Essays on Technology and Exporting by Indian Firms in a Globalised World

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Abstract

This thesis consists of three self-contained studies on technology and exporting of Indian firms in the post-liberalization era.

In Chapter 1, we describe the background of Indian economic reforms, provide a general introduction and motivation, and give a brief outline of the thesis.

Chapter 2 introduces the data, the variables used in the empirical estimations of the followed chapters, the sample selection steps, and presents some descriptive statistics.

Chapter 3 studies regional and national productivity convergence among manufacturing firms in India, using a panel data over the period 1999 to 2010. We find that firms are converging to both their national and regional frontier, and they converge faster to their national frontier than to the regional frontier. We pay attention to the effects of globalisation on the speed of convergence, and find that both export and outward FDI facilitates firms' productivity growth but slows down the convergence speed.

Chapter 4 investigates the role of financing sources on the joint decision to invest in technology and to export, for both manufacturing and service firms in India. We find that firms with higher internal financing are more likely to engage in technology investment and exporting, and this pattern is consistent between manufacturing and service firms. The effects of external financing sources are not statistically significant for manufacturing firms, but show a significant and positive effect on service firms' decision to undertake technology investments. We further investigate the impact of financial

reforms in India for the manufacturing firms, and find a weak effect of the financial reforms in reducing the effects of internal sources on exporting.

Chapter 5 summarises the main findings and implications of the thesis, and provides a short discussion of future research directions.

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Chapter 1

Introduction

1.1 Background

The last two decades have witnessed an unprecedented wave of globalisation in the world economy. Since 1991, triggered by a balance-of-payments crisis, India has launched a succession of economic reforms. These reforms have progressively moved the Indian economy away from its former national self-sufficiency strategy towards a market-based economic system, and eventually have allowed India to take part in the world globalisation process. The reforms include macroeconomic stabilization policies and structural reforms, covering trade policy, industrial and import licenses, the financial sector, tax system and so on (Khandelwal and Topalova, 2011). The Indian economy has responded well to the ongoing process of these reforms and experienced an impressive increase in growth, with an average annual GDP growth rate of 6.3%[1] over the period 1991-2009. This growth has been particularly rapid since 2003, averaging around 7.9%[2] per annum. Because of this rapid growth, India has become one of the largest developing economies in the world, this development owing much to this series of economic reforms.

Trade liberalization forms an important part of the recent Indian economic reforms. Prior to reform, the trade regime in India was highly protectionist, with high nominal tariffs and nontariff barriers. The earlier policy emphasized

[1] Author's own calculation based on data from the World Bank.
[2] Author's own calculation based on data from the World Bank.

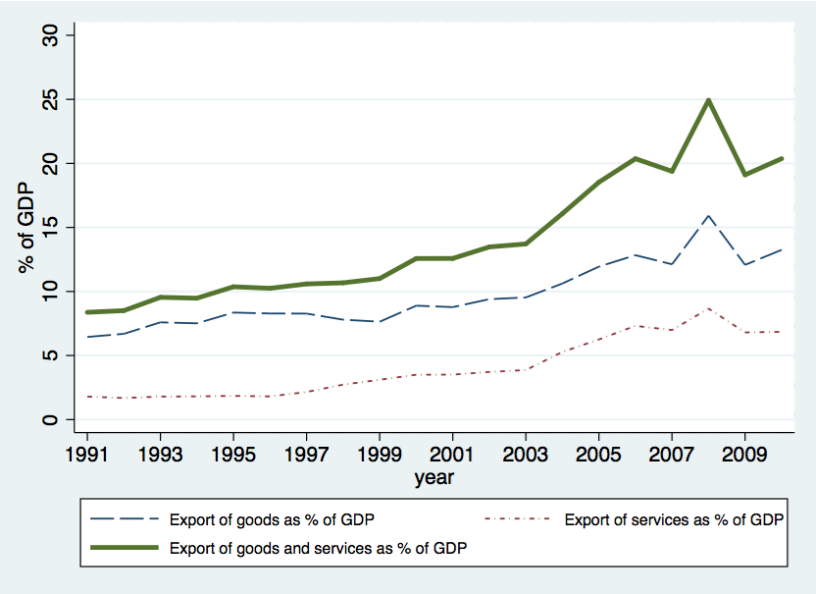
import substitution, which results in relatively rapid industrialisation and the development of heavy industry (Goldberg et al., 2010). Initial attempts at liberalization date from the late 1970s, and featured the gradual removal of quantitative import restrictions along with expansion in the open general license list of imports, but these changes constituted relatively limited reforms. The major thrust towards globalisation began in 1991. A major set of policies has been implemented to ease trade restrictions and promote exports, including the abandonment of the import licensing system, the reducing of tariff rates, the removal of restrictions on import quantities, and the liberalization of capital inflows and foreign direct investment (FDI). Specifically, the average tariff rate dropped from more than 80 percent in 1990 to 39 percent in 1996, and the import coverage of nontariff barriers decreased from 87% in 1987 to 45% in 1994 (Goldberg et al., 2010). In addition, the government has also been actively involved in trade negotiations and signed a number of bilateral and regional free-trade agreements to facilitate exporting.

Following these trade promotion policies, Indian export volumes have increased sharply since the 1990s, surging from US$23 billion in 1991 to US$260 [3] billion in 2009, and the country has been amongst the fastest-growing exporters in the world. The ratio of exports to GDP has also experienced a substantial rise over this period. Figure 1.1 shows the evolution of the share of exports of goods and services in GDP over the period 1991-2009. Exports accounted for a very small fraction in GDP prior to the reforms, and we observe from the figure that the ratio of total export of goods and services to GDP increases dramatically after 1991, especially after 2003, rising from around 13.7% in 2003 to 24.9% in 2008. A distinctive feature is the contribution of exports of services to this growth, increasing from a mere 1.7%

[3] Refers to total exports of goods and services, and the data is from the World Bank.

in 1991 to 8.6% of GDP in 2008. In particular, India has become a major supplier of software and IT-related services in the world.

Figure 1. 1 Evolution of exports as % of GDP



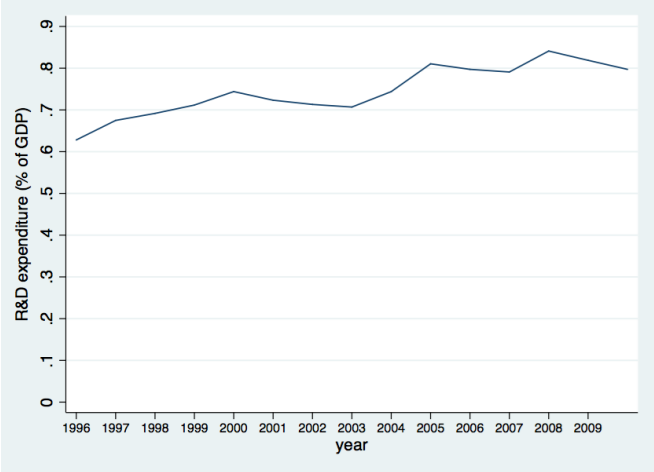
Notes: The figure shows the evolution of the share of exports of goods and services in GDP during 1991-2009.

Source: Author's own calculation based on the World Bank data.

With the liberalization of trade, Indian policy makers also relaxed restrictions on oversea investments to promote outward FDI (OFDI), with the belief that OFDI helps firms to improve productivity by gaining access to new technologies, managerial and other skills and other competitive assets from foreign countries. The new policy regime for OFDI began with the modification of guidelines for Indian joint ventures and wholly owned subsidiaries abroad which were issued in 1992. These were accompanied by a series of liberalizations of the rules during last decade, which has effectively allowed Indian firms to invest abroad. The OFDI stock has increased from US$124 million in 1990 to US$1,859 million in 2000, and further surged to US$61,756 million in 2008.

Technology has been seen as an important source of productivity growth. Along with the promotion of exports and OFDI, the Indian government also has made great effort to encourage technology investment. Figure 1.2 shows the ratio of R&D expenditure to GDP in India. From around 0.62% in 1996, this ratio gradually increases to 0.84% in 2008. However, this number is still much lower when compared with some other developing countries such as China where the ratio was 1.46% in 2008.

Figure 1. 2 Evolution of R&D as % of GDP



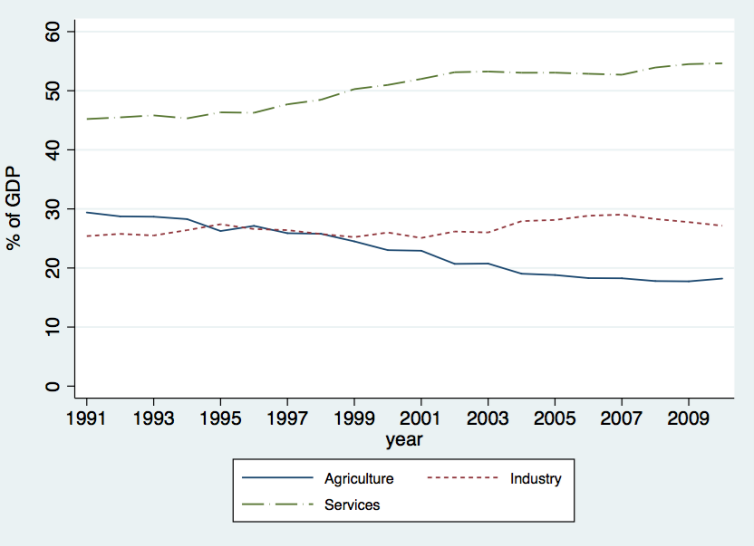
Notes: The figure shows the evolution of the share of R&D expenditure in GDP during 1996-2009.

Source: Author's own calculation based on the World Bank data.

Unlike many other developing countries, a notable feature of the Indian economy is the development of its service sector. Services constitute a large part of the Indian economy in terms of employment as well as its contribution to the national income (Das & Raut 2014). Figure 1.3 presents the occupation of agriculture, industry and services, respectively, in GDP during 1991-2009. We can see that services accounts for a substantial part of Indian GDP, especially after 1999, with an contribution of more than 50%. The growth in output in this particular sector has mostly come from the rapid development of

more skill intensive services in the information technology and professional service sectors (Das & Raut 2014).

Figure 1. 3 Evolution of industry structure in India



Notes: The figure shows the evolution of the share of agriculture, industry and services, respectively, in GDP during 1991-2009.

Source: Author's own calculation based on the World Bank data.

1.2 Motivation and objectives

Rapid globalisation, featuring high growth rates for exports and fast expansion of OFDI by Indian firms gives rise to concern about the relationship between globalisation and firm behaviour. This thesis aims to deliver some new empirical insights into the relationship between globalisation and firm behaviour in a context of the Indian post-liberalization era, and seeks to draw policy implications for India and other developing countries.

A massive literature has explored the effects of exporting on firm performance. Based on the existing findings (Van Biesebroeck, 2005; Loecker, 2007), most trade economists agree that exporting requires and stimulates firms'

productivity growth. With respect to OFDI, the theoretical work also predicts that only the most productive firms engage in OFDI (Melitz, 2003). Whether OFDI helps to improve firm productivity has not been explored much. A further concern regarding the influence of globalisation on the convergence of firm productivity growth, especially on regional productivity convergence, has not received much attention. The empirical literature on this aspect is still limited with mixed results. Chevalier et al. (2012) find that globalisation slows down the convergence process for French firms, while Iacovone and Crespi (2010) show that trade facilitates the speeding up of Mexican firms convergence to the national frontier.

Given the restricted number of empirical studies analysing the relationship between globalisation and productivity convergence, Chapter 3 is devoted to study the role of globalisation on firm productivity convergence in the context of India. We investigate the process of firms' productivity convergence to both of their national and regional frontiers, and explore whether firms converging faster to their national frontier or to their regional frontier. We examine the role of exporting and outward FDI in fashioning the process of convergence, and whether these features of globalisation facilitate or hinder the speed of convergence.

A major reason for Indian government wishing to promote exporting is based on the belief that by participating in foreign markets firms may acquire new technologies and skills which are required to improve productivity and achieve better economic performance in a competitive world economy. The recent literature indicates a two-way relationship between technology and exporting, and suggests that firms are likely to make their technology investment and exporting decisions simultaneously (Aw et al., 2007; Lileeva and Trefler, 2010; Aw et al., 2011; Bustos, 2011).

For a long time, international trade and technology investment have been strongly associated with manufacturing firms, with these activities by service firms tending to be neglected or under-researched in the literature. Even though there has been growing recognition of the importance of services in the economy in recent decades, little is known about the behaviour towards exporting and technology investment of services firms, or about the factors that determine service firms' ability to engage in these activities. Besides the nature of services, another important reason for this gap in the literature is often the unavailability of data on services firms' trade and technology investment decisions.

In light of the rapid growth of exporting and gradual rise of technology investment in India, and firms' joint decision of technology and exporting shown in the literature, Chapter 4 seeks to investigate the role of financing sources on the joint decision about technology investment and exporting, for both manufacturing and service firms, given the impressive contribution of manufacturing and service sector on the Indian economy and the rapid growth of exports in these two sectors. The context of India offers a distinctive and invaluable opportunity for studying the decisions of both manufacturing and services firms regarding technology investments and exporting, and the factors that affect firms' participation in these activities. We compare of the effects of internal and external financing, and see whether pecking order theory about alternative sources of finance holds for Indian manufacturing and service firms, and make some comparison between decision making on these issues in the services and manufacturing sectors.

1.3 Contributions and structure of the thesis

This thesis consists of three core chapters and contributes to the empirical literature on globalisation and firm behaviour by examining technology and exporting of Indian firms. Each chapter addresses a specific topic and is therefore presented as self-contained empirical investigation, but there is a certain degree of inter-connection between the studies under the broad theme of globalisation and firm behaviour of Indian firms.

Chapter 2 introduces the data, the variables used in the empirical estimations of the followed chapters, the sample selection steps, and presents some descriptive statistics.

Chapter 3, entitled "Globalisation and Regional Productivity Convergence: A Firm-level Analysis from India", studies the process of firms' productivity convergence to both of their national and regional frontiers, paying particular attention to the role of export and outward FDI. We employ panel data of Indian manufacturing firms from 13 major states and 1 territory over the period 1999 to 2010. This chapter extends the literature by studying firm level productivity convergence to national frontier as well as to regional frontier. By contrast, previous firm-level studies have mainly focussed on convergence to the national frontier. In addition, we add to the literature by providing evidence on the effects of globalisation on productivity convergence, which has not been comprehensively previously explored in the case of India, especially regarding the role of outward FDI. We find that firms are converging to both their national and regional frontier, and they converge faster to their national frontiers than to the regional frontiers. In line with the previous literature, we find that globalisation facilitates firms' productivity growth but slows down the convergence process.

Chapter 4, entitled "Financing Sources, Technology investment and Exporting Decisions", explores the role of financing sources on firms' joint decisions to invest in technology and to export, for both manufacturing and service firms. The existing empirical studies have mostly tended to focus on each of these decisions separately of the firm, while we contribute to the literature by looking at them together. In addition, technology investment and exporting have traditionally been strongly associated with manufacturing firms, while these activities by service firms have been given little or no attention. This chapter is to my knowledge the first to explore the link between financing sources, technology investment and exporting for services firms. We compare the effects of internal and external sources, which in turn allows us to infer whether the pecking order theory on financing sources holds for Indian manufacturing and service firms. By estimating a dynamic bivariate probit model based on panel data of Indian manufacturing and service firms, we find that firms with higher internal financing are more likely to engage in technology investment and exporting, and this pattern is consistent between manufacturing and service firms. The difference between this two sectors is that the effects of external financing sources are not statistically significant for manufacturing firms, while it has a significantly positive effect on services firms' technology investment decisions. When disaggregating the external sources, we find that this effect is mainly associated with bank loans. We investigate the effects of financial reforms initiated from the 1990s, and find a weak effect of the financial reforms in reducing the effects of internal sources on exporting. Further, our results also suggest that the export of modern service firms are less dependent on external sources, while technology intensive firms are less sensitive to internal financing sources.

Finally, Chapter 5 summarises the main findings and implications of this thesis, and points to some possible directions for future research.

Chapter 2

Data

2.1 Data source

The data used in this thesis is collected from the Prowessdx database which is compiled by the Centre for Monitoring the Indian Economy (CMIE), India. The Prowessdx database is one of the most comprehensive firm-level databases in India, and it contains annual financial statements of listed companies, unlisted public companies and private companies of all sizes and ownership groups belonging to manufacturing, services, financial sectors, and other utilities. The firms covered by this database account for more than 70% of industrial output, 75% of corporate taxes and more than 95% of excise taxes collected by the government. This database contains 37 parts, including detailed information of firms' identity (i.e. company name, ownership, incorporation year, industry, main product/service name etc.), history of company name changes, board meetings, equity ownership pattern, standalone annual financial statements, consolidated annual financial statements, credit ratings and so on.

The Prowessdx database is an annual subscription-based service and it provides data from 1988 onwards till most recent years. We subscribed this database in 2014 and collected the data from 1988 to 2013. However, the number of firms are quite few before 1999, and many firms miss data information after 2010. Therefore, we concentrate on the period of 1999 to 2010. The data used in this study is mainly compiled from the standalone annual financial statements.

2.2 Measurements of the key variables

We introduce the measurements of the main variables used in this thesis. All the continuous variables are deflated by Indian wholesale price index based on financial year 1993-1994, provided by the Office of the Economic Adviser, India Ministry of Commerce and Indutry.

Productivity (TFP)

We employ total factor productivity (TFP) to measure productivity, and adopt the Levinsohn and Petrin (2003) approach to estimate and calculate TFP. To construct TFP, it requires firms' capital stock, intermediate inputs, value added and employee numbers. The measurements of these variables are followed.

Capital stock

The capital stock is measured by net fixed assets. The Prowessdx define net fixed assets as the net value of the fixed assets of a company after adjusting for additions/(deductions) to gross fixed assets and the cumulative depreciation on gross fixed assets.

Intermediate inputs

The intermediate inputs variable is calculated by aggregating the amount of raw materials and imported raw materials.

Value added

The value added variable equals sales minus intermediate inputs.

Employees

A main limitation of our dataset is that most firms miss the information of employee numbers, while the majority of them report wages. We therefore, use wages as a proxy when constructing our measure of TFP, and test the validity of using wages in the appendix of chapter 3.

Inverse Mills ratio

We model a firm's exit decision as a function of productivity, firm size, age, capital stock, technology investment, the ratio of debt and equity, inward foreign investment, outward foreign investment, and export.

Exporting (EX)

For the manufacturing firms, the export is measured as total export which equals the sum of exports of goods and services. The export intensity is measured as the ratio of total export to sales. The dummy of exporting equals 1 if firms export goods or services or both during a financial year, otherwise 0. For service firms, export refers to the export of services, and the dummy of exporting equals 1 if firms export services during a financial year, otherwise 0. In our data, export of services means services which are provided to a customer outside India. Generally, companies report earnings from export of services under the nomenclatures, technical knowhow, service charges, royalty, professional and consultation fees, etc.

Outward foreign direct investment (OFDI)

OFDI is measured by the total value of all investments made by the firm in group companies outside India. The dummy of OFDI equals 1 if firms conduct OFDI, otherwise 0.

Measurements of technology investment

a. R&D investment (R&D)

In Chapter 4, we measure the technology investment of manufacturing firms as Research & Development (R&D) investment. We employ the expense on Research & Development to proxy to R&D investment. The Prowess database reports information of R&D on the current account, capital account as well as the total expenditures of the two. We use the total expenditures incurred on both capital account and current account to acquire the total expenses of the company on R&D. The R&D intensity is measured as the ratio of R&D expense to sales. The dummy of R&D equals 1 if a firm shows positive value of R&D, otherwise 0.

b. Broad technology investment (Tech)

Although some services have a high technological capability, Research & Development (R&D) is still mainly carried out by manufacturing sector. In our services dataset, there are only around 1.3% of service firms engaging in R&D investment. Therefore, we use both R&D investment and other purchased technology to proxy to technology investment in services. Sirilli and Evangelista (1998) summarize the following four characteristics that are thought in the literature to have direct implications for technology investment in services.

1. a close interaction between production and consumption (co-terminality);
2. a high information–intangible content of services products and processes;
3. an important role played by human resources as a key competitive factor;
4. a critical role played by organisational factors for firms' performance.

According to these criteria, we measure technology investment as a sum of research & development expenses (capital & current account), royalties, technical know-how fees, etc., forex spending royalty/technical knowhow, software additions, and computer systems additions.

In order to make it comparable between manufacturing and services, we also calculate this broad technology investment for manufacturing firms using the same criteria for services.

Financing sources (FIN)

We measure internal financing sources using firms' retained profits during the year, which has been used in the literature (Girma and Vencappa, 2014). In our dataset, this indicator is "Profit retained/Loss' during the year", we replace the loss (negative values) to zero. This is reasonable as 'Loss' means no profits retained in that year, as they are both likely to bear similar effects on the two regressands. The external sources are measured as the total borrowings. We disaggregate the external sources into three broad categories and later we investigate their individual effects as well. The first is government borrowings, including secured and unsecured borrowings from central and state governments. The second is secured and unsecured loans from banks and financial institutions, termed bank loans for our purpose. The third is non-bank loans including hire purchase loans, deferred credit, debentures and bonds, borrowings syndicated across banks & institutions, loans from promoters, directors and shareholders, Inter-corporate loans, commercial papers, fixed deposits, foreign currency borrowings and other borrowings. The financing source variables are in their natural logarithm.

Size

Size is measured by firms' total assets. In chapter 3, size is expressed in natural logarithm. In chapter 4, since the logarithm of size is correlated with financing sources variables, and the scale of total assets is large, the effect of its one unit change on the likelihood of export and technology investment is trivial, therefore, we measure size as total assets divided by the mean value of total assets of all observations.

Age

Age is measured as the current year minus firms' incorporation year.

Ownership

We category firms into four ownerships, namely, private firms without group affiliations, foreign firms, private firms with group affiliations, and state-owned firms.

Other controls

The other controls used in this study include import of raw materials, import of capital goods and import of services, and these variables are expressed in natural logarithm.

2.3 Construction of the sample

We create a sample of manufacturing and services firms from 1999 to 2010. Generally, we clean the dataset by excluding observations according to the following criteria (Wang and Yu, 2012):

1. Observations with missing or zero value of sales and total assets;

2. Observations with negative values of the following variables: exports, imports, raw materials, total assets;

3. Observations with total assets less than total fixed assets, or with total sales less than exports.

4. Observations with missing incorporation year or incorporation year being greater than year.

And we further clean the data for each of the study according to the individual research purpose.

2.3.1 Sample for productivity convergence

The Prowess database provides information of the different states in which firms are located. This information allows us to evaluate the speed of productivity convergence of Indian manufacturing firms towards their national and regional frontiers, which is a central objective of Chapter 3. It is worthwhile to mention that India includes 28[4] states and 7 union territories. Of these states, 14[5] are traditionally regarded as major states based on their Gross State Domestic Product, population and geographical size. These 14 states contribute about 70% of India's GDP and 87% of its population, which means results of these major states would be representative of the Indian economy (Shingal 2010). We exclude the non-major states in India from our empirical analysis as very few firms in our dataset are located in these states and we would have very few observations to conduct any meaningful empirical analysis. With the exception Delhi, in our empirical approach we include the union territories in India (which are usually cities) as part of the states in which they are located in or close by[6]. In our empirical analysis we focus on the 13

[4] Telangana was separated from Andhra Pradesh in June 2014, so India has 29 states now. But as our study period is 1999-2010, we treat Telangana as part of Andhra Pradesh.

[5] The 14 major states in India are Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

[6] To be specific, we took "Chandigarh" as part of Punjab, "Dadra and Nagar Haveli" and "Daman and Diu" to Gujarat, "Pondicherry" to Tamil Nadu; "Andaman and Nicobar" and "Lakshadweep" are small islands with no data and were ignored in this study.

major states in India (excluding Bihar, as it is a service-oriented state) plus the capital territory, Delhi, as listed in Table 2.1.

We first construct our total factor productivity (TFP) variable. A main limitation of the dataset is that it does not report information on the number of employees for most of the firms. We therefore, use wages as a proxy. We exclude observations with missing or zero value or less than zero value of wages and net fixed assets, and observations with missing value of raw materials. To control for outliers, we excluded observations in the 0.1% tails for each of the variables that employed to calculate TFP, namely, sale, net fixed assets, wage, raw materials, imported raw materials. We adopt the Levinsohn and Petrin (2003) approach to estimate TFP, and we exclude the observations with missing TFP values and further delete the observations in the upper and lower 0.1% for the TFP that we calculated, and other continuous variables that included in the empirical estimation.

Finally, we base our analysis on an unbalanced panel dataset that include 7142 manufacturing firms with 43918 observations spanning over a period of 12 years, from 1999 to 2010. In our empirical analysis we calculate the productivity frontiers based on the 10 two-digit manufacturing industries included in the Prowessdx dataset and the year. We regress on the lagged values of the distance between frontiers and the laggards, and we drop the frontiers in the regressions. Therefore, the number of the observations in the empirical results are fewer than 43918.

Table 2. 1 List of states in this study

	name	type	obs
1	Andhra Pradesh	major state	3262
2	Gujarat	major state	4704
3	Haryana	major state	1125
4	Karnataka	major state	1780
5	Kerala	major state	1096
6	Madhya Pradesh	major state	829
7	Maharashtra	major state	11338
8	Orissa	major state	496
9	Punjab	major state	1896
10	Rajasthan	major state	1242
11	Tamil Nadu	major state	5589
12	Uttar Pradesh	major state	1515
13	West Bengal	major state	3774
14	Delhi	National Capital Territory	5272

Notes: This table shows the regions that studied in chapter 3. "obs" refers to the number of observations in each region.

2.3.2 Sample for financing sources, technology investment and exporting decisions

The main interest of this chapter is to explore the role of financing sources on firms' joint decision to invest in technology and to export. We exclude observations with negative values of the borrowings. Since manufacturing and service firms are different in many aspects, we clean the datasets separately.

2.3.2.1 Manufacturing firms

As productivity is a crucial factor in driving firm exporting, we employ total factor productivity (TFP) as a control variable in our empirical analysis. We

first construct the TFP variable, as sample selection in Chapter 3, we exclude observations with missing or zero value or less than zero value of wages and net fixed assets, and observations with missing value of raw materials, and exclude observations in the 0.1% tails for each of the variables that employed to calculate TFP. We adopt the Levinsohn and Petrin (2003) approach to estimate and calculate TFP. We drop those observations with missing TFP values.

To address correlated unobserved firms' heterogeneity in the empirical estimation, we follow Máñez et al. (2014) using the fixed effects approach developed by Blundell et al. (1999, 2002) which show that the pre-sample means of the dependent variables are sufficient statistics for the unobserved fixed effects. Therefore, we treat 1999-2001 as pre-sample period and estimate for the period of 2002-2010.

To control for outliers, we excluded observations in the 0.1% tails for each of the continuous variables in the empirical regressions, namely, financing sources variables, TFP, total assets, imported capital goods. We drop firms without pre-sample information and we test the validity of this restricted sample in the appendix 4.3.

Finally, we are left with an unbalanced panel dataset including 3205 manufacturing firms (21,356 firm-year observations) from 2002 to 2010. Since the regressors are regressed on their one-year lagged values, there are 2981 firms with 17,299 observations in the regressions. All data are deflated by wholesale price index based on financial year 1993-1994.

2.3.2.2 Services

We exclude firms that belongs to Non-banking finance companies and Banking companies, and we also exclude the industries of trading, retail trading,

electricity distribution and other construction & allied activities. We also exclude observations that export goods.

We employ an empirical strategy similar to the manufacturing firms to control for correlated unobserved firms' heterogeneity. That is to include the pre-sample means of the dependent variables as additional regressors. However, since around two thirds of observations in the services sample have missing information during 1999-2001, which is used as the pre-sample period in the manufacturing firms, we shorten our estimation period to the years 2005-2010 and treat 2001-2004 as the pre-sample period.

We excluded observations in the 0.1% tails for each of the continuous variables in the empirical regressions to control for outliers. We drop those observations without pre-sample information, and we test the validity of this approach shown in the appendix 4.3. Therefore, we are left with an unbalanced panel dataset including 2290 service firms with 10340 observations during 2005-2010. Although we have 10340 observations, the model will only be estimated for 7702 of them with 2080 firms, because we regress on lagged variables and lose the data for 1 year.

2.4 Data Description

In this section, we provide some general statistics of our samples. Table 2.2 and 2.3 presents summary statistics of TFP, TFP growth rate, regional gap and national gap by industry and ownership respectively for the manufacturing sample used in Chapter 3. From table 2.2 we can observe that TFP and TFP growth varies across industries. The industries of food products and basic metals alloys & metals products see relatively higher level of TFP and TFP growth, while Cement and other Non-Mettallic Mineral Products show lower

average TFP but higher growth rate than other industries. We can find from table 2.3 that state-owned firms show the lowest TFP and TFP growth rate among the four ownerships, while private firms with group affiliations enjoy the highest TFP and TFP growth rate, indicating the inefficiency of state-owned firms in India.

Table 2.4 and 2.5 report the average financing sources by firm ownership for our manufacturing and services samples respectively used in the empirical analysis. For manufacturing firms, we can see that foreign firms have more internal financing, while private with group affiliations have more bank loans and nonbank loans. For service firms, foreign firms gain relatively more bank loans and nonbank loans. We can also find that for both manufacturing and services, state-owned firm have relatively more government loans, suggesting that state-owned firms have the advantage in gaining government funds. More descriptive statistics are provided in each individual studies.

Figure 2.1 shows the proportion of firms that export in our manufacturing sample and services sample respectively during 1999-2010. We can observe that more than half of the manufacturing firms export during this period, while the proportion of service firms that export is much lower at around 25%. Figure 2.2 and 2.3 show the proportion of manufacturing firms and service firms that invest in R&D and technology investment respectively over time from 1999-2010. Figure 2.2 illustrates that around 20% manufacturing firms conduct R&D investment while very few service firms directly participate in this activity. From figure 2.3 we can see that both manufacturing firms and service firms experience an upward trend in the involvement in technology investment. We explore more about Indian firms technology and exporting behaviours in the following studies.

Table 2. 2 Summary statistics by industry

Industries	obs	lnTFP	Std.Dev.	△lnTFP	Std.Dev.	lnGAP_NA	Std.Dev.	lnGAP_state	Std.Dev.
Food Products	3256	2.171	1.08	0.00555	0.688	3.19	1.14	2.279	1.189
Textiles & Leather Products	8190	1.766	0.954	-0.0132	0.57	3.622	1.006	2.45	1.182
Paper & Wood Products	2521	1.648	0.848	-0.0012	0.588	2.437	0.94	1.468	0.988
Chemicals & Chemical Products	7833	1.644	0.922	-0.0219	0.602	3.542	0.956	2.445	1.173
Rubber & Plastic Products	3536	1.977	0.859	-0.03	0.532	2.692	1.079	1.628	0.968
Cement and other Non-Mettallic Mineral Products	2001	1.604	1.046	0.0386	0.591	3.825	1.076	2.015	1.492
Basic Metals Alloys & Metals Products	6660	1.979	1.012	0.0184	0.653	3.226	1.148	2.206	1.181
Machinery & Machine Tools	6288	1.231	0.9	-0.0195	0.616	2.868	0.945	2.02	1.025
Transport Equipment & Parts	3105	1.979	0.725	-0.00396	0.418	2.25	0.951	1.465	0.847
Misc. Manufactured Articles	528	1.567	1.019	-0.0326	0.601	2.323	1.174	1.377	1.047

Note: The sample includes 43918 observations in manufacturing over the period 1999-2010 used in Chapter 3. The national frontier is the firm with the highest TFP level in an industry in a year, and the regional frontier is the firm with the highest TFP level in the state in an industry and year. The term of "△lnTFP" refers to average TFP growth rate The term of "lnGAP_NA" ("lnGAP_state") is the average gap between national frontiers (regional frontiers) and laggards.

Source: Authors' calculations using the dataset.

Table 2. 3 Summary statistics by ownership

ownership	obs	lnTFP	Std.Dev.	△lnTFP	Std.Dev.	lnGAP_NA	Std.Dev.	lnGAP_state	Std.Dev.
Private without group affiliations	29436	1.716	0.985	-0.0098	0.621	3.226	1.127	2.17	1.175
Foreign firms	1458	1.728	0.888	-0.00743	0.541	2.861	1.082	1.996	1.135
Private with group affiliations	11682	1.854	0.94	0.000483	0.534	3.024	1.099	2.032	1.177
State-owned firms	1342	1.463	1.039	-0.0316	0.585	3.295	1.191	1.899	1.276

Note: The sample includes 43918 observations in manufacturing over the period 1999-2010 used in Chapter 3. The national frontier is the firm with the highest TFP level in an industry in a year, and the regional frontier is the firm with the highest TFP level in the state in an industry and year. The term of "△lnTFP" refers to average TFP growth rate The term of "lnGAP_NA" ("lnGAP_state") is the average gap between national frontiers (regional frontiers) and laggards.

Source: Authors' calculations using the dataset.

Table 2. 4 Financing sources by ownership: manufacturing

ownership	internal sources	external sources	government loans	bank loans	non-bank loans
Private without group affiliations	1.566	3.832	0.0641	3.344	2.164
Foreign firms	2.746	3.631	0.00634	2.841	2.269
Private with group affiliations	2.652	4.993	0.102	4.388	3.269
State-owned firms	1.978	5.035	2.206	3.287	2.678

Notes: The table shows the financing sources by ownership for a sample of Indian manufacturing firms during the period of 2002-2010. The financing sources are in natural logarithm.

Source: Authors' calculations using the dataset.

