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THE INNOVATION- PRODUCTIVITY LINK

COMPARING THAILAND WITH A SAMPLE OF OECD COUNTRIES

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Abstract:

A recent OECD exercise applied a CDM-model to firm-level data from innovation surveys in order establish the relationship between innovation activities and labour productivity in 18 countries. This paper extends the analysis to Thailand by estimating an identical econometric model for data from the 1st Thailand R&D/ Innovation Survey and compares the results with those of the OECD project. The main message of the analysis is: Large, international oriented firms that belong to an enterprise group have a higher probability to be innovative and invest more in innovation activities. Firms receiving public financial support and participating in innovation cooperation show higher innovation expenditure. Innovation input positively correlates with innovation output, which in turn increases labour productivity. In contrast to expectations, not evidence for a positive impact of process innovation on productivity can be found. The results for Thailand show noteworthy deviations from the international pattern regarding the effects of export, public financial support and cooperation.

Keywords: Microdata, innovation survey, CDM model, Thailand

JEL Classification: O31, D24

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Vienna, September 2009

Martin Berger

1 Introduction

What is the impact of innovation on productivity? Albeit not new, this question is still highly relevant in terms of empirical analysis and policy advice. This paper presents evidence from a joint OECD project in which the author participated and extends the econometric analysis to Thailand as an example of a late-industrialising South-East Asian country.

Currently, empirical research tries to better take into account firm heterogeneity by using micro (i.e. firm-level) data. The main motivation is that aggregated data at the sector or country level hides a lot of differences between individual enterprises and neglects level at which primary business activities take place (cf. "nations do not trade; it is firms that trade", Mayer and Ottaviano 2007: i). Consequently, the following analysis is based on micro data from innovation surveys which have flourished in the aftermath of the first publication of the OECD Oslo manual in 1992.

- Key questions for the empirical analysis are:
- What firm characteristics determine, whether a firm decides to carry out innovation activities?
- What firm characteristics have impacts on the amount of resources spent on innovation activities?
- What firm characteristics influence the amount of innovation output produced?
- And finally, how do these factors relate to labour productivity?

The paper is structured as follows: Section two provides a brief literature review, section three introduces the data, section four describes the econometric model and section five presents the main results in international comparison. Finally, section six presents the main conclusions of the analysis.

2 Literature Review

Since the 1950s neoclassical growth models started to include technological change (Solow 1957, Arrow 1962, Romer 1990, Grossman and Helpman 1991). These models (e.g. Romer 1990) predict a clear relationship between R&D and productivity growth. As a consequence, empirical work included not only labour and physical capital in its models, but also the R&D capital stock as a variable for the existing stock of accumulated knowledge in a firm (Griliches 1979, Griliches and Pakes 1980)

This paper draws heavily on the empirical model developed by Crepon, Duguet and Mairesse (1998) (henceforth called CDM-model) who use a structural model to analyse the link between R&D, innovation output and productivity. Thereby, they explain productivity by innovation output and innovation output by R&D expenditure using a cross-section of French firm data from the European Community Innovation Survey (CIS). The results show that the propensity of a firm to conduct R&D increases with firm size, market share and diversification as well as with demand pull and technology push indicators. Research effort (R&D capital intensity) depends on the same set of variables except firm size. Innovation output (either measured as number of patents or innovative sales) increases with R&D input and with demand and technology variables. Moreover, innovation output correlates positively with productivity.

The CDM-model triggered a lot of further research on the relationship between innovation and firm performance. The main finding of almost all of these studies is that innovation output positively and significantly affects firm performance, regardless of how performance is measured. Examples are:

Lööf et al. (2003) report on a comparative study on Finland, Norway and Sweden using CIS-2 data. Even though their study focuses more on methodological and data issues, the results are by and large in line with the CDM findings. However, no significant relation between innovation and productivity are found for Finland.

Janz et al. (2003) apply a modified CDM-model to a pooled dataset for Swedish and German knowledge intensive manufacturing firms using CIS-3 data. The impact of innovation input on innovation output and of innovation output on productivity are significant and of similar size in both countries.

Griffith et al. (2006) estimate a variation of the CDM-model for France, Germany, Spain, and the United Kingdom using CIS-3 data. They find that the innovation output is significantly determined by the innovation effort, while a significant productivity effect of product innovations can only be confirmed for France, Spain and the UK, but not for Germany.

Arvanitis (2008) using panel data on manufacturing firms in the period 1994-2002 from the Swiss innovation survey finds a clear-cut positive effect of innovation (measured by eight different variables) on productivity. Moreover, his results underline that innovation performance depends on demand, competition and appropriability conditions as well as the use of patent disclosures, users and universities as knowledge sources.

Roper et al (2008) model what they call the 'innovation value chain' from knowledge production (in-house and sourcing) to (product and process) innovation production to output production (productivity, growth) using firm-level data on manufacturing plants in Ireland and Northern Ireland for 1991-2002. In terms of firm performance, their analysis shows that product and process innovations have a strong and significant impact on firm growth, but no (process) or even a negative (product) effect on productivity. They interpret this as a disruption effect (introduction of new products may disrupt the existing production process and consequently reduce productivity) or product-life-cycle effect (newly introduced products are initially produced inefficiently).

In addition, there are recently similar analyses focusing on emerging economies.

Benavente (2006) applies the CDM-model to Chilean firm data for the period 1995 to 1998. His results show that R&D and innovative activities are related with firm size and market power, but that innovation output (or R&D activity) does not influence firm performance.

Jefferson et al. (2006) use data on large and medium-size manufacturing enterprises in China. For R&D performing firms they find a significant relation between R&D intensity and firm size, profitability, and market concentration; a robust association between R&D intensity and new product sales; as well as significant returns to R&D expenditure.

Cassey (2008) estimates a CDM-model based on firm-level data from the Malaysian manufacturing sector. His findings are that the decision to carry out R&D activities is significantly determined by firm size, export and the technology intensity of a firm's sector. Furthermore, the level of R&D expenditure is significantly correlated with firm size. Output (product and process innovations) is positively and significantly determined by R&D expenditure, firm size, exports and local ownership. Productivity is positively influenced by investment intensity (fixed asset per worker), process innovation and human capital (share of university graduates) but negatively correlated to product innovation. The author concludes that the findings show the importance of process innovation as driver of growth in developing countries.

3 Data

3.1. THAILAND R&D/ INNOVATION SURVEY

The paper is based on a unique and original datasets that was retrieved in the first R&D/ Innovation Survey in Thailand in 2000. It was commissioned by the Thailand National Science and Technology Development Agency (NSTDA), and conducted by the Brooker Group plc. The survey concentrated on manufacturing companies. The questionnaire is based on definitions from OECD's Oslo and Frascati manuals (OECD 2002, OECD 1997). The survey was conducted from January to April 2001 (Virasa & Brimble 2001) and is comprised of the following parts (see Berger 2007 for a copy of the questionnaire):

- Section A: General information on companies including type of products, year of establishment, number of employees, etc.
- Section B: R&D activities including types of activities, expenditure and personnel, etc.
- Section C: Innovation activities other than R&D
- Section D: External collaboration for R&D and innovation
- Section E: R&D and innovation environment in Thailand

3.1.1 Sampling Strategy

For the 1st RD/ Innovation Survey the 'Business Online Database' was used, which includes comprehensive information on around 35,000 manufacturing establishments registered with the Commercial Registration Department at the Ministry of Commerce. Thereby, the survey concentrated on medium- and large-sized manufacturing firms, with minimum annual revenue of 12 million Bhat in 1999. From a total sampling frame of 13,415 companies, 2,166 firms were selected (16.2%) using a three-stage sampling procedure consisting of stratified random sampling, probability proportional to size (PPS) and systematic random sampling within each industrial sector in each stratum. The three strata were created according to firm size (measured in 1999 turnover). Then, for each sector (Table 1), all firms from the first stratum (200 largest companies), 20% from the second stratum (next 2000 medium to large companies) and 3.3% from the third stratum (remaining 11,215 small firms) were selected by applying a systematic random sampling technique. Of the 2,166 firms sampled, a total of 1,019 completed questionnaires were received representing a response rate of 47% (Brooker Group, 2001).

