.373	-0.011			
FDI (in logs)				0.060	0.003	0.060				0.033	0.006	0.031
HMTFDI (in logs)				0.019	0.378	0.019				0.115	0.017	0.021
Intercept	-1.422	0.001		0.192	0.880		-0.552	0		0.601	0.994	
ρ (Std. Err.)				0.038	(0.131)					-0.041	(0.135)	
σ_2 (Std. Err.)				1.317	(0.028)					1.370	(0.022)	
Number of observations	7244			1170			12907			2113		

N.B. Sub-industry, region and year dummies are controlled for but not reported.

*: marginal effect conditional on being innovative

The determinants of innovation output measured by the share in total sales due to new products are reported in table 10. We have included the same set of explanatory variables as for the explanation of R&D, except for three differences. First, R&D as an innovation input is naturally introduced as a determinant of innovation output, recognizing the endogeneity of R&D. This is done by introducing the estimated probability of doing R&D in the probability of innovation output equation and the estimated intensity of innovation in the innovation output intensity equation.[3] Time dummies were removed in both equations because they were not significant and size was removed from the innovation output intensity equation after a likelihood-ratio test showed that including size did not increase significantly the likelihood. Actually, since time and size are already included as regressors in the R&D equations they enter indirectly as explanatory variables in the innovation output equations.

During the two periods that we examine R&D seems to have had a positive effect on innovation output. R&D performing firms were 4% more likely to introduce new products in 2002-2003, a probability that increased to 14% in 2005-2006. The elasticity of the share of innovative sales with respect to R&D intensity was around 0.4 in the first subperiod, 0.3 in the second. Obviously, large-scale and middle-scale firms are more likely to introduce new products in the market than small-scale firms. The Schumpeterian market share argument is not confirmed for the Chinese automobile industry. In 2002-2003 foreign-controlled firms, especially those controlled from Hong Kong, Macao and Taiwan, were less likely to innovate than mainland Chinese controlled firms. The effect of foreign ownership on the likelihood to innovate was no longer significant in 2005-2006. But for those that innovated in new products, the share of innovative sales increased with foreign ownership. If foreign ownership doubled, the share of sales due to products new to the firm increased by 3 to 6%, closer to 2% for ownerships from Hong Kong, Macao and Taiwan.[4]

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[3] Because the predicted value for R&D is used as a regressor, the standard errors in table 10 are somewhat too small. Attempts to bootstrap the standard errors failed, maybe because of the small size of our sample.

[4] The marginal effects reported in tables 9 and 10 are obtained by taking the first derivative of the expression for the expected conditional intensity $E(y_2 \mid x_1, x_2) = x_2'\beta_2 + \rho\sigma_2 \frac{\varphi(x_1'\beta_1)}{\Phi(x_1'\beta_1)}$ with respect to each element contained in x_1 and x_2, which are the regressors in the selection equation and in the intensity equation respectively.

6. Conclusion

Since joining the WTO Chinese automobile producers have kept innovating by introducing new products on the market, but the percentage of R&D performers, at least in our the sample, has been decreasing. At the same time the proportion of foreign-funded firms has been increasing, especially from sources other than Hong Kong, Macao and Taiwan. The question we have been investigating in this chapter is whether R&D and innovation output differ for domestic-funded and foreign-funded (FDI) firms.

It does not appear from our multivariate analysis that FDI-firms are more prone to be R&D performers than the domestic-funded firms. They also seem to be less likely to introduce new products, although the differences in innovation propensities with respect to domestic-funded firms are most of the time insignificant. What is striking though is that foreign-funded firms are less R&D–intensive but, when they innovate, they have a higher share of their total sales attributable to new products than domestic-funded firms. This finding is reminiscent of the often-voiced argument that foreign-owned firms are innovative but keep their R&D generally in their home-base.

Our results for the Chinese automobile industry confirm those obtained by Fu and Gong (2008) for all industries in China and by Huang and Sharif (2009) for the province of Guangdong. Unless FDI fosters innovation in Chinese-controlled firms in the automobile industry, something we have not investigated in this paper, the burden of R&D that, as we have shown, stimulates innovation, rests on the shoulders of Chinese-controlled firms. The fact the foreign-funded firms are more innovative when they innovate suggests that Chinese firms have to do more R&D to compete with the foreign-funded firms and/or that they have to increase the productivity of their R&D in transforming research into marketable new products.

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