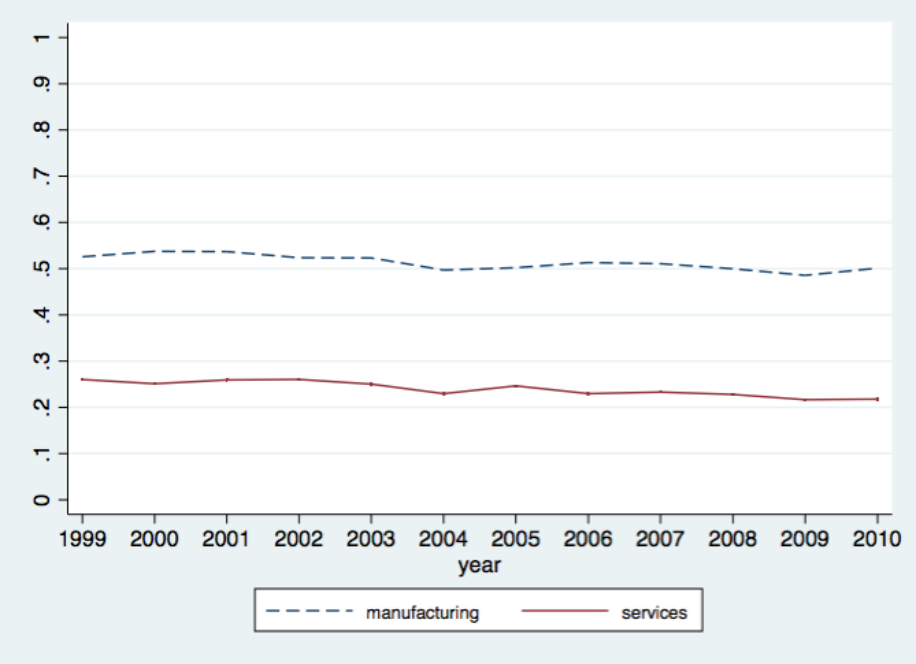
Table 2. 5 Financing sources by ownership: services

ownership	internal sources	external sources	government loans	bank loans	non-bank loans
Private without group affiliations	0.998	1.851	0.0165	1.275	1.103
Foreign firms	2.103	3.209	0.0127	2.148	2.256
Private with group affiliations	1.887	3.077	0.0148	2.059	2.15
State-owned firms	2.107	3.675	1.268	2.11	2.039

Notes: The table shows the financing sources by ownership for a sample of Indian services firms during the period of 2005-2010. The financing sources are in natural logarithm.

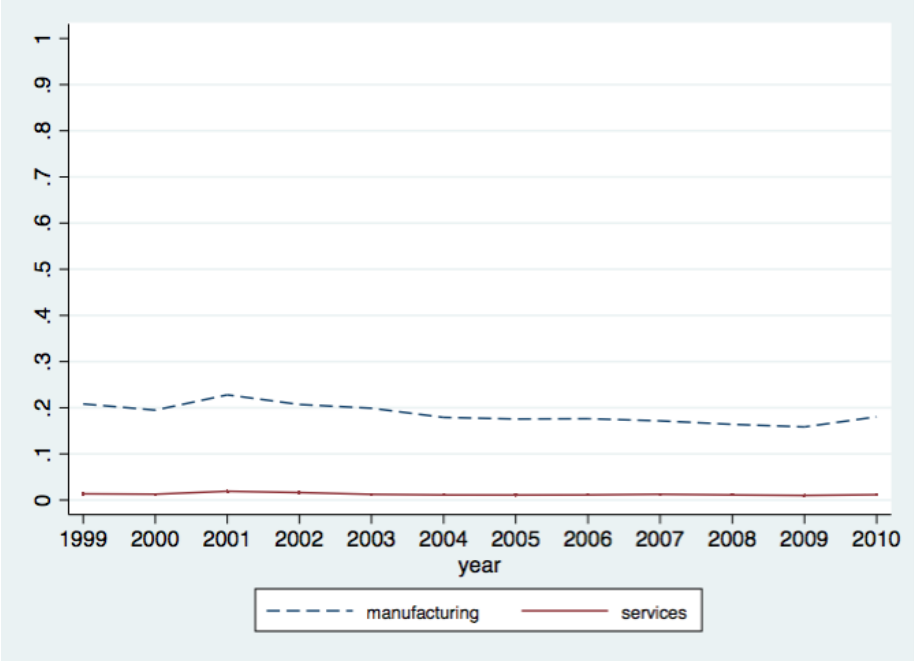
Source: Authors' calculations using the dataset.

Figure 2. 1 Proportion of exporters



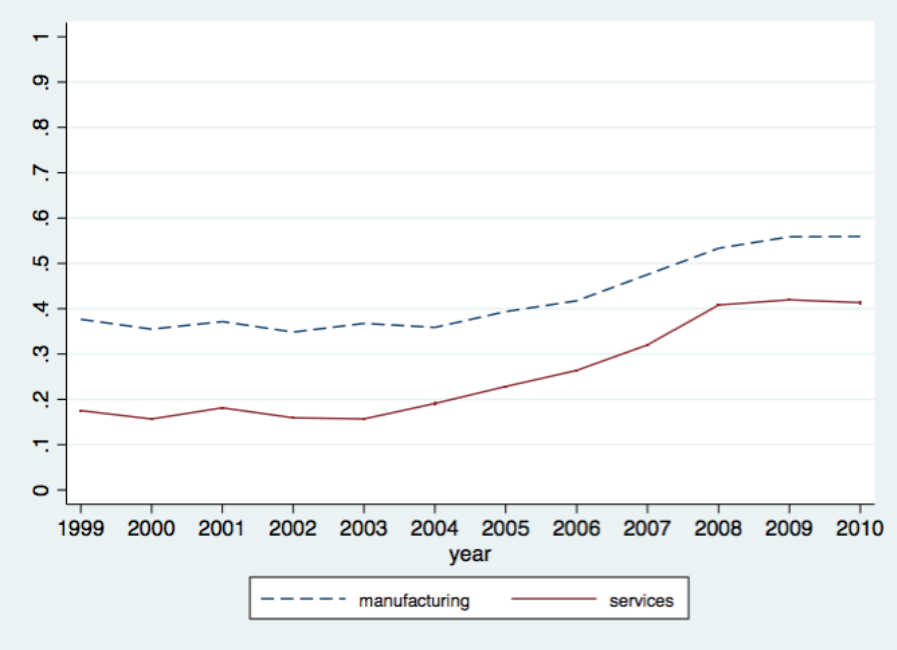
Notes: The figure shows the proportion of firms that are exporters in a sample of Indian manufacturing and services firms respectively during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Figure 2. 2 Proportion of firms investing in R&D



Notes: The figure shows the proportion of firms that invest in R&D in a sample of Indian manufacturing and services firms respectively during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Figure 2. 3 Proportion of firms investing in technology



Notes: The figure shows the proportion of firms that invest in technology (broad measure) in sample of Indian manufacturing and services firms respectively during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Chapter 3

Globalisation and Regional Productivity Convergence: A Firm-level Analysis from India

3.1 Introduction

In the macroeconomic literature of economic growth, productivity convergence is a process in which poor economies tend to grow faster and converge to rich economies, because of technological diffusion from the leaders to the followers (Barro and Sala-i-Martin 1992; Barro and Sala-i-Martin 1997). Much of the existing literature investigates cross-country productivity convergence and finds mixed results. For example, Bernard and Jones (1996) find little evidence of productivity convergence in the manufacturing sectors of 14 OECD countries, while Lee (2009) shows significant convergence in manufacturing sectors of 25 OECD countries. However, as emphasized by Pascual and Westermann (2002), it is important to compare industries which use similar technologies when analysing productivity convergence, as studies at the sectoral level still hide diverse industrial behaviour. Investigating how firms converge to their industry leader is therefore more informative. This is so since the transfer of technology occurs mainly through activities among firms.

Despite its importance, there has been little empirical work examining productivity convergence among firms. These few firm-level studies have mainly focused on how firms converge to their national frontier (Nishimura et

al., 2005; Girma & Kneller, 2005; Chevalier et al., 2012), while the issue of productivity convergence to the regional frontier has tended to be ignored. Regional productivity convergence is important because firms located in the same region share many common local characteristics, such as language, culture, and natural resources, etc., which might facilitate productivity convergence. In addition, the close spatial distance between firms in the same region would assist technology transfer among them. Given this, it is expected that the speed of convergence is faster to the regional frontier than to the national frontier. However, with the distance to the national frontier being generally larger than to the regional frontier, this provides more scope for convergence, and importantly the regional frontier may not be advanced enough for firms to converge. In this case, the convergence speed to the national frontier should be much higher. Which effect dominates is a question to be explored.

This chapter fills a literature gap by studying the productivity of lagging (non-frontier) firms' convergence to both the national frontier and the regional frontier. We also pay particular attention to the role of globalisation, which is measured by export and outward foreign direct investment (OFDI). Specifically, we conjecture that globalisation probably help improve firms' productivity growth rate but slow down the speed of convergence. This is because globalisation activities are largely confined to the most productive firms, where the positive effects of globalisation may have bigger impact on these most productive firms.

We study both national and regional productivity convergence in India, using a firm level manufacturing panel data across 14 Indian regions (13 states and 1 territory) from 1999 and 2010[7]. Our analysis extends the literature in two dimensions. First, we study how firms converge to the regional frontier and the

[7] In India, a financial year is from April 1st this year to March 31st the next year. Wherever we refer to a calendar year in this study, it actually represents this corresponding financial year. For instance, a reference to 1998 would indicate the financial year starting in April 1998 and ending in March 1999.

national frontier, while previous firm-level studies mainly investigate how firms converge to the national frontier only. Second, we study the effects of globalisation on productivity convergence, paying particular attention to the role export and OFDI, which are both important for India since Indian firms have been active in exporting and investing abroad.

Based on the macroeconomic literature of economic growth, we employ a framework of productivity convergence proposed by Bernard and Jones (1996) and Cameron et al. (2005), which has been widely used in studying productivity convergence. We use total factor productivity (TFP) as a measure of productivity.

The results of this chapter show that the Indian manufacturing firms converge to both their national and regional frontier. We find that firms converge faster to their national frontier than to their regional frontier. This is mainly because national frontier has higher productivity which provides larger scope to convergence, while the regional frontiers in some states are not that productive. Further, the examination of the effects of globalisation on productivity growth and convergence show that globalisation facilitates firms' productivity growth; but it slows down the speed of convergence. We also find that private and foreign firms converge faster than state-owned firms.

3.2 Literature review

3.2.1 The measurement of productivity

One concern of this study is the measure of productivity. Some studies use labour productivity. However, this measurement has some limitations on the depth of the analysis (Bernard and Jones, 1996). One main problem is its sensitivity to the capital intensity of firms. A change in the share of labour inputs in production would change the productivity of labour. In addition,

capital-intensive firms tend to have higher labour productivity than their labour-intensive counterparts, but this do not necessarily mean that labour-intensive firms would find it difficult to survive and develop compared to capital-intensive firms. To this end, we employ total factor productivity (TFP) as the measure of productivity in this study.

The estimation of TFP at the micro level has long been a concern for economists. Usually, one assumes that the production takes the form of a Cobb-Douglas production function and the TFP is obtained as the Solow residual. The traditional OLS estimation of the production function suffers from two major econometric issues. One problem is simultaneity bias or endogeneity, which resulted from the correlation between inputs decision and productivity. Another problem is the selection bias, which is due to the correlation between the exit decision and productivity. To address these problems, Olley and Pakes (1996) (O-P for short) propose a semi-parametric estimation approach, using investment to proxy for unobserved productivity shocks and incorporating firm's exit decision in the model. The O-P approach performs well in practice, but one problem is that the investment proxy is only valid for firms reporting positive investment, which will result in a significant loss in efficiency if many firms report zero investment.

Levinsohn and Petrin (2003) (L-P for short) extend the O-P approach by using intermediate inputs instead of investment to proxy for unobserved productivity shocks. This method works well because firms almost always report positive use of intermediate inputs. Many studies employ this method to compute TFP (Khandelwal and Topalova, 2011; Girma and Vencappa, 2014). Since around half of the observations in our dataset report zero investment, we adopt the Levinsohn and Petrin (2003) approach to estimate and calculate TFP.

3.2.2 Productivity convergence

The concept of convergence is from neoclassical growth theory, which proposes that poor economies tend to grow faster than rich economies in terms of per capita income and product because of diminishing returns to capital (Solow, 1956). Barro and Sala-I-Martin, X (1997) emphasize that technological diffusion is an important source of economic growth for countries behind the technological frontier because copying or imitation is typically cheaper than invention. The relatively low cost of imitation makes followers grow relatively fast and converge to the leaders. Barro, and Sala-I-Martin (1992) point out that it is possible to find convergence effects associated with technological diffusion in an open economy even if the returns to capital are constant. Howitt (2000) shows that countries that are further behind the technology frontier find it easier to improve upon their current technology and catch-up.

Most literature investigates convergence at the aggregate level among countries or regions (Bernard and Jones, 1996; Esteban, 2000; Aiello and Scoppa, 2008; Villaverde and Maza, 2008; Lee, 2009). For example, Bernard and Jones (1996) investigate productivity convergence of 6 sectors in 14 OECD countries and find little evidence of productivity convergence in manufacturing. Villaverde and Maza (2008) show weak convergence at aggregate and sectoral levels among European regions for the period of 1980-2003, and it also indicates that geographic location matters. Aiello and Scoppa (2008) show conditional convergence in Italian regions. There are also studies of productivity convergence at the industry-level. For example, Cameron et al. (2005) analyse productivity growth for a panel of 14 UK manufacturing industries and find that other things equal, the further an industry lies behind the technological frontier, the higher its rate of TFP growth.

The productivity convergence at the firm-level has been drawn growing attention recently. A few firm-level empirical studies have found evidence of productivity convergence to their national frontiers (Nishimura et al., 2005; Girma and Kneller, 2005; Peri and Urban, 2006; Álvarez and Crespi, 2007; Chevalier et al., 2012). For instance, Nishimura et al. (2005) find strong evidence of productivity convergence among firms in most industries in Japan. Girma and Kneller (2005) show firm-level productivity convergence in the UK service sector. Álvarez and Crespi (2007) find productivity catching-up in Chilean manufacturing.

Some works comparing productivity convergence to the global[8] frontier and the national frontier show that firms tend to convergence faster to the national frontier than to the global frontier (see Bartelsman et al., 2008 for UK firms; Iacovone and Crespi, 2010 for Mexican plants). Bartelsman et al. (2008) explore the productivity convergence process of UK firms to the global frontier and to the national frontier, and find that the national frontier exerts a stronger pull on domestic firms than the global frontier. Iacovone and Crespi (2010) evaluate the process of convergence towards national versus global frontier among plants in Mexico, and find that plants converge much faster to national frontier than to global frontier. This study also shows that exposure to trade allows firms to speed up convergence to the national frontier but has little effect on convergence to the global frontier. The results of these two studies suggest that firms that lag so far technologically cannot learn from the global frontier. Alternatively, the global frontier might be located far away from domestic firms limiting the potential learning effects.

The process of firms' productivity convergence to the regional frontier has been less studied in the literature. To the best of our knowledge, the only paper that has examined firms' productivity convergence to the regional frontier is

[8] Bartelsman et al., (2008) construct the global frontier as the envelop of the national frontiers of a set of developed countries. Iacovone and Crespi (2010) define the global frontier using the same approach.

Griffith et al. (2009). This paper examines establishment level productivity convergence to both the national and regional frontiers in the UK. The results show that establishments further behind their industry frontier experience faster growth rate, and converge to both the national and regional frontiers. The convergence speed is faster to the regional frontier than to national frontier, because knowledge spillovers may be to some extent geographically concentrated, so firms benefit more from frontiers that are located nearby, as explained by the authors.

3.2.3 The impact of globalisation

With increasing trade liberalization in many countries, the impact of globalisation on productivity growth has garnered attention in the literature. Many studies have found that globalisation enhances firms' productivity growth. For example, De Loecker (2007) uses micro data of Slovenian manufacturing firms and finds that firms become more productive once they start exporting. Van Biesebroeck (2005) finds similar results among sub-Saharan African manufacturing firms. Potterie and Lichtenberg (2001) show evidence that outward FDI is effective in the international diffusion of technology. Amiti and Konings (2007) show that imported inputs raise productivity via learning, variety and quality effects. Khandelwal and Topalova (2011) examine the effect of India's trade reforms on firm productivity in the manufacturing sector and show that lower tariffs on the intermediate inputs generate significant productivity boost.

However, less work has been devoted to examine the effects of globalisation on the *speed* of firms' productivity convergence. For example, Chevalier et al. (2012) study the effect of globalisation (measured by export) and information and communication technologies (ICT) on productivity convergence of French firms during 1991-2004. They find a positive

relationship between exporting and productivity growth, but they show that exporting slows down the speed of productivity convergence to the technological frontier, because exporters usually have the highest productivity and are the frontiers; the positive effect of export on productivity has bigger impact on those most productive firms. While Iacovone and Crespi (2010) find that exposure to trade allows firms to speed up convergence to the national frontier but has little effect on convergence to the global frontier.

In summary, the extant literature shows evidence that firms are converging to the technological frontiers with those laggard firms growing faster, while the regional productivity convergence has not received its deserved attention. Thus, the issue of whether firms converge faster to their national frontier or to their regional frontier is still a question to explore. The literature also confirms that globalisation facilitates firms' productivity growth rate, but its effects on the speed of convergence to the regional frontiers is not known yet, especially for a developing country like India.

3.3. Empirical framework

3.3.1 The baseline model

Our main interest lies in investigating firm level productivity convergence towards both the national and regional frontier and examining the role of globalisation in this process. We employ a formulation from the macroeconomic literature of productivity growth and convergence (see Bernard and Jones 1996 and Cameron et al. 2005), which has been extensively used in analysing cross-country productivity convergence. The model has also been widely employed in recent firm level productivity convergence studies (Nishimura et al., 2005; Griffith et al., 2009). This approach allows us to capture productivity convergence, productivity persistence over time and

heterogeneity in productivity levels across firms. Equation (3.1) describes the starting point:

$$\ln A_{i,t} = \gamma_i + \lambda\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \ln A_{i,t-1} + \ln \epsilon_{i,t} \quad (3.1)$$

where $\ln A_{i,t}$ is the logarithm of firm *i*'s productivity level in year *t*; the term ($\ln A_{F,t-1}$- $\ln A_{i,t-1}$) is a catch-up variable, which represents the distance in productivity between the firm with the highest productivity level in the industry – or technological frontier (F) – and the productivity level of firm *i*. Thus, a positive and significant value of λ provides evidence of productivity convergence (i.e. firms further behind the technological frontier grow faster than firms near the frontier). In our model, we also include firm's prior productivity level $\ln A_{i,t-1}$ in order to capture productivity persistence. The parameter γ_i reflects heterogeneity of firms' productivity growth and $\ln \epsilon_{i,t}$ represents the error term.

Re-arranging equation (3.1), taking the third term on the right-hand side over to the left-hand side, we obtain:

$$\Delta \ln A_{i,t} = \gamma_i + \lambda\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \ln \epsilon_{i,t} \quad (3.2)$$

This provides our baseline specification. We use this model to study how firms converge to their national and regional frontiers.

3.3.2 The effects of globalisation on productivity convergence

We extend our baseline model to test the effects of globalisation on convergence. Globalisation is measured by export and OFDI, which are denoted by the vector of $Z_{i,t}$. We add the globalisation vector to capture the direct effect of globalisation on rates of productivity growth, and an interaction

term with $\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right)$ to capture its effect on the speed of productivity convergence. Then equation (3.2) becomes:

$$\Delta \ln A_{i,t} = \eta_i + \delta Z_{i,t-1} + \rho\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \mu Z_{i,t-1}\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \ln \varepsilon_{i,t} \quad (3.3)$$

Positive and significant coefficients of our globalisation measures ($\delta>0$) provide evidence of enhancing direct effects of exporting and OFDI on firms' productivity growth; whereas positive and significant coefficients of the interaction terms ($\mu>0$) indicates that globalisation helps firms to speed up their rate of technology convergence towards their frontiers.

3.3.3 Empirical strategy

A well-known issue when estimating equations (3.2) and (3.3) is the potential sample selection problem, as the most productive firms are likely to be those that survive and, therefore, the ones that we observe in our dataset (Fariñas and Ruano, 2005; Nishimura et al., 2005). To account for any potential correlation between a firm's productivity level and its decision to exit the market we calculate the inverse Mills ratio resulting from estimating a firm's survival equation and then include this term as an additional explanatory variable in equations (3.2) and (3.3)[9]. We model a firm's exit decision as a function of productivity, firm size, age, capital stock, technology investment, the ratio of debt and equity, inward foreign investment, outward foreign investment, and export.

Another issue that emerges when estimating equations (3.2) and (3.3) is that since $\ln A_{i,t-1}$ appears on both sides of the regression equations, shocks such as measurement errors to $\ln A_{i,t-1}$ could lead to biased estimation of the speed of convergence. Thus, on the one hand, the method of ordinary least squares (OLS) tends to underestimate the speed of convergence as it produces a

[9] This strategy has been adopted by Griffith et al. (2009) in a similar context.

negative correlation between the gaps and the error term, while on the other hand, the fixed effects model tend to overestimate the speed of convergence (Iacovone and Crespi, 2010). A solution is to find proper instruments which unfortunately are not readily available in our dataset. Given these problems, following Iacovone and Crespi (2010), we estimate our baseline model using the OLS and fixed effect and bear in mind that OLS has a potential downward bias and fixed effect has a likely upward bias.

3.4. Data and measurement issues

3.4.1 Data

Our data is collected from the Prowess database, which is compiled by the Centre for Monitoring the Indian Economy (CMIE). In this study, we concentrate on the manufacturing firms from 1999 to 2010. The Prowess database provides information of the different states in which firms are located. This information allows us to evaluate the speed of productivity convergence of Indian manufacturing firms towards their national and regional frontiers, which is a central objective of this chapter. In our empirical analysis we focus on the 13 major states in India (excluding Bihar, as it is a service-oriented state) plus the capital, Delhi, which together contribute with about 70% of India's GDP and 87% of its population (Shingal 2014). The detailed information of data selection procedures is provided in Chapter 2.

We base our analysis on an unbalanced panel dataset that include 7142 manufacturing firms with 43918 observations spanning over a period of 12 years, from 1999 to 2010. All data are deflated by wholesale price index based on financial year 1993-1994. We employ total factor productivity (TFP) to measure productivity, which is calculated using Levinsohn and Petrin (2003) approach. A main limitation of the dataset is that it does not report information

on the number of employees for most of the firms. We therefore, use wages as a proxy when constructing our measure of TFP, and we test the validity of using wages in the appendix 3.1.

3.4.2 The productivity frontier

The distance to the frontier is one of the key elements in our study. For each year, we define the national and regional productivity frontier as the firm with the highest TFP in each industry in the country and the region respectively. This approach allows for endogenous changes in the frontier over time, as one firm may catch up and overtake the initial frontier next year.

This approach is not without problems. A main difficulty is that we cannot distinguish the speed of convergence towards the national and the regional frontiers for those firms located in regions where their technological leader is also the national leader. Another issue is the potential measurement error on TFP. To address these problems, as a robustness test, following Griffith et al. (2009), we define the national productivity frontier as a weighted average of the top five firms with the highest levels of TFP in each industry and year, and the regional frontier as a weighted average of the top five highest TFP firms in the state in each industry and year.

3.4.3 Other variables

We measure exporters as firms that export in the year, and OFDI firms as those invest abroad in the year. Since firms often ship their goods abroad at intervals, we define continuous exporters, switchers and non-exporters later as robustness test. Size is measured by the logarithm of total asset, and age is measured as the difference between current year and incorporation year. We also control for firm ownership, industry and year. The detailed information of measurements are provided in Chapter 2.

3.4.4 Descriptive analysis

3.4.4.1 Productivity growth rate and productivity gap

Table 3.1 reports an aggregate summary statistics of our main measures of interest and Table 3.2 shows the characteristics of our sample by states. $\triangle \ln TFP_{ijt}$ refers to the average TFP growth rate of non-frontier firms during the study period, and "$\triangle \ln TFP_{Fjt}$" denotes to the average TFP growth rate of regional frontiers during the study period and "$\triangle \ln TFP_{Ft}$" the average TFP growth rate national frontiers. From Table 3.1 we can observe that the average TFP growth rate of national frontiers are much higher than that of the regional frontiers, and the regional frontiers see a higher average TFP growth rate than non-frontier firms. Similar pattern can also be found between non-frontier firms and regional frontier firms for many states in Table 3.2. The non-frontiers show a negative average TFP growth rate, and this negative average growth rates may largely be driven by some firms with negative average TFP growth rate.

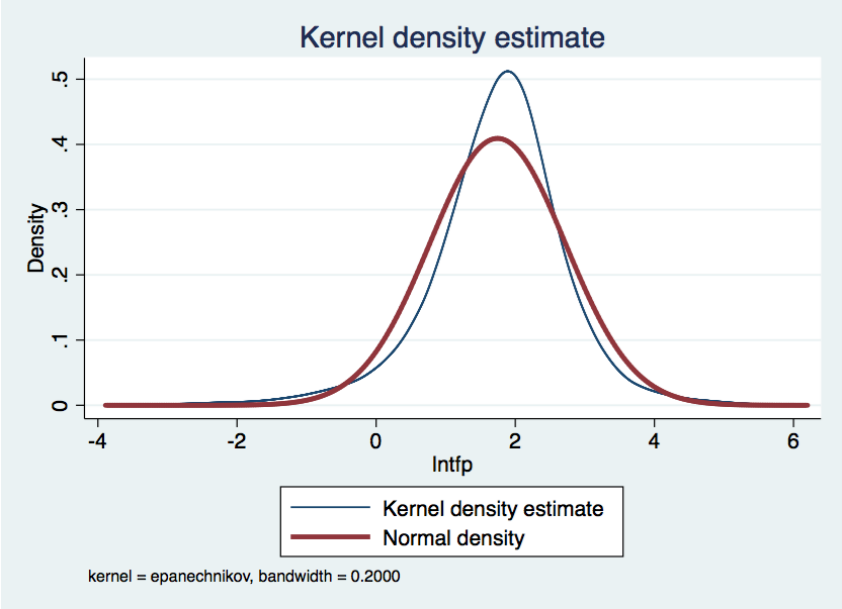
The average log gap between national frontiers and laggards is much higher than that between regional frontiers and laggards (3.15 versus 2.04), providing larger scope for firms catching up to national frontiers. For some states, the difference between the average national gap and state gap is large, such as Karnataka, Kerala, Orissa, Rajasthan and Uttar Pradesh. While some other states show much small difference between the two gaps, such as Maharashtra and Tamil Nadu, indicating that firms in these states have higher productivity and many national frontiers are located in these states. The standard deviations show that there is substantial variation in the gaps among firms. Figure 3.1 depicts the Kernel density distribution of logarithm TFP and TFP growth rate of the sample, showing that there is variation in TFP levels and growth rate.

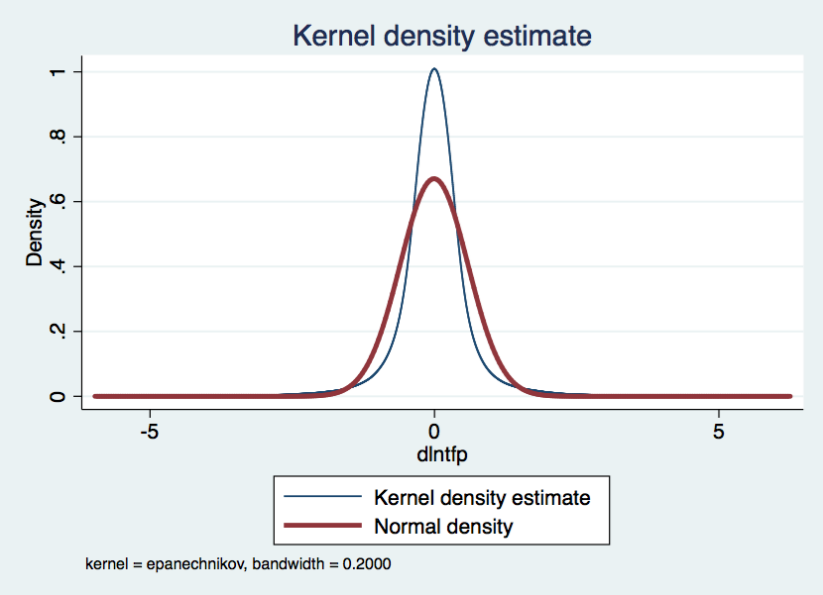
Table 3. 1 Overall Descriptive Statistics

Variable	Definition	obs	mean value	S.D	min	max
lnTFP	logarithm of TFP	43918	1.746	0.975	-3.691	6.001
△lnTFP	the average TFP growth of all firms	34785	-0.008	0.595	-5.768	6.054
$\triangle lnTFP_{ijt}$	the TFP growth rate of non-frontiers	33521	-0.015	0.595	-5.768	6.054
$\triangle lnTFP_{Fjt}$	the TFP growth rate of regional frontiers	1264	0.181	0.557	-1.567	3.509
$\triangle lnTFP_{Ft}$	the TFP growth rate of national frontiers	85	0.362	0.699	-1.042	3.509
lnGAP_NA	the distance behind the national frontier	43918	3.153	1.136	0	9.437
lnGAP_state	the distance behind the regional frontier	43918	2.040	1.225	0	9.087
S_et	export intensity, equals the ratio of total export to sales	43918	0.119	0.227	0	1.002
D_et	a dummy indicating a firm either exporting goods or exporting services	43918	0.522	0.500	0	1
S_OFDI	OFDI intensity, equals the ratio of OFDI to sales	43918	0.014	1.437	0	294.000
D_OFDI	a dummy indicating a firm invests abroad	43918	0.059	0.236	0	1
age	firm age	43918	23.997	17.430	1	132
size	the logarithm of total asset	43918	5.264	1.669	-0.400	11.190

Note: The sample includes 43918 observations in manufacturing over the period 1999-2010. The national frontier is the firm with the highest TFP level in an industry in a year, and the regional frontier is the firm with the highest TFP level in an industry in a year in the state. The term of "$\triangle lnTFP_{ijt}$" refers to average TFP growth rate of non-frontiers, and "$\triangle lnTFP_{Fjt}$" denotes to the average TFP growth rate of regional frontiers and "$\triangle lnTFP_{Ft}$" the average TFP growth rate of national frontiers. The term of "lnGAP_NA" ("lnGAP_state") is the average gap between national frontiers (regional frontiers) and laggards.
Source: Authors' calculations using the dataset.

Figure 3. 1 Distribution of TFP and TFP growth





Note: The figures show the distribution of logarithm TFP and TFP growth rate respectively of our sample of manufacturing firms.

Source: Authors' calculations using the dataset.

Table 3. 2 Descriptive Statistics by State

statename	lnTFP	Std.Dev.	$\triangle lnTFP_{ijt}$	Std.Dev.	$\triangle lnTFP_{Fjt}$	Std.Dev.	lnGAP_NA	Std.Dev.	lnGAP_state	Std.Dev.
Andhra Pradesh	1.542	1.015	-0.0281	0.657	0.266	0.604	3.421	1.137	1.871	1.121
Gujarat	1.729	0.955	-0.0101	0.586	0.31	0.681	3.201	1.071	1.994	1.081
Haryana	1.805	0.863	-0.0337	0.466	0.101	0.453	2.984	1.175	1.284	0.893
Karnataka	1.523	0.972	-0.019	0.582	0.136	0.407	3.221	1.093	1.621	1.057
Kerala	1.412	0.824	-0.00396	0.623	0.0494	0.375	3.364	1.044	1.317	0.845
Madhya Pradesh	1.679	0.967	-0.0136	0.552	0.0997	0.399	3.291	1.091	1.723	1.046
Maharashtra	1.799	0.978	-0.00985	0.588	0.362	0.715	3.086	1.117	2.664	1.186
Orissa	1.887	1.082	-0.0234	0.692	0.119	0.575	3.222	1.213	1.576	1.086
Punjab	1.761	0.873	-0.0179	0.6	0.222	0.593	3.249	1.075	1.54	0.905
Rajasthan	1.729	0.923	-0.0147	0.572	0.0788	0.496	3.357	1.038	1.511	0.958
Tamil Nadu	1.706	0.925	-0.00192	0.586	0.0984	0.446	3.226	1.129	2.221	1.131
Uttar Pradesh	1.841	1.05	-0.019	0.552	0.177	0.486	3.097	1.155	1.568	1.032
West Bengal	1.83	1.048	-0.0221	0.617	0.178	0.649	3.162	1.148	2.238	1.218
Delhi	1.853	0.978	-0.0239	0.606	0.331	0.678	2.955	1.145	2.058	1.047

Note: The sample includes 43918 observations in manufacturing over the period 1999-2010. The national frontier is the firm with the highest TFP level in an industry in a year, and the regional frontier is the firm with the highest TFP level in the state in an industry and year. The term of "$\triangle lnTFP_{ijt}$" refers to average TFP growth rate of non-frontiers, and "$\triangle lnTFP_{Fjt}$" denotes to the average TFP growth rate of regional frontiers. The term of "lnGAP_NA" ("lnGAP_state") is the average gap between national frontiers (regional frontiers) and laggards.
Source: Authors' calculations using the dataset.

3.4.3.2 Globalisation and productivity growth

One of our main interests in this study is to examine the effects of globalisation on productivity growth and convergence. We use the behaviour of export and OFDI to measure globalisation.

Table 3.3 compares the logarithm TFP and TFP growth between exporters, non-exporters and OFDI firms, by firm size[10]. We define 4 size groups (namely, very small, small, medium and large) across all observations by industry, and each size group shares almost the same number of observations. Table 3.3 shows that exporters are on average more productive than non-exporters, and those exporters that engage in OFDI show higher productivity levels than exporters and non-exporters. This is consistent with the well-established empirical evidence indicating that exporters have superior performance relative to non-exporters but only the most productive firms conduct OFDI. We can also observe that the TFP growth rate of exporters is on average lower than that of non-exporters and the average productivity growth rate of OFDI firms is slightly lower than that of exporters. Interestingly, the exporters and OFDI firms in small size show higher average productivity growth rate than non-exporters. It is also worth noting that, firms bigger in size exhibit relatively higher productivity levels, but smaller size firms on average grow faster than bigger size firms.