Table 1: Manufacturing Sectors by two-digit Thai Standard Industry Classification

31	Manufacture of food, beverages and tobacco
32	Manufacture of textiles, wearing apparel, leather and leather products
33	Manufacture of wood and wood products, including furniture
34	Manufacture of paper and paper products, printing and publishing
35	Manufacture of chemicals and chemical products, petroleum, coal, rubber and plastic products
36	Manufacture of non-metallic mineral products
37	Basic metal industries
38	Manufacture of fabricated metal products, machinery and equipment
39	Jewellery, diamond, gem and ornaments

Source: Department of Labour, 1972

Representativeness

In order to evaluate the quality of the sample, data on the population is compulsory. The National Statistics Office of Thailand conducted an industrial census in 1997. More current information is available in the manufacturing industry surveys from 2000 and 2001, which are based on samples and only include enterprises with ten employees or more (see National Statistical Office 2004).

Table 2: Structure of the sample and the population for the 1st R&D/ Innovation Survey

TSIC-2		Number of establishments			Number of employees		
		Pop.	Sample	Sample/ Pop. (%)	Pop.	Sample	Sample/ Pop. (%)
31	Food, beverages, tobacco	3,470	146	4.21	402,760	94,060	23.4
32	Textiles, leather products	3,728	140	3.76	489,858	97,789	20.0
33	Wood, wood products	865	38	4.39	56,967	13,935	24.5
34	Paper, printing, publishing	1,256	55	4.38	84,759	11,753	13.9
35	Chemicals, rubber, plastic	2,661	235	8.83	259,202	67,000	25.8
36	Non-metallic, glass, clay	1,825	35	1.92	111,350	21,662	19.5
37	Basic metal	465	19	4.09	38,758	12,317	31.8
38	Metal products, machinery, equip.	4,942	327	6.62	549,847	247,608	45.0
39	Other manufacturing	1,639	24	1.46	177,799	5,810	3.3

Source: R&D/ Innovation Survey 2000; National Statistical Office & Office of the Prime Minister, 2000, own calculations

Table 2 depicts the size of the population, the sample and the relation between sample and population. Additionally, the share of employees in the R&D/innovation surveys is compared with that in the manufacturing surveys. In terms of number of establishments, sectors 31-34 are fairly equally represented. Sector 35 and 38 are over- whereas sector 36 and 39 are underrepresented. The number of employees represented by the sample is much higher than for the number of establishments. The sampling procedure is the primary cause for this, as it favours large firms. As with the number of establishments, the sample displays an uneven composition. Sector 37 and 38 are over-, while sector 34 and especially 39 are underrepresented.

The overrepresentation of some sectors is likely a result of the sampling procedure, since turnover was a criterion for both the strata and the probability of selection. Sectors 35 and 38 are among those with the highest sales per establishment, whereas firms in sectors 36 and 39 show lower sales per establishment (based on National Statistical Office & Office of the Prime Minister 2001; own calculations). Moreover, the chemicals and machinery/ equipment industries can be considered more innovation-affined than the primarily raw material-oriented sectors of non-metallic, glass, clay, and others (including e.g. jewellery, gem etc.). Hence, the response-propensity for an R&D/ innovation survey can be supposed to be higher in the first group. In terms of firm size, the distribution of the sample reveals a strong bias towards larger companies, which is again the result of a sampling procedure which applies a threshold and designates a higher probability to larger companies.

In conclusion, it is not possible to get a current and comprehensive picture of the population at the time of the R&D/ Innovation survey because the latest industrial census is outdated (being conducted in the crisis year of 1997) and the later manufacturing survey is based on a restricted sample used for estimations about the population. Still, the sample shows no obvious major biases and can consequently be considered sufficiently representative.

3.2. INNOVATION SURVEY DATA OF COUNTRIES PARTICIPATING IN THE OECD PROJECT

The data from the benchmarking countries which have been analysed in the OECD-project (OECD 2008, Criscuolo forthcoming) comes from a variety of innovation surveys. Even though all of them have a common core following the OECD's Oslo Manual (OECD 1997) they display (more or less) marked differences. These refer to the sampling and data collection procedure; questionnaire-design; phrasing, number and ordering of questions etc. (see OECD 2008, Criscuolo forthcoming for an overview). Not even the nationally implemented Community Innovation Surveys in European countries are uniform, although they are based on a harmonised questionnaire (OECD 2004). In order to improve international comparability the OECD project group decided to use the 'core' CIS-4 coverage in terms of sectors and similar firm size (OECD 2008).

3.3. DESCRIPTIVE STATISTICS

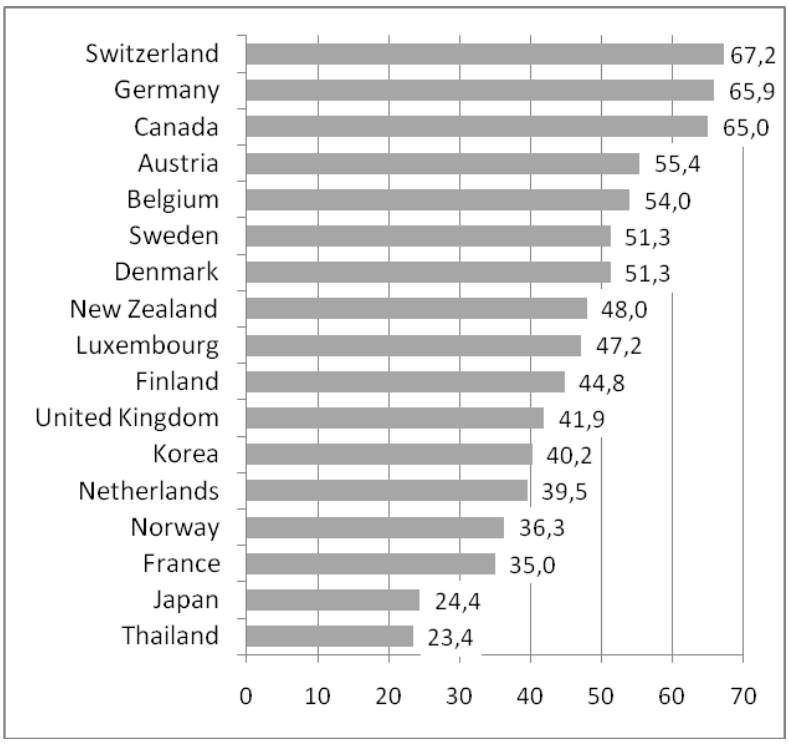
Due to different country sizes and data collection procedures (obligatory vs. voluntary; see above) the size of the sample in participating countries varies widely – ranging from 500 firms in Luxembourg to 18,000 in France. With around 1,000 enterprises the Thai sample is rather small by comparison (Table 3). For the modelling exercise this poses a problem; especially since the share of innovators is the lowest of all considered countries (Figure 1). As a consequence, the absolute number of innovators is low as well: The total number of firms that introduced a product or process innovation is 238. According to the strict 'innovative firm' definition applied in section 4 (having R&D-/innovation expenditure and R&D-related turnover/ turnover with product innovations) the Thai sample consists of only 98 (R&D) and 101 (innovation activities other than R&D) innovators respectively.