From the descriptive analysis, we can observe that global firms are on average more productive than non-global firms. As firms can gain new knowledge and advanced technologies when entering foreign markets, this allows them to improve their productivity and grow faster. Therefore, we conjecture that globalisation may improve firms' productivity growth. However, as global firms are more productive and closer to the frontier, their scope for catching up is more limited, hence their speed of technological

[10] Size is measured by the logarithm total assets, deflated by wholesale price index based on financial year 1993-1994.

convergence might occur at a slower pace than their domestic counterparts. This is our hypothesis.

Table 3. 3 Productivity Difference Across Size Groups

size	lnTFP				△lnTFP			
	all	exporters	non-exporters	OFDI	all	exporters	non-exporters	OFDI
Very small	1.37802	1.41445	1.36743	1.36796	0.00338	-0.00130	0.00486	0.00758
Small	1.73435	1.69242	1.76689	1.59504	0.00311	0.00478	0.00170	0.04121
Medium	1.84781	1.79710	1.93518	1.76319	-0.01136	-0.01769	0.00023	-0.01619
Large	2.02208	2.03274	1.98118	2.04568	-0.02317	-0.02631	-0.01010	-0.04207
total	1.74552	1.82345	1.66044	1.96516	-0.00757	-0.01486	0.00129	-0.03254

Note: The table compares logarithm TFP and TFP growth between exporters, non-exporters and OFDI firms. Exporters refer to firms export in the year. The OFDI refers to firms that invest abroad in the year. Size is measured by the logarithm of total assets, deflated by wholesale price index. We define 4 size groups across all observations by industry, and each size group shares almost same number of observations.

3.5 Empirical Results

In this section we present our empirical results to examine our hypothesis. First, we start by estimating the baseline model to explore the relationship between TFP growth rate and the distance behind the productivity frontier, comparing the convergence process to both the national and regional frontier. We then extend our baseline model to study the effect of exporting and OFDI on firms' productivity convergence, followed by a number of robustness tests.

3.5.1 Productivity convergence

We start by examining the relationship between a firm's TFP growth rate and its distance to the national and the regional TFP frontier using OLS and a fixed effects model. In our baseline model we control for year and industry effects for the OLS estimates; and for year effects for the fixed effects model. The results, shown in columns (1) and (2) in Table 3.4, show a positive and significant correlation between firms' productivity growth rate and the distance to the national and regional frontiers, supporting the hypothesis of productivity convergence. Interestingly, the coefficient of the national gap is higher than that of the regional gap, indicating that firms converge faster to the national frontier than to the regional frontier. To further examine this result, in column (3) we regress firms' productivity growth rate on both the national and the regional gap. Our results confirm that Indian manufacturing firms converge faster to the national frontier than to the regional frontier, suggesting that there is not much scope to learn from regional frontiers in India. In column (4), (5) and (6), we add size, age and the inverse Mills ratio resulting from estimating a firm's survival equation as mentioned in section 3.3 in order to correct for a possible bias due to sample selection. The coefficients of the national gap and regional gap are similar as the previous results. The negative and significant coefficients of size and age show that smaller and younger firms grow faster,

consistent with the idea that small and young firms are more dynamic than large firms. The results also show that compared with state-owned firms, private firms and foreign firms grow faster.

Overall, the results of the OLS and fixed effects model are highly consistent, except for the fact that the coefficients of the TFP gap terms resulting from the fixed effects method are higher than the OLS estimates, which suggests that the OLS results have a downward bias on the convergence speed.

3.5.2 The effect of globalisation

As mentioned previously, one of our main interests lies in examining the effect of globalisation on firms' productivity growth and convergence. To investigate this, we extend our model by including a globalisation vector to capture the direct effects of exporting and investing abroad on firms' productivity growth. We also add interaction terms between these two global indicators and the productivity gap in order to capture the impact of firms' international activities on their speed of convergence.

Tables 3.5 presents the results of the effect of export on productivity growth and convergence. In line with our previous results, the coefficients of the national gap and regional gap remain positive and significant, thus evidencing convergence. The coefficients of export are positive and significant, showing that export facilitates firms' growth. This is consistent with the literature that exporters gain new knowledge and expertise in the export markets, which allows them to improve their productivity level (De Loecker 2007). The coefficients of the interaction terms between exporting and the national and regional gaps are negative and significant, indicating that export has a negative effect on the speed of convergence. An explanation is that exporters are generally the most productive firms, and the positive effects of

export may have a bigger impact on these firms (Chevalier et al. 2012) and thus should slow down the convergence process. The negative and significant coefficients of age demonstrate that younger firms grow faster than older ones. Also, the private firms grow faster than state-owned firms.

In addition to export, Indian firms have recently gone a step further in their globalisation process by undertaking overseas investments. Amongst the exporting firms in our sample, around 10.76% have expanded their operations abroad via OFDI, and most firms that conduct OFDI are exporters as well. In our sample, 95.18% firms that conduct OFDI are exporters. Whether this new form of globalisation helps the already international firms to grow and converge is of great interests to explore. In this study, we examine the effect of OFDI on firms' productivity growth and convergence process. The results are presented in table 3.6.

The coefficients of national gap and regional gap are consistent with our previous results, positive and significant. The coefficients of OFDI are positive but not quite significant, indicating the possibility that OFDI helps improve firms' productivity growth. The coefficients of the interactive terms of OFDI and regional gap are negative and significant but not significant for the coefficients of interactive terms of OFDI and natioanl gap, exhibiting that OFDI slows down regional convergence, as OFDI is generally confined in most productive firms and the positive effects of OFDI exerts bigger impact on those most productive firms. The other controls maintain similar sign and significance level.

Table 3. 4 Productivity Convergence Basic Results

Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)
OLS						
$lnGAP\_NA_{it-1}$	0.1849***		0.1478***	0.1980***		0.1601***
	(0.006)		(0.006)	(0.006)		(0.006)
$lnGAP\_State_{it-1}$		0.1415***	0.0563***		0.1469***	0.0581***
		(0.005)	(0.004)		(0.005)	(0.004)
Size				0.0030	-0.0105***	0.0025
				(0.003)	(0.003)	(0.003)
Age				-0.0022***	-0.0025***	-0.0024***
				(0.000)	(0.000)	(0.000)
Inverse Mills ratio				-0.6254***	-0.6496***	-0.6680***
				(0.059)	(0.061)	(0.060)
Private without group affiliations				0.0732***	-0.0197	0.0468**
				(0.018)	(0.020)	(0.019)
Foreign firms				0.0568**	-0.0519**	0.0195
				(0.023)	(0.025)	(0.024)
Private with group affiliations				0.0705***	-0.0193	0.0409**
				(0.018)	(0.020)	(0.019)
_cons	-0.5286***	-0.2887***	-0.5450***	-0.3990***	0.0484	-0.3681***
	(0.022)	(0.020)	(0.023)	(0.049)	(0.046)	(0.050)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes	yes	yes
N	34699	33481	33481	34699	33481	33481

Table 3.4 Productivity Convergence Basic Results (Continued)

Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)
Fixed effect						
$lnGAP\_NA_{it-1}$	0.3898***		0.2439***	0.3921***		0.2443***
	(0.009)		(0.008)	(0.009)		(0.008)
$lnGAP\_State_{it-1}$		0.3802***	0.2233***		0.3843***	0.2272***
		(0.010)	(0.008)		(0.010)	(0.008)
Size				-0.0394***	-0.0247**	-0.0262**
				(0.011)	(0.011)	(0.011)
Age				-0.0445***	-0.0362***	-0.0452***
				(0.003)	(0.003)	(0.003)
Inverse Mills ratio				-0.9814***	-1.0862***	-1.0932***
				(0.079)	(0.081)	(0.081)
_cons	-1.0910***	-0.7091***	-1.1114***	0.3263***	0.5029***	0.2883***
	(0.028)	(0.023)	(0.028)	(0.085)	(0.088)	(0.087)
year dummies	yes	yes	yes	yes	yes	yes
N	34699	33481	33481	34699	33481	33481

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on non-frontier firms of manufacturing over the period of 1999-2010 in India, using OLS and fixed effect respectively. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. The term "lnGAP_NA" denotes the distance to the national frontier, while "lnGAP_State" the distance to the regional frontier. Size is defined as the logarithm of firms' total assets.

Table 3. 5 Globalisation and Productivit

Dependent variable: TFP growth

	OLS			FE		
	(1)	(2)	(3)	(4)	(5)	(6)
$lnGAP\_NA_{it-1}$	0.2117***		0.1720***	0.4161***		0.2528***
	(0.008)		(0.008)	(0.012)		(0.011)
$lnGAP\_State_{it-1}$		0.1645***	0.0593***		0.4106***	0.2387***
		(0.007)	(0.007)		(0.013)	(0.011)
$Export_{it-1}$	0.0533**	0.0302*	0.0443	0.1410***	0.1061***	0.1003**
	(0.026)	(0.017)	(0.027)	(0.041)	(0.031)	(0.041)
Export * lnGAP_NA	-0.0288***		-0.0259***	-0.0497***		-0.0190
	(0.009)		(0.009)	(0.013)		(0.012)
Export * lnGAP_State		-0.0342***	-0.0015		-0.0537***	-0.0235*
		(0.009)	(0.008)		(0.015)	(0.013)
Size	0.0060*	-0.0068**	0.0060*	-0.0364***	-0.0227**	-0.0242**
	(0.003)	(0.003)	(0.003)	(0.011)	(0.011)	(0.011)
Age	-0.0023***	-0.0027***	-0.0025***	-0.0439***	-0.0360***	-0.0448***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.003)	(0.003)
Inverse Mills ratio	-0.6742***	-0.7052***	-0.7207***	-0.9650***	-1.0799***	-1.0838***
	(0.060)	(0.062)	(0.061)	(0.079)	(0.081)	(0.081)
Private without group affiliations	0.0856***	-0.0068	0.0605***			
	(0.018)	(0.020)	(0.020)			
Foreign firms	0.0690***	-0.0379	0.0333			
	(0.023)	(0.025)	(0.024)			
Private with group affiliations	0.0824***	-0.0079	0.0541***			
	(0.018)	(0.020)	(0.020)			
_cons	-0.4401***	0.0133	-0.4079***	0.2222**	0.4329***	0.2183**
	(0.051)	(0.048)	(0.053)	(0.089)	(0.089)	(0.092)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes			
N	34699	33481	33481	34699	33481	33481

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on non-frontier firms of manufacturing over the period of 1999-2010 in India. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. The term "lnGAP_NA" denotes the distance to the national frontier, while "lnGAP_State" the distance to the regional frontier. "Export" is a dummy variable equals 1 if a firm export in that year. Size is defined as the logarithm of firms' total assets.

Table 3. 6 Globalisation and Productivity Convergence: OFDI

Dependent variable: TFP growth

	OLS			FE		
	(1)	(2)	(3)	(4)	(5)	(6)
$lnGAP\_NA_{it-1}$	0.1997***		0.1605***	0.3923***		0.2427***
	(0.006)		(0.006)	(0.009)		(0.008)
$lnGAP\_State_{it-1}$		0.1501***	0.0600***		0.3873***	0.2297***
		(0.005)	(0.004)		(0.010)	(0.008)
$OFDI_{it-1}$	0.0427	0.0483*	0.0406	0.0115	0.1112**	0.0150
	(0.048)	(0.027)	(0.051)	(0.066)	(0.045)	(0.070)
OFDI * lnGAP_NA	-0.0299*		-0.0165	-0.0047		0.0182
	(0.017)		(0.019)	(0.023)		(0.022)
OFDI * lnGAP_State		-0.0486***	-0.0216		-0.0560**	-0.0372*
		(0.015)	(0.013)		(0.024)	(0.020)
Size	0.0050	-0.0079**	0.0049	-0.0392***	-0.0242**	-0.0258**
	(0.003)	(0.003)	(0.003)	(0.011)	(0.011)	(0.012)
Age	-0.0022***	-0.0025***	-0.0024***	-0.0445***	-0.0360***	-0.0450***
	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)	(0.003)
Inverse Mills ratio	-0.6321***	-0.6517***	-0.6737***	-0.9805***	-1.0791***	-1.0903***
	(0.059)	(0.061)	(0.060)	(0.079)	(0.081)	(0.081)
Private without group affiliations	0.0783***	-0.0147	0.0521***			
	(0.018)	(0.020)	(0.019)			
Foreign firms	0.0606***	-0.0487**	0.0231			
	(0.023)	(0.025)	(0.024)			
Private with group affiliations	0.0761***	-0.0142	0.0467**			
	(0.018)	(0.020)	(0.019)			
_cons	-0.4193***	0.0212	-0.3916***	0.3237***	0.4888***	0.2826***
	(0.049)	(0.047)	(0.051)	(0.086)	(0.088)	(0.089)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes			
N	34699	33481	33481	34699	33481	33481

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on all non-frontier firms of manufacturing over the period of 1999-2010 in India. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. The term "lnGAP_NA" denotes the distance to the national frontier, while "lnGAP_State" the distance to the regional frontier. "OFDI" is a dummy variable equals 1 if a firm invests outside India in that year. Size is defined as the logarithm of firms' total assets.

3.5.3 Robustness checks

We present a number of robustness checks to address potential data and econometric concerns. First, we use an alternative measure of distance behind the frontier by employing the weighted average logarithm TFP in the top five firms with the highest TFP levels as the national frontier to address potential measurement errors in frontiers. Then we impute employees to calculate TFP and test for the robustness of our empirical results. We also test productivity convergence for different types of exporters and firms in different ownerships.

3.5.3.1 Measurement error

To address the potential measurement errors in productivity frontiers, we use the weighted average logarithm TFP in the top five firms with the highest TFP levels as the national frontier. That is we take the weighted average logarithm TFP of top five highest productive firms in each year and industry as the national frontier, and the regional frontier is still the firm with the highest TFP in each year and industry in each states.

The empirical results are shown in Table 3.7. Columns (1) – (2) depict the basic results for productivity convergence to the national and regional frontier using OLS and fixed effect respectively. The results show that firms are converging to both their national frontiers and regional frontiers, and the higher coefficients of national gap reveals that firms converge faster to their national frontiers than to the regional frontiers, confirming our previous basic results in Table 3.4. Columns (3) and (4) report the effect of export on productivity growth and convergence, and columns (5) and (6) examine the effect of OFDI on growth and convergence. The positive coefficients of export and OFDI indicate the possibility that globalisation exert a positive impact on firm productivity growth, while the negative coefficients of the interactive terms of

globalisation and gaps show that globalisation tend to slow down the convergence process. The results are consistent with our previous empirical results.

3.5.3.2 Imputed employees

Following Girma and Vencappa (2014), we construct the employment data by running a regression in logs of the total number of employees (for those that are available) on the firm's total assets, controlling for year and industry, and use the predicted values for all other firms to impute the missing employment data. Then we use this imputed employment data to calculate TFP, and re-estimate our model to examine productivity convergence. The results are reported in Table 3.8.

Columns (1) - (2) show the basic results of productivity convergence to the national frontier and regional frontier. Columns (3) and (4) examine the effect of export on productivity convergence, and columns (5) and (6) show the effect of OFDI on convergence. The results are consistent with the previous results, showing they are robust.

3.5.3.3 Different exporters

We treat exporters as those export in the year, while during our study period, some firms export continously while other firms export at intervals. In this section, following Greenaway et al. (2007), we define "continuous exporters" as those firms that exported in all the years in which they are present in the sample, "non-continuous exporters" (switchers) as those firms that export at intervals, and the rest as "non-exporters", and examine and compare productivity convergence among firms in these different categories. The results are shown in Table 3.9. The coefficients of national gap and regional gap are positive and significant for all the three types of firms, indicating that

convergence occurs among all these firms, and they converge faster to the national frontier than to the regional frontier as the coefficients of the national frontier is higher than that of the regional frontier, which is consistent with our previous results. The coefficients of the gap terms of non-exporters are higher than non-continuous exporters, of which are higher than exporters, suggesting that non-exporters are converging faster than non-continuous exporters, and exporters converge slower than other types of firms. This confirms our previous results that export slows down the convergence speed.

3.5.3.4 Ownership

We further test productivity convergence for firms in different ownerships. In our sample, firms belong to four ownerships, namely, private firms without group affiliations, foreign firms, private firms with group affiliations and state-owned firms. We compare productivity convergence across these four ownership groups. The results are presented in Table 3.10. The coefficients of national gap and regional gap are positive and significant except the regional gap of state-owned firms using OLS method, showing evidence of convergence. The coefficients of the gap terms are higher for private firms without group affiliations, foreign firms, private firms with group affiliations than state-owned firms, indicating that state-owned firms converge slower than firms in other ownerships.

Table 3. 7 Productivity Convergence Robustness Checks: Measurement errors

Dependent variable: TFP growth

	OLS	FE	OLS	FE	OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)
$lnGAP\_NA_{it-1}$	0.2092***	0.4528***	0.2206***	0.4608***	0.2105***	0.4521***
	(0.007)	(0.011)	(0.009)	(0.014)	(0.007)	(0.011)
$lnGAP\_State_{it-1}$	0.0341***	0.1081***	0.0334***	0.1148***	0.0351***	0.1094***
	(0.004)	(0.007)	(0.007)	(0.011)	(0.004)	(0.008)
$Export_{it-1}$			0.0217	0.0754*		
			(0.025)	(0.039)		
Export * lnGAP_NA			-0.0247**	-0.0186		
			(0.011)	(0.016)		
Export * lnGAP_State			0.0019	-0.0131		
			(0.008)	(0.013)		
$OFDI_{it-1}$					0.0463	0.0138
					(0.043)	(0.061)
OFDI * lnGAP_NA					-0.0304	0.0063
					(0.021)	(0.027)
OFDI * lnGAP_State					-0.0114	-0.0175
					(0.014)	(0.020)
Size	0.0070**	-0.0157	0.0102***	-0.0148	0.0092***	-0.0153
	(0.003)	(0.012)	(0.003)	(0.012)	(0.003)	(0.012)
Age	-0.0024***	-0.0457***	-0.0025***	-0.0455***	-0.0024***	-0.0456***
	(0.000)	(0.003)	(0.000)	(0.003)	(0.000)	(0.003)
Inverse Mills ratio	-0.6779***	-1.1437***	-0.7338***	-1.1368***	-0.6865***	-1.1414***
	(0.061)	(0.080)	(0.062)	(0.080)	(0.061)	(0.080)
Private without group affiliations	0.0665***		0.0797***		0.0719***	
	(0.019)		(0.020)		(0.020)	
Foreign firms	0.0405*		0.0541**		0.0443*	
	(0.024)		(0.024)		(0.024)	
Private with group affiliations	0.0593***		0.0723***		0.0651***	
	(0.019)		(0.020)		(0.019)	
_cons	-0.4908***	0.0614	-0.5190***	0.0153	-0.5116***	0.0559
	(0.048)	(0.089)	(0.050)	(0.093)	(0.048)	(0.090)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes		yes		yes	
N	33332	33332	33332	33332	33332	33332

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on non-frontier firms of manufacturing over the period of 1999-2010 in India. The national productivity frontier is defined as the weighted average logarithm TFP of the top five firms with highest levels of TFP in each industry and year, and the regional frontier is the firm with highest TFP firms in the state in each industry and year. "Export" and "OFDI" are dummies. Size is defined as the logarithm of firms' total assets.

Table 3. 8 Productivity Convergence Robustness Checks: Imputed employees

Dependent variable: TFP growth

	OLS	FE	OLS	FE	OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)
$lnGAP\_NA_{it-1}$	0.1897***	0.3655***	0.2084***	0.3711***	0.1922***	0.3628***
	(0.008)	(0.011)	(0.012)	(0.015)	(0.009)	(0.011)
$lnGAP\_State_{it-1}$	0.0657***	0.2512***	0.0649***	0.2686***	0.0683***	0.2563***
	(0.007)	(0.011)	(0.011)	(0.016)	(0.008)	(0.011)
$Export_{it-1}$			0.0734***	0.1054***		
			(0.024)	(0.034)		
Export * lnGAP_NA			-0.0405***	-0.0142		
			(0.014)	(0.018)		
Export * lnGAP_State			-0.0014	-0.0369**		
			(0.014)	(0.018)		
$OFDI_{it-1}$					0.1238***	0.0677
					(0.038)	(0.050)
OFDI * lnGAP_NA					-0.0464*	0.0269
					(0.024)	(0.029)
OFDI * lnGAP_State					-0.0517**	-0.0767**
					(0.026)	(0.032)
Size	-0.0452***	-0.1108***	-0.0444***	-0.1103***	-0.0432***	-0.1106***
	(0.003)	(0.014)	(0.003)	(0.014)	(0.003)	(0.014)
Age	-0.0044***	-0.0239***	-0.0046***	-0.0237***	-0.0044***	-0.0238***
	(0.000)	(0.003)	(0.000)	(0.003)	(0.000)	(0.003)
Inverse Mills ratio	-1.7391***	-2.0158***	-1.7842***	-2.0050***	-1.7551***	-2.0115***
	(0.069)	(0.095)	(0.071)	(0.095)	(0.069)	(0.096)
Private without group affiliations	-0.0007		0.0053		0.0040	
	(0.020)		(0.020)		(0.020)	
Foreign firms	-0.0213		-0.0174		-0.0192	
	(0.025)		(0.025)		(0.025)	
Private with group affiliations	0.0217		0.0261		0.0260	
	(0.020)		(0.020)		(0.020)	
_cons	0.3383***	0.2226**	0.3090***	0.163	0.3165***	0.2172**
	(0.049)	(0.106)	(0.050)	(0.110)	(0.050)	(0.107)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes		yes		yes	
N	33439	33439	33439	33439	33439	33439

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on non-frontier firms of manufacturing over the period of 1999-2010 in India. The TFP is calculated using imputed employees to test the robustness of the empirical results. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. "Export" and "OFDI" are dummies. Size is defined as the logarithm of firms' total assets.

Table 3. 9 Productivity Convergence Robustness Checks: different exporters

Dependent variable: TFP growth

	continuous exporters		non-continuous exporters		non-exporters	
	OLS	FE	OLS	FE	OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)
$lnGAP\_NA_{it-1}$	0.1324***	0.2101***	0.1569***	0.2409***	0.1887***	0.2758***
	(0.010)	(0.013)	(0.010)	(0.013)	(0.011)	(0.015)
$lnGAP\_State_{it-1}$	0.0511***	0.1891***	0.0677***	0.2202***	0.0581***	0.2699***
	(0.006)	(0.012)	(0.007)	(0.013)	(0.008)	(0.016)
Size	0.0095**	-0.0519***	0.0029	-0.0304*	-0.0217***	-0.0229
	(0.005)	(0.018)	(0.006)	(0.018)	(0.007)	(0.025)
Age	-0.0006**	-0.0285***	-0.0024***	-0.0546***	-0.0078***	-0.0693***
	(0.000)	(0.003)	(0.000)	(0.005)	(0.001)	(0.007)
Inverse Mills ratio	-0.1768**	-0.5528***	-0.7334***	-1.4115***	-1.8919***	-2.0568***
	(0.086)	(0.113)	(0.118)	(0.156)	(0.172)	(0.208)
Private without group affiliations	-0.0222		0.0973***		0.0621*	
	(0.026)		(0.037)		(0.033)	
Foreign firms	-0.0106		0.0538		0.0424	
	(0.030)		(0.048)		(0.071)	
Private with group affiliations	0.0044		0.0787**		0.0250	
	(0.025)		(0.037)		(0.035)	
_cons	-0.4955***	0.2294*	-0.3995***	0.6327***	0.182	0.6536***
	(0.071)	(0.138)	(0.096)	(0.159)	(0.115)	(0.211)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes		yes		yes	
N	10969	10969	12354	12354	10158	10158

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on non-frontier firms of manufacturing over the period of 1999-2010 in India. The term "lnGAP_NA" denotes the distance to the national frontier while "lnGAP_State" the distance to the regional frontier. Size is defined as the logarithm of firms' total assets.

Table 3. 10 Productivity Convergence Robustness Checks: ownership

Dependent variable: TFP growth

	Private without group affiliations		Foreign firms		Private with group affiliations		State-owned firms	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$lnGAP\_NA_{it-1}$	0.1629***	0.2466***	0.1758***	0.2967***	0.1569***	0.2354***	0.1561***	0.2467***
	(0.007)	(0.009)	(0.032)	(0.049)	(0.011)	(0.015)	(0.033)	(0.044)
$lnGAP\_State_{it-1}$	0.0665***	0.2477***	0.0654***	0.2086***	0.0463***	0.1875***	-0.0076	0.1431***
	(0.005)	(0.010)	(0.025)	(0.042)	(0.007)	(0.014)	(0.026)	(0.052)
Size	-0.0072	-0.0206	0.0252*	-0.1246**	0.0084	-0.0520**	-0.0084	-0.0031
	(0.005)	(0.014)	(0.015)	(0.059)	(0.005)	(0.022)	(0.017)	(0.071)
Age	-0.0040***	-0.0586***	0.0011	-0.0269***	-0.0014***	-0.0345***	-0.0020	-0.0556***
	(0.000)	(0.004)	(0.001)	(0.009)	(0.000)	(0.004)	(0.002)	(0.016)
Inverse Mills ratio	-0.9738***	-1.6465***	0.0828	-0.0889	-0.4478***	-0.7027***	-1.0368**	-1.0915**
	(0.090)	(0.122)	(0.197)	(0.277)	(0.109)	(0.149)	(0.441)	(0.441)
_cons	-0.2332***	0.5031***	-0.8117***	0.2401	-0.4749***	0.4267**	0.1261	1.054
	(0.060)	(0.118)	(0.222)	(0.374)	(0.074)	(0.167)	(0.306)	(0.682)
year dummies	yes	yes	yes	yes	yes	yes	yes	yes
industry dummies	yes		yes		yes		yes	
N	22131	22131	1110	1110	9225	9225	1015	1015

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on non-frontier firms of manufacturing over the period of 1999-2010 in India. The term "lnGAP_NA" denotes the distance to the national frontier while "lnGAP_State" the distance to the regional frontier. Size is defined as the logarithm of firms' total assets.

3.6 Conclusion

In this chapter we have studied the process of productivity convergence to both national and regional frontiers at the firm level, using a comprehensive micro manufacturing panel data in Indian 14 regions (13 states and 1 territory) from 1999 to 2010. Our results confirm the process of convergence among firms. The results show that firms are converging to both their national and regional frontiers. We compare the convergence speed of the national frontier to the regional frontier, and find that firms converge quicker to their national frontier than to the regional frontier, indicating that firms are mainly learning from the national frontiers while the regional frontiers do not provide much scope to catch up.

Since the trade liberalization in 1991, Indian firms have been quite active in globalisation activities. Exploring the role of globalisation on productivity growth and convergence is of great importance. We first examine the role of export on firms' catching up and growth, where we find that export facilitates productivity growth but slows down the convergence process. This is because exporters are more productive than non-exporters and they are closer to the frontiers and have less scope to converge or they are the frontiers. Then we examine whether OFDI further facilitates productivity growth for exporters and the results confirm this conjecture, showing that OFDI helps improve the productivity growth but slows down the convergence process. Our results also indicate that compared with state-owned firms, the private firms and foreign firms see a relatively higher growth rate and converge faster.

This study implicates that the productivity gap helps improve the laggards' productivity growth, and policies that encourage globalization activities can facilitate firms' productivity growth.

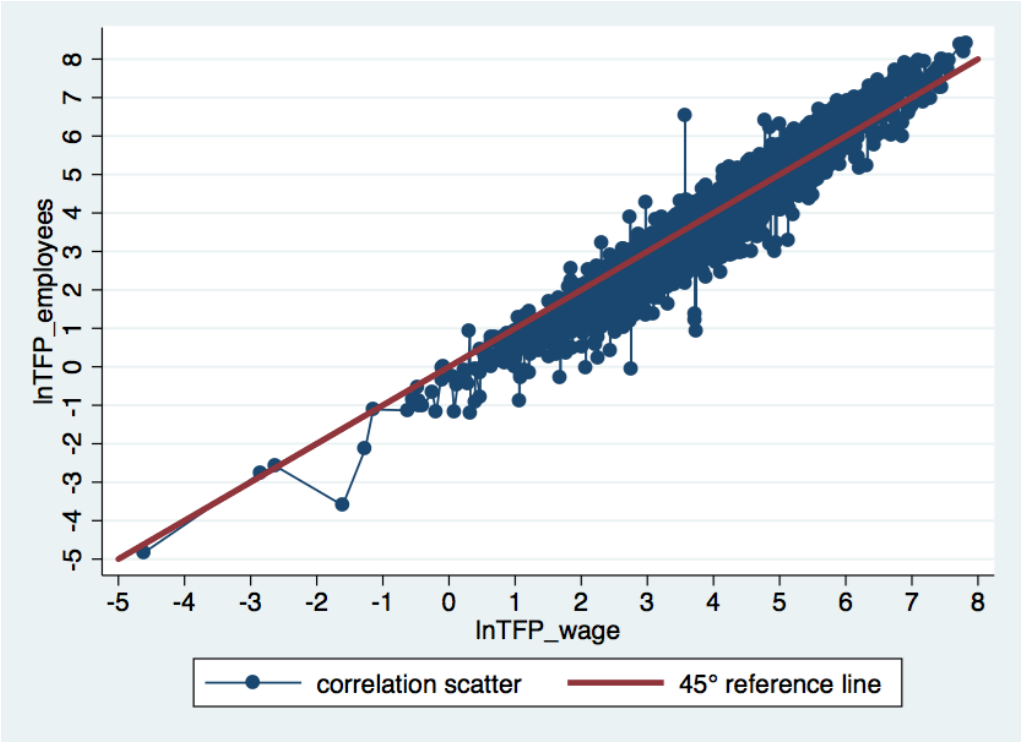
Appendices

Appendix 3.1: Test the validity of using wage to calculate TFP

A problem of our dataset is that most firms' employment information is missing, only a small fraction of firms report employee numbers. Fortunately, most firms have the wage information. Therefore, we use wage as a proxy for the employee numbers in calculating TFP. To test whether it is valid to use wage to proxy to employee numbers, we calculate TFP for those observations that have both the employment data and wages, using employee numbers and wages as free input respectively, and then compare the results.

There are 4858 observations that have both the information of employee numbers and wage. We calculate TFP for this subsample. The correlation between those two TFPs is as high as 0.9633, implying that our method of using wages to compute TFP is valid. We also depict the relationship between these two TFP, which is shown in Figure A.3.1. The y-axis indicates the TFP using employee numbers and the x-axis refers to the TFP using wages. The red thick line is the 45 degree reference line. From this graph we can see that the two TFPs are highly correlated. Therefore, it is safe to use wages as proxy for employee numbers to calculate TFP in our sample, and our results are convincing.

Figure A.3. 1 Correlation between the two TFPs



Note: The figure shows the correlation between TFP calculated using employees and wage for the sub-sample (4858 observations) that has both employees and wage information. The y-axis indicates the TFP using employee numbers and the x-axis refers to the TFP using wage. The thick line is a 45 degree reference line.

Chapter 4

Financing Sources, Technology Investment and Exporting Decisions

4.1 Introduction

The recent technology and trade literature shows that firms' decisions to invest in technology and export are simultaneously determined (Aw et al., 2007; Lileeva and Trefler, 2010; Aw et al., 2011; Bustos, 2011). Since both technology investment and exporting involve large sunk costs, access to financing sources is crucial in determining firms' ability to participate in these two activities. However, what remains unclear are which sources of financing are better associated with these activities, especially in a developing country context with underdeveloped financial system.

From a theoretical point of view, the trade-off hypothesis incorporates the costs of taxes, agency and bankruptcy, and proposes that firms tend to maintain an optimal leverage which reflects a trade-off between the tax benefits of debt and the deadweight costs of bankruptcy (Kraus and Litzenberger**,** 1973). While the pecking-order theory takes into account the costs of asymmetric information and suggests that firms seek finance in a hierarchical pecking order, that is firms prefer internal to external financing and debt to equity if external financing is required (Myers, 1984; Myers and Majluf, 1984).

Many empirical studies have tested the applicability of pecking order theory and trade-off theory, and have found conflicting results. Some studies show that the financing choice of large firms in developed countries exhibits some aspects of pecking order behaviour, while that of small firms do not

behave according to the pecking order theory (Frank and Goyal, 2003). Hogan and Hutson (2005) and Beck et al. (2008) find that firms prefer internal sources to external sources and support the pecking order theory. While López-Gracia and Sogorb-Mira (2008) show that both theories hold, and Chen (2004) find no evidence supporting either of these theories.

For the developing countries with underdeveloped financial systems, Guariglia et al. (2011) find that private firms in China show high sensitivities of assets growth to cash flow, which suggests that these firms use internal funds to finance their growth. Ayyagari et al. (2010) and Du and Girma (2012) show that informal financing is not as effective as formal financing (bank loans) to firm performance in China, whereas Allen et al. (2012) show that informal finance constitutes the most important form of external finance, while bank loans provide the second most important form of external finance in India. Girma and Vencappa (2014) find that bank loans have the strongest impact on firm growth in India, followed by non-bank loans and internal finance shows negligible or even no impact.

There has been little empirical work examining the role of financing sources on firms' joint decision to invest in R&D and export. To the best of our knowledge, so far there are only two papers that have studied this joint decision question and its link to finance: Máñez et al. (2014) investigate financial constraints on firms' simultaneous strategy to export and conduct R&D in Spain, and Altomonte et al. (2015) examines the mutual relationships between financial constraints, R&D investments, exporting and productivity of manufacturing firms from France, Germany, Italy and Spain.

However, these two papers mainly focus on financial constraints instead of financing sources. Typically, financial constraints are measured using an indirect approach, as the sensitivity of investment to cash flow (Fazzari et al., 1988). Máñez et al. (2014) use cash flow to measure internal financial constraints and the cost of firms' new long-term debt to measure external financial constraint, and Altomonte et al. (2015) employ bank credit rationing to proxy for financing constraints. An important drawback of these approaches is that they ignore the possible availability of other forms of financing sources,

such as government loans and nonbank loans. Thus, the identification of the presence of financing constraints in these papers provides an incomplete picture. Besides, both papers study the associations in a developed country context, with developing countries remaining unexplored.