Table 3: Sample size in analysed countries

Country	Number of observations
France	18,056
Italy	15,915
United Kingdom	11,162
Brazil	9,384
Netherlands	6,858
Canada	5,355
Australia	3,697
New Zealand	3,426
Germany	3,242
Sweden	2,954
Belgium	2,695
Finland	2,155
Switzerland	1,964
Norway	1,852
Denmark	1,729
Korea	1,335
Thailand	1,019
Austria	1,001
Luxembourg	545

Source: OECD 2008, Thailand R&D/ Innovation Survey 2000

Figure 1: Share of manufacturing firms having introduced a product or process innovation 2002-2004



Canada: Lower threshold is more than 20 employees and more than CAD 250 000 in revenues. New Zealand: Two-year reference period (2004-05). Thailand: 1997-99
Source: data from Bloch and López-Bassols forthcoming, Thailand R&D/ Innovation Survey 2000

4 Econometric Model

The analysis follows basically the structural model developed by Crépon, Duguet and Mairesse (1998) which determines the innovation investment decision, the innovation process and the role of innovation in labour productivity. Using a three stage model CDM correct for two main problems: first, only some of the surveyed firms carry out innovation activities and can consequently report innovation expenditure. As a result, the analysis is restricted to a non-random subset of firms with innovation expenditure, which requires a correction for a (potential) selection bias. Second, CDM take into account the problem of endogeneity, which might result from the fact that explanatory variables are simultaneously determined as the dependent variables (e.g. in a knowledge production function, innovation inputs might be endogenous because firms that are more likely to have successful innovation output might also spend more on innovation; see Criscuolo forthcoming, OECD 2008).

In a first step and prior to such a structural model, the OECD project estimates three simple probit and OLS models in order to determine the impact of different variables on (1) the probability to innovate, (2) the extent of innovation inputs allocated and (3) labour productivity.

(1) Probability to innovate = β1 + β2log(employment) + β3group + β4foreign market+ β5obstacle: knowledge + β6obstacle: market+ β7obstacle: cost+ βisector + u

(2) log(innovation input) = β1 + β2group+ β3foreign market+ β4innovation cooperation + β5public support + βisector+ u1

(3) log(innovation output) = β1 + β2log(employment) + β3group+ β4process innovation + β5log(innovation expenditure per employee) +βisector + u

In a second step, a three stage, four equation structural model is implemented. In order to account for selectivity, the first stage applies a generalised Tobit model (known as Heckman selection model; Heckman 1979). The first equation of the first stage (4) investigates the propensity of a firm to carry out innovation activities . The probability depends on the size of the firm (employment), its affiliation to an enterprise group, its orientation towards foreign markets and perceived obstacles to innovation in respect to knowledge, market or costs. In addition the model controls for industry sectors.

A major restriction for the modelling is the limited number of available variables for non-innovative firms provided by almost all innovation surveys.

(4) Probability to innovate = β1 + β2log(employment) + β3group + β4foreign market+ β5obstacle: knowledge + β6obstacle: market+ β7obstacle: cost+ βisector + u

The second equation of the first stage (5), determines the innovation expenditure (per employee). In addition to those independent variables used in (4), this equation includes informa-

tion on participation in innovation co-operation (regardless of the co-operation partner) and receiving of public financial support.

(5) log(innovation input) = β1 + β2group+ β3foreign market+ β4innovation cooperation + β5public support + βisector+ u; if innovation =1

The second stage (6) covers a knowledge production function. Here, innovation output (innovative sales per employee) depends on innovation input (expenditure), firm size, group affiliation, process innovation and innovation co-operation with four different groups of actors (customers, suppliers, other private firms and public institutes). Because the model is only estimated for innovative firms, the estimation includes the mills-ratio of the Heckman selection in the first stage to control for selectivity.

(6) log(innovation output) = β1 + β2log(employment) + β3group+ β4process innovation + β5cooperation: customer+ β6 cooperation: supplier + β7 cooperation: other firm+ β8 cooperation: public organisation+ β9mills ratio + β10log(innovation expenditure per employee) +βisector + u; if innovation =1

The third stage (7) estimates labour productivity using an augmented Cobb-Douglas production function. Thereby, labour productivity is – due to a lack of more appropriate indicators – measured as turnover per employee. Besides standard firm characteristics such as firm size and group affiliation the list of independent variables also include process innovation and innovation output (innovative sales per employee). The latter one is treated as an instrumental variable in order to deal with potential endogeneity. Again, the mills ratio is included to control for selectivity.

(7) log(labour productivity) = β1 + β2log(employment) + β3group+ β4process innovation+ β5mills ratio + β6log(turnover with new products per employee) + βisectori + u; if innovation =1

- instrumented log(turnover with new products per employee)
- instruments: log(innovation expenditure per employee), cooperation: customer, cooperation: supplier, cooperation: other firm, cooperation: public organization

Table 4 gives an overview of the variable definitions. Due to differences between the harmonized questionnaire for the fourth Community Innovation Survey (OECD 2004), which is the base for the OECD project, and the questionnaire of the Thailand R&D/ Innovation Survey (see Berger 2007: Appendix 2) many variables needed to be adjusted. Such a procedure was also necessary for other non EU countries and some EU countries using older CIS data such as Austria. For example, Korea and Canada also had to restrict its sample to manufacturing firms and New Zealand also had to use mid-point estimation for innovative sales (OECD

2008). Still these adjustments limit the international comparability. A major caveat is the fact that the R&D/ Innovation Survey in Thailand treats R&D and innovation activities other than R&D in separate sections of the questionnaire. This is unique. All other innovation surveys in the OECD project group regard R&D as one aspect of innovation activities and do not distinguish between R&D and (other) innovation expenditure, sales, cooperation etc. Consequently, it was decided to estimate the model for Thailand twice: Once for R&D and once for innovation activities other than R&D.

Table 4: Definition of variables

Name	Standard Definition of OECD project*	Definition for Thailand dataset+
innovate	dummy, which is 1 if a firm reports innovation expenditure and turnover with new products	due to questionnaire design split into - R&D dummy: R&D expenditure in 1999 and turnover with R&D-related products and processes - Innovation dummy: expenditure for innovation activities other than R&D in 1999 and turnover with new products
employment	employment 2004	employment 1999
group	dummy for whether the firm is part of an enterprise group	dummy for whether the firm is part of a foreign enterprise group (belongs (partly) to a foreign owner)
foreign market	dummy for selling on the international market (in which geographic markets do you sell?)	dummy for selling on the international market (export share 1999 > 0)
obstacle: knowledge	dummy which is 1 if any of the following obstacles for innovation has a high importance: lack of qualified personnel, lack of information on technology, lack of information on markets, difficulty in finding cooperation partners for innovation	due to questionnaire design split into - R&D: dummy which is 1 if any of the following obstacles for R&D has a high or very high importance: in-house lack of R&D personnel, lack of information on R&D opportunities, insufficient supply of R&D personnel - Innovation: : dummy which is 1 if any of the following obstacles for innovation other than R&D has a high or very high importance: lack of information on technology, lack of information on markets, lack of qualified personnel
obstacle: market	dummy which is 1 if any of the following obstacles for innovation has a high importance: market dominated by established enterprises, uncertain demand for innovative goods or services	due to questionnaire design split into - R&D: dummy which is 1 if any of the following obstacles for R&D has a high or very high importance: lack of competition in the domestic market - Innovation: : dummy which is 1 if any of the following obstacles for innovation other than R&D has a high or very high importance: lack of customer interests in innovation, lack of competition in the domestic market