This study seeks to fill a gap by examining firms' joint decision about technology investment and exporting, paying particular attention to the role of financing sources. We employ a panel of firms in the Indian manufacturing and services sector during the period 1999-2010 to explore this issue. We compare the effects of internal and external financing sources, and then disaggregate the external sources into government loans, bank loans and nonbank loans and examine their separate effect. Further, we pay attention to the impacts of Indian financial reforms on manufacturing firms' technology investment and exporting decisions, and investigate the difference between modern and traditional services, technology intensive and less technology intensive industries. We also highlight the major similarities and differences between services and manufacturing.

We contribute to the existing literature in the following manner. First, this study contributes to our understanding on the role of financing sources on the joint decision of technology investment and exporting. This investigation enables us to compare the effects of internal and external sources, which in turn allows us to infer whether the pecking order theory holds for Indian firms. Our investigation then should also inform us as to the workings of the components of external sources, i.e. government loans, bank loans and non-bank loans. The question as to what type of external sources of finance matters most remains unsettled as this literature shows (Allen et al., 2012; Ayyagari et al., 2010). Added to this it might tell us more about the joint determination of technology and exporting decisions. While past studies have mostly tended to focus on a single decision of the firm, we look at them together. This makes sense as technology investment and exporting tend to have inter-changeable connection and have been shown to be most likely jointly determined (Costantini and Melitz, 2007; Aw et al., 2007). Despite recent effort to study these two factors jointly, the literature is still in its infancy.

Second, we investigate the context of India, one of the largest and fastest growing developing economies in the world, which still has an immature financial system. With the focus on India we can examine the role of financial reforms on the link between financing sources and the joint decisions to engage in technology and export. These reforms allow us to study the effects of an easing of financial regulation and thus in turn financial constraints. Indeed, ex-ante to the reforms firms would have been expected to face greater constraints to get external finance, as opposed to ex-post. As such one of the objectives of a financial reform is to facilitate and encourage access to finance, which would have been otherwise restricted. In addition, it sheds lights on the policy implications for other developing countries, which in general have similar undeveloped financial system but have been engaged in financial reforms to enable its further development.

Third, we study both manufacturing and services firms. Much of the existing theoretical and empirical literature on technology investment and exporting has in fact been focused on manufacturing, while the services have been rather neglected. India is notable for the development of its services sector. The study of technology investment and exporting in Indian services has important policy implications, especially for developing countries with the potential to promote growth through the development of services.

Fourth, we extend the literature that makes comparison between them by highlighting their major similarities and differences with regard to the influence of alternative sources of finance on the joint decision to invest in new technology and to export.

We employ a dynamic bivariate probit model to conduct our empirical analysis. The model is estimated by maximum likelihood. Following the approach of Blundell et al. (1999, 2002) and Máñez et al. (2014), we address the initial conditions problem and endogeneity of the lagged dependent variables by including the pre-sample means of the dependent variables as additional regressors and estimating the technology investment and exporting decisions simultaneously. We also instrument the financing variables with their

lagged values to deal with the potential reverse relationship between financing sources and technology investment/exporting.

For the manufacturing firms, we treat 1999-2001 as pre-sample period and estimate for the period of 2002-2010. However, for services firms, around two thirds of observations in our sample have missing information for the period 1999-2000, we curtail our estimation sample to the years of 2005-2010 and use 2001-2004 as the pre-sample period. As part of the robustness exercise, we include the estimation of bivariate linear probability model that has the advantage of allowing us to use the same sample period as the manufacturing firms.

Our findings are compatible with previous research which provides evidence of firms' reliance on internal financing in developing countries. The results of manufacturing firms indicate that internal financing plays an important role in determining firms' joint decision of technology investment and exporting, while the effects of external sources are not significant, suggesting that the pecking order theory holds for Indian manufacturing firms. The decomposition of external financing shows insignificant effects for both bank loans and nonbank loans on the joint decisions of R&D investment and exporting. The results also reveal that financial reforms in India reduced the effects of internal sources on exporting. Compared with small firms, we find large firms are less dependent on internal sources than small firms. In addition, our results show that productive firms are less confined to internal sources but exhibit higher sensitivity to external sources.

The results of the services firms also show that internal sources play a crucial role in determining Indian services firms' technology investment and exporting decisions, which is consistent with that of manufacturing firms. However, external sources have a significantly and positive effect on the decision of technology investment, while insignificant influence for exporting. When decomposing external sources, we find that this effect is mainly provided by bank loans. We also find that exporting by modern services firms is less dependent on external sources, and technology intensive firms are less

sensitive to internal financing sources in determining technology investment decision.

The rest of this chapter is organized as follows. Section 4.2 summarises the related literature. Section 4.3 provides some descriptive analysis on the Indian firms' technology investment, exporting and financing sources. Section 4.4 presents the methodology and data description, and section 4.5 the empirical analysis. Finally, section 4.6 concludes.

4.2 Literature review

4.2.1 The theoretical background of corporate financing

The behavioural influence of firms' financial structure and financing patterns has long drawn a lot of attention. Although the theory of corporate finance is still evolving, it has made considerable progress. Modigliani and Miller (1958) put forward that the total value of the firms is independent of the financial structure. That is, the level of debt and equity, dividend distributions, and many other characteristics or policies relative to the financial structure have no impact on total value (Tirole, 2006). This theory assumes that firms have a particular set of expected cash flows, and they divide up the cash flows among investors when choosing the proportion of debt and equity. Given the assumption that investors and firms have equal access to financial markets, and the investor can create or get rid of any leverage level, the leverage of the firm has no effect on the market value of the firm. However, this theory fails under a variety of circumstances, especially with consideration of the influence of taxes, transaction costs, bankruptcy costs, agency conflicts, adverse selection, time-varying financial market opportunities and so on. Thus, alternative and different theories, including the trade-off theory and the pecking order theory, are considered.

The debate over the Modigliani-Miller theorem has given rise to the trade-off theory. The term trade-off theory refers to a set of related theories. According to these theories, companies pursue an optimum capital structure

and then gradually move towards the target (Myers, 1984). Kraus and Litzenberger (1973) summarise the theory that optimal leverage reflects a trade-off between the tax benefits of debt and the deadweight costs of bankruptcy. Frank and Goyal (2007) break this theory into two parts: static trade-off theory and target adjustment behaviour. The former refers to that a firm's leverage is determined by a single period trade-off, while the latter relates to how the firm's leverage gradually adjusts to target over time.

The pecking order theory emerged based on asymmetric information in financial markets. According to Myers (1984) and Myers and Majluf (1984), firms prefer to use internal finance sources (retained profits, initial equity) to finance their investments. If internal finance is insufficient and external finance is required, firms first issue debt, which is the safest security, and regard equity as a last resort. The idea is that internal finance and default-free debt suffers little from the informational asymmetries. If these do not suffice to meet firms' financing needs, firms would strive to issue those funds that are least affected by the asymmetry of information (Tirole, 2006).

Many studies explore the applicability of these theories of corporate finance. The pecking order theory receives substantial empirical support. Tirole (2006) shows that internal financing, usually measured by retained earnings, is the dominant source of finance, while bank loans form the bulk of external financing in the OECD countries investigated. Beck et al. (2008) find evidence in support of the pecking order hypothesis from a survey of firms in 48 countries. Newman et al. (2011) investigate the capital structure of the Chinese small and medium-sized enterprises, and find evidence supporting pecking-order theory. López-Gracia and Sogorb-Mira (2008) test the applicability of pecking order theory and trade-off theory to the financial policies in Small and Medium-Sized Enterprises (SMEs) covering all sectors in Spain, and find that firms follow a funding source hierarchy (pecking order model), but also move towards optimum leverage (trade-off model). For modern services firms, Hogan and Hutson (2005) investigate the capital structure of new technology-based firms, using a survey data of 117 Irish software companies. Consistent with the pecking order hypothesis, this paper

finds that internal financing is the most important source of funding for these software firms. This paper also finds that the software firm founders prefer outside equity to debt when internal financing is insufficient. They use little debt from the banking sector, and the prime source of external finance is equity financing, due to information asymmetries in the banking sector. On the other hand, some studies show that pecking order theory does not hold. For example, Frank and Goyal (2003) use a sample of American firms to test the pecking order theory and find some aspects of evidence challenging the theory. Chen (2004) finds that neither the trade-off nor the Pecking order theories are applicable for the financing of a panel of Chinese-listed companies.

4.2.2 Financing sources and firm performance

Financing is an essential factor for operating a business and is of great importance for firm performance. Rahaman (2011) examines the effects of financing sources on firm growth using a sample of quoted and unquoted firms in the UK and Ireland from 1991 to 2001. The results show that access to internal financing significantly affects firm growth, while this effect decreases with an increase in the firm's access to an external bank credit facility. Du and Girma (2012) investigates the relationship between firm size, financing sources, and total factor productivity growth, using a firm-level data from China. The results show that bank loans are more effective for larger firms, while self-raised finance is more beneficial to smaller firms' growth.

Girma and Vencappa (2014) study the link between financing sources and firm growth in India, and find that bank loans having the strongest impact on firm level productivity growth, followed by non-bank sources and government finance, with the internal sources (retained profits) having the least or even no impact. Ferrando and Ruggieri (2015) investigate the relation between financial structure, access to external finance and labour productivity, using a firm-level data for several euro area countries during the period 1995-2011. The results provide evidence that financial constraints do significantly lower productivity in most of the sectors in these countries. Chen and Guariglia (2013) find that productivity is strongly constrained by the availability of internal finance for Chinese manufacturing firms.

Firms in many developing countries face poor financial institutions characterized by corruption and inefficiency. Some literature shows that in countries with weak financial systems, firms obtain less external financing which results in lower growth. Beck et al. (2008) examine the effects of financial and institutional development on financing firms using a firm-level data covering 48 countries, and find that financial development, property rights and firm size are important factors in financing patterns. The results show that small firms and firms in countries with poor institutions use less external finance, and the improvement of financial systems increases the external financing of firms, and this increase is more significant for small firms than large firms.

On the other hand, some studies demonstrate that financial underdevelopment does not necessarily constrain all firms' growth opportunities, given that they can access alternative non-bank finance sources. Allen et al. (2005) find that the non-legal mechanisms and alternative financing channels are the main driver behind the fast economic growth during the past 30 years in China. Allen et al. (2012) study the legal and business environments, financing channels, and growth patterns of different types of firms in India, and find that alternative nonbank finance sources constitute the most important form of external finance, while bank loans provide the second most important external financing source. The results also show that firms with access to bank or market finance are not associated with higher growth rates, indicating that bank and market finance are not superior to alternative finance in fast-growing economies such as India. However, Ayyagari et al. (2010) use a firm-level data from China and find that bank financing is associated with faster growth whereas informal financing is not. As such there is a question as to whether non-bank loans outperform bank loans in their effects.

4.2.3 Financing sources and technology investment

Much of the literature shows that financing is an important factor for firms' technology investment decisions. A number of studies show that financial constraints exert a negative effect on technology investment (Almeida and Campello 2007; Aghion et al., 2012; Gorodnichenko and Schnitzer, 2013;

Männasoo and Meriküll, 2015). For instance, Gorodnichenko and Schnitzer (2013) show that financial constraints restrain the ability of domestically owned firms to innovate and hence to catch up to the technological frontier. Männasoo and Meriküll (2015) find that the probability of financial constrained firms undertaking R&D activities is around 70% lower than for other firms in Central and Eastern Europe countries.

Some studies show that financial factors affect both manufacturing and services firms' technology investment (Sirilli and Evangelista, 1998; Canepa and Stoneman, 2007; Gorodnichenko and Schnitzer, 2013). Sirilli and Evangelista (1998) investigate technological innovation in the service sector, using a survey data of Italian firms. The results show that the major obstacles for introducing technological innovation in services are the lack of finance sources and the cost of innovation is high. The results also show that services and manufacturing share many similarities in the basic dimensions of the innovation process. Canepa and Stoneman (2007) explore the role of financial constraints on innovation in UK using survey data including both manufacturing and services firms. The results show that financial factors constrain innovative activity, and this impact is greater for firms in high technology sectors, especially for small firms. Gorodnichenko and Schnitzer (2013) examine how financial constraints affect a firm's innovation activities, using a large survey data including firms from both manufacturing and service sector in 27 transition countries. The results show that financial constraints restrain the ability of domestically owned firms to innovate. The authors further investigate the causal effects of financial constraints on innovation across firm types, and find similar effects for firms in services and manufacturing.

However, some studies show weak effects of financial constraints on technology investment. For example, Harhoff (1998) finds a significant but weak relation between R&D investment and cash flow for small and large German firms. Hall et al. (1998) studies the relationship between cash flow and R&D investment for firms in the scientific (high technology) sectors, and find that R&D is much more sensitive to cash flow for U.S. firms than for French

and Japanese firms. Bond et al. (2005) test cash flow on investment in R&D for firms from UK and Germany, and find firms in neither of these two countries display a correlation between the level of R&D and cash flow.

Most of the existing studies on the relationship between finance and firms' technology investment are focused on the effects of financial constraints on technology investment. However, a problem with financial constraints is that they are difficult to be identified in applied works. Typically, financial constraints are proxied using an indirect approach measured by the sensitivity of investment to cash flow (Fazzari et al., 1988). A drawback of this measurement is that it ignores the possible availability of other forms of financing and could suffer from ineffective identification of the presence of financing constraints (Kaplan and Zingales, 1997). Some studies extend the financial constraints by including both internal and external financing, and make some comparison of the effects of these two. Hall and Lerner (2010) survey the evidence on the "funding gap" for investment innovation in the literature, and find that large firms appear to prefer internal funds to finance investments, and they manage their cash flow to guarantee this. Brown et al. (2012) find strong evidence that both internal and external equity finance matters for R&D investment for European firms when expanding the analysis to include stock issues as a source of funds and changes in cash holdings to control for endogenous R&D smoothing. Guariglia and Liu (2014) show that Chinese firms' innovation activities are constrained by the availability of internal finance, especially for private firms. Sasidharan et al. (2015) find significantly positive relationship between internal cash flow and firms' R&D expenditure for Indian manufacturing firms, and they observe that the firms do not use external equity to finance their R&D.

4.2.4 Financing sources and export

There is now a substantial literature that shows that access to finance is an important determinant of firm export status, of which many focus on the role of financial/credit constraints on exporting (Minetti and Zhu, 2011; Chaney, 2013; Feenstra et al., 2013; Wagner, 2014; Manova et al., 2015). Minetti and Zhu (2011) use detailed survey data of Italian manufacturing firms to study the

impact of credit rationing on firms' export, and find that the probability of exporting is 39% lower for the rationed firms. Chaney (2013) theoretically show that given large fixed costs of exporting, only those firms that have sufficient liquidity are able to export. Manova et al. (2015) show that credit constraints restrict international trade flows. However, Greenaway et al. (2007) examines financial health and export market participation using a panel of UK manufacturing firms, and find that exporters exhibit better financial health than non-exporters, but this is because participation in export markets improves firms' ex-post financial health rather than better ex-ante financial health being more likely to start to export. Stiebale (2011) analyses the impact of financial constraints on export participation using a panel data of French manufacturing firms. The results exhibit no evidence of financial constraints affecting export decisions after controlling for firm heterogeneity.

Which financing sources play a more important role in determining export or the preferences of firms to finance their exporting activity has not been well explored in the existing literature. Some studies pay attention to one or two financing sources on exporting. Du and Girma (2007) find that access to bank loans is associated with greater export market orientation among Chinese domestic private enterprises in the manufacturing sector. Bellone et al. (2010) find that external funds are an important determinant of firm export status. El-Said et al. (2015) find that access to banks has a positive effect on the probability of exporting for Egyptian small and medium enterprises.

Since services are often treated as nontradable, most of the existing studies concentrate on the manufacturing sector. Some studies show that service exporters and manufacturing exporters have many different characteristics. For example, Ariu (2016) compares trade in goods and trade in services at the firm level using transaction data from Belgium, and find that firms trading services are fewer and trade smaller values than those trading goods. They also find that services traders experience higher entry and exit rates and a lower survival probability, but the surviving firms grow more rapidly than those trading goods. Very few studies investigate the role of finance on the export of service firms. To our knowledge, the only paper that studies this aspect is Lancheros and

Demirel (2012), which examines the role of finance in determining exporting decisions of Indian services firms. The results indicate no significant evidence that access to finance influences the decision to export. However, this paper focuses on external financing sources which are measured by long- and short-term borrowings, while other forms of financing such as firms' retained profits and non-bank loans are ignored. Another relevant study is Sahoo and Dash (2014), which examines the determinants of Indian modern services' exports, and the results show that financial development as well as human capital, infrastructure and some other factors have important impacts on services exports in India.

4.2.5 Comparison between manufacturing and service firms

Although a vast literature exists on the exporting and technology investment decision of manufacturing firms, the literature on these activities by services firms, especially the effects of financing sources, is limited. One reason is that for a long time, international trade has been dominated by manufactured goods, while the services have been largely regarded as non-tradable (Francois and Hoeckman 2010). Another reason is due to data constraints, because the information on services firms' trade and technology investment is not widely available.

Some studies show that services firms are less financial constrained when compared with their manufacturing counterparts. Westhead and Storey (1997) employ survey data of high technology firms including both manufacturing and services in the UK to test financial constraints on firms' growth. They find that high technology manufacturing firms are much more likely to be financially constrained than those of similar businesses in the services sector. They also find that technology-intensive firms are more likely to be financially constrained than low technology firms. Efthyvoulou and Vahter (2016) use survey data of innovative firms from 11 European countries to examine the effects of financial constraints on innovation performance, comparing between firms from the production and services sector. The results show that firms in production industries are significantly more sensitive to financial frictions than

those in the service sector. This paper also indicates that financial constraints are particularly detrimental for firms with no exporting activities.

However, on the other hand, Silva and Carreira (2010) find that financial constraints are more severe for services than for manufacturing firms, by studying a panel of Portuguese firms. The authors point out that service firms on average require a lower initial investment (lower sunk costs) than manufacturing firms, while on the other hand, for most services, the main input is human and the output is of an intangible nature, which is harder to use as collateral when resorting to external finance. Due to this reason, services firms have more difficulty in accessing external finance.

4.2.6 Technology investment and export

The literature indicates that most productive firms self-select into the exporting market (Melitz, 2003). A large number of empirical studies favour this theory and show that technology investment and innovation activities improve firms' productivity and then increase the probability of exporting (Roper and Love, 2002; Yang et al., 2004; López Rodríguez and García Rodríguez 2005; Lachenmaier and Wößmann, 2006; Cassiman et al., 2010; Liu and Lu, 2015). For example, Lachenmaier and Wößmann (2006) find that innovation is one of the major driving forces of exporting among German manufacturing firms. Cassiman et al. (2010) find strong evidence that product innovation improves productivity and facilitates small non-exporting firms into the foreign market for Spanish manufacturing firms. They argue that firms' prior investment decision is a potential underlying mechanism for the self-selection into exporting market. Liu and Lu (2015) find that firm investment in technology significantly and substantially increases the likelihood of exporting for Chinese firms, and this is largely due to the positive effect of technology investment on improving firm productivity.

On the other hand, some literature shows that there could be reverse causality from exporting to technology investment. Exporting facilitates the transfer of knowledge across countries and promotes the innovation process. Baldwin and Gu (2004) show evidence that plants that enter into export

markets increase their investments in R&D and staff training to enhance their absorptive capacities for foreign advanced technologies, using a plant level data from Canadian manufacturing sector. Ederington and McCalman (2008) show that exporting has a positive impact on the equilibrium rate of adoption, and hence on firms' productivity. Damijan et al. (2010) examine both directions of the relationship between innovation activity and the decision to export, using a firm-level data from Slovenia. They find no evidence that innovations increase the probability of becoming an exporter, but do find evidence that exporting increases the likelihood of medium and large firms to become process innovators, and that exporting improves productivity. Bratti and Felice (2012) investigate whether exporters are more likely to carry out product innovations using data of Italian manufacturing firms, and find significant correlation between a firm's export status and the probability of product innovations. Parameswaran (2010) shows that export encourages investment in innovation using data of Indian manufacturing firms over 1994-1999.

Recent literature argues that firms' technology investment and export decisions are jointly determined. The theoretical works of Costantini and Melitz (2007) and Atkeson and Burstein (2010) model the interdependence between these two activities and identify how they are linked. Costantini and Melitz (2007) construct a model showing that the anticipation of trade liberalisation causes a firm to bring forward the decision to innovate for future exporting. Some empirical studies examine the simultaneous selection of investment in technology and exporting, and confirm the interdependence between these two activities (Aw et al., 2007, 2008, 2011; Lileeva and Trefler, 2010; Bustos, 2011; Esteve-Pérez & Rodríguez, 2013). For example, Aw et al. (2011) develop a dynamic structural model of a producer's decision to invest in R&D and export, and estimate this model using plant-level data from the Taiwanese electronic industry. They find a complex set of interactions between R&D, exporting and productivity. Lileeva and Trefler (2010) show that improved access to foreign markets encourage firms to simultaneously export and invest in raising productivity.

The joint decision of technology investment and exporting for service firms has not been explored much. Harris and Moffat (2011) examine the contemporaneous links between exporting, R&D investment and innovation and the determinants of these activities, using a dataset of UK manufacturing and service firms. They find that for both manufacturing and services, being involved in exporting increased the probability of spending on R&D. Spending on R&D has a much larger impact on the probability of exporting for manufacturing firms, while it has no significant impact on exporting for service firms but does increase the probability of innovating. Vogel and Wagner (2012) investigate export and R&D investment on firm performance using data relating to German business services firms. The results show that in line with firms in manufacturing, service firms that export and invest in R&D have a higher productivity level than firms that export but do not undertake R&D, which in turn demonstrate higher productivity levels than firms that neither export nor engage in R&D.

4.2.7 Finance, technology investment and export

Both technology investment and exporting involve important start-up sunk costs, and there are usually fixed costs to maintain these activities. In addition, both activities are associated with higher risks as compared to other activities (Máñez et al.2014). The outcomes of technology investment are uncertain and exporting faces exchange rate fluctuations and unfamiliar foreign markets. These features of technology investment and exporting make them sensitive to the availability of financing sources.

To the best of our knowledge, so far there are only two papers that examine the effects of financial factors on the joint decision of R&D investment and exporting, namely Manez et al. (2014) and Altomonte et al. (2015). Máñez et al. (2014) investigates the role of internal and external financial constraints on firms' simultaneous decision to export and conduct R&D investments, using a panel data of Spanish manufacturing firms during the period of 1990–2011. The external financial constraint is measured by the cost of firms' long-term debts with banks and other lenders, and the internal financial constraint is measured as cash flow. The empirical results show that

both internal and external financial constraints are relevant for the joint decision of technology investment and exporting, and small firms are generally more financially constrained. However, although this paper takes into account of both internal and external financial constraints, it only considers one source of external finance and ignores the other available sources such as government loans, other nonbank loans, and these sources can benefit firms and provide opportunities to export and innovate as well.

The study by Altomonte et al. (2015) examines the mutual relationships between financial constraints, R&D investments, exporting and productivity. Using data of manufacturing firms from France, Germany, Italy and Spain, the results confirm the simultaneous relationship between export and R&D investment, and also the existence of a circular relationship between exporting and financial constraints, but find no direct correlation between investments in R&D and financial constraints. This paper measures financial constraint variables as a dummy to indicate whether firms are denied by banks, and it ignores other financial sources as well.

In summary, the existing literature corroborates that financing is a crucial factor on firm performance, but with mixed results on the relative importance of internal and external financing, which is also affected by the availability of external financing due to the development of the financial system. The literature confirms the interdependence between R&D investment and exporting, and some theoretical works as well as empirical studies have investigated the simultaneous decision of firms' R&D investment and export. Yet, the role of financing sources on this joint decision is still limited, and which financing sources are more important for these two activities is still underexplored.

The service sector has been rather neglected in the past, especially regarding technology investment and exporting behaviour, and the role of financing on these activities. With the growing importance of this sector in economies, and the new availability of high-quality data for the service firms, a growing body of empirical research has begun to study this particular sector. For example, some empirical literature compares services to manufacturing

sectors, and finds that service firms are less financial constrained than manufacturing firms (Westhead and Storey, 1997; Efthyvoulou and Vahter, 2016), while Silva and Carreira (2010) find the opposite. The literature also finds that high small technology firms are more sensitive to finance than other types of firms. With respect to service firms' technology investment, the existing literature shows that financing plays an important role. However, the effects of financing on exporting, and whether the decision of service firms' technology investment and exporting are simultaneously determined as in the manufacturing sector, and the role of financing on this joint decision, have not been well explored.

4.3 Exporting and technology investment in India

India has experienced a rapid growth since the economic reforms began in the early 1990s. One of the most important features of the reforms has been the promotion of technology and exporting. In this section, we provide some descriptive graphs to analyse exporting, technology investment and financing sources of Indian manufacturing and services firms, and offer some comparison between firms in these two sectors. We first plot the proportion of firms that invest in technology over time, comparing exporters to non-exporter, large firms to small firms. Then we describe the variation of technology investment/export across industries. Further, we provide a comparison regarding the internal and external financing sources between technology investment firms and non-technology investment firms, exporters and non-exporters. The detailed information of data sources and variable definitions are introduced in Chapter 2.

Figure 4.1 shows the proportion of firms that invest in R&D and technology during 1999-2010. The figure illustrates that the proportion of manufacturing firms that invests in R&D fluctuates around 20% and slightly decreases since 2007, while the proportion of services firms that invest in R&D is low with a proportion around 1%, and this does not change much over our study period. This is in line with Czarnitzki and Fier (2002) who study the innovation of the services sector in Germany. This paper points out that even

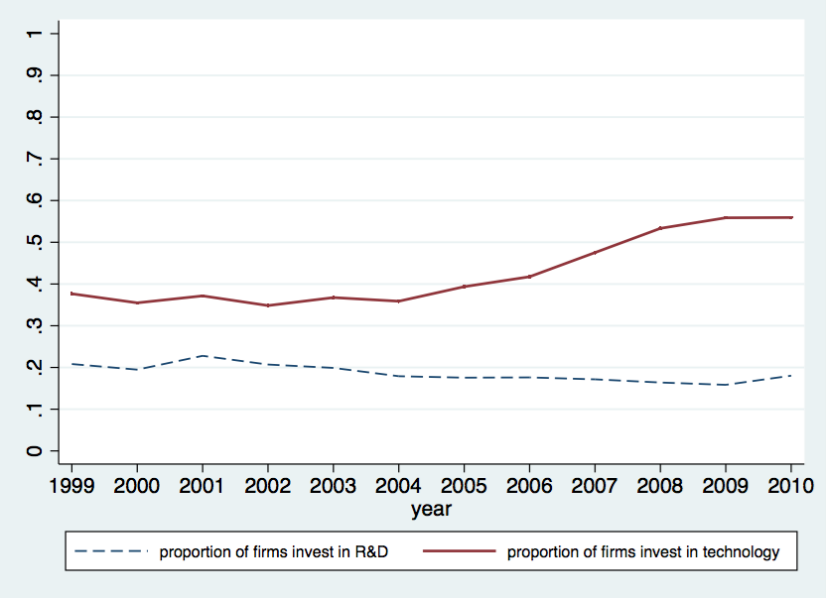
though new services have a high technological capability, R&D is still mainly carried out by manufacturing. As for technology investment, the figures for both manufacturing and services firms witnesses a gradual increase since 2004, but the proportion of services firms is still much lower when compared with the manufacturing firms for which the proportion increases from around 38% during 1999-2004 to more than 58% in 2010, while that of the services firms increases from 20% during 1999-2004 to 40% in 2010.

The literature shows that exporters are more likely to conduct technology investment to assimilate the new technology or ideas they gain from exporting (Aw et al., 2007). To show whether this is true for manufacturing and services firms in India, we plot the proportions of exporters and non-exporters that invest in R&D and technology in figure 4.2[11]. We observe that the proportion of manufacturing firms engaging in R&D investment slightly fluctuates and does not change much for both exporters and non-exporters, while both exporters and non-exporters see an increase in the proportion of firms that participate in technology investment during our study period, and similar phenomenon can be found in the services firms. Also, we can see that the proportion of exporters that invest in technology is much higher than that of non-exporters, indicating that exporters are more likely to engage in technology investment, which is consistent with the literature.

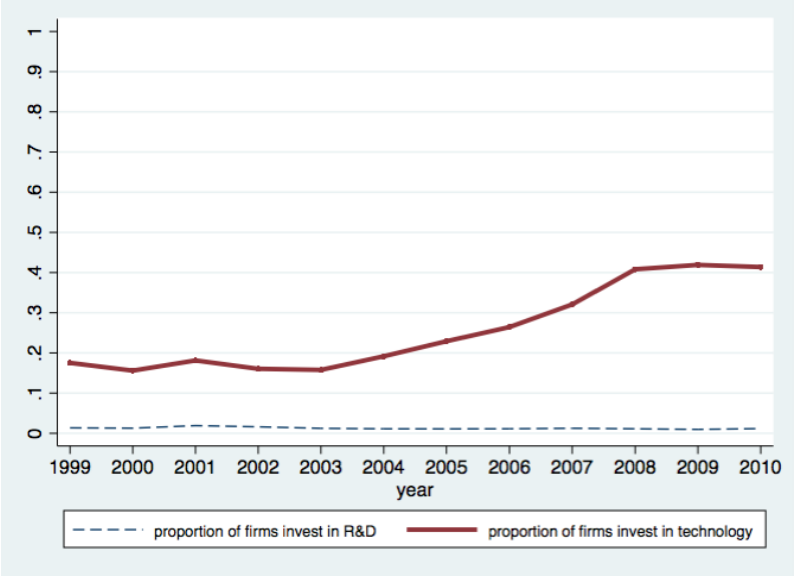
[11] Given that the proportion of services firms that invest in R&D is negligible, we only plot the proportions of exporters and non-exporters that invest in R&D for manufacturing firms.