Name	Standard Definition of OECD project*	Definition for Thailand dataset+
obstacle: cost	dummy which is 1 if any of the following obstacles for innovation has a high importance: lack of funds within your enterprise or group, lack of finance from sources outside your enterprise, innovation costs too high	due to questionnaire design split into - R&D: dummy which is 1 if any of the following obstacles for R&D has a high or very high importance: limited financial resources - Innovation: : dummy which is 1 if any of the following obstacles for innovation other than R&D has a high or very high importance: perceived cost too high, limited financial resources
sector	dummies for 10 manufacturing sectors and 6 service sectors following the OECD STAN database classification	dummies for following 6 manufacturing sectors: - food (TSIC 31) - textile (TSIC 32) - woodpaper (TSIC 33, 34) - chemicals (TSIC 35) - machinery (TSIC 38) - other (TSIC 36, 37, 39)
INNOVATION INPUT	total innovation expenditure 2004 per employee in 2004	due to questionnaire design split into - R&D expenditure 1999 per employee 1999 - Expenditure for innovation activities other than R&D 1999 per employee 1999
innovation cooperation	during the three years 2002 to 2004, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions? Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit.	due to questionnaire design split into - R&D dummy: How intensely do you cooperate with the following external parties in R&D? 1 if hardly intensely to very intensely - Innovation dummy: How intensely do you cooperate with the following external parties in a) product innovation b) process innovation? : 1 if either one is hardly intensely to very intensely
public financial support	dummy for receiving any public financial support for innovation activities from a) local/ regional authorities, b) central government, c) European Union from 2002 to 2004.	dummy for receiving a) tax deduction for R&D activities, b) loans and grants either from NSTDA or MOI, c) funds from government for R&D activities
INNOVATION OUTPUT	turnover with new products per employee: sales income from products new to the market and new to the firm (share defined to be between 0 and 1) multiplied by turnover 2004 divided by employment	turnover with new products per employee: due to questionnaire design split into - sales income from R&D related products and processes; share categorized in 5 classes; using mid-point estimation for multiplication with turnover 1999; division by employment 1999 - sales income from new/ improved products from innovation activities other than R&D; share categorized in 5 classes; using mid-point estimation for multiplication with turnover 1999; division by employment 1999

Name	Standard Definition of OECD project*	Definition for Thailand dataset+
process innovation	dummy for implementing a process innovation (yes/ no question) either new to the market or new to the firm	dummy for implementing a process innovation (yes/ no question) as a result of innovation activities other than R&D
cooperation: customer	dummy for innovation cooperation with clients regardless of the location of the cooperation partner	due to questionnaire design split into - R&D dummy: How intensely do you cooperate with customers in R&D? 1 if hardly intensely to very intensely - Innovation dummy: How intensely do you cooperate with customers in a) product innovation b) process innovation? : 1 if either one is hardly intensely to very intensely
cooperation: supplier	dummy for innovation cooperation with suppliers regardless of the location of the cooperation partner	due to questionnaire design split into - R&D dummy: How intensely do you cooperate with locally owned or foreign owned suppliers in R&D? 1 if either one is hardly intensely to very intensely - Innovation dummy: How intensely do you cooperate with locally owned or foreign owned suppliers in a) product innovation b) process innovation? : 1 if either one is hardly intensely to very intensely
cooperation: other firm	dummy for innovation cooperation with competitors or other enterprises, consultants, commercial labs, or private R&D institutes regardless of the location of the cooperation partner	due to questionnaire design split into - R&D dummy: How intensely do you cooperate with parent/associate companies, business service providers, technical service providers, competitors, other firms in R&D? 1 if either one is hardly intensely to very intensely - Innovation dummy: How intensely do you cooperate with parent/associate companies, business service providers, technical service providers, competitors, other firms in a) product innovation b) process innovation? : 1 if either one is hardly intensely to very intensely
cooperation: public organisation	dummy for innovation cooperation with universities or other higher education institutions, government or public research institutes regardless of the location of the cooperation partner	due to questionnaire design split into - R&D dummy: How intensely do you cooperate with R&D institutes/university in R&D? 1 if either one is hardly intensely to very intensely - Innovation dummy: How intensely do you cooperate with R&D institutes/university in a) product innovation b) process innovation? : 1 if either one is hardly intensely to very intensely
LABOR PRODUCTIVITY	turnover 2004 divided by employment 2004	turnover 1999 divided by employment 1999

*based on harmonized questionnaire for Community Innovation Survey (see OECD 2004), deviations for non-EU countries and older survey data (see OECD forthcoming); + see Berger 2007, Appendix 2 for questionnaire

5 Results

5.1. THAI RESULTS IN DETAIL

Which firms are more likely to innovate and carry out R&D?

The results of the simple probit and OLS estimations are presented in Table 5 those of the structural model in Table 6. They show that firm size has a highly significant positive effect on the probability to innovative and to perform R&D. In contrast, having a foreign owner (i.e. being part of a foreign enterprise group), has – ceteris paribus – a significantly negative impact (see column 1 and 4 in Table 5 and column 1 and 5 in Table 6). Moreover, some of the obstacles for innovation/ R&D are positively correlated with the probability of being innovative/ perform R&D. This result is counter intuitive but can also be witnessed in other countries (see5.2). A possible explanation is that the questions on obstacles do not adequately cover obstacles for non-innovative firms, but rather problems experienced by firms during the innovation activities. Consequently only innovative firms are in the position to judge. In terms of sectors, it seems clear that almost all industries are more likely to carry out R&D than the textiles industry (which is the reference category). Especially, chemicals and machinery have a high marginal effect. Regarding innovation activities other than R&D, the results are mixed: The simple model displays no significant differences whereas the structural model shows a higher likelihood for innovation in the chemicals, machinery and food industry.

Which firms spend more on innovation and R&D?

The model cannot explain the amount of resources allocate to R&D and other innovation activity very well. Most determinants are not significant. However, R&D and innovation cooperations reduce (mostly) significantly the amount R&D/ innovation expenditure (see column 2 and 5 in Table 5 and column 2 and 6 in Table 6). This is s striking result to which we will come back in section 5.2.