Figure 4. 1 Proportion of firms conducting R&D and technology investment

(a) Manufacturing firms



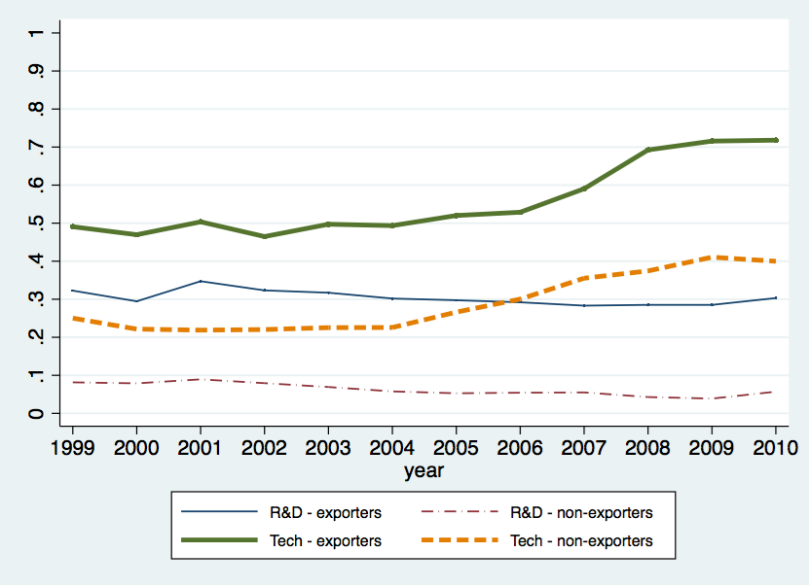
(b) Services firms



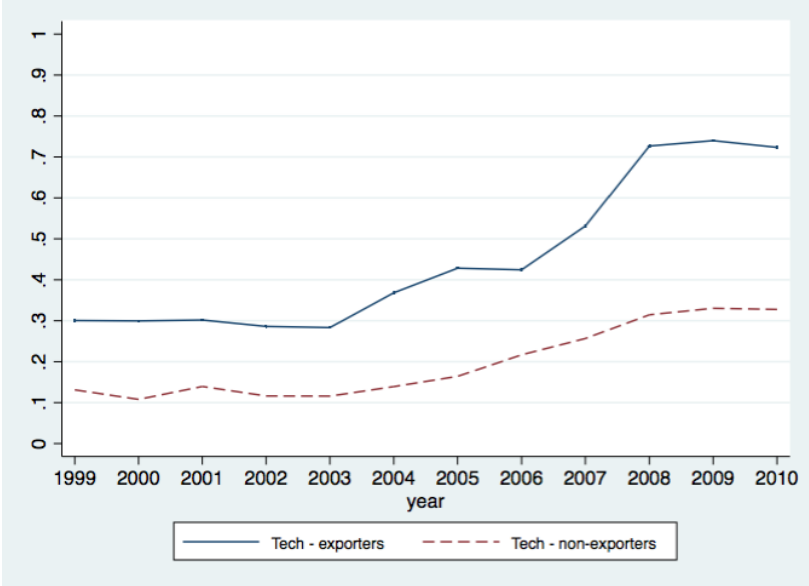
Notes: The figure shows the proportion of firms that conduct R&D and technology investment respectively over time for a sample of Indian manufacturing and services firms respectively during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 2 Proportion of exporters and non-exporters investing in technology

(a) Manufacturing firms



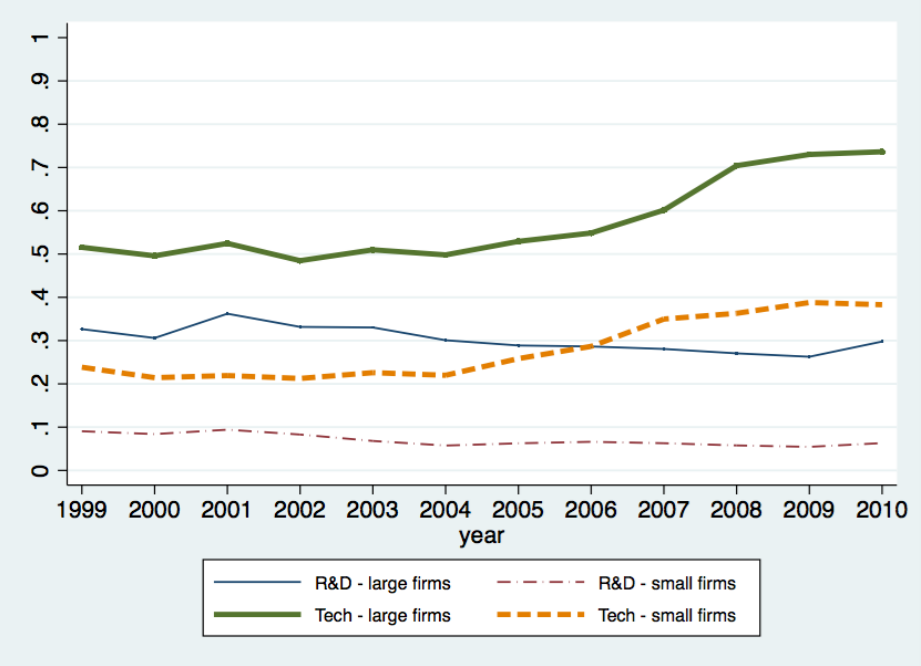
(b) Services firms



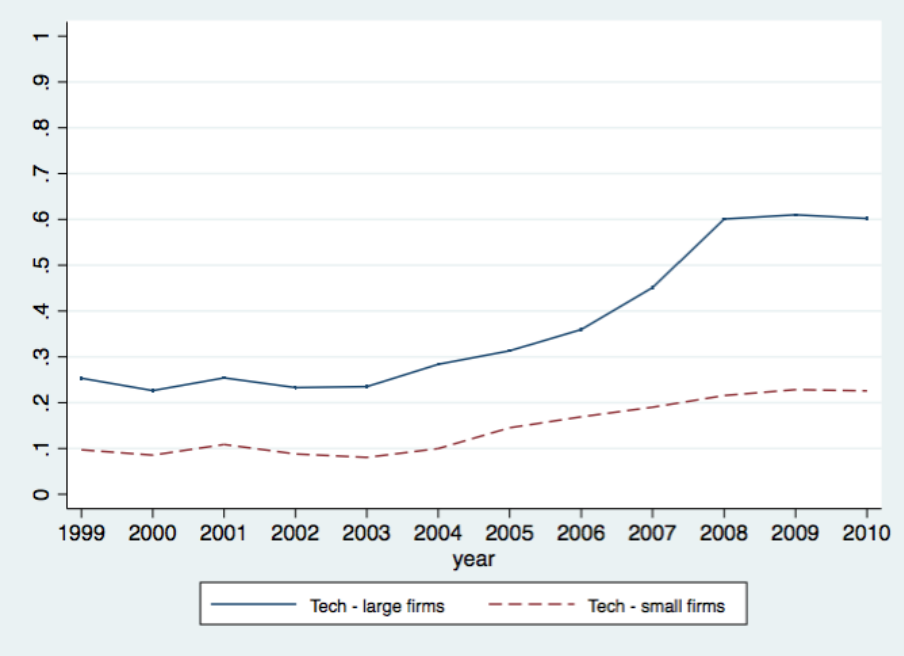
Notes: The figure shows the proportion of exporters and non-exporters that conduct R&D and technology investment over time for a sample of Indian manufacturing and services firms respectively during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 3 Proportion of large and small firms investing in R&D and technology

(a) Manufacturing firms



(b) Services firms



Notes: The figure shows the proportion of large firms and small firms that conduct R&D and technology investment over time for a sample of Indian manufacturing and services firms respectively during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Since technology investment involves large sunk costs and uncertainty, large firms usually find it easier to access funds while small firms are relatively more likely to be financial constrained. We expect that large firms have a higher probability of conducting technology investment than small firms. We classify large and small firms by the median of size which is measured by total assets, and compare the proportion of large firms and small firms that invest in R&D and technology respectively in figure 4.3[12]. The figure shows that the proportion of manufacturing firms invest in R&D does not change significantly for both large firms and small firms. Large firms show a higher proportion of firms engage in R&D than small firms. For both manufacturing and services firms, the figure shows that the proportion of large firms engaging in technology investment is higher than that of small firms, revealing that large firms tend to be more like to invest in technology. Also, for both large and small firms there is a gradual rise in the proportion of firms investing in technology. This pattern is consistent between manufacturing and services firms.

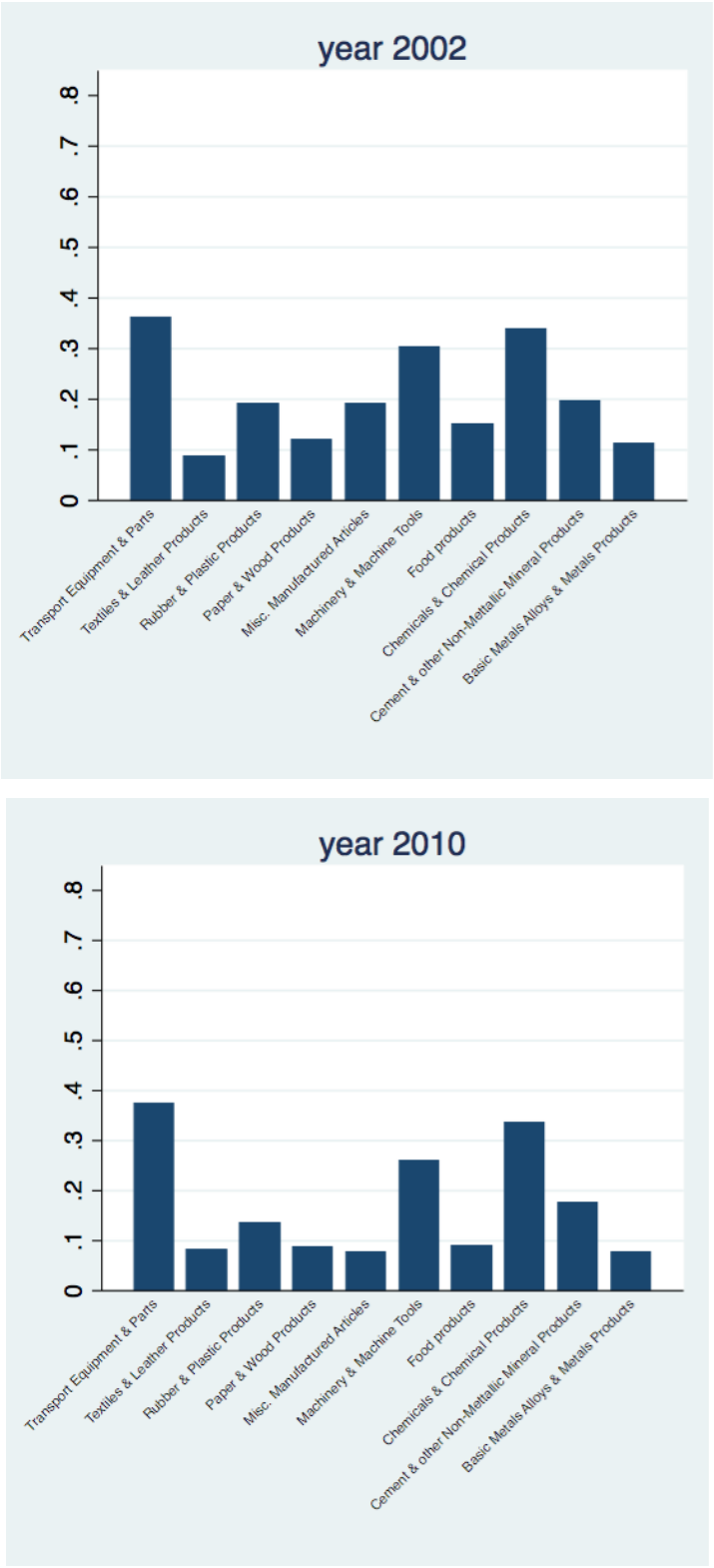
Since traditional manufacturing industries require little technology such as textile and leather, while other industries are more intensive in technology, we plot the proportion of manufacturing firms that engage in R&D and technology investment by industry, which is shown in Figures 4.4 and 4.5. We graph this for two representative years, 2002 and 2010. The figures confirm that the behaviour of R&D and technology investment varies across industries. We see from Figure 4.4 that the industries of transport equipment and parts, machinery and machine tools, chemicals and chemical products enjoy relatively higher proportion of firms conducting R&D than other industries, and this pattern is stable for 2002 and 2010. Similar case can be observed for technology investment shown in Figure 4.5, these three industries demonstrate higher proportions of firms that invest in technology than other industries. Another feature can be found in Figure 4.5 is that compared with 2002, in 2010, all industries see an obvious rise in the proportion of firms that invest in technology.

[12] Given that the proportion of services firms that invest in R&D is negligible, we only plot the proportions of large and small firms that invest in R&D for manufacturing firms.

Similar to manufacturing, some service industries are closely related to technology such as computer software, while other industries like commercial are less related to technology. We expect that firms' technology investment varies across industries. Figure 4.6 graphs the proportion of services firms that invest in technology in each industry for the years of 2002 and 2010. The figure proves that technology investment differs by industries. Specifically, technology intensive industries show a relatively higher proportion of firms investing in technology in both years, such as computer software and telecommunication services. The figure also indicates that the proportions of firms conducting technology investment in most industries experienced an increase in 2010 compared with 2002.

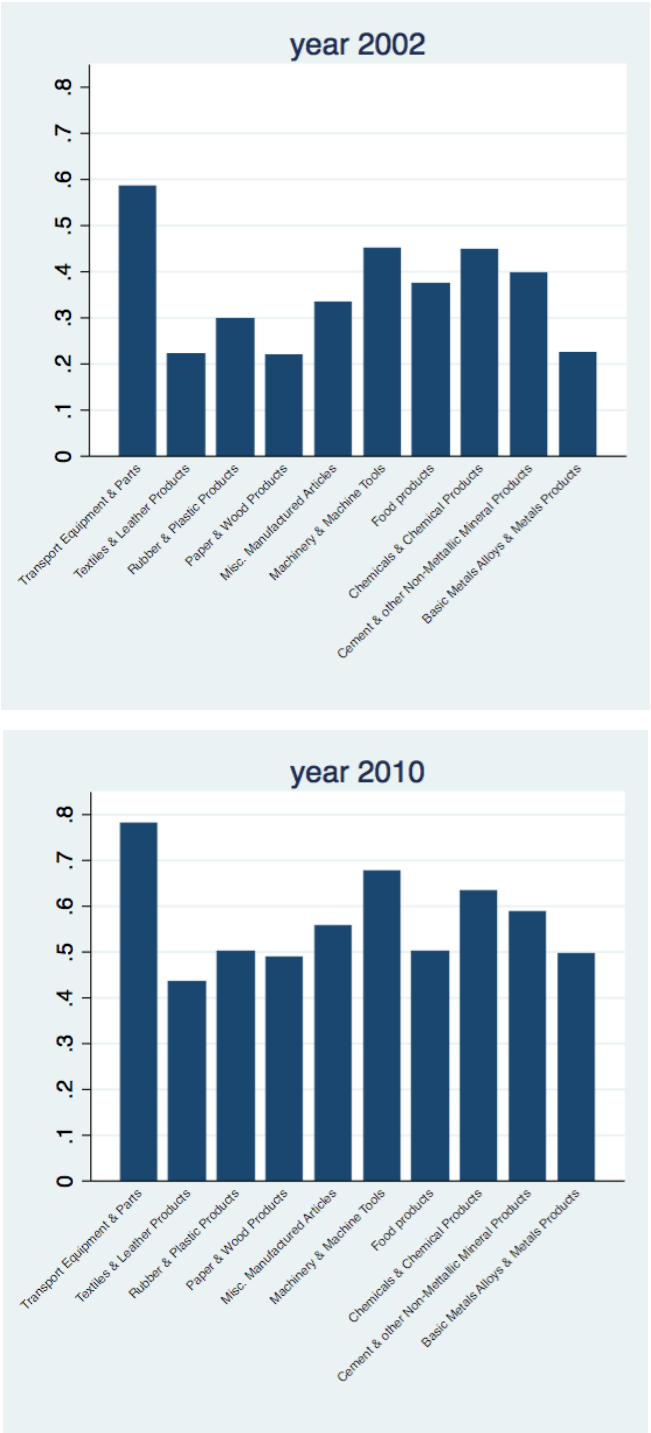
Due to the nature of exporting, i.e. the regulations of destination countries, the transportation costs and so on, some industries find it easier to participate in foreign markets, while the barriers to exporting in other industries are much higher. We expect that both manufacturing and services firms' exporting activity varies across industries. We plot the proportion of firms that export by industry for manufacturing and services in years of 2002 and 2010 which are shown in Figure 4.7 and Figure 4.8 respectively. The figures demonstrate that the proportion of exporters in each industry varies. Specifically, Figure 4.7 shows that the industries of paper and wood products, food products, share relatively less proportion of firms that participate in exporting markets than other industries. In Figure 4.8, we can find that some technology intensive industries enjoy a relatively higher proportion of firms that participate in exporting, such as computer software and ITES. This is possibly because India is famous for its developing of modern technology and has a comparative advantage in software industries.

Figure 4. 4 Proportion of manufacturing firms conducting R&D by industry



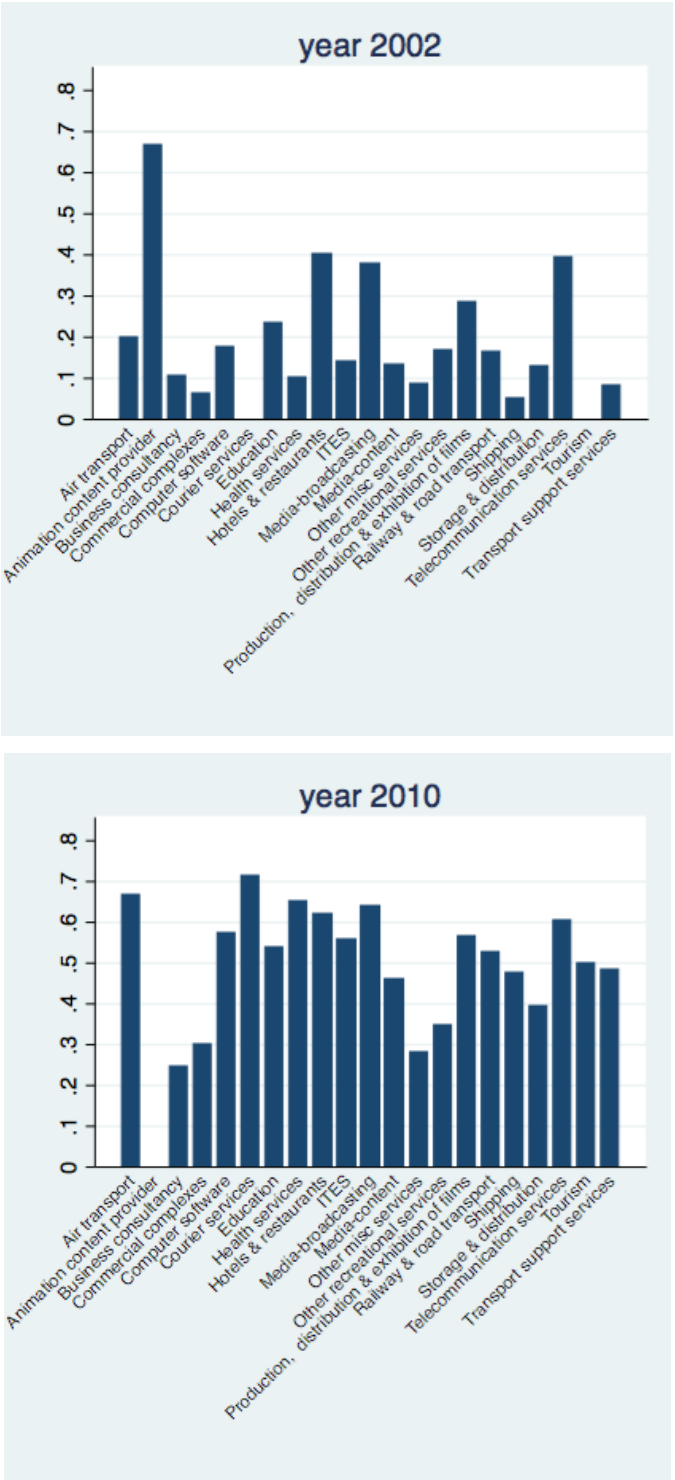
Notes: The figure shows the proportion of firms that conduct R&D for the year of 2002 and 2010 by industry for a sample of Indian manufacturing firms.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 5 Proportion of manufacturing firms conducting technology investment by industry



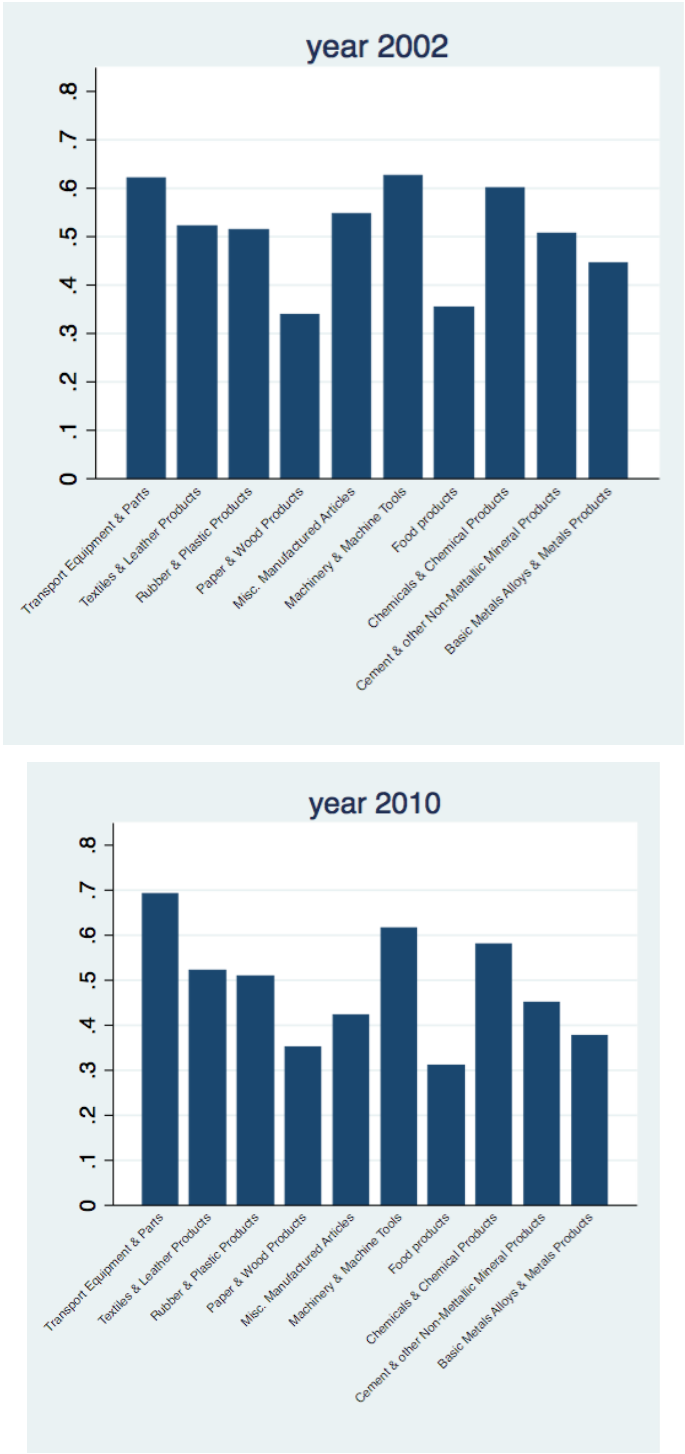
Notes: The figure shows the proportion of firms that conduct technology investment for the year of 2002 and 2010 by industry for a sample of Indian manufacturing firms.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 6 Proportion of services firms conducting technology investment by industry



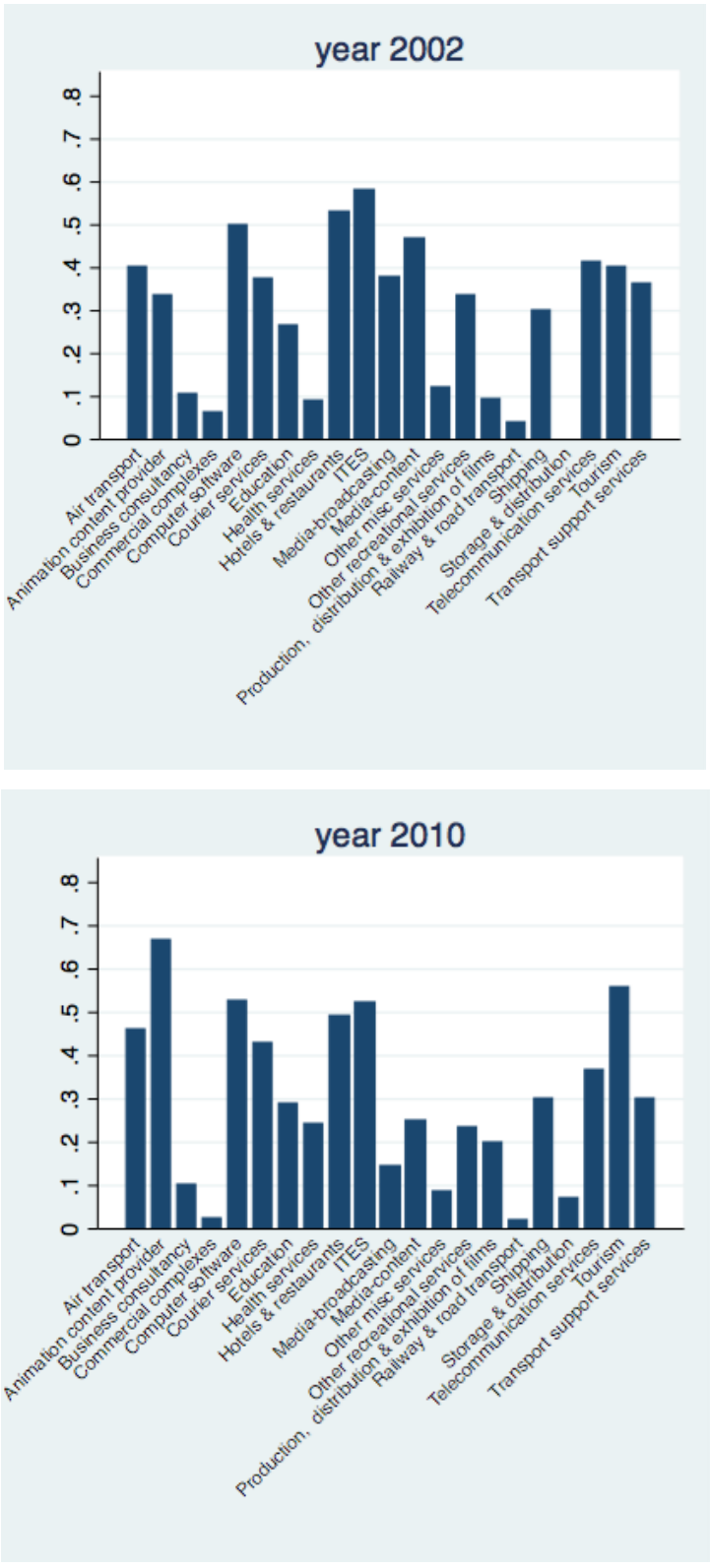
Notes: The figure shows the proportion of firms that conduct technology investment for the year of 2002 and 2010 by industry for a sample of Indian services firms.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 7 Proportion of manufacturing exporters by industry



Notes: The figure shows the proportion of exporters for the year of 2002 and 2010 by industry for a sample of Indian manufacturing firms.
Source: The Prowess database and authors' calculations using the dataset.

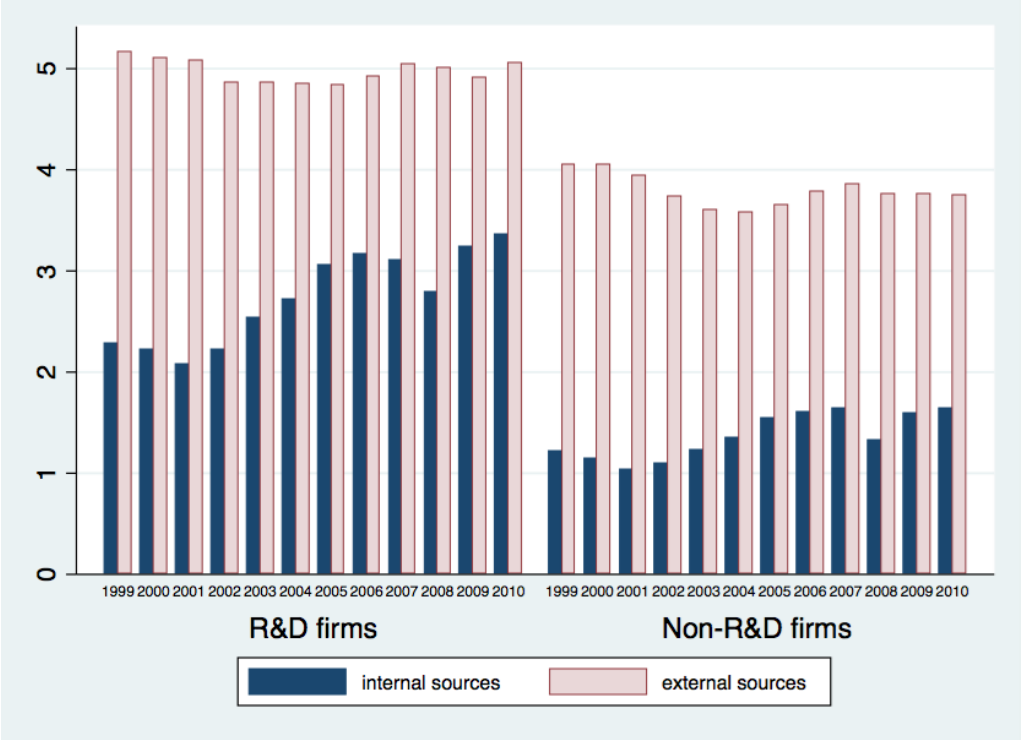
Figure 4. 8 Proportion of services exporters by industry



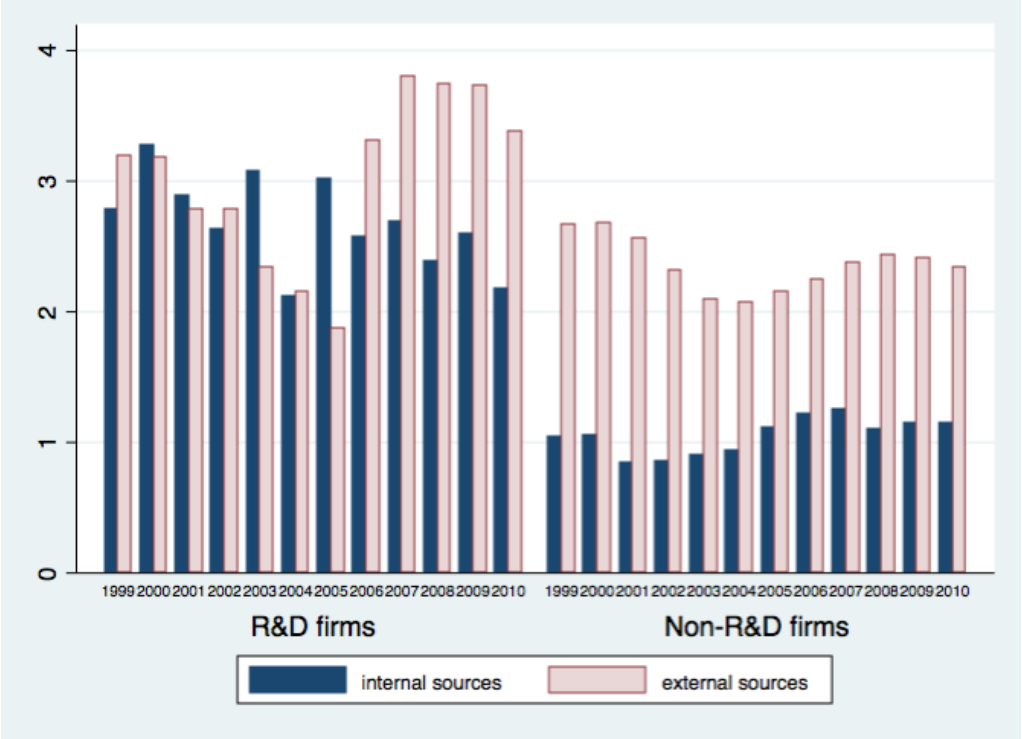
Notes: The figure shows the proportion of exporters for the year of 2002 and 2010 by industry for a sample of Indian services firms.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 9 Finance sources: R&D VS Non-R&D firms

(a) Manufacturing firms



(b) Services firms

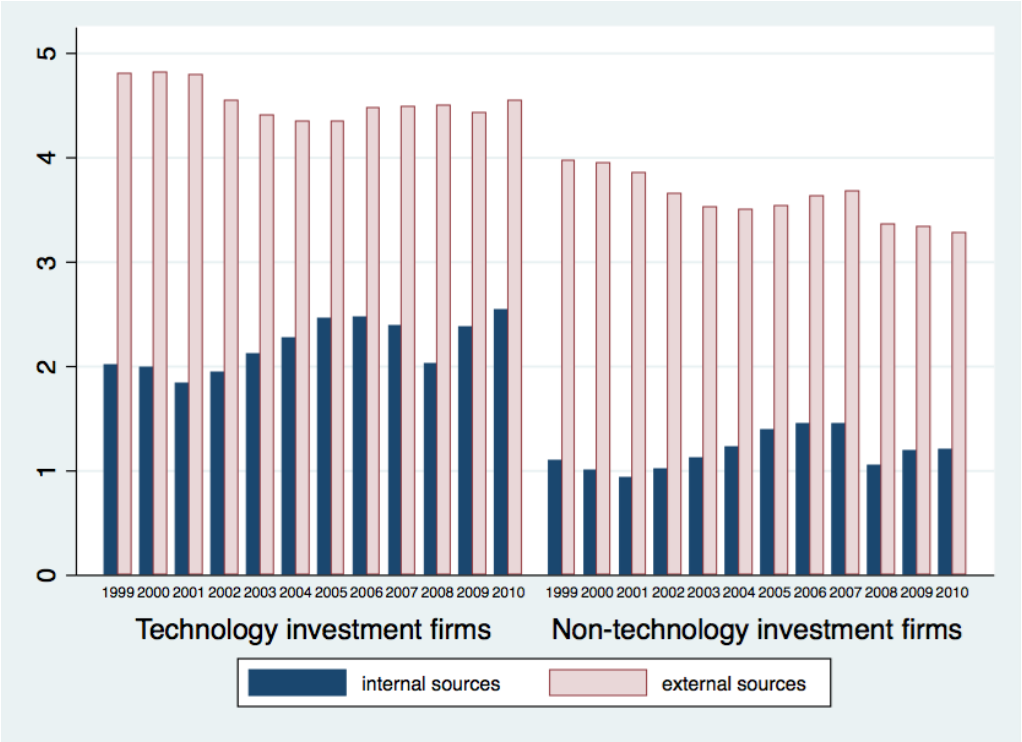


Notes: The figure shows the average natural logarithm value of internal and external financing for R&D and non-R&D firms respectively over time for a sample of Indian manufacturing and service firms during the period of 1999-2010.