Table 5: Thai results of the simple probit and OLS models for R&D and innovation activity

Independent variables	(1) Probability: R&D+	(2) R&D Input	(3) Labor Productivity	(4) Probability: other innovation activity+	(5) Innovation Input	(6) Labor Productivity
employment	**0.0267*** **		0.0489	**0.0222*** **		0.0624
	(-0.008)		(-0.059)	(-0.008)		(-0.056)
group	**-0.0323***	-0.528	0.215	**-0.0360***	-0.521	0.242
	(-0.018)	(-0.321)	(-0.155)	(-0.020)	(-0.328)	(-0.161)
foreign market	0.0268	-0.51		-0.00115	-0.336	
	(-0.019)	(-0.373)		(-0.022)	(-0.301)	
obstacle:	**0.0914*** **			**0.0348***		
knowledge	(-0.020)			(-0.021)		
obstacle:	-0.0232			**-0.0356***		
market	(-0.019)			(-0.019)		
obstacle:	-0.0176			**0.0409** **		
cost	(-0.020)			(-0.021)		
cooperation		**-0.983** **			**-1.049*** **	
		(-0.461)			(-0.339)	
public financial		0.3			0.478	
support		(-0.567)			(-0.479)	
process			**-0.286***			-0.222
innovation			(-0.153)			(-0.153)
INNOVATION/ R&D OUTPUT			**0.582*** **			**0.542*** **
			(-0.063)			(-0.069)
sectors (reference: textiles)						
food	**0.150** **	0.631	0.135	0.0776	0.919	**0.609** **
	(-0.067)	(-1.505)	(-0.264)	(-0.052)	(-0.848)	(-0.260)
woodpaper	0.122	0.5	0.161	0.0188	0.581	-0.00289
	(-0.079)	(-1.475)	(-0.375)	(-0.052)	(-0.783)	(-0.267)
chemicals	**0.149** **	1.297	**0.585** **	0.0783	0.474	**0.806*** **
	(-0.060)	(-1.510)	(-0.246)	(-0.048)	(-0.789)	(-0.247)
machinery	**0.133*** **	0.618	0.188	**0.0878** **	1.029	**0.587*** **
	(-0.050)	(-1.499)	(-0.235)	(-0.042)	(-0.768)	(-0.216)
other	**0.169***	-0.355	-0.035	0.0866	0.654	0.312
	(-0.087)	(-1.496)	(-0.282)	(-0.067)	(-0.863)	(-0.287)
Constant		9.322***	-7.303***		9.258***	-7.265***
		(-1.332)	(-0.841)		(-0.701)	(-0.954)
Observations	988	129	149	988	149	136
R-squared		0.133	0.494		0.144	0.528

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, + defined as having R&D (innovation) expenditure and turnover with R&D related products/processes (product innovation)

Source: Thailand R&D/ Innovation Survey 2000 (own calculations)

Which firms have a higher turnover with innovative products and R&D-related products and processes?

The results for the innovation output need to be discussed separately for a) R&D- related products and process and b) new products from innovation activities other than R&D.

a) Turnover with R&D-related output (see column 3 in Table 6) is positively correlated to belonging to a foreign group, cooperation with clients and public research institutes/ universities as well as the amount of money spend on R&D. These results seem sensible: higher input should be expected to relate into higher output and suppliers are traditionally the (second) most important collaboration partners (after customer) whereas universities and research institutes play a minor role (e.g. Revilla Diez and Berger 2005, EC 2004, Parvan 2007, Koschatzky and Sternberg 2000). Still, both can be expected to contribute highly relevant knowledge for joint R&D on inputs and basic research results. The positive impact of foreign ownership comes a bit of a surprise since it has a negative impact on the probability to be innovative. Presumably, the logic behind the numbers is that foreign firms have a lower propensity to carry out R&D in Thailand, but if they choose to do so, they are more efficient.

b) For innovation activities other than R&D (see column 7 in Table 6) the results are less telling, since only firm size plays a significant role. The theoretical relationship between firm size and innovation output is not clear cut (see also5.2). However, empirical work by Janz et al. (2003) and Falk (2007) on European firms show a negative relationship between size and share of turnover with new products. Consequently, a strong positive correlation with firm size hints towards a weakness of small and medium sized firms in terms of innovative performance, which is unusual in international comparison.

Table 6: Thai results of the structural model for R&D and innovation activity

Independent variables	(1) R&D+ probability	(2) R&D input	(3) R&D output	(4) Labour productivity	(5) Innovation+ probability	(6) Innovation input	(7) Innovation output	(8) Labour productivity
employment	**0.220*** **		0.202	0.103	**0.198*** **		**0.412***	-0.0479
	(-0.044)		(-0.147)	(-0.121)	(-0.0414)		(-0.232)	(-0.289)
group	**-0.242** **	-0.569	**0.587** **	0.0756	**-0.261** **	-0.344	-0.0022	0.0158
	(-0.123)	(-0.372)	(-0.248)	(-0.230)	(-0.120)	(-0.415)	(-0.457)	(-0.363)
foreign	0.178	-0.152			-0.0362	-0.0754		
market	(-0.139)	(-0.446)			(-0.129)	(-0.471)		
obstacle: knowledge	**0.524*** **				**0.217***			
	(-0.136)				(-0.113)			
obstacle: market	**-0.252** **				-0.169			
	(-0.128)				(-0.118)			
obstacle: cost	-0.0372				0.136			
	(-0.118)				(-0.118)			
cooperation		-0.483				**-0.983** **		
		(-0.463)				(-0.459)		
public fin. support		-0.204				0.556		
		(-0.423)				(-0.504)		
process			-0.124	-0.231			-0.167	-0.193
innovation			(-0.254)	(-0.193)			(-0.307)	(-0.29)
cooperation: customer			-0.573				-0.0064	
			(-0.371)				(-0.639)	
cooperation: supplier			**0.713***				0.674	
			(-0.375)				(-0.600)	
cooperation: other firm			-0.155				-0.256	
			(-0.328)				(-0.580)	
cooperation: public inst.			**0.538***				-0.294	
			(-0.279)				(-0.341)	
INNOVATION/ R&D INPUT			**0.210*** **				0.0789	
			(-0.075)				(-0.087)	
INNOVATION/ R&D OUTPUT				**0.659*** **				**1.219** **
				(-0.248)				(-0.511)
sectors (reference: textiles)								
food	**0.696*** **	-0.193	0.254	0.209	**0.378***	1.088	-0.413	0.874
	(-0.249)	(-0.963)	(-0.633)	(-0.421)	(-0.225)	(-0.857)	(-0.714)	(-0.591)
woodpaper	**0.612** **	-0.0026	1.069	0.0362	0.154	1.218	0.914	-0.834
	(-0.292)	(-1.026)	(-0.727)	(-0.539)	(-0.274)	(-1.022)	(-0.665)	(-0.805)
chemicals	**0.768*** **	0.942	0.594	0.517	**0.467** **	**1.513***	0.212	0.84
	(-0.242)	(-0.920)	(-0.627)	(-0.470)	(-0.212)	(-0.805)	(-0.677)	(-0.629)
machinery	**0.736*** **	0.557	0.718	0.0101	**0.493** **	**1.839** **	0.682	0.288
	(-0.232)	(-0.893)	(-0.649)	(-0.448)	(-0.200)	(-0.781)	(-0.699)	(-0.750)
other	**0.760*** **	-0.681	0.314	-0.105	0.424	1.301	-0.272	0.653
	(-0.286)	(-1.026)	(-0.665)	(-0.457)	(-0.266)	(-1.008)	(-0.663)	(-0.650)
mills ratio			0.498	0.0674			1.819	0.039
			(-0.691)	(-0.519)			(-1.290)	(-1.455)
Constant	-3.477***	6.219***	7.639***	-8.602***	-2.800***	4.795***	5.71	-14.91***
	(-0.368)	(-1.477)	(-2.179)	(-3.110)	(-0.318)	(-1.464)	(-3.605)	(-4.631)
Observations	988	988	97	97	988	988	97	97
R-squared			0.232	0.435			0.198	
P-val. LR test	0.001	0.001			0.003	0.003		

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, + defined as having R&D (innovation) expenditure and turnover with R&D related products/processes (product innovation), Thailand R&D/ Innovation Survey 2000 (own calculations)

Which firms have higher labour productivity?

A remarkable result of the analysis is the very clear and significant link between innovation output – either measured as turnover with R&D- related products / processes or new products from other innovation activities per employee – and labour productivity (see column 3 and 6 in Table 5 and column 4 and 8 in Table 6).

In contrast to expectations neither size, nor foreign ownership or successful process innovation have a significant impact on labour productivity. We will discuss these results in 5.2.

5.2. THAI RESULTS IN INTERNATIONAL COMPARISON

Which firms are more likely to innovate and carry out R&D?

Table 7 shows that internationally the picture is very clear: Large firms operating in foreign markets (export) and belonging to an enterprise group have a higher likelihood to innovate.

The results for Thailand and Austria (CIS4), where only affiliation to a foreign group can be identified, display the negative correlation between foreign ownership and innovation activities. Empirical evidence in this respect is mixed: Sadowski and Sadowski-Rasters (2006) assert—based CIS-2 data for the Netherlands—that foreign ownership has a significant and positive impact on the propensity to be innovative, whereas Ebersberger and Lööf (2005) cannot establish differences in innovativeness between foreign-owned and domestic firms while analysing CIS 3 data for the Nordic European countries. Balcet and Evangelista (2004) using Italian CIS 2 data, find that foreign affiliates are more innovative and have a higher R&D-expenditure than domestic firms. However, once they adjusted data for sector and firm size, statistically significant differences could no longer be established. Annique Un and Cuervo-Cazurra (2008) find that subsidiaries of foreign multinationals in Spain invest less in R&D than domestic firms, mainly because they spend less on external R&D while having similar internal R&D expenditure.

The effect of exports differs strikingly between Thailand (no significance) and Brazil (significantly negative) on the one hand and OECD countries (significantly positive) on the other hand. Presumably, this hints towards the dominating competitive advantage of firms in late-industrialising countries and so called developed economies: While the export success of the first group still relies on (labour) cost advantages, the latter (high cost) group needs to be innovative in order to compete successfully on the global market.

Moreover, the counter intuitive (mostly) positive effect of obstacles to innovation is quite common in other countries as well and – as mentioned earlier – probably related to the weakness of this set of questions as an indicator for capturing problems for non-innovative firms.

Table 7: Which firms are more likely to be innovative?

	Belonging to a (foreign[0]) group	Operating in a foreign market	Being large (size)	Barriers related to knowledge[1]	Barriers related to markets[2]	Barriers related to costs[3]	rho[4]	No. Obs.	P-value[5]
Thailand: R&D[0]	**-0.242****	0.178	**0.220*****	**0.524*****	**-0.252****	-0.037	1.124***	988	0.001
Thailand: Innovation[0]	**-0.261****	-0.036	**0.198*****	**0.217***	-0.169	0.136	1.165***	988	0.001
Austria (CIS4)[0]	**-0.211***		**0.556*****	-0.025	0.017	**0.174***	0.362***	2 546	0.005
Austria (CIS3)	**0.213***	**0.454*****	**0.253*****	-0.077	-0.182	-0.001	0.223	1 001	0.226
Australia	**0.352*****		**0.153*****	**0.232*****	**0.207*****	**0.348*****		3 697	0.522
Belgium	**0.198*****	**0.617*****	**0.267*****	0.043	-0.05	**0.455*****	0.41	2 695	0.001
Brazil	**0.424*****	**-0.264*****	**0.123*****	**0.152*****	**0.131*****	0.032	2.019***	9 384	0.000
Canada	**-0.105***	**0.290*****	**0.140*****				1.005***	5 355	0.000
Denmark	**0.186****	**0.637*****	**0.253*****	**0.243****	0.029	**0.391*****	0.324**	1 729	0.020
Finland	0.065	**0.532*****	**0.254*****	**0.190****	**0.259*****	-0.027	0.477***	2 155	0.002
France	**0.227*****	**0.778*****	**0.204*****	**0.201*****	**0.068*****	**0.227*****	0.643***	18 056	0.000
Germany	**0.144*****	**0.529*****	**0.088*****	0.014	-0.107	**0.173*****	0.256**	3 242	0.066
Italy	**0.203*****	**0.478*****	**0.185*****	**0.110*****	**-0.068****	**0.091*****	0.753***	15 915	0.000
Korea	-0.064		**0.202*****	**0.201*****	0.006	**0.136***	0.662	1 335	0.007
Luxembourg	**0.267***	**0.314****	**0.248*****	0.191	-0.101	**0.359***	0.192	545	0.701
Netherlands	**0.164*****	**0.546*****	**0.213*****	**0.175*****	**-0.111****	0.012	0.727***	6 858	0.000
New Zealand	**0.113****	**0.349*****	**0.079*****	**0.089***	0.027	**0.138*****	1.337***	3 426	0.000
Norway	-0.072	**0.643*****	**0.320*****	**0.301*****	0.048	**0.301*****	0.739***	1 852	0.000
Sweden	**0.173*****	**0.576*****	**0.090*****	**0.556*****	**0.160*****	**0.119****		2 954	0.563
Switzerland		**0.312*****	**0.045***	0.075	**0.201***	-0.065	0.927***	1 964	0.000
United Kingdom	**0.174*****	**0.464*****	**0.047*****	**0.287*****	**0.088****	**0.088****	-0.04	11 162	0.261

Notes: Coefficients reported are marginal effects, i.e. they predict the likelihood of being innovative.
For example, an Austrian firm operating on a foreign market is 45% more likely to be innovative than an Austrian firm only active in the local market. For Canada and Brazil the regressions are weighted to the population. Results are based on 2004 innovation surveys (CIS-4 for European countries), except for Austria which used CIS3 data and Australia where the innovation survey has 2005 as the reference year. For Australia the group variable is imputed. Switzerland does not have information on whether firms belong to groups; Australia does not have information on whether firms serve a foreign market and in Canada the survey does not ask about obstacles to innovation.
0. The group variable in Thailand and for Austrian CIS 4 data only refers to foreign ownership/ groups.
1. Knowledge factors are defined e.g. as lack of qualified personnel, lack of technological and/or market information or lack of co-operation partners).
2. Market factors refer e.g. to market dominated by established enterprises or uncertain demand for innovative goods or services.
3. Cost factors refer e.g. to lack of internal funds, lack of external finance and costs of innovation too high). All three variables are defined as a 0/1 dummy that equals one if any of the factors included was a very important obstacle.
4. "rho" is the correlation coefficient between the error terms of the selection and outcome equation.
5. The p-value is used to test whether correction for selection bias is necessary or not. The null hypothesis, rho=0, assumes that there is no link between the selection and outcome equations. The null hypothesis is rejected at the 10% level in most countries, hence correcting for selection improves the model, except for Australia, Austria, Luxembourg and the United Kingdom.
Industry dummies included but not reported.
* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: OECD 2008 except for Thailand and Austria (CIS4) (own calculations)

Which firms spend more on innovation and R&D?

In most analysed countries group affiliation, export activities, innovation cooperation and public financial innovation support show a significant positive correlation with innovation expenditure (see Table 8). This is not true for Thailand, where most independent variables are not significant. Again, this might be related to the restriction of the group variable to foreign ownership (Austrian CIS4 data also shows not positive relationship) and the less stimulating effect of international competition, i.e. export, (even though the negative coefficient for Switzerland speaks against this reading of the data).