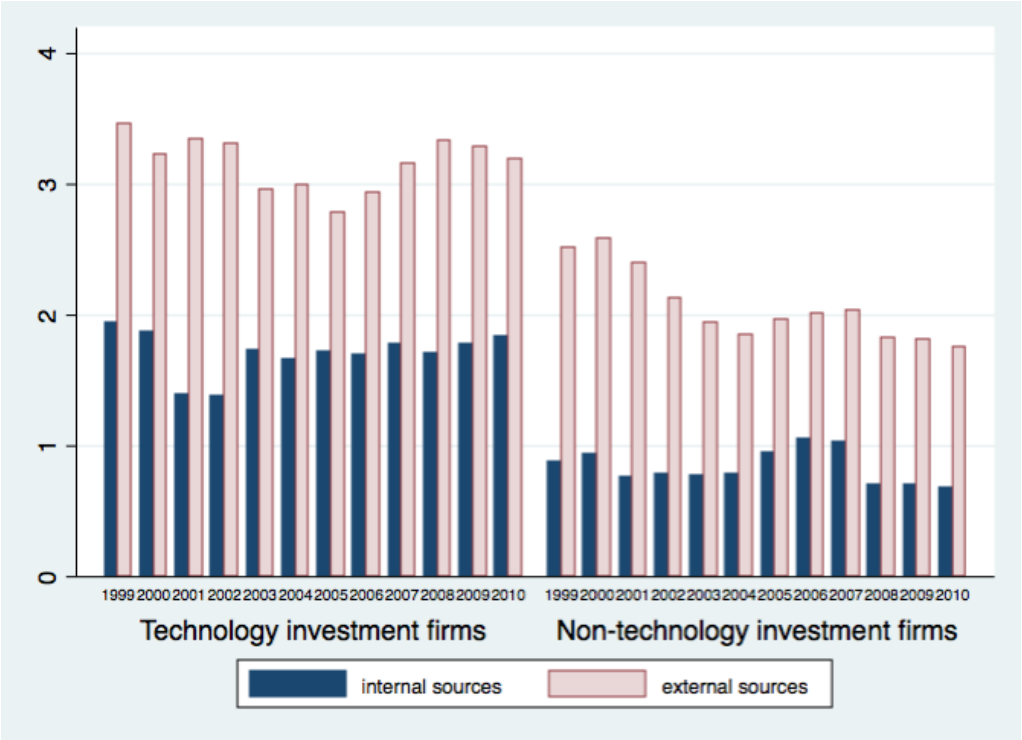
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 10 Finance sources: Technology VS Non-technology investment firms

(a) Manufacturing firms



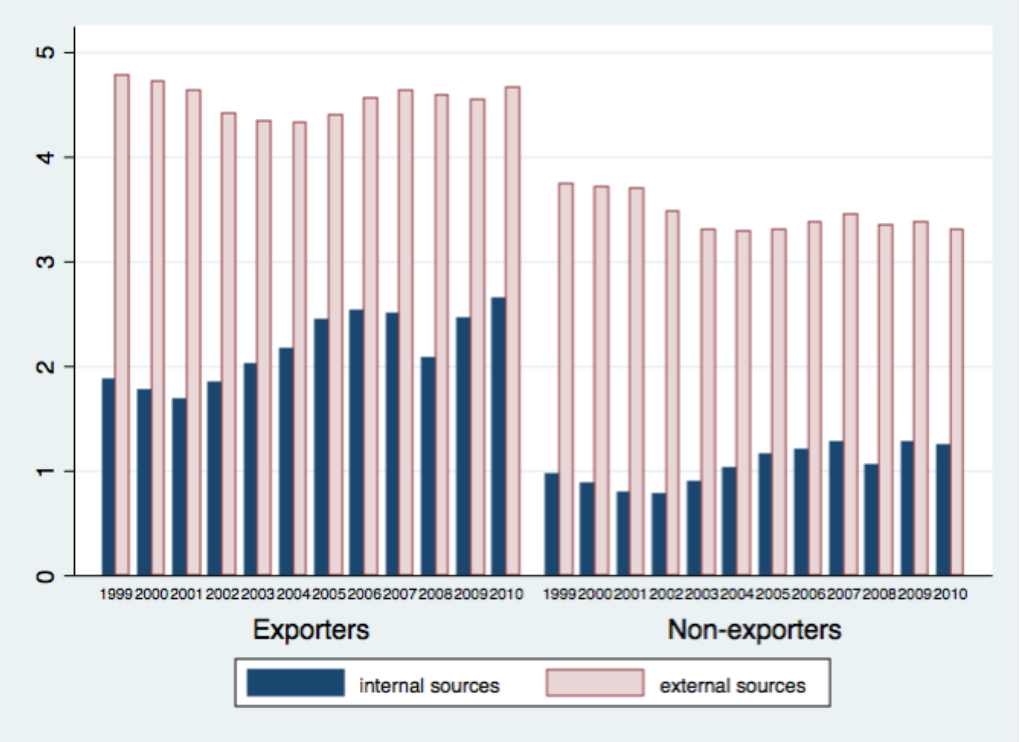
(b) Services firms



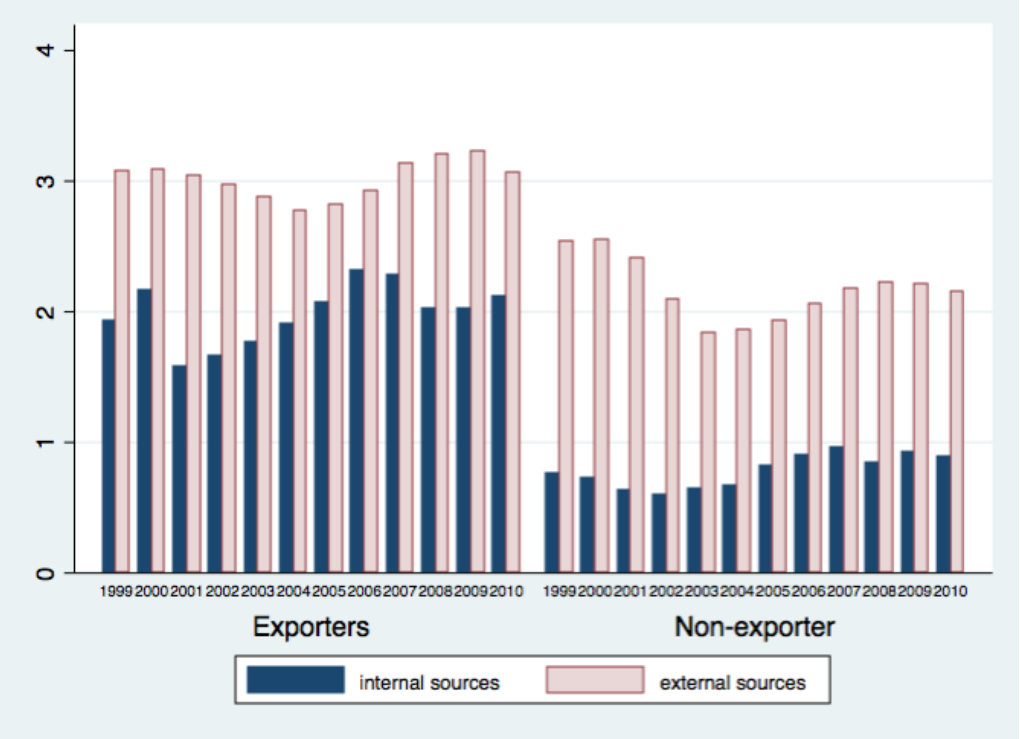
Notes: The figure shows the average natural logarithm value of internal and external financing for technology investment and non-technology investment firms respectively over time for a sample of Indian manufacturing and service firms during the period of 1999-2010.
Source: The Prowess database and authors' calculations using the dataset.

Figure 4. 11 Finance sources: Exporter VS Non-exporters

(a) Manufacturing firms



(b) Services firms



Notes: The figure shows the average natural logarithm value of internal and external financing for exporters and non-exporters respectively over time for a sample of Indian manufacturing and service firms during the period of 1999-2009.
Source: The Prowess database and authors' calculations using the dataset.

Our interest lies in investigating the role of financing sources on manufacturing and services firms' technology investment and exporting behaviour. The literature shows that financing is an important factor that determines firms' technology investment and/or exporting (Männasoo and Meriküll, 2015; Manova et al., 2015), while which financing dominates in determining these activities of Indian manufacturing and services firms is an issue to be explored. Figure 4.9 shows the average natural logarithm value of internal and external financing over the sample period, comparing between firms that invest in R&D and do not invest in R&D. The figure indicates that both manufacturing and services firms that invest in R&D enjoy both a higher average value of internal and external financing. The figure also reveals that R&D firms have a relatively greater share of internal sources than non-R&D firms. Similarly, Figure 4.10 compares the financing patterns between firms that invest in technology and do not invest in technology. We find that both manufacturing and services firms that invest in technology have a higher average value of internal financing as well as external financing than other firms. Also, technology investment firms have a higher share of internal financing than their non-technology investment firms. These financing patterns are very similar between manufacturing firms and services firms.

We further compare the internal and external financing sources over time between exporters and non-exporter in figure 4.11. The figure indicates that both manufacturing and services exporters on average have more internal and external financing than non-exporters, and we can also find that firms that export have a much higher share of internal financing than non-exporters, revealing that internal finance plays a significant role in determining firms' export status. This pattern is consistent between Indian manufacturing and services firms.

In summary, our descriptive analysis illustrates that around 20% of Indian manufacturing firms invest in R&D, and it did not experience significant changes during our study period of 1999-2010, while there are very few service sector firms in India directly conduct R&D investment, and the R&D activities is still mainly carried out by manufacturing firms. Although service firms

rarely participate in R&D investment, most of them invest in indirect technology. The proportion of both manufacturing and services firms that invest in technology gradually increased during our study period. However, when compared with manufacturing firms, the proportion of services firms that invest in technology is much lower. A much higher proportion of both manufacturing exporters and services exporters engage in technology investment than their non-exporting counterparts. These firms also show a consistent pattern of technology investment with firm size. A higher proportion of large firms invest in technology than small firms, which is compatible with the literature. In addition, the graphs indicate that technology investment and exporting of manufacturing and service firms varies across industries. Specifically, the manufacturing industries of transport equipment and parts, machinery and machine tools, chemicals and chemical products, and some technology intensive industries in services such as computer software and telecommunication services have a higher proportion of firms participating in these activities. Further, we graph the average natural logarithm value of internal and external financing over the sample period, and find that firms that engage in technology investment/export enjoy both more financing in absolute terms from internal and external sources, and the figures also reveal that firms conducting these activities have a relatively high share of internal financing sources compared to their counterparts, suggesting that internal finance plays a significant role in determining firms' technology investment and export decisions.

4.4 Methodology and data

4.4.1 The empirical model

The main interest of this study lies in examining firms' decisions about technology investment and exporting, paying particular attention to the role of financing sources. Following the framework of Aw et al. (2007) and (2011) and Máñez et al. (2014), we employ a dynamic bivariate probit model where technology investment and exporting are treated as two separate binary

decisions. The relatedness of these two decisions occurs via the correlation of the errors. Specifically, the two outcomes are determined by two unobserved latent variables $Tech_{it}^{*}$ and EX_{it}^{*}:

$$Tech_{it}^{*} = X_{i,t-1}'a + \varepsilon r_{it} \quad (4.1a)$$

$$EX_{it}^{*} = X_{i,t-1}'b + \varepsilon x_{it} \quad (4.1b)$$

Where $X_{i,t-1}'$is a vector of regressors, the errors εr_{it} and εx_{it} are jointly normally distributed with means of 0, variances of 1, and the correlations of ρ. The two binary activities are:

$$Tech_{it} = \begin{cases} 1 & if\ Tech_{it}^{*} > 0 \\ 0 & if\ Tech_{it}^{*} \leq 0 \end{cases} \quad (4.2a)$$

$$EX_{it} = \begin{cases} 1 & if\ EX_{it}^{*} > 0 \\ 0 & if\ EX_{it}^{*} \leq 0 \end{cases} \quad (4.2b)$$

Where $Tech_{it}$is an indicator variable for firms that invest in Tech, and EX_{it} is an indicator variable for firms that export. The correlations of the errors εr_{it} and εx_{it} ρ are non-zero, otherwise the model collapses to two separate probit models.

Thus, we estimate the following dynamic bivariate probit model:

$$Tech_{it} = \begin{cases} 1 & if\ a_1 Tech_{i,t-1} + a_2 EX_{i,t-1} + a_3 FIN_{it-1} + a_4 Z_{it-1} + a_t + a_j + \varepsilon r_{it} > 0 \\ 0 & otherwise \end{cases} \quad (4.3a)$$

$$EX_{it} = \begin{cases} 1 & if\ b_1 EX_{i,t-1} + b_2 Tech_{i,t-1} + b_3 FIN_{it-1} + b_4 Z_{it-1} + b_t + b_j + \varepsilon x_{it} > 0 \\ 0 & otherwise \end{cases} \quad (4.3b)$$

$$(\varepsilon r, \varepsilon x) \sim Bivariate\ Normal\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right] \quad (4.3c)$$

Where $Tech_{i,t-1}$ and $EX_{i,t-1}$ are dummies that indicate firms invest in technology and/or export, respectively, in year *t-1*; FIN_{it-1} is a vector of financing sources variables, and Z_{it-1} is a vector of control variables (age, size,

ownership, TFP, import of raw materials, import of services, import of capital goods). This is followed by time dummies (a_t and b_t) and industry dummies (a_j and b_j). Finally, εx_{it} and εr_{it} are error terms, and ρ is the error correlation parameter. If the decisions of technology investment and exporting are simultaneously determined, ρ will be non-zero.

We estimate equations (4.3a) and (4.3b) simultaneously by maximum likelihood (ML). An econometric problem of the dynamic model is the potential correlation between past technology investment/export status and unobserved heterogeneity. We address this problem following the approach of Máñez et al. (2014) and Blundell et al. (1999, 2002) by including the pre-sample means of the dependent variables as additional regressors in the regressions. We treat 1999-2001 as pre-sample period for the manufacturing firms and estimate for the period of 2002-2010. Since around two thirds of observations during 2002-2010 in our services sample are missing during 1999-2001, we curtail our services estimation sample to the years of 2005-2010 and use 2001-2004 as the pre-sample period.

Another problem is the potential endogeneity concern of the reverse relationship between financing sources and technology investment/exporting. Given the data limitation, we are not able to find other proper instruments, therefore, we instrument the financing variables with their lagged values to address this problem.

The coefficients of $Tech_{i,t-1}$ and $EX_{i,t-1}$, a_1 and b_1 capture the effects of past experiences on current activities. A positive sign of a_1 (b_1) means firms with past experiences of technology investment (export) are more likely to invest in technology (export) in the current period, while a negative sign indicates that past experiences make firms less likely to engage in technology investment (exporting). Given the large entry costs of both activities, firms invest in technology or export in the past periods are more likely to continue to engage in these activities (Roberts and Tybout, 1997), we expect that both a_1 and b_1 to be positive. The coefficient a_2 identifies the effects of past exporting decision on the probability of current technology investment and b_2 accounts for the effects of past technology investment decision on the probability of

current exporting. Given exporters tend to invest in technology to assimilate and utilise the new technology they gain from exporting (Aw et al., 2007), and technology investment improves productivity and facilitates exporting in manufacturing, we assume this is also true for services firms, and expect that both a_2 and b_2 will be positive.

With respect to our variables of interest, the financing sources, given both technology investment and exporting involve fixed entry costs, it is reasonable to assume that both internal and external sources have positive effects on firms' decisions to invest in technology and exporting. Thus, we expect that the coefficients of financing sources, namely a_3 and b_3, to be positive.

For the control variables, we expect that TFP has a positive effect on exporting as the massive literature show that only the most productive firms can break into the export market (Robert and Tybout, 1997). We also expect that the imports of raw materials, services, capital goods have positive impact on firms' technology investment and exporting, since imports generates positive technological spillover effect and the connection with foreign parties facilitates exporting.

As a response to the shorter estimation period compared with the manufacturing sector, we include the estimation of a dynamic bivariate linear probability model that has the advantage of using the same sample period of 2002-2010 as part of the robustness testing. The linear probability model assumes the dependent variable to be continuous, and treats the model as a linear model. Although this model has several flaws, for example, it could systematically yield probability predictions outside the range of 0 to 1, and have no known distributional properties. It allows us to analyse the same sample period for manufacturing and services firms and make comparison between them, and the coefficients can be directly interpreted and compared. We estimate the following equations simultaneously:

$$Tech_{it} = c_1 Tech_{i,t-1} + c_2 EX_{i,t-1} + c_3 FIN_{it-1} + c_4 Z_{it-1} + c_t + c_j + \varepsilon r_{it} \quad (4.4a)$$

$$EX_{it} = d_1 EX_{i,t-1} + d_2 Tech_{i,t-1} + d_3 FIN_{it-1} + d_4 Z_{it-1} + d_t + d_j + \varepsilon x_{it} \quad (4.4b)$$

We use the SURs estimation procedure proposed by Zellner (1962, 1963) and Zellner and Huang (1962) to estimate equations (4.4a) and (4.4b) as a system of linear equations. The regressors are the same as in the previous dynamic bivariate probit model except that we exclude imports of services in equation (4.4a) and exclude imports of capital goods in equation (4.4b) since if each equation contains exactly the same set of regressors, the regression will be reduced to equation-by-equation OLS. To address the unobserved individual heterogeneity, we demean the variables to estimate the equation. The coefficients show the marginal effect of the independent variable of interests on the change in the probability of technology investment/exporting.

4.4.2 Data and measurements

Our main data is collected from the Prowess database, which is compiled by the Centre for Monitoring the Indian Economy (CMIE). We provide detailed information for this database and the procedures of processing the data in Chapter 2.

The main variables of interest in this study is financing sources variables, technology investment and exporting. We measure internal financing sources using firms' retained profits during the year, which has been used in the literature (Girma and Vencappa, 2014). The external sources are measured as the sum of government borrowings, banks and financial institutions borrowings and other non-bank borrowings. We disaggregate the external sources into three broad categories, namely government loans, bank loans and non-bank loans and later we investigate their individual effects as well. The financing source variables are in their natural logarithm.

We employ Research & Development (R&D) investment to proxy to technology investment for manufacturing firms. Given that R&D is still mainly carried out by manufacturing firms while very few services firms engaging in R&D investment, we define a broad technology investment (Tech) including the direct R&D investment as well as other purchased technology to proxy to technology investment for services firms. We also use this broad technology investment for manufacturing firms as robustness test and make comparison

with services firms. Exporting refers to firms that export in the corresponding year.

The control variables include age, size, ownership, TFP (only for manufacturing), imports of raw materials (only for manufacturing), imports of capital goods, imports of services (only for services) plus year and industry dummies. The detailed measurements of the main variables and the control variables are provided in Chapter 2.

4.4.3 Descriptive analysis

Table 4.1 and 4.2 provides summary statistics on our main measures for manufacturing and services firms respectively. In Table 4.1, the mean value of the R&D dummy indicates that around 24.6% observations in our manufacturing sample conduct R&D, while on average 47.6% observations invest in technology. From table 4.2 we see that around 33.6% of observations in services invest in technology while only 1.3% conduct R&D. The proportion of service exporters is 26.1%, which is much lower than that of manufacturing firms with a proportion of over 50%. As for the financing sources, the percentage of manufacturing firms using internal sources (retain profits) and external sources are 76.3% and 95.7% respectively, compared to that of services firms with 67.1% and 71.6% respectively. Of the external sources, very few firms have government loans, many firms have obtained bank loans and nonbank loans. Also, the table illustrates substantial variation in financing sources across firms.

Tables 4.3, 4.4 and 4.5 documents the variation in the composition of firms participating in different activities, namely, neither R&D (technology investment) nor export, only R&D (technology investment), only export and both R&D (technology investment) and export. We observe that on average firms conduct both R&D (technology investment) and exporting on average have more internal financing than firms in other groups. The average value of external financing for firms engaging in both activities is higher than other groups, but the mean proportion of firms with external sources is higher for firms that invest in R&D / technology. Another feature is that the government

loans mainly support technology investment. Further, we can see that firms engage in both R&D / technology and exporting are much larger in size, age and TFP and active in imports than other firms. These patterns are consistent between manufacturing and services firms.

Table 4. 1 Descriptive statistics of manufacturing firms

Variable	obs	mean value	S.D	min	max
R&D intensity	21356	0.00262	0.0137	0	0.831
D_rnd	21356	0.246	0.431	0	1
Tech intensity	21356	0.00553	0.0218	0	0.997
D_tech	21356	0.476	0.499	0	1
export intensity	21356	0.132	0.23	0	1
D_et	21356	0.597	0.491	0	1
internal sources	21356	1.961	1.828	0	7.961
D_internal	21356	0.763	0.426	0	1
external sources	21356	4.236	1.988	0	9.606
D_external	21356	0.957	0.204	0	1
government loans	21356	0.153	0.819	0	8.362
D_govt	21356	0.0477	0.213	0	1
bank loans	21356	3.655	2.105	0	9.363
D_bank	21356	0.897	0.303	0	1
non-bank loans	21356	2.535	1.991	0	9.291
D_nonbank	21356	0.824	0.381	0	1
age	21356	28.19	17.96	2	132
size	21356	5.562	1.631	0.0774	11.19
TFP	21356	1.832	0.949	-3.625	5.993
imported raw materials	21356	1.879	2.156	0	8.757
imported capital goods	21356	0.808	1.419	0	6.816

Notes: The table shows the descriptive statistics for the main variables of a sample of Indian manufacturing firms during the period of 2002-2010. “obs” refers to the number of firm-year observations; “mean value” refers to the average value of the observations. “S.D” is the standard deviation. “min” and “max” refers to the minimum and the maximum value of the corresponding variables, respectively. All the money values are in Millions of Rupees. The “internal sources”, “external sources”, “government loans”, “bank loans”, “non-bank loans”, “TFP”, “imported raw materials” and “imported capital goods” are in natural logarithm.

Table 4. 2 Descriptive statistics of services firms

Variable	obs	mean value	S.D	min	max
Tech intensity	10340	0.0242	0.2434	0	15
D_tech	10340	0.3365	0.4725	0	1
R&D intensity	10340	0.0014	0.0331	0	1.8813
D_rnd	10340	0.0130	0.1131	0	1
export intensity	10340	0.1017	0.2558	0	1
D_et	10340	0.2608	0.4391	0	1
internal sources	10340	1.3093	1.7256	0	8.7197
D_internal	10340	0.6705	0.4701	0	1
external sources	10340	2.2895	2.4163	0	10.6683
D_external	10340	0.7157	0.4511	0	1
government loans	10340	0.0731	0.6157	0	10.4315
D_govt	10340	0.0191	0.1367	0	1
bank loans	10340	1.5405	2.2060	0	10.3528
D_bank	10340	0.4894	0.4999	0	1
non-bank loans	10340	1.4490	2.0438	0	10.6579
D_nonbank	10340	0.5670	0.4955	0	1
age	10340	22.7608	17.6205	2	116
size	10340	1.0000	4.3436	0.0000466	88.4531
imported services	10340	0.5318	1.3353	0	8.8572
imported capital goods	10340	0.3503	1.1160	0	8.4106

Notes: The table shows the descriptive statistics for the main variables of a sample of Indian service firms during the period of 2005-2010. “obs” refers to the number of firm-year observations; “mean value” refers to the average value of the observations. “S.D” is the standard deviation. “min” and “max” refers to the minimum and the maximum value of the corresponding variables, respectively. All the money values are in Millions of Rupees. The “internal sources”, “external sources”, “government loans”, “bank loans”, “non-bank loans”, “imported services” and “imported capital goods” are in natural logarithm.

Table 4. 3 Firm characteristics: manufacturing (I)

Variable	No R&D No Exporting	Only R&D	Only Exporting	Both R&D and Exporting	All firms
R&D intensity	0	0.00887	0	0.0109	0.00262
D_rnd	0	1	0	1	0.246
export intensity	0	0	0.239	0.186	0.132
D_et	0	0	1	1	0.597
internal sources	1.155	1.903	2.093	3.139	1.961
D_internal	0.669	0.693	0.806	0.859	0.763
external sources	3.5	4.599	4.43	5.102	4.236
D_external	0.95	0.963	0.961	0.959	0.957
government loans	0.182	0.666	0.0639	0.179	0.153
D_govt	0.0565	0.15	0.0232	0.0601	0.0477
bank loans	2.807	3.791	3.951	4.569	3.655
D_bank	0.856	0.898	0.924	0.921	0.897
non-bank loans	2.013	2.813	2.588	3.302	2.535
D_nonbank	0.81	0.81	0.83	0.838	0.824
age	25.29	32.57	26.8	35.06	28.19
size	4.589	5.927	5.768	6.824	5.562
TFP	1.725	1.759	1.912	1.886	1.832
imported raw materials	0.568	1.714	2.149	3.702	1.879
imported capital goods	0.187	0.529	0.96	1.663	0.808
N	7,854	758	8,250	4,494	21,356

Notes: The table compares the mean of the main variables among firms in different groups. The dataset is a sample of Indian manufacturing firms during the period of 2002-2010. “No R&D No Exporting” refers to firms that neither export nor invest in research & development; “Only R&D” refers to firms conduct in research & development but did not export; “Only Exporting” refers to firms that export but did not invest in research & development; “Both R&D and Exporting” means firms both export and invest in research & development. “All firms” shows the mean values of all firms. All the money values are in Millions of Rupees. The “internal sources”, “external sources”, “government loans”, “bank loans”, “non-bank loans”, “TFP”, “imported raw materials” and “imported capital goods” are in natural logarithm.

Table 4. 4 Firm characteristics: manufacturing (II)

Variable	No Tech No Exporting	Only Tech	Only Exporting	Both Tech and Exporting	All firms
Tech intensity	0	0.0105	0	0.012	0.00553
D_tech	0	1	0	1	0.476
export intensity	0	0	0.249	0.2	0.132
D_et	0	0	1	1	0.597
internal sources	1.016	1.691	1.884	2.86	1.961
D_internal	0.637	0.749	0.78	0.855	0.763
external sources	3.403	4.042	4.351	4.885	4.236
D_external	0.951	0.951	0.968	0.955	0.957
government loans	0.187	0.31	0.0593	0.135	0.153
D_govt	0.0596	0.0768	0.0229	0.0453	0.0477
bank loans	2.69	3.359	3.865	4.378	3.655
D_bank	0.848	0.886	0.931	0.917	0.897
non-bank loans	1.949	2.391	2.514	3.064	2.535
D_nonbank	0.81	0.81	0.834	0.832	0.824
age	25.2	27.6	26.23	32.11	28.19
size	4.422	5.358	5.586	6.522	5.562
TFP	1.632	1.948	1.875	1.922	1.832
imported raw materials	0.51	1.035	1.922	3.23	1.879
imported capital goods	0.135	0.405	0.828	1.469	0.808
N	5,994	2,618	5,195	7,549	21,356

Notes: The table compares the mean of the main variables among firms in different groups. The dataset is a sample of Indian manufacturing firms during the period of 2002-2010. “No Tech No Exporting” refers to firms that neither invest in technology nor export; “Only Tech” refers to firms invest in technology but did not export; “Only Exporting” refers to firms that export but did not invest in technology; “Both Tech and Exporting” means firms both export and invest in technology. “All firms” shows the mean values of all firms. All the money values are in Millions of Rupees. The “internal sources”, “external sources”, “government loans”, “bank loans”, “non-bank loans”, “TFP”, “imported raw materials” and “imported capital goods” are in natural logarithm.

Table 4. 5 Firm characteristics: services

Variable	No Tech No Exporting	Only Tech	Only Exporting	Both Tech and Exporting	All firms
Tech intensity	0	0.0816	0	0.0607	0.0242
export intensity	0	0	0.413	0.374	0.102
internal sources	0.739	1.595	2.015	2.541	1.309
D_internal	0.604	0.715	0.757	0.799	0.671
external sources	1.663	3.021	2.873	3.281	2.29
D_external	0.657	0.802	0.796	0.768	0.716
government loans	0.059	0.17	0.0346	0.0361	0.0731
D_govt	0.0153	0.0371	0.0126	0.0157	0.0191
bank loans	0.937	2.202	2.069	2.571	1.541
D_bank	0.368	0.639	0.613	0.663	0.489
non-bank loans	1.083	1.856	1.795	2.049	1.449
D_nonbank	0.536	0.615	0.624	0.584	0.567
age	24.95	20.68	18.87	20	22.76
size	0.342	1.72	1.527	2.158	1
imported services	0.0692	0.294	1.45	1.849	0.532
imported capital goods	0.0611	0.346	0.765	1.114	0.35
N	5,754	1,889	1,107	1,590	10,340

Notes: The table compares the mean of the main variables (lagged one) among firms in different groups. The dataset is a sample of Indian service firms during the period of 2005-2009. “No Tech No Exporting” refers to firms that neither invest in technology nor export; “Only Tech” refers to firms invest in technology but did not export; “Only Exporting” refers to firms that export but did not invest in technology; “Both Tech and Exporting” means firms both export and invest in technology. “All firms” shows the mean values of all firms. The continuous variables are in natural logarithm except age and size. All the money values are in Millions of Rupees.

4.5 Empirical results

In this section, we empirically analyse the role of financing sources on firms' joint decision of technology investment and exporting. Given that the sample period of manufacturing and services are different and the nature difference between these two sectors, we first focus on the manufacturing firms, and then examine the services, and some comparisons are followed.

4.5.1 The empirical results of manufacturing firms

4.5.1.1 The basic results

We start by comparing the effects of internal and external financing sources on the joint decision of R&D investment and exporting. We then decompose external financing into government loans, bank loans and nonbank loans, and examine their individual effects. Further, we investigate the role of internal and external financing on the joint decision of broad technology investment and exporting. In addition, we explore the effect of financial reforms, and also the role of size and TFP on the joint decision to invest in R&D and to export.

Table 4.6 shows the correlation matrix of this study's explanatory variables. From the table, we can find that the correlation between our main explanatory variables, namely, the financing sources and the control variables are low, except with the size, imported raw materials and capital goods, which are around 0.5. We compare the results with and without controlling for imported raw materials/ capital goods as well as size as further robustness checks[13].

Table 4.7 reports our main regression results. Columns (1) and (2) only include the financing variables and industry and time dummies. The internal and external financing sources are measured with their logarithm values, deflated by the wholesale price index. The coefficients of both internal and external financing sources are positive and significant. Columns (3) and (4) add the control variables of firm characteristics that are likely to affect R&D

[13] We examined this for our preferred specifications of column (9) and (10) in table 4.7, and the results are still robust.

investment and exporting decisions. The coefficients of internal and external sources are still positive and significant but diminish in magnitude, indicating that columns (1) and (2) could suffer from an omission of important variables, and control for firms' characteristics reduces any potential bias. In columns (5) and (6), we accommodate dynamics in the model by including firms' past R&D investment and export status in both equations. The coefficients of internal and external sources remain positive and significant. The positive and significant coefficients of the lagged R&D investment and export variables suggest that firms with R&D investment and/or export experiences are more likely to conduct R&D investment and export in the current period.

To control for correlated unobserved firms heterogeneity, we follow the approach of Máñez et al. (2014) and Blundell et al. (1999, 2002) by including the pre-sample means or initial conditions of the dependent variables as additional regressors. The pre-sample information on R&D investment and export defines an entry R&D investment and export stock for firms, which enables us to strip out many of the unobserved advantages enjoyed by different firms. We take the years of 1999-2001 as pre-sample period and carry out the estimation for the period of 2002-2010. The pre-sample means of R&D investment is defined as the average of R&D dummy during 1999-2001, and that of export is defined as the average of export dummy during 1999-2001. The results are shown in columns (7) and (8) in table 4.7, and are consistent with previous specifications with positive and significant coefficients of internal sources, and the external sources of R&D investment, while the coefficient of external sources of export becomes insignificant.

Table 4. 6 Correlation matrix between variables: manufacturing

	internal sources (retained profits)	external sources	government loans	bank loans	non-bank loans	age	size	TFP	imported raw materials	imported capital goods
internal sources (retained profits)	1.0000									
external sources	0.3467	1.0000								
government loans	-0.0034	0.1859	1.0000							
bank loans	0.3284	0.8980	0.0744	1.0000						
non-bank loans	0.2932	0.7173	0.0565	0.5094	1.0000					
age	0.1558	0.1187	0.0995	0.0928	0.1201	1.0000				
size	0.5111	0.4609	0.0699	0.4108	0.4219	0.1667	1.0000			
TFP	0.3109	0.1321	-0.0587	0.1623	0.0814	0.0282	0.1319	1.0000		
imported raw materials	0.5330	0.4091	-0.0060	0.4111	0.3284	0.1446	0.4489	0.0268	1.0000	
imported capital goods	0.5259	0.4290	-0.0076	0.4186	0.3384	0.1047	0.4958	0.1333	0.5330	1.0000

Note: The table shows the correlation between the main variables of manufacturing firms in our sample during 2002-2010.

Table 4. 7 The main results: manufacturing

Variables	(1) R&D	(2) Export	(3) R&D	(4) Export	(5) R&D	(6) Export	(7) R&D	(8) Export	(9) R&D	(10) Export
constant	-2.0176***	-1.3051***	-1.7345***	-1.9730***	-2.3806***	-2.3887***	-2.4669***	-2.3905***	-2.4132***	-2.3452***
	(0.124)	(0.102)	(0.199)	(0.185)	(0.143)	(0.124)	(0.166)	(0.134)	(0.169)	(0.136)
internal sources	0.1798***	0.2354***	0.0688***	0.0809***	0.0643***	0.0615***	0.0771***	0.0691***	0.1042***	0.1169***
	(0.013)	(0.012)	(0.014)	(0.013)	(0.013)	(0.012)	(0.014)	(0.013)	(0.023)	(0.019)
external sources	0.1572***	0.1395***	0.0696***	0.0628***	0.0426***	0.0228**	0.0370***	0.0156	0.0266*	0.0063
	(0.015)	(0.012)	(0.016)	(0.013)	(0.011)	(0.009)	(0.013)	(0.010)	(0.015)	(0.011)
$R\&D_{t-1}$					3.0518***	0.1646***	2.6063***	0.0875	2.6033***	0.0874
					(0.051)	(0.041)	(0.060)	(0.057)	(0.059)	(0.056)
$Export_{t-1}$					0.1999***	2.5420***	0.1157**	2.2061***	0.1130**	2.1933***
					(0.045)	(0.040)	(0.058)	(0.041)	(0.057)	(0.041)
age			0.0110***	0.0036***	0.0037***	0.0007	0.0015	-0.0014	0.0015	-0.0015
			(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
size			0.0083	0.0003	-0.0023	-0.0095	0.0020	-0.0128	-0.0006	-0.0191**
			(0.014)	(0.015)	(0.008)	(0.009)	(0.009)	(0.009)	(0.010)	(0.009)
TFP			-0.0216	0.0837***	-0.0254	0.0679***	-0.0222	0.0802***	-0.0335	0.0578***
			(0.026)	(0.024)	(0.024)	(0.018)	(0.026)	(0.020)	(0.028)	(0.021)
imported raw materials			0.1590***	0.2496***	0.0550***	0.1095***	0.0363***	0.0987***	0.0312**	0.0878***
			(0.015)	(0.015)	(0.011)	(0.010)	(0.012)	(0.011)	(0.013)	(0.012)
imported capital goods			0.0348*	0.1640***	0.0295*	0.0777***	0.0378**	0.0771***	0.0335**	0.0665***
			(0.018)	(0.021)	(0.015)	(0.016)	(0.017)	(0.017)	(0.017)	(0.017)

Table 4. 7 The main results: manufacturing (Continued)

Variables	(1) R&D	(2) Export	(3) R&D	(4) Export	(5) R&D	(6) Export	(7) R&D	(8) Export	(9) R&D	(10) Export
Private without group affiliations			-0.3345**	0.7924***	-0.2000**	0.4464***	-0.1198	0.3942***	-0.1417	0.3745***
			(0.135)	(0.138)	(0.085)	(0.083)	(0.107)	(0.090)	(0.107)	(0.089)
Foreign firms			0.1580	1.3164***	-0.1477	0.6364***	-0.1868	0.4636***	-0.2051	0.4515***
			(0.197)	(0.217)	(0.119)	(0.137)	(0.152)	(0.140)	(0.152)	(0.138)
Private with group affiliations			0.0482	0.7951***	-0.1027	0.4212***	-0.1079	0.3142***	-0.1227	0.3011***
			(0.136)	(0.140)	(0.087)	(0.084)	(0.110)	(0.090)	(0.109)	(0.090)
Mean R&D							0.9698***	0.0115	0.9730***	0.0131
							(0.062)	(0.068)	(0.062)	(0.068)
Mean export							0.1181**	0.7775***	0.1194**	0.7820***
							(0.060)	(0.042)	(0.059)	(0.042)
year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	ρ=0.3750***		ρ=0.2719***		ρ=0.1795***		ρ=0.1641***		ρ=0.1664***	
	(0.0283)		(0.0321)		(0.0357)		(0.0369)		(0.0367)	
	N obs: 17299		N obs: 17299		N obs: 17299		N obs: 17299		N obs: 17299	
	N firms: 2981		N firms: 2981		N firms: 2981		N firms: 2981		N firms: 2981	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our sample for the period 2002-2010. The regressors are regressed on t-1 values. "R&D" is an indicator that refers to firms conducting research & development which is proxy to technology investment for manufacturing firms. "Export" is an indicator that refers to firms that export, either goods or services or both. The continuous variables are in natural logarithm except age and size. For Columns (9) and (10), the internal and external sources are instrumented with their t-3 lagged values.