Moreover, public financial support has no stimulating effect on R&D/ innovation expenditure in Thailand. There are two possible explanations for this: On the one hand it might be a methodological artefact. The variable 'public financial support' in the model for European countries includes any public funding either from a) national government, b) local/ regional government or c) European Union. In contrast, the same variable for Thailand is defined more narrowly only encompassing central government (see Table 4). However, even for this category the share Thai firms receiving public support is at the lower end of the range (Table 9) . Another indicator about public support can be derived from the questions concerning the lack of funding as a barrier for innovation. Again, the share of firms reporting problems with internal or external funding is much higher in Thailand than in the European countries of the OECD sample (Table 10). As a consequence, both indicators – i.e. share of publicly supported firms and firms reporting lack of funds as an innovation obstacle – give evidence that the 'lack' of a positive impact of public funding on innovation expenditure reflect more than just a methodological problem.

Table 8: Which firms spend more on innovation?

	Belonging to a (foreign*) group	Operating in a foreign market	Being engaged in co-operation	Receiving financial public support	No. of observations
Thailand R&D	-0.569	-0.152	-0.483	-0.204	988
Thailand Innovation	-0.344	-0.075	**-0.983****	0.556	988
Austria (CIS4)	0.097		**0.522*****	**0.421*****	2 546
Austria (CIS3)	0.161	**0.737*****	**0.408*****	**0.746*****	1 001
Australia	**0.443****		-0.161	-0.033	3 697
Belgium	**0.233***	**0.524*****	-0.021	**0.714*****	2 695
Brazil	**0.875*****	**-0.204***	**0.384*****	**0.332*****	9 384
Canada	**0.145***	**0.448*****	**0.173****	**0.183***	5 355
Denmark	**0.477*****	**0.762*****	0.182	**0.735*****	1 729
Finland	**0.260****	**0.361***	**0.495*****	**0.460*****	2 155
France	**0.231*****	**1.158*****	**0.427*****	**0.683*****	18 056
Germany	**0.054**	**0.610*****	**0.402*****	**0.469*****	3 242
Italy	**0.268*****	**0.511*****	**0.310*****	**0.412*****	15 915
Korea	-0.167		0.079	**0.407*****	1 335
Luxembourg	0.212	0.434	0.102	0.352	545
Netherlands	**0.247*****	**0.675*****	**0.389*****	**0.569*****	6 858
New Zealand	**0.664*****	**0.740*****	**0.225*****	Confidential	3 426
Norway	-0.044	**0.706*****	**0.354*****	**0.657*****	1 852
Sweden	**0.173*****		**0.576*****		2 954
Switzerland		**-0.717****	**0.370****	-0.128	1 964
United Kingdom	0.051	**0.513*****	**0.377*****	**0.537*****	11 162

Notes: Coefficients reported are marginal effects for the co-operation and financial support variables but not for the group and foreign markets variables because the latter enter both the selection (probability to innovate) and the outcome (innovation intensity) equation. When variables enter both the selection and outcome equations their marginal effect can be broken down into two parts: the first is the direct effect on the mean of the dependent variable (which is reported in this table) and the second comes from its effect through its presence in the selection equation
For Canada and Brazil, the regressions are weighted to the population. Results are based on 2004 innovation surveys (CIS-4 for European countries), except for Austria which used CIS3 data and Australia where the innovation survey has 2005 as the reference year.
Belonging to a group; operating in a foreign market; being engaged in co-operation and receiving financial support are 0/1 dummies
For Australia the group variable is imputed from responses to the question about whether the enterprise collaborated with other members of their group and is underreported as it omits enterprises that are part of an enterprise group but did not collaborate with other enterprises within the group on innovation projects.
For New Zealand information on innovation expenditure is codified as a categorical variable; to transform it to a continuous variable midpoints of each range are used and multiplied by total reported expenditure.
Industry dummies included but not reported.
* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: OECD 2008 except for Thailand and Austria (CIS4) (own calculations)

Table 9: Public financial support: Share of enterprises with innovation activities receiving funding from… (manufacturing only)*

	any public funding	European Union	central government (incl. agencies or ministries)	local or regional authorities
Thailand			12.1	
Austria (CIS3)	50.5	15.5	39.0	25.8
Austria (CIS4)	42.6	11.4	32.6	25.7
Belgium	29.1	4.3	12.1	19.5
Germany	17.9	4.8	9.5	10.0
Denmark	21.7	9.8	12.2	2.5
Finland	45.6	10.8	39.7	9.9
France	26.0	5.6	19.2	10.7
Italy	43.8	3.5	16.8	29.4
Luxembourg	46.3	4.9	42.6	6.1
Netherlands	49.4	7.2	43.4	8.6
Norway	54.8	1.6	54.3	2.0
UK (CIS3)	12.4			

*Thailand: R&D and/ or other innovation activities Source: CIS4 and (partly) CIS3, see Eurostat 2009, Thailand R&D/ Innovation Survey 2000

Table 10: Financial obstacles1 to innovation: Share of firms reporting… (manufacturing only)

	Lack of finance from sources outside your enterprise		Lack of funds within your enterprise or enterprise group	
	firms with innovation activity*	firms without innovation activity*	firms with innovation activity*	firms without innovation activity*
Thailand: R&D[2]	46	36	35	38
Thailand: Innovation[3]	48	42	37	45
Austria	18	16	22	22
Belgium	13	10	21	17
Germany	12	15	13	18
Denmark	9	10	22	18
Finland	9	7	15	14
France	10	7	33	22
Italy	20	18	21	27
Luxembourg	3	1	17	4
Netherlands	9	17	18	25
Norway	13	5	14	7
Sweden	14	13	23	19

1 hampering factors of high importance (CIS) or high and very high importance (Thailand) 2 Based on the question "During 1997-1999, importance of following factors limiting R&D within your firm?" "External factors: Lack of government R&D incentives", "Internal factors: Limited financial resources" 3 Based on the question "Please indicate the importance of the following as factors limiting innovation within your firm:" "External factors: Lack of government support" "Internal factors: Limited financial resources", *Thailand: R&D and/ or other innovation activities

Source: CIS4, see Eurostat 2009, Thailand R&D/Innovation Survey 2000

Furthermore, innovation cooperation which displays a positive relationship with innovation expenditure in many countries of the OECD sample is not significant for R&D expenditure and significantly negative for investment in other innovation activities in the Thai case. While cooperating firms usually invest more in innovation than non-cooperating firms, this is not true for Thailand. This finding could be an indication for the "cooperation from weakness" thesis (see Günther 2004): In context of a weak national innovation system and surrounded by firms and public organisations that lack innovation capabilities (Intarakumnerd et al. 2002, Berger 2007) innovative firms might prefer to stay away from innovation collaboration since the perceived costs (knowledge losses) may be higher than the benefits (knowledge gains). In contrast, less capable firms (need to) seek cooperation in order to pool scarce resources and knowledge in order to enhance their innovative capabilities.

Against this interpretation speaks the fact that another emerging economy (Brazil) shows a very significant and positive relationship between cooperation and innovation expenditure while some more mature innovation system such as Belgium, Denmark and Korea do not.

Table 11: Which firms have a higher innovation output in terms of sales from product innovation per employee?

	Belonging to a (foreign*) group	Being large (Size)	Process inno.	-------- clients	Co-operation: suppliers	other firm	---------- - public	Innovation (R&D) input	No. of obs.
Thailand R&D*	**0.587****	0.202	-0.124	-0.573	0.713*	-0.155	**0.538***	**0.210*****	97
Thailand Inno.*	-0.002	**0.412***	-0.167	-0.006	0.674	-0.256	-0.294	0.079	97
Austria (CIS4)*	0.087	0.077	0.077	**0.312***	0.186	-0.073	-0.282	**0.288*****	391
Austria (CIS3)	0.217	-0.020	0.104	-0.113	-0.084	0.313	-0.118	**0.209*****	359
other countries	sig. + in 8/18 countries	indifferent	sig. + in 6/18 countries	little evidence for + influence				**sig. + in all countries** except CH	

Source: internal OECD presentation and own calculations

Which firms have a higher turnover with innovative products and R&D-related products and processes?