To address potential endogeneity concern of the causal links type going from financing sources to R&D investment and export, we instrument the financing variables with their t-3 lagged values in the estimation[14]. We estimate a system of four equations that besides the R&D investment and export ones, two equations in which internal and external variables are regressed on their respective instruments and control variables[15]. The results are shown in columns (9) and (10) in table 4.7, the coefficients of internal sources are positive and significant, while that of external sources for R&D investment is significant at 10% and for export is insignificant, indicating that internal sources play a much more important role in determining R&D investment and exporting. Since Indian firms face poor financial institutions characterized by corruption and inefficiency, this result is consistent with Beck et al. (2008), which show that firms in countries with poor institutions use less external finance. This is also in line with Sasidharan et al. (2015) which find that internal cash flow matters for firms' R&D expenditure, and they observe that the firms do not use external equity to finance their R&D in India.

We test the statistical difference between the coefficients of internal sources and external sources, and the results show the coefficients are significantly different from each other in both equations. We further calculated the average marginal effects for the main variables for our preferred specifications, namely (9) and (10), and the results are presented in the appendix in table A.4.2. We observe that the average marginal effects of internal sources are indeed higher than that of external sources in both R&D and export equations, which further reinforce our results.

The coefficients of TFP are positive and significant in the export equations while not significant in the R&D equations, indicating that productive firms are more likely to export which is consistent with the literature. The coefficients of imported raw materials and imported capital goods are positive and significant for both R&D and exporting equations, showing that importing activities facilitate firms R&D and exporting behavior. Compared with the state-owned

[14] Since we regress using one-year lags, we actually instrument the lagged financing variables with their t-2 lags. We test the validity of the instruments, and the lagged variables are positively and significantly correlated with the level variables.

[15] The estimation is performed by using the Stata command "cmp" developed by Roodman (2011).

firms, the coefficients of private firms without group affiliations, foreign firms and private firms with group affiliations in export equations are positive and significant, suggesting that firms of these ownerships are more likely to export. The positive and statistically significant value of the correlation ρ indicates that the activities of R&D investment and export are jointly determined. This lends credence to the literature that have examined these two decisions jointly.

4.5.1.2 The decomposition of external sources

In table 4.8, we further decompose the external sources into government loans, bank loans and non-bank loans for our preferred specifications, i.e. (9) and (10) in table 4.7. The coefficients of internal sources remain positive and significant, confirming our previous results that internal sources matter for firms' joint decision of R&D investment and exporting. While the coefficients of the three external sources are insignificant, except for the coefficient on government loans in the R&D equation shows a positive and significant influence, indicating that firms with government loans being more likely to conduct R&D investment. However, overall it doesn't detract from our earlier findings on the non-importance of external sources of finance.

4.5.1.3 The measure of broad technology investment

In table 4.9, we extend our measure of technology investment to include not only the direct R&D investment, but also the other forms of indirect technology investment. This broad technology investment is compatible with the measurement of technology investment for the services firms, which enable us to make comparisons between these two sectors. We examine the financing sources on the joint decision of this broad technology investment and exporting. In columns (1) and (2), we only include pre-sample information (corresponding to (7) and (8) from table 4.7), and in columns (3) and (4), we instrument for financing sources (corresponding to (9) and (10) from table 4.7). The coefficients of internal sources remain positive and significant, while that of the external sources are insignificant, indicating that internal sources play a key role in determining firms' technology investment and export behaviour, which are consistent with our previous results.

Table 4. 8 Decomposition of external sources: manufacturing

Variables	(1) R&D	(2) Export
constant	-2.6483***	-2.3254***
	(0.174)	(0.137)
retained profits	0.1075***	0.1161***
	(0.022)	(0.019)
government loans	0.0997***	-0.0149
	(0.027)	(0.024)
bank loans	0.019	0.0069
	(0.015)	(0.012)
non-bank loans	0.0134	0.0142
	(0.014)	(0.012)
$R\&D_{t-1}$	2.5944***	0.0853
	(0.060)	(0.057)
$Export_{t-1}$	0.1180**	2.1900***
	(0.058)	(0.042)
age	0.0012	-0.0016
	(0.001)	(0.001)
size	-0.0028	-0.0230**
	(0.009)	(0.009)
TFP	-0.0305	0.0570***
	(0.028)	(0.021)
imported raw materials	0.0286**	0.0863***
	(0.013)	(0.012)
imported capital goods	0.0315*	0.0642***
	(0.017)	(0.017)
Private without group affiliations	0.0670	0.3352***
	(0.123)	(0.095)
Foreign firms	0.0049	0.4154***
	(0.160)	(0.141)
Private with group affiliations	0.0833	0.2579***
	(0.125)	(0.095)
Mean R&D	0.9849***	0.0148
	(0.062)	(0.069)
Mean export	0.1182**	0.7822***
	(0.060)	(0.042)
	ρ=0.1686***(0.0366)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our sample for the period 2002-2010, including industry and time dummies. The financing sources are in natural logarithm and are instrumented with their t-3 lagged values, and the other regressors are regressed on t-1 values. There are 2981 firms with 17299 observations in the regression. "R&D" is an indicator that refers to firms conducting research & development. "Export" is an indicator that refers to firms that export, either goods or services or both. The continuous variables are in natural logarithm except age and size.

Table 4. 9 The results of broad technology investment: manufacturing

Variables	(1) Tech	(2) Export	(3) Tech	(4) Export
constant	-1.4656***	-2.4194***	-1.3981***	-2.3792***
	(0.113)	(0.135)	(0.117)	(0.136)
internal sources	0.0699***	0.0688***	0.0773***	0.1167***
	(0.010)	(0.013)	(0.014)	(0.020)
external sources	0.0143*	0.0153	0.0002	0.0071
	(0.008)	(0.010)	(0.010)	(0.011)
$Tech_{t-1}$	1.5801***	0.1128***	1.5773***	0.1098***
	(0.038)	(0.039)	(0.038)	(0.039)
$Export_{t-1}$	0.1310***	2.2038***	0.1260***	2.1915***
	(0.036)	(0.042)	(0.036)	(0.042)
age	0.0009	-0.0012	0.0008	-0.0013
	(0.001)	(0.001)	(0.001)	(0.001)
size	0.0012	-0.0115	0.0029	-0.0180**
	(0.009)	(0.009)	(0.009)	(0.009)
TFP	0.0730***	0.0764***	0.0711***	0.0539***
	(0.016)	(0.020)	(0.017)	(0.021)
imported raw materials	0.0320***	0.1005***	0.0318***	0.0894***
	(0.009)	(0.011)	(0.009)	(0.012)
imported capital goods	0.0284**	0.0753***	0.0296**	0.0644***
	(0.013)	(0.017)	(0.013)	(0.017)
Private without group affiliations	0.0472	0.3867***	0.0282	0.3690***
	(0.077)	(0.090)	(0.078)	(0.089)
Foreign firms	0.0279	0.4627***	0.0233	0.4513***
	(0.120)	(0.139)	(0.120)	(0.138)
Private with group affiliations	-0.0486	0.3163***	-0.0580	0.3044***
	(0.079)	(0.091)	(0.079)	(0.090)
Mean Tech	0.8548***	-0.0541	0.8595***	-0.0511
	(0.042)	(0.048)	(0.042)	(0.048)
Mean export	-0.0028	0.7884***	0.0041	0.7924***
	(0.039)	(0.043)	(0.039)	(0.042)
	ρ=0.1125***(0.0235)		ρ=0.1131***(0.0235)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our sample for the period 2002-2010, including industry and time dummies. The financing sources are in natural logarithm and are instrumented with their t-3 lagged values, and the other regressors are regressed on t-1 values. There are 2981 firms with 17299 observations in the regression. "Tech" is an indicator that refers to firms invest in technology investment which including one or more of the following activities: research & development expenses (capital & current account), royalties, technical know-how fees, etc., forex spending royalty/ technical knowhow, software additions and computer systems additions. "Export" is an indicator that refers to firms that export, either goods or services or both. The continuous variables are in natural logarithm except age and size.

4.5.1.4 The effects of financial reform in India

Before 1990s, the banking sector in India was nationalised and dominated by public sector banks. Since 1994, India has implemented a series of financial reforms. In 1994, the government approved the entry of new private sector banks, but with stringent RBI regulatory supervision, so the entry was not easy. In 2000, the government revised the norms to make the entry of new banks in the private sector much easier. Also, the government signaled its intention to eventually withdraw from being a major player in the banking sector by reducing the minimum government equity share in nationalised banks to 33% and enabling the public sector banks to raise fresh equity from the capital (Arnold et al., 2016). In 2001/2, the deregulation of interest rates began and banks were allowed to set their own lending rates and to undercut them when necessary (Arnold et al., 2016). In 2002/3, the restrictions to foreign participation in the banking sector were significant reduced. In the Union Budget for 2004, the limit of FDI in banking companies was raise from 49% to 74%. But overall, the liberalisation in the banking sector has taken place gradually.

We explore the effects of these financial reforms on the joint decision of R&D investment and export. The financial reform is depicted as an event dummy, which takes value 1 post-2005 (D05-10)[16], otherwise 0. This is to capture the fact that most major reforms took place pre-2005 and it is often the case that these reforms require some time to bear its fruit. In particular, we are interested in the interaction terms between the financing sources variables and this event dummy. The results are reported in table 4.10. Columns (1) and (2) are the results just including pre-sample but without instruments (corresponding to (7) and (8) from table 4.7), and in columns (3) and (4), instruments for the financing sources are added (corresponding to (9) and (10) from table 4.7). The coefficients on internal sources maintain their expected signs and significance. The coefficients of external sources for R&D equation are significant but not significant for exporting. While the event time dummy

[16] We also test for the years between 2006 and 2008 to avoid the effects from the global financial crisis arising during the same period. The results are very similar.

D05-10 and its interaction with external finance are insignificant, the coefficients on the interaction terms with internal finance in the export equation are negative and significant. This indicates that the effects of internal sources in determining exporting are reduced since 2005, suggesting the weak effects of financial reforms. This is consistent with Rahaman (2011) who shows that when external financing constraint is alleviated, firms rely less on internal funds and switch to external funds. In our case the switching has yet to materialise completely and thus it is suggestive of the fact that the financial system has yet to fully develop mechanisms to enable and facilitate the greater usage of external sources of finance. In short, the full effect of financial reform in terms of our study is yet to happen.

4.5.1.5 The role of size and TFP

The literature shows that small firms have less access to formal sources of external finance (Beck et al., 2005; Beck and Demirguc-Kunt, 2006). We investigate whether the effects of financing sources are different between small and large firms in determining R&D and export for Indian manufacturing firms. We divide firms into small and large according to the median by year and industry, and use the specifications of columns (7) and (8), (9) and (10) from table 4.7 to incorporate size group by including the interaction terms of internal sources/external sources and size groups, respectively. The results are shown in table 4.11. The positive and significant coefficients of the large firm dummy indicate that large firms are more likely to conduct R&D and exporting. The coefficients of the interaction term between internal sources and large firm dummy is negative and significant, demonstrating that compared with small firms, the effects of internal sources are reduced for large firms when making R&D investment and export decisions. This is consistent with Du and Girma (2012) showing that bank loans (external source) are more effective for larger firms, while internal finance is more beneficial to smaller firms.

We also examine the effects of financing sources between productive and less productive firms. The firms are classified into productive and less productive according to the median of TFP by year and industry. We incorporate the interaction terms of internal sources/external sources and

higher TFP dummy (which equals to 1 if firms belong to productive group), into specifications columns (7) and (8), (9) and (10) from table 4.7. The results are shown in table 4.12. The coefficients of the interaction term between internal sources and higher TFP dummy is negative and significant, while that of the interaction term between external sources and higher TFP dummy is positive and significant, indicating that compared with less productive firms, productive firms are less confined to internal sources and more sensitive to external sources.

In summary, our empirical results for manufacturing firms show that internal financing sources are crucial in determining the joint decision of R&D investment and export while the role of external sources are not quite significant. Government loans are more likely to facilitate firms to conduct R&D investment. The impacts of internal sources are reduced since 2005 because of the weak effects of financial reforms in India, depicting a still immature but developing financial system. The effects of internal sources are weakened for firms with larger size and higher TFP level.

Table 4. 10 The effects of financial reform in India: manufacturing

Variables	(1) R&D	(2) Export	(3) R&D	(4) Export
constant	-2.4712***	-2.2759***	-2.4622***	-2.2400***
	(0.174)	(0.137)	(0.174)	(0.137)
internal sources	0.0626***	0.1075***	0.1141***	0.1237***
	(0.019)	(0.018)	(0.023)	(0.023)
external sources	0.0483***	0.007	0.0530***	0.0023
	(0.018)	(0.014)	(0.019)	(0.015)
$R\&D_{t-1}$	2.6059***	0.0905	2.5925***	0.0928*
	(0.060)	(0.056)	(0.060)	(0.056)
$Export_{t-1}$	0.1153**	2.2073***	0.1096*	2.2024***
	(0.058)	(0.041)	(0.057)	(0.042)
internal sources*D05-10	0.0230	-0.0604***	0.0418*	-0.0531**
	(0.022)	(0.021)	(0.022)	(0.021)
external sources*D05-10	-0.0181	0.0153	-0.0276	0.0086
	(0.019)	(0.016)	(0.020)	(0.016)
D05-10	0.0069	-0.0977	0.0161	-0.0820
	(0.115)	(0.087)	(0.114)	(0.087)
age	0.0015	-0.0014	0.0014	-0.0015
	(0.001)	(0.001)	(0.001)	(0.001)
size	0.0017	-0.0109	-0.0085	-0.013
	(0.009)	(0.009)	(0.009)	(0.009)
TFP	-0.0220	0.0792***	-0.0531*	0.0695***
	(0.026)	(0.020)	(0.027)	(0.021)
imported raw materials	0.0365***	0.0981***	0.0216*	0.0941***
	(0.012)	(0.011)	(0.013)	(0.012)
imported capital goods	0.0386**	0.0774***	0.023	0.0738***
	(0.017)	(0.017)	(0.017)	(0.018)
Private without group affiliations	-0.1149	0.3941***	-0.1175	0.3797***
	(0.108)	(0.090)	(0.106)	(0.089)
Foreign firms	-0.1831	0.4627***	-0.1836	0.4583***
	(0.152)	(0.140)	(0.151)	(0.139)
Private with group affiliations	-0.1042	0.3143***	-0.1057	0.3056***
	(0.110)	(0.091)	(0.109)	(0.090)
Mean R&D	0.9702***	0.0071	0.9694***	0.0078
	(0.062)	(0.068)	(0.061)	(0.068)
Mean export	0.1204**	0.7758***	0.1177**	0.7796***
	(0.060)	(0.042)	(0.059)	(0.042)
	ρ=0.1661***(0.0367)		ρ=0.1694***(0.0365)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our sample for the period 2002-2010, including industry and time dummies. The regressors are regressed on t-1 values. There are 2981 firms with 17299 observations in the regression. "R&D" is an indicator that refers to firms conducting research & development. "Export" is an indicator that refers to firms that export, either goods or services or both. The financing sources are in natural logarithm and are instrumented with their t-2 lagged values. The continuous variables are in natural logarithm except age and size.

Table 4. 11 The role of size: manufacturing

Variables	(1) R&D	(2) Export	(3) R&D	(4) Export
constant	-2.5062***	-2.3880***	-2.4490***	-2.3333***
	(0.177)	(0.135)	(0.180)	(0.137)
internal sources	0.0960***	0.0848***	0.1242***	0.1258***
	(0.029)	(0.021)	(0.034)	(0.026)
external sources	0.0308	-0.0075	0.0187	-0.0204
	(0.021)	(0.013)	(0.022)	(0.015)
$R\&D_{t-1}$	2.6039***	0.0776	2.6003***	0.0774
	(0.060)	(0.057)	(0.060)	(0.057)
$Export_{t-1}$	0.1014*	2.1973***	0.0990*	2.1865***
	(0.058)	(0.042)	(0.058)	(0.041)
age	0.0016	-0.0015	0.0015	-0.0016*
	(0.001)	(0.001)	(0.001)	(0.001)
internal sources*size_large	-0.0332	-0.0515**	-0.0360	-0.0566**
	(0.030)	(0.023)	(0.030)	(0.023)
external sources*size_large	-0.0059	-0.0044	-0.0057	-0.0033
	(0.020)	(0.015)	(0.020)	(0.015)
size_large	0.1948**	0.3009***	0.1979**	0.2974***
	(0.085)	(0.070)	(0.085)	(0.070)
TFP	-0.0295	0.0650***	-0.0409	0.0472**
	(0.026)	(0.020)	(0.028)	(0.021)
imported raw materials	0.0315**	0.0896***	0.0263**	0.0816***
	(0.013)	(0.011)	(0.013)	(0.012)
imported capital goods	0.0397**	0.0704***	0.0349**	0.0623***
	(0.017)	(0.017)	(0.017)	(0.017)
Private without group affiliations	-0.0968	0.4511***	-0.1162	0.4340***
	(0.108)	(0.088)	(0.108)	(0.088)
Foreign firms	-0.1874	0.4711***	-0.2034	0.4660***
	(0.152)	(0.138)	(0.153)	(0.137)
Private with group affiliations	-0.0920	0.3451***	-0.1050	0.3360***
	(0.111)	(0.090)	(0.111)	(0.089)
Mean R&D	0.9696***	0.0148	0.9736***	0.0158
	(0.062)	(0.068)	(0.062)	(0.068)
Mean export	0.1200**	0.7814***	0.1214**	0.7873***
	(0.060)	(0.043)	(0.060)	(0.042)
	ρ=0.1596***(0.0367)		ρ=0.1618***(0.0366)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our sample for the period 2002-2010, including industry and time dummies. The regressors are regressed on t-1 values. There are 2981 firms with 17299 observations in the regression. "R&D" is an indicator that refers to firms conducting research & development. "Export" is an indicator that refers to firms that export, either goods or services or both. The financing sources are in natural logarithm and are instrumented with their t-3 lagged values. The continuous variables are in natural logarithm except age and size.

Table 4. 12 The role of TFP: manufacturing

Variables	(1) R&D	(2) Export	(1) R&D	(2) Export
constant	-2.4967***	-2.2113***	-2.4585***	-2.2146***
	(0.164)	(0.128)	(0.167)	(0.130)
internal sources	0.0825***	0.0968***	0.1032***	0.1460***
	(0.020)	(0.018)	(0.026)	(0.023)
external sources	0.0342**	-0.0052	0.0243	-0.0128
	(0.016)	(0.011)	(0.017)	(0.012)
$R\&D_{t-1}$	2.6055***	0.0838	2.6035***	0.0829
	(0.060)	(0.057)	(0.059)	(0.057)
$Export_{t-1}$	0.1127*	2.2081***	0.1102*	2.1941***
	(0.058)	(0.041)	(0.057)	(0.041)
age	0.0015	-0.0014	0.0014	-0.0016
	(0.001)	(0.001)	(0.001)	(0.001)
size	0.0025	-0.0117	0.0006	-0.0194**
	(0.009)	(0.009)	(0.010)	(0.009)
internal sources*TFP_large	-0.0157	-0.0410*	-0.0142	-0.0397*
	(0.023)	(0.022)	(0.023)	(0.022)
external sources*TFP_large	0.0043	0.0449***	0.0027	0.0436***
	(0.014)	(0.011)	(0.014)	(0.011)
TFP_large	0.0110	-0.0332	0.0118	-0.0406
	(0.052)	(0.040)	(0.052)	(0.040)
imported raw materials	0.0372***	0.0975***	0.0337***	0.0870***
	(0.012)	(0.011)	(0.013)	(0.011)
imported capital goods	0.0383**	0.0747***	0.0351**	0.0621***
	(0.017)	(0.017)	(0.017)	(0.017)
Private without group affiliations	-0.1258	0.3921***	-0.1480	0.3733***
	(0.107)	(0.088)	(0.107)	(0.087)
Foreign firms	-0.1922	0.4768***	-0.2103	0.4634***
	(0.152)	(0.137)	(0.153)	(0.136)
Private with group affiliations	-0.1138	0.3158***	-0.1287	0.3027***
	(0.110)	(0.088)	(0.110)	(0.088)
Mean R&D	0.9718***	0.0158	0.9744***	0.0169
	(0.062)	(0.069)	(0.062)	(0.068)
Mean export	0.1190**	0.7784***	0.1208**	0.7816***
	(0.060)	(0.042)	(0.060)	(0.042)
	ρ=0.1636***(0.0371)		ρ=0.1654***(0.0369)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our sample for the period 2002-2010, including industry and time dummies. The regressors are regressed on t-1 values. There are 2981 firms with 17299 observations in the regression. "R&D" is an indicator that refers to firms conducting research & development. "Export" is an indicator that refers to firms that export, either goods or services or both. The financing sources are in natural logarithm and are instrumented with their t-3 lagged values. The continuous variables are in natural logarithm except age and size.

4.5.2 The empirical results of services firms

We now turn to empirically analysing the role of financing sources on service firms' joint decision to invest in technology and to export. More precisely, we compare the effects of internal and external financing sources on this joint decision, and then further decompose external financing into government loans, banks loans and nonbank loans and investigate their separate effects. A series of complementary sensitivity analyses are undertaken.

4.5.2.1 The basic results

To start with, Table 4.13 presents the correlation between our main explanatory variables. We observe that the correlations among our variables are within reasonable ranges, so it is safe to conduct the empirical regressions.

Table 4.14 reports our main empirical results. We start by examining the relationship between the decisions about technology investments and exporting and financing sources. We include only the internal and external financing variables and industry and time dummies. The results are shown in columns (1) and (2). Both internal and external financing sources show positive and significant coefficients. In columns (3) and (4), we include the control variables of firm characteristics in the estimation, and the coefficients of internal sources remain positive and significant, but diminish in magnitude, and so does the coefficient of external sources in the technology investment equation, while the coefficient of external sources in the export equation becomes insignificant, indicating that columns (1) and (2) could suffer from an omission of important variables.

Since firms investing in technology and exporting in the past are more likely to continue in current period, we further accommodate dynamics in the model by including firms' past technology investment and exporting status in both equations, and the results are shown in columns (5) and (6) in table 4.14. The positive and significant coefficients of the lagged technology investment and export variables are in line with the literature showing that firms with technology investment and/or export experiences are more likely to continue to conduct technology investment and export in the current period. The

coefficients of financing sources are consistent with that of specification in columns (3) and (4), with positive and significant internal sources in both equations and external sources in technology investment equation, but insignificant for external sources in export equation.

In columns (7) and (8) we report estimations where we control for unobserved firms' heterogeneity following the Máñez et al. (2014) and Blundell et al. (1999, 2002) approach by including the pre-sample means of the dependent variables as additional regressors in the regression. The pre-sample information of the dependent variables defines an entry of technology investment and export stock, which enables us to strip out many of the unobserved advantages enjoyed by different firms (Blundell et al., 1999). We define the pre-sample mean of technology investment as the average of the technology investment indicator during the years 2001-2004, and the pre-sample mean of exporting as the mean of export dummy for 2001-2004. The coefficients of internal and external sources maintain their signs and significance levels.

To address concern about potential endogeneity of the causal links going from financing sources to technology investment and export, we instrument the financing variables with their t-3 lagged values[17] in the estimation[18]. We estimate a system of four equations; besides the technology investment and export ones, two additional equations in which internal and external variables are regressed on their respective instruments. The results are shown in columns (9) and (10), and which are quite consistent with the previous specifications such that the coefficients of internal sources are positive and significant, while the coefficients of external sources are positive and significant for the technology investment equation but not significant for exporting, suggesting that both internal and external sources matter for service firms' technology investment, while the effect of external sources is not significant for exporting. This is consistent with Lancheros and Demirel (2012) which shows that long-

[17] Since we regress on lagged regressors, we actually instrument the lagged financing variables with their t-2 lagged values. We tested the validity of the instruments and they are positively and significantly correlated with the level variables.

[18] The estimation is performed by using the Stata command "cmp" developed by Roodman (2011).

and short-term borrowing (external financing) are insignificant for Indian service firms' exporting decision.

We further test the statistical difference between the coefficients of internal and external sources for technology investment and export equations in our preferred specification in column (9) and (10) respectively, and the results show that the coefficients are statistically different from each other. In addition, we calculate the average marginal effects for our main variables in the preferred specification, and the results are shown in the Table A.4.3 in the appendix. We see that for technology investment, the average marginal effects of internal sources and external sources are 0.0257 and 0.0083, respectively, while for exporting, the average marginal effect of internal sources is 0.0053 and that of external sources is insignificant.

Therefore, we draw the conclusion that internal sources play a much more important role than external sources in determining Indian service firms' technology investment and exporting decisions. This is in line with the manufacturing firms in our previous chapter that internal sources significantly affect firms' technology investment and exporting. The difference between services and manufacturing is that the external sources matters for service firms' technology investment decision while it is not quite significant for that of the manufacturing firms. This result also provides evidence for the pecking order theory that services firms prefer internal sources to external sources as the manufacturing firms.

The coefficients of imported services are positive and significant for export equation, showing that firms that import services are more likely to export. The coefficients of imported capital goods are positive but insignificant for both equations, showing a weak effect in facilitating these activities. Compared with state-owned firms, the coefficients of private firms without group affiliations, foreign firms and private firms with group affiliations in technology investment equations are negative and significant while in export equations are positive and significant, suggesting that firms of these ownerships are more likely to export while the state-owned firms are relatively more likely to conduct technology investment. The positive and statistically

significant value of the correlation ρ indicates that the activities of technology investment and export are jointly determined.

Table 4. 13 Correlation matrix between variables: services

	internal sources	external sources	government loans	bank loans	non-bank loans	age	size	imported services	imported capital goods
internal sources	1								
external sources	0.4064	1							
government loans	0.0038	0.1972	1						
bank loans	0.4214	0.8337	0.0593	1					
non-bank loans	0.2831	0.7979	0.0887	0.4969	1				
age	-0.0332	-0.0757	0.0391	-0.0924	-0.0333	1			
size	0.3888	0.414	0.2328	0.3648	0.3935	-0.0038	1		
imported services	0.4708	0.3152	0.0159	0.314	0.2492	-0.0777	0.3623	1	
imported capital goods	0.4277	0.3852	-0.0152	0.3925	0.3149	-0.057	0.4069	0.5329	1

Note: The table shows the correlation between the main variables of service firms in our sample during 2005-2010.

Table 4. 14 The main results: services

Variables	(1) Tech	(2) Export	(3) Tech	(4) Export	(5) Tech	(6) Export	(7) Tech	(8) Export	(9) Tech	(10) Export
constant	0.0006	-0.5489	0.4754	-1.3048***	-0.4245	-2.3309***	-0.4451	-2.4694***	-0.3858	-2.4068***
	(0.370)	(0.490)	(0.363)	(0.357)	(0.316)	(0.316)	(0.310)	(0.359)	(0.314)	(0.362)
internal sources	0.1818***	0.2373***	0.1662***	0.1809***	0.1203***	0.1028***	0.1168***	0.0929***	0.0997***	0.0675***
	(0.014)	(0.019)	(0.015)	(0.021)	(0.012)	(0.019)	(0.013)	(0.020)	(0.016)	(0.024)
external sources	0.0825***	0.0600***	0.0727***	0.0056	0.0525***	-0.0135	0.0455***	-0.0092	0.0322***	-0.0129
	(0.011)	(0.015)	(0.012)	(0.017)	(0.009)	(0.013)	(0.010)	(0.014)	(0.011)	(0.015)
$Tech_{t-1}$					1.2586***	0.2148***	1.1267***	0.2195***	1.1182***	0.2147***
					(0.047)	(0.058)	(0.045)	(0.065)	(0.045)	(0.066)
$Export_{t-1}$					0.3070***	2.8202***	0.2481***	2.4740***	0.2408***	2.4728***
					(0.047)	(0.072)	(0.060)	(0.082)	(0.060)	(0.082)
age			-0.0064***	-0.0021	-0.0054***	-0.0015	-0.0056***	-0.0013	-0.0057***	-0.0015
			(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
size			-0.0140*	-0.0377***	-0.0078	-0.0049	-0.0100*	-0.0024	-0.0064	0.0003
			(0.008)	(0.011)	(0.006)	(0.009)	(0.005)	(0.009)	(0.006)	(0.009)
imported services			0.0658***	0.4751***	0.007	0.1636***	-0.0003	0.1271***	0.0072	0.1340***
			(0.024)	(0.037)	(0.019)	(0.032)	(0.019)	(0.031)	(0.019)	(0.031)
imported capital goods			0.0122	0.0829**	-0.0014	0.0295	-0.0037	0.0339	0.0057	0.0427
			(0.025)	(0.037)	(0.021)	(0.029)	(0.021)	(0.030)	(0.021)	(0.030)

Table 4. 14 The main results: services (Continued)

Variables	(1) Tech	(2) Export	(3) Tech	(4) Export	(5) Tech	(6) Export	(7) Tech	(8) Export	(9) Tech	(10) Export
Private without group affiliations			-0.5775***	0.4021*	-0.3971***	0.1858	-0.3626***	0.1856	-0.3781***	0.1754
			(0.117)	(0.238)	(0.085)	(0.142)	(0.087)	(0.154)	(0.087)	(0.152)
Foreign firms			-0.3424**	1.0338***	-0.2699**	0.5627***	-0.2151*	0.4857**	-0.2184*	0.4891**
			(0.167)	(0.325)	(0.127)	(0.194)	(0.129)	(0.220)	(0.129)	(0.220)
Private with group affiliations			-0.5375***	0.6835***	-0.4051***	0.3536**	-0.3800***	0.3527**	-0.3839***	0.3465**
			(0.120)	(0.237)	(0.088)	(0.143)	(0.091)	(0.154)	(0.091)	(0.153)
Mean Tech							0.7721***	0.0212	0.7843***	0.0327
							(0.070)	(0.089)	(0.069)	(0.089)
Mean export							0.0435	0.8012***	0.0597	0.8116***
							(0.069)	(0.083)	(0.069)	(0.083)
year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	ρ=0.3020***		ρ=0.2650***		ρ=0.2045***		ρ=0.2113***		ρ=0.2115***	
	(0..0294)		(0.0314)		(0.0381)		(0.0393)		(0.0393)	
	N obs: 7702		N obs: 7702		N obs: 7702		N obs: 7702		N obs: 7702	
	N firms: 2080		N firms: 2080		N firms: 2080		N firms: 2080		N firms: 2080	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on service firms in our sample for the period 2005-2010. The regressors are regressed on t-1 values. "Tech" is an indicator that refers to firms conducting technology investment. "Export" is an indicator that refers to firms that export services. The continuous variables are in natural logarithm except age and size. For Columns (9) and (10), the internal and external sources are instrumented with their t-3 lagged values.

4.5.2.2 The decomposition of external sources

In table 4.15, we further decompose the external sources into government loans, bank loans and non-bank loans and regress on our specification in column (7) and (8), (9) and (10) in table 4.14. The coefficients of internal sources maintain its positive and significant sign. While the bank loans show positive and significant coefficient in the technology investment equation, revealing that bank loans play an important role in supporting service firms' technology investment. While this is different from the case of manufacturing firms, for which the bank loans show insignificant effect.

4.5.2.3 Comparison between traditional and modern services

Following Eichengreen and Gupta (2013), we treat industries of business consultancy, commercial complexes, computer software, ITES and telecommunication services as modern services and the rest as the traditional services. We create a dummy variable D_modern which takes 1 if firms belong to these modern services, otherwise 0, and estimate an augmented version of our specification of column (7) and (8), (9) and (10) in table 4.14 by including interaction terms between the financing sources variables and this dummy variable. The results are shown in table 4.16. The coefficients of internal and external sources are similar with the previous results. The interaction terms of the external sources and modern service dummy are negative and significant for the exporting equation, showing that the export of modern service are less dependent on external sources.

We then further explore whether the effects of financing sources are different between technology intensive and less technology intensive firms. The dummy variable D_in-tech equals 1 if firms belong to industries of computer software, ITES and telecommunication services, otherwise 0. The results are shown in table 4.17. The coefficients of the financing sources are in line with our previous results. The coefficients of the interaction terms between internal sources and technology intensive dummy is negative for the technology investment equations, showing that technology intensive firms are

less sensitive to internal financing sources in determining technology investment decision.