For the OECD group, innovation input shows a significant positive correlation with innovation output in all countries except Switzerland(Table 11). In Thailand, this is only true for R&D-, not for innovation expenditure. This indicates problems in the efficiency of the innovation process outside the R&D-domain. For all other determinants the pattern is less clear. Some countries show positive effects of belonging to an enterprise group and having implemented process innovation, other do not. The picture for firm size and innovation cooperation (by partner) is even less consistent, not allowing for any straight forward conclusion.

A remarkable result is the fact that Thai firms engaging in R&D and in cooperation with universities and public R&D institutes have a significant higher output in terms of turnover with

R&D-related products and processes – this is rarely the case in the other countries. If true, Thai universities seem to be able to offer substantial support to R&D activities by the business sector, despite its relatively low quality, severe gaps between academic supply (knowledge production) and business demand (technological needs) as well as low absorptive capacity on behalf of the business sector (see Liefner and Schiller 2008, Schiller 2006a, b, Mildahn and Schiller 2006)

Which firms have higher labour productivity?

There are several remarkable results (Table 12): First, product innovation output has a highly significant and positive effect on labour productivity in all countries but Switzerland. Thailand is not different in this respect. Consequently, there is strong evidence that product innovation goes hand in hand with labour productivity – even in late-industrialising countries such as Thailand or Brazil.

Second, process innovation has never a positive effect: it is either indifferent or even significant negatively related to labour productivity. This is contrary to expectations. One would assume that the purpose of process innovations is to increase productivity; hence this should be visible in the results. Possible explanations can be found with regard to methodology as well as content. Due to a lack of information on value added in most innovation survey, the construction of the labour productivity variable had to rely on sales – this is a problematic approach, especially since sales is also part of the innovation output variable. Moreover, process innovations may have a considerable time lag before they improve labour productivity. Consequently, the 'wrong sign' could also be caused by the usage of cross section data. Time series data would be more telling. In addition, the results could be an indication for the fact that firms see the need for process innovation more often in times of economic hardship than in boom phases.

Third, group affiliation and size tend to have a positive effect on labour productivity in most countries. Thailand belongs to a minority group of countries where this is not the case. Especially, the indifferent impact of foreign ownership is surprising, since foreign subsidiaries usually tend to have higher productivity and more modern equipment than domestic enterprises in Thailand (see e.g. Berger 2007).

Table 12: What is the impact of product innovation on labour productivity?

	Belonging to a (foreign*) group	Being large (Size)	Having implemented a process innovation	Log innovation sales per worker (product innovation)	Number of observations
Thailand R&D*	0.076	0.103	-0.231	**0.659*** **	97
Thailand Innovation*	0.016	-0.048	-0.193	**1.219** **	97
Austria (CIS4)*	**0.168** **	0.138	-0.180	**0.278*** **	391
Austria (CIS3)	**0.182** **	0.011	0.044	**0.312*** **	359
Australia	0.120	**0.144*** **	-0.089	**0.557*** **	509
Belgium	**0.303*** **	0.002	**-0.119** **	**0.543*** **	718
Brazil	**0.183** **	**0.140*** **	**-0.211*** **	**0.647*** **	1 954
Canada	**0.250*** **	**0.077** **	**-0.122** **	**0.436*** **	2 273
Denmark	**0.186** **	**0.073*** **	-0.041	**0.345*** **	584
Finland	**0.244*** **	**0.086** **	-0.068	**0.314*** **	698
France	**0.232*** **	**0.054*** **	**-0.129*** **	**0.474*** **	2 511
Germany	**0.084** **	**0.063*** **	**-0.116*** **	**0.500*** **	1390
Italy	0.093	0.004	**-0.192** **	**0.485*** **	747
Korea	**0.152***	0.045	**-0.118***	**0.859*** **	628
Luxembourg	**0.434*** **	0.035	-0.142	**0.226***	207
Netherlands	0.022	**0.090*** **	-0.044	**0.409*** **	1 374
New Zealand	**0.128** **	**0.066*** **	**-0.135*** **	**0.682*** **	993
Norway	**0.256*** **	0.041	-0.072	**0.344*** **	672
Switzerland		**0.113*** **	-0.091	0.295	394
United Kingdom	**0.150*** **	**0.058*** **	**-0.121*** **	**0.550*** **	2 989

Notes: For Canada and Brazil the regressions are weighted to the population. Results are based on 2004 innovation surveys (CIS-4 for European countries), except for Austria which used CIS3 data and Australia where the innovation survey has 2005 as the reference year.
Belonging to a group; and having implemented process innovation are 0/1 dummies. Size is measured as log employment.
Industry dummies and inverse Mills ratio are included but not reported.
For Australia the group variable is imputed from responses to the question about whether the enterprise collaborated with other members of their group and is underreported as it omits enterprises that are part of an enterprise group but did not collaborate with other enterprises within the group on innovation projects.
For New Zealand information on innovation sales is codified as a categorical variable; to transform it to a continuous variable midpoints of each range are used and multiplied by total reported expenditure.
* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: OECD 2008 except for Thailand and Austria (CIS4) (own calculations)

6 Conclusion

The results of the OECD project and its extension to Thailand are not surprising, but remarkable clear and stable. The main message is: Large, international oriented firms that belong to an enterprise group have a higher probability to be innovative and invest more in innovation activities. In addition, firms receiving public financial support and participating in innovation cooperation show higher innovation expenditure. Moreover, innovation input positively correlates with innovation output, which in turn increases labour productivity. In contrast to expectations, the model does not find evidence for a positive impact of process innovation on productivity in any country.

These results also hold for Thailand with some noteworthy deviations:

- Firms with international business activities show neither a higher propensity of being innovative nor do they spend more on innovation than firms focusing on the domestic market. The reason could be that the international competitive advantage of Thai firms is based on (labour) cost advantages and not (as in most OECD countries) on innovative products.
- There is neither a positive effect by public financial support nor by the participation in innovation cooperation on innovation expenditure. Besides methodological problems, the cause could be seen in a lack of public financial innovation support. Moreover, the results support the notion of 'cooperation from weakness': in a less favourable environment (weak innovation system) firms with better innovation capabilities might stay away from cooperation in order to avoid unintended knowledge flows (i.e. loss), whereas less capable firms seek cooperation in order to pool limited resources.
- While there is no statistical link between innovation input (other than R&D) and output, the relationship between R&D- input and output is positive and highly significant, indicating a lack of efficiency in the innovation processes of Thai firms. Remarkably, the cooperation with universities and public R&D-institutes increases the R&D output significantly underlining the potential role of the public academic sector in upgrading firms' technological capabilities.

Appraising the empirical approach, it has to be underlined that the structural model is state-of-the-art accounting for selection bias and potential endogeneity problems. However, the modelling suffers from the fact that the innovation surveys only include very few information on firm characteristics, especially for non-innovative firms. This causes some problematic variable definitions (such as labour productivity based on sales instead of value added) and model specifications (obstacles to innovation as exclusion restrictions in the first stage of the model). Moreover, the international character of the project requires a trade-off between model-quality/ -sophistication and international comparability. For the sake of the latter, the model had to be elaborated using a 'least common denominator' approach.

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