Table 4. 15 Decomposition of external sources

Variables	(1) Tech	(2) Export	(3) Tech	(4) Export
constant	-0.418	-2.5205***	-0.3613	-2.4153***
	(0.323)	(0.358)	(0.331)	(0.364)
internal sources	0.1124***	0.0952***	0.0934***	0.0695***
	(0.013)	(0.020)	(0.016)	(0.023)
government loans	0.0055	0.0507	0.0171	0.005
	(0.028)	(0.047)	(0.038)	(0.056)
bank loans	0.0545***	-0.0114	0.0566***	-0.0011
	(0.011)	(0.017)	(0.012)	(0.018)
non-bank loans	0.0152	0.0009	-0.0138	-0.0261
	(0.011)	(0.016)	(0.013)	(0.018)
$Tech_{t-1}$	1.1194***	0.2207***	1.1089***	0.2205***
	(0.045)	(0.066)	(0.046)	(0.066)
$Export_{t-1}$	0.2445***	2.4764***	0.2393***	2.4747***
	(0.060)	(0.082)	(0.060)	(0.082)
age	-0.0055***	-0.0013	-0.0055***	-0.0014
	(0.001)	(0.002)	(0.001)	(0.002)
size	-0.0109**	-0.0052	-0.0053	0.0015
	(0.005)	(0.008)	(0.005)	(0.007)
imported services	-0.0001	0.1268***	0.0081	0.1331***
	(0.019)	(0.031)	(0.019)	(0.031)
imported capital goods	-0.0106	0.0386	0.0013	0.0453
	(0.021)	(0.030)	(0.021)	(0.030)
Private without group affiliations	-0.3948***	0.2349	-0.3853***	0.2040
	(0.098)	(0.172)	(0.100)	(0.166)
Foreign firms	-0.2388*	0.5288**	-0.2108	0.5261**
	(0.137)	(0.235)	(0.138)	(0.231)
Private with group affiliations	-0.4061***	0.3997**	-0.3774***	0.3840**
	(0.102)	(0.173)	(0.104)	(0.167)
Mean Tech	0.7634***	0.0250	0.7748***	0.0341
	(0.070)	(0.089)	(0.069)	(0.088)
Mean export	0.0413	0.7993***	0.0527	0.7974***
	(0.069)	(0.082)	(0.069)	(0.082)
	ρ=0.2119***(0.0394)		ρ=0.2139***(0.0394)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on service firms in our sample for the period 2005-2010, including industry and time dummies. The financing sources are in natural logarithm and are instrumented with their t-3 lagged values, and the other regressors are regressed on t-1 values. There are 2080 firms with 7702 observations in the regression. "Tech" is an indicator that refers to firms conducting technology investment. "Export" is an indicator that refers to firms that export, either goods or services or both. The continuous variables are in natural logarithm except age and size.

Table 4. 16 Compare traditional services and modern services

Variables	(1) Tech	(2) Export	(1) Tech	(2) Export
constant	-0.4495	-2.5545***	-0.3936	-2.4931***
	(0.314)	(0.367)	(0.318)	(0.369)
internal sources	0.1134***	0.0772***	0.0966***	0.0534*
	(0.017)	(0.026)	(0.020)	(0.029)
external sources	0.0475***	0.0132	0.0347**	0.0093
	(0.013)	(0.018)	(0.014)	(0.019)
$Tech_{t-1}$	1.1265***	0.2157***	1.1180***	0.2111***
	(0.045)	(0.066)	(0.046)	(0.066)
$Export_{t-1}$	0.2478***	2.4696***	0.2402***	2.4684***
	(0.060)	(0.082)	(0.060)	(0.082)
internal sources*D_modern	0.0071	0.0420	0.0067	0.0397
	(0.023)	(0.038)	(0.023)	(0.038)
external sources*D_modern	-0.0043	-0.0552**	-0.0053	-0.0544**
	(0.018)	(0.027)	(0.018)	(0.027)
D_modern	0.0626	0.2478	0.0604	0.2288
	(0.328)	(0.381)	(0.331)	(0.383)
age	-0.0056***	-0.0011	-0.0057***	-0.0012
	(0.001)	(0.002)	(0.001)	(0.002)
size	-0.0100*	-0.0017	-0.0064	0.0008
	(0.005)	(0.008)	(0.006)	(0.008)
imported services	-0.0005	0.1302***	0.007	0.1370***
	(0.019)	(0.032)	(0.020)	(0.032)
imported capital goods	-0.0038	0.0320	0.0056	0.0406
	(0.021)	(0.030)	(0.021)	(0.031)
Private without group affiliations	-0.3611***	0.1928	-0.3762***	0.1829
	(0.087)	(0.151)	(0.087)	(0.150)
Foreign firms	-0.2132	0.5158**	-0.2161*	0.5191**
	(0.130)	(0.221)	(0.129)	(0.221)
Private with group affiliations	-0.3787***	0.3618**	-0.3823***	0.3557**
	(0.091)	(0.152)	(0.090)	(0.150)
Mean Tech	0.7715***	0.0183	0.7837***	0.0299
	(0.070)	(0.090)	(0.069)	(0.089)
Mean export	0.0439	0.8095***	0.0604	0.8193***
	(0.069)	(0.083)	(0.070)	(0.083)
	ρ=0.2111***(0.0394)		ρ=0.2113***(0.0393)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The Tech and Export equations are estimated simultaneously using maximum likelihood on service firms in our sample for the period 2005-2010, including industry and time dummies. The regressors are regressed on t-1 values. There are 2080 firms with 7702 observations in the regression. "Tech" is an indicator that refers to firms conducting technology investment. "Export" is an indicator that refers to firms that export services. All independent variables, except for dummies are expressed in natural logarithm. The continuous variables are in natural logarithm except age and size.

Table 4. 17 Compare technology intensive and less intensive industries

Variables	(1) Tech	(2) Export	(1) Tech	(2) Export
constant	-0.5517*	-2.5106***	-0.4957	-2.4494***
	(0.317)	(0.364)	(0.322)	(0.366)
internal sources	0.1419***	0.0886***	0.1251***	0.0632**
	(0.015)	(0.023)	(0.017)	(0.027)
external sources	0.0478***	-0.0016	0.0348***	-0.0050
	(0.011)	(0.015)	(0.012)	(0.016)
$Tech_{t-1}$	1.1207***	0.2169***	1.1120***	0.2120***
	(0.046)	(0.065)	(0.046)	(0.066)
$Export_{t-1}$	0.2330***	2.4719***	0.2253***	2.4703***
	(0.060)	(0.082)	(0.060)	(0.082)
internal sources*D_in-tech	-0.0928***	0.0206	-0.0910***	0.0203
	(0.024)	(0.043)	(0.024)	(0.043)
external sources*D_in-tech	-0.0148	-0.0386	-0.0179	-0.0399
	(0.021)	(0.032)	(0.021)	(0.031)
D_in-tech	0.2960	0.2249	0.2981	0.2110
	(0.331)	(0.389)	(0.334)	(0.391)
age	-0.0055***	-0.0012	-0.0056***	-0.0014
	(0.001)	(0.002)	(0.001)	(0.002)
size	-0.0108**	-0.0018	-0.0072	0.0009
	(0.005)	(0.009)	(0.005)	(0.008)
imported services	0.017	0.1303***	0.0246	0.1374***
	(0.019)	(0.032)	(0.020)	(0.032)
imported capital goods	0.0019	0.0351	0.0113	0.0440
	(0.021)	(0.030)	(0.021)	(0.030)
Private without group affiliations	-0.3476***	0.1821	-0.3629***	0.1721
	(0.088)	(0.154)	(0.087)	(0.153)
Foreign firms	-0.1918	0.4869**	-0.1951	0.4910**
	(0.128)	(0.220)	(0.128)	(0.220)
Private with group affiliations	-0.3701***	0.3490**	-0.3734***	0.3430**
	(0.092)	(0.154)	(0.091)	(0.153)
Mean Tech	0.7674***	0.0183	0.7797***	0.0297
	(0.070)	(0.089)	(0.069)	(0.089)
Mean export	0.0570	0.8093***	0.0734	0.8199***
	(0.070)	(0.083)	(0.070)	(0.083)
	ρ=0.2105***(0.0393)		ρ=0.2106***(0.0393)	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The Tech and Export equations are estimated simultaneously using maximum likelihood on service firms in our sample for the period 2005-2009, including industry and time dummies. The regressors are regressed on t-1 values. There are 2080 firms with 7702 observations in the regression. "Tech" is an indicator that refers to firms conducting technology investment. "Export" is an indicator that refers to firms that export services. All independent variables, except for dummies are expressed in natural logarithm. The continuous variables are in natural logarithm except age and size.

4.5.2.4 Sensitivity analysis: exploring full sample period

We estimate a dynamic bivariate linear probability model. Although the linear probability model has several well-known disadvantages, such as the probability predictions could be outside the range of 0 to 1 and heteroscedastic errors, it allows us to estimate the model for the full sample period of 2002-2010, and the coefficients of the variables can be directly interpreted and compared. We estimate the model using SURs estimation procedure proposed by Zellner (1962, 1963) and Zellner and Huang (1962). The results are shown in Table 4.18. We demean the variables on both sides of the equation to eliminate unobserved firm specific heterogeneity, although there still exists endogeneity issues, we can have a preliminary outlook of the results. The coefficients of internal and external sources are in line with our main findings from above. The coefficients of internal sources are higher than the corresponding ones for external sources in both equations, indicating that internal sources plays more important role in determining service firms' technology investment and exporting decisions. This is consistent with the results for manufacturing firms in the previous section.

Table 4. 18 Dynamic bivariate linear probability model

Variables	(1) Tech	(2) Export
constant	0.0563***	0.0072*
	(0.006)	(0.004)
internal sources	0.0202***	0.0068***
	(0.004)	(0.002)
external sources	0.0137***	0.0011
	(0.004)	(0.003)
$Tech_{t-1}$	-0.0810***	0.0094*
	(0.011)	(0.005)
$Export_{t-1}$	0.0177	0.1962***
	(0.017)	(0.019)
age	0.0285***	-0.0009
	(0.002)	(0.001)
size	0.0091***	-0.0002
	(0.002)	(0.001)
imported services		-0.0004
		(0.005)
imported capital goods	0.0129*	
	(0.007)	
year dummies	yes	yes
	ρ=0.0572***	
	(0.0110)	
	N obs: 16460	
	N firms: 4329	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated using SURs on service firms in our sample for the period 2002-2010. The regressors are regressed on t-1 values. "Tech" is a dummy equal 1 if firms invest in technology, otherwise 0. "Export" is a dummy which equals 1 if firms export services. The continuous variables are in natural logarithm except age and size.

4.6 Conclusion

The recent literature shows that firms' decisions to conduct technology investment and to export are jointly determined. Since both of these activities involve large sunk costs, the access to financing sources is crucial for firms to performing these activities. The corporate finance theories provide conflicting predictions on firms' financing choice, and the empirical research on firms' financing sources for the joint decisions of these two activities, especially for developing countries, is still underexplored.

In this chapter we investigate the role of financing sources in determining firms' joint decisions to invest in technology and to export for both manufacturing firms and service firms. The technology investment and exporting behaviour of services firm has traditionally been under-explored. In recent years, the importance of these activities of services firms has been gradually recognized. Yet we still know very little about the elements that stimulate service firms' ability to invest in technology and export, especially regarding the role of financing sources. This study considers, to the best of our knowledge for the first time, the link between financing sources, technology investment and exporting for services firms.

We employ a panel data of firms in the Indian manufacturing and services sectors to study the role of financing sources on firms' joint decision of technology investment and export behaviour in a typical developing country context. We follow Aw et al. (2007) and Máñez et al. (2014) to estimate a dynamic bivariate probit model of technology investment and exporting in which we characterize the joint decision as depending on financing sources and other controls. For the manufacturing firms, we treat the years of 1999-2001 as the pre-sample period and estimate for the period of 2002-2010. For the services, due to data limitation, we curtail our estimation to the period of 2005-2010. As a remoteness check, we include the estimation of a dynamic bivariate linear probability model that has the advantage of using the same sample period of 2002-2010 as the manufacturing firms and make comparisons between these two sectors.

We find that internal financing plays an important role in determining manufacturing firms' joint decision of technology investment and exporting, while the effects of external sources are not quite significant for manufacturing firms in India. This is possibly due to the poor but still developing financial system in India and firms have limited access to external financing sources. India has implemented a series of financial reforms since the 1990s, and we further investigate the impact of these financial reforms. The results reveal some weak effort of the financial reforms on reducing the effects of internal sources on exporting. Furthermore, compared with small firms, our results show that large firms are less dependent on internal finance. We also find that productive firms are less confined to internal sources and more sensitive to external sources.

For the service firms, the results also show that internal sources play more important role in determining Indian services firms' technology investments and exporting decisions than external sources, which is consistent with the findings for manufacturing firms. External financing sources are shown to have a significant and positive effect on the decision to undertake technology investments, although this effect is not quite significant in the case of manufacturing firms. From the decomposition of the external sources, we find that this effect for service firms is mainly due to bank loans. The result is in line with the pecking order theory that firms prefer internal financing to external financing. In addition, our results show that the export of modern services firms is less dependent on external sources than traditional services, and that the decisions of technology intensive firms are less affected by internal financing sources than their non-technology intensive counterparts in determining technology investment.

Our results implicate that the poor financial institutions in India limit firms' access to external financing sources and confine firms' ability to conduct technology investment and export. Further financial reforms aimed at easing firms' access to external sources are still necessary.

Appendices

Appendix 4.1: The definition of the main variables

Table A.4. 1 Definition of variables

Variable	Definition	Explanation
R&D intensity	the ratio of R&D expense to sales	proxy to R&D investment intensity
D_rnd	a dummy indicating a firm conduct R&D	R&D investment dummy
Tech intensity	the ratio of Tech expense to sales	proxy to technology investment intensity
D_tech	a dummy indicating a firm invest in technology	technology investment dummy
export intensity	the ratio of total export to sales	proxy to export intensity
D_et	a dummy indicating a firm either exporting goods or exporting services	export dummy
internal sources	the logarithm of profits retained during the year	internal finance
D_internal	a dummy indicating a firm retains profits	
external sources	the logarithm of the sum of government loans, bank loans and non-bank loans	external finance
D_external	a dummy indicating a firm obtains external finance	
government loans	the logarithm of funds from central & state govt borrowings	belongs to external finance
D_govt	a dummy indicating a firm borrows from governments	
bank loans	the logarithm of funds from banks and/or financial institutions borrowings	belongs to external finance, formal finance
D_bank	a dummy indicating a firm borrows from banks and/or financial institutions	
non-bank loans	the logarithm of funds from other borrowings sources	belongs to external finance, informal finance
D_nonbank	a dummy indicating a firm borrows from other sources	
age	firm age	
size	total assets divided by mean assets	
TFP	total factor productivity	productivity
ownership	Private without group affiliations, Private with group affiliations, Foreign firms, State-owned firms	
imported raw materials	the logarithm of import of raw materials	
imported services	the logarithm of import of services	
imported capital goods	the logarithm of import of capital goods	

Appendix 4.2: The average marginal effects of the main variables

Table A.4. 2 Average marginal effects (dy/dx): manufacturing

Variables	(1) R&D	(2) Export
internal sources	0.0081***	0.0151***
	(0.0018)	(0.0026)
external sources	0.0021*	0.0008
	(0.0011)	(0.0015)
$R\&D_{t-1}$	0.2027***	0.0113
	(0.0044)	(0.0073)
$Export_{t-1}$	0.0088**	0.2834***
	(0.0045)	(0.0040)
age	0.0001	-0.0002
	(0.0001)	(0.0001)
size	-0.0000	-0.0025**
	(0.0007)	(0.0012)
TFP	-0.0026	0.0075***
	(0.0022)	(0.0027)
imported raw materials	0.0024**	0.0113***
	(0.0010)	(0.0015)
imported capital goods	0.0026**	0.0086***
	(0.0013)	(0.0022)

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The table shows the average marginal effects of the main variables in our preferred specification in column (9) and (10) in table 4.7.

Table A.4. 3 Average marginal effects (dy/dx): services

Variables	(1) Tech	(2) Export
internal sources	0.0257***	0.0053***
	(0.0040)	(0.0019)
external sources	0.0083***	-0.0010
	(0.0028)	(0.0012)
$Tech_{t-1}$	0.2886***	0.0168***
	(0.0092)	(0.0051)
$Export_{t-1}$	0.0621***	0.1936***
	(0.0153)	(0.0059)
age	-0.0015***	-0.0001
	(0.0003)	(0.0001)
size	-0.0017	0.0002
	(0.0015)	(0.0007)
imported services	0.0018	0.0105***
	(0.0050)	(0.0025)
imported capital goods	0.0015	0.0033
	(0.0055)	(0.0024)

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The table shows the average marginal effects of the main variables in our preferred specification in column (9) and (10) in table 4.14.

Appendix 4.3: Test the validity of restricted sample

An econometric problem of our empirical estimation is unobserved heterogeneity. We address this problem following the approach of Máñez et al. (2014) and Blundell et al. (1999, 2002) by including the pre-sample means of the dependent variables as additional regressors in the regressions. We treat the years of 1999-2001 as the pre-sample period for manufacturing firms and the years of 2001-2004 as the pre-sample period for service firms. There are many firms miss the pre-sample information in our samples, and we exclude these observations and regress on the restricted sample with those that have pre-sample information. We examine the representativeness of this restricted sample by comparing the regression results of our estimated sample (restricted sample) with this larger sample without dropping firms without pre-sample information.

The results of manufacturing firms are reported in table A.4.4 and of service firms are reported in table A.4.5. For both tables, columns (1), (2) and (5), (6) show the results of baseline dynamic model, and columns (3), (4) and (7), (8) instrument the internal and external sources with their t-3 lagged values. The results are consistent between our estimated sample (restricted sample) and the larger sample for both manufacturing firms and service firms, which suggest that the restricted samples are valid in testing the effects of financing sources on technology investment and exporting for Indian manufacturing and service firms.

Table A.4. 4 Compare the results between restricted and large sample: manufacturing

Variables	restricted sample				large sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	R&D	Export	R&D	Export	R&D	Export	R&D	Export
constant	-2.3806***	-2.3887***	-2.3456***	-2.3810***	-2.5060***	-2.4042***	-2.4960***	-2.4037***
	(0.143)	(0.124)	(0.147)	(0.125)	(0.117)	(0.097)	(0.119)	(0.097)
internal sources	0.0643***	0.0615***	0.0827***	0.1046***	0.0656***	0.0686***	0.0832***	0.1009***
	(0.013)	(0.012)	(0.020)	(0.018)	(0.011)	(0.009)	(0.016)	(0.013)
external sources	0.0426***	0.0228**	0.0358***	0.0208**	0.0440***	0.0334***	0.0419***	0.0327***
	(0.011)	(0.009)	(0.013)	(0.010)	(0.009)	(0.007)	(0.010)	(0.008)
$R\&D_{t-1}$	3.0518***	0.1646***	3.0515***	0.1637***	3.0033***	0.1750***	3.0017***	0.1730***
	(0.051)	(0.041)	(0.051)	(0.041)	(0.043)	(0.036)	(0.043)	(0.035)
$Export_{t-1}$	0.1999***	2.5420***	0.1983***	2.5329***	0.2358***	2.5818***	0.2340***	2.5758***
	(0.045)	(0.040)	(0.045)	(0.040)	(0.037)	(0.030)	(0.037)	(0.030)
age	0.0037***	0.0007	0.0036***	0.0006	0.0036***	0.0008	0.0035***	0.0007
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
size	-0.0023	-0.0095	-0.0042	-0.0164*	-0.0057	-0.0158*	-0.0083	-0.0211**
	(0.008)	(0.009)	(0.008)	(0.010)	(0.007)	(0.008)	(0.007)	(0.008)
TFP	-0.0254	0.0679***	-0.0329	0.0472**	-0.0186	0.0449***	-0.0267	0.0295**
	(0.024)	(0.018)	(0.025)	(0.019)	(0.018)	(0.013)	(0.019)	(0.014)

Table A.4.4 Compare the results between restricted and large sample: manufacturing (Continued)

Variables	restricted sample				large sample			
	(1) R&D	(2) Export	(3) R&D	(4) Export	(5) R&D	(6) Export	(7) R&D	(8) Export
imported raw materials	0.0550***	0.1095***	0.0516***	0.0991***	0.0445***	0.1055***	0.0405***	0.0973***
	(0.011)	(0.010)	(0.012)	(0.011)	(0.009)	(0.009)	(0.010)	(0.009)
imported capital goods	0.0295*	0.0777***	0.0264*	0.0671***	0.0386***	0.0857***	0.0349***	0.0784***
	(0.015)	(0.016)	(0.015)	(0.017)	(0.013)	(0.013)	(0.013)	(0.014)
Private without group affiliations	-0.2000**	0.4464***	-0.2147**	0.4380***	-0.1549**	0.4185***	-0.1599**	0.4163***
	(0.085)	(0.083)	(0.085)	(0.083)	(0.074)	(0.070)	(0.074)	(0.070)
Foreign firms	-0.1477	0.6364***	-0.1596	0.6270***	-0.0768	0.6013***	-0.0827	0.5941***
	(0.119)	(0.137)	(0.119)	(0.136)	(0.100)	(0.105)	(0.100)	(0.104)
Private with group affiliations	-0.1027	0.4212***	-0.1127	0.4139***	-0.0128	0.4203***	-0.0157	0.4183***
	(0.087)	(0.084)	(0.087)	(0.083)	(0.076)	(0.072)	(0.076)	(0.071)
	ρ=0.1795***(0.0357)		ρ=0.1804***(0.0357)		ρ=0.1856***(0.0301)		ρ=0.1865***(0.0301)	
	N obs: 17299		N obs: 17299		N obs: 28444		N obs: 28444	
	N firms: 2981		N firms: 2981		N firms: 6334		N firms: 6334	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The regressions are estimated on manufacturing firms in our samples for the period 2002-2010. The "restricted sample" refers to firms that have the data information during 1999-2001 while the "large sample" refers to the whole sample. "R&D" is an indicator that refers to firms conducting research & development. "Export" is an indicator that refers to firms that export, either goods or services or both. The continuous variables are in natural logarithm except age and size. For columns (3), (4) and (7), (8), the internal and external sources are instrumented with their t-3 lagged values.

Table A.4. 5 Compare the results between restricted and large sample: services

Variables	restricted sample				large sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Tech	Export	Tech	Export	Tech	Export	Tech	Export
constant	-0.4245	-2.3309***	-0.3764	-2.2874***	-0.3232	-2.2731***	-0.3003	-2.2487***
	(0.316)	(0.316)	(0.320)	(0.315)	(0.213)	(0.227)	(0.214)	(0.226)
internal sources	0.1203***	0.1028***	0.1079***	0.0857***	0.1234***	0.0966***	0.1167***	0.0938***
	(0.012)	(0.019)	(0.016)	(0.022)	(0.010)	(0.015)	(0.013)	(0.018)
external sources	0.0525***	-0.0135	0.0421***	-0.0164	0.0564***	-0.0070	0.0513***	-0.0136
	(0.009)	(0.013)	(0.011)	(0.014)	(0.007)	(0.011)	(0.008)	(0.011)
$Tech_{t-1}$	1.2586***	0.2148***	1.2538***	0.2127***	1.1962***	0.1922***	1.1944***	0.1911***
	(0.047)	(0.058)	(0.047)	(0.058)	(0.036)	(0.047)	(0.036)	(0.047)
$Export_{t-1}$	0.3070***	2.8202***	0.3087***	2.8240***	0.2714***	2.7709***	0.2733***	2.7714***
	(0.047)	(0.072)	(0.047)	(0.072)	(0.039)	(0.057)	(0.040)	(0.057)
age	-0.0054***	-0.0015	-0.0055***	-0.0016	-0.0095***	-0.0039***	-0.0095***	-0.0040***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
size	-0.0078	-0.0049	-0.0052	-0.0030	-0.0088**	-0.0090	-0.0075**	-0.0080
	(0.006)	(0.009)	(0.006)	(0.008)	(0.004)	(0.007)	(0.004)	(0.008)
imported services	0.007	0.1636***	0.0132	0.1690***	0.0223	0.1356***	0.0254	0.1379***
	(0.019)	(0.032)	(0.019)	(0.032)	(0.017)	(0.026)	(0.017)	(0.026)

Table A.4.5 Compare the results between restricted and large sample: services (Continued)

Variables	restricted sample				large sample			
	(1) Tech	(2) Export	(3) Tech	(4) Export	(5) Tech	(6) Export	(7) Tech	(8) Export
imported capital goods	-0.0014	0.0295	0.0058	0.0357	0.0070	0.0440*	0.0104	0.0474**
	(0.021)	(0.029)	(0.021)	(0.029)	(0.018)	(0.024)	(0.018)	(0.024)
Private without group affiliations	-0.3971***	0.1858	-0.4095***	0.1780	-0.3291***	0.1511	-0.3351***	0.1479
	(0.085)	(0.142)	(0.085)	(0.141)	(0.076)	(0.125)	(0.076)	(0.124)
Foreign firms	-0.2699**	0.5627***	-0.2721**	0.5647***	-0.3237***	0.5537***	-0.3238***	0.5580***
	(0.127)	(0.194)	(0.127)	(0.193)	(0.111)	(0.167)	(0.111)	(0.165)
Private with group affiliations	-0.4051***	0.3536**	-0.4081***	0.3490**	-0.3901***	0.3012**	-0.3934***	0.3004**
	(0.088)	(0.143)	(0.088)	(0.141)	(0.078)	(0.126)	(0.078)	(0.125)
	ρ=0.2045***(0.0381)		ρ=0.2047***(0.0381)		ρ=0.2291***(0.0292)		ρ=0.2294***(0.0292)	
	N obs: 7702		N obs: 7702		N obs: 11734		N obs: 11734	
	N firms: 2080		N firms: 2080		N firms: 3914		N firms: 3914	

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors are displayed in parentheses. The Tech and Export equations are estimated simultaneously using maximum likelihood on service firms in our sample for the period 2005-2010. The regressors are regressed on t-1 values. The "restricted sample" refers to firms that have the data information during 2001-2004 while the "large sample" refers to all the firms during 2005-2010. "Tech" is an indicator that refers to firms conducting technology investment. "Export" is an indicator that refers to firms that export services. The continuous variables are in natural logarithm except age and size. For columns (3), (4) and (7), (8), the internal and external sources are instrumented with their t-3 lagged values.

Chapter 5

Conclusions

5.1 Conclusions and summary of research

This thesis contributes to the empirical literature on globalisation and firm behaviour with a special focus on technology and exporting of Indian firms in the post-liberalization era. India has implemented a series of economic reforms since 1991 regarding trade policy, industrial and import licenses, the tax system and the financial sector. A key feature of these reforms has been the promotion of trade and innovation which have been regarded as two important policy tools to simulate the growth of the domestic economy. The study is motivated by the active engagement of Indian firms in exporting and technology during the recent decades and the potential consequences of this for firm performance and behaviour. It has explored the effect of exporting on firms' productivity convergence, and the relationship between technology investment and exporting, paying attention to the role of financing sources, both for manufacturing and services, the two main sectors that have contributed to Indian economic growth and global expansion in recent years.

Overall, the results tend to highlight the importance of the effects of exporting on facilitating firms' productivity growth, and the role of internal financing on firms' joint decision to invest in new technology and to start and increase export activities. Furthermore, the findings of this thesis also underline the importance of the efficiency of the financial system and the necessity for further reforms. The issues addressed here are not only specific to

India, given the general context of India's economic reforms and development; the setting of India offers rich policy implications for other developing countries.

In light of the macroeconomic literature on economic growth and regarding how and whether poor economies converge to richer ones, Chapter 3 provides micro evidence of firms' productivity convergence. Differing from the existing firm level studies which mainly focus on convergence to the national frontier, we investigate the process of firms' productivity convergence to both of their national and regional frontiers, using a comprehensive panel data of Indian manufacturing firms from 13 states and 1 territory over the period 1999 to 2010. This chapter reveals interesting insights. We find evidence of convergence among firms that are laggards as converging to both their national and regional frontiers, and that they converge faster to the national frontier than to their regional frontier. We also examine the effects of export behaviour on this process of convergence, and the results demonstrate that exporting promotes productivity growth but slows down the convergence process. This is mainly because exporters are usually more productive firms and have lesser scope to converge, and many of them are already defining the frontier itself. Further, we inspect the effect of Outward Foreign Direct Investment (OFDI) on firms' productivity growth and convergence among exporters. Likewise, the results show that OFDI facilitates firms' productivity growth but decelerates the speed of convergence. This finding implies that engaging in globalisation assists firms' productivity growth, although it slows down the convergence process.

Given the interdependence between firms' technology investment and exporting, Chapter 4 studies firms' joint decisions to invest in technology and to export, and examines the effects of financing sources on these decisions,

since both technology investment and exporting involves large entry costs. This chapter explores both manufacturing and service firms. Technology investment and exporting have traditionally been strongly associated with manufacturing firms, while these two activities of services firms have largely been neglected in previous studies. This chapter adds to the current literature by investigating both manufacturing and service firms' technology investment and exporting decisions, and in particular the role of financing sources in determining these decisions. The empirical literature on the relationship between financing sources and technology investment and/or exporting is still limited and tends to be characterized by mixed findings. In addition, we provide some comparison between manufacturing and services. We employ a dynamic bivariate probit model of technology investment and exporting in which we characterize the joint decision as depending on financing sources and other controls. We use R&D expenses to measure technology investment of manufacturing firms. Though some service industries exhibit high technological capability, R&D is still mainly conducted by the manufacturing sector. Therefore, we extend the study of R&D investment in manufacturing to a broader technology investment measure which includes R&D investment as well as purchased technology for services.

Using a panel data of Indian manufacturing firms and service firms, we find that firms with higher internal financing are more likely to engage in technology investment and exporting, this is consistent between manufacturing and services, providing support for the pecking order theory that firms prefer to use internal finance sources to finance their investments than external sources. Further, calculating the average marginal effects for the key variables as well as estimating a bivariate linear probability model, the results tend to confirm our finding. The difference between this two sectors is that the effects of external financing sources are not statistically significant for manufacturing

firms, but presents positive and significant effort in determining technology investment for service firms. Decomposing the external sources into government loans, bank loans and nonbank loans, we find that this positive effect is mainly provided by bank loans. Given the use of a similar empirical methodology to the studies for the manufacturing and services, the differences in the results indicate that it is important to recognize the differences between manufacturing and services and the role of financing sources. We further investigate the impact of financial reforms on these decisions, and the results depict some weak effect of the financial reforms in reducing the impacts of internal sources on exporting. This suggests that financial reforms have to some extent reduced firms' reliance on internal financing. However, these results also reveal that the financial system in India is still inefficient, and further reforms are required. Comparing between modern and traditional services, technology intensive and less intensive industries, and the results tend to suggest that the export of modern service firms are less dependent on external sources, while technology intensive firms are less sensitive to internal financing sources. In addition, the positive and significant correlation between the error terms confirms that the decisions of technology investment and exporting are simultaneously determined.

5.2 Avenues for future research

The studies in this thesis are not without limitations. In the future, we would try to address these limitations. Firstly, a limitation of the data is that it has missing information on the number of firm employees which is commonly used to measure firm size and an element to calculate TFP. Although we address this problem by employing total assets as an alternative to measure firm size and using wages instead of employee number to calculate TFP, it

would be better if we have the employee information. Secondly, we adopt the approach of Levinsohn and Petrin (2003) to estimate and calculate TFP in Chapter 3, which is the best way given the data and time period. However, if we had more time, we could also obtain the measures of TFP by employing the methods of Ackerberg et al. (2006) (known as ACF) and the superlative index number approach as robustness tests. Thirdly, given the limit data span, we take three years as pre-sample (1999-2001 for manufacturing firms and 2001-2004 for service firms) to control for correlated unobserved heterogeneity, while theoretically it works better if having a longer time as the pre-sample period. But usually we do not have a long enough data span to enable us to use many years of information as the pre-sample period. Given more time, we would also explore an alternative approach proposed by Miranda (2010) to estimate the dynamic bivariate probit model.

The research in this thesis can be extended to study some other interesting topics. For instance, in light of the findings presented in Chapter 3, and the limited research on productivity convergence in the service sector in the context of developing countries, it seems worthwhile to empirically investigate whether service firms are converging to their productivity frontiers, at both national and regional level, and examine the role of exporting in this convergence/divergence process. Given the distinguishing nature between services and manufacturing, i.e. the production process, the intermediate inputs employed, the exporting approach and so on, this extension would contribute to the empirical literature by providing some interesting comparison of productivity growth and productivity convergence between manufacturing and services at the firm level. With the availability of the Indian state-level data and detailed information regarding state domestic product, banking, public finance, education, infrastructure, we could perform deeper analysis of regional level productivity convergence, an area that has not been well explored in the

literature. In addition, services are recognized as a promising sector for growth, employment and a source of new technologies, the study of service productivity in India would shed light on the development of services in other developing countries.

Another possible direction for future research is to study the relationship between financing sources, exporting and outward foreign direct investment (OFDI). A distinguishing feature of our data is that it provides information on firms' investment abroad, and offers us a unique opportunity for studying this aspect. As far as we are concerned, there is a large literature looking into how access to finance facilitates exporting, and some theoretical and empirical literature on the relationship between exporting and OFDI, while little is known about how financing actually influences firms' OFDI, and the causal link between financing sources, export and OFDI, partly due to data availability. Any subsequent study could provide insights into the empirically underlying mechanisms on the relationship between financing sources, export and OFDI, and offer policy implications on promoting firms' OFDI activity.

In light of the findings presented in Chapter 3 that OFDI plays a role in facilitating firms' productivity growth, while the theoretical literature indicates that only the most productive firms engage in OFDI, this may therefore represent another interesting agenda for future research to deeper explore the causal link between OFDI and firm productivity in India, and contribute to the literature by providing empirical evidence on globalisation and productivity in the context of a developing country.

Another plausible extension of this dissertation is to compare the relationship between financing sources and productivity growth for manufacturing and service firms between China and India, two of the largest developing economies in the world, depending on the availability of the

corresponding data of China in the future. China is well-known for the rapid development of its manufacturing sector, while India is notable for the growth of services. The comparison of financing and productivity of manufacturing and services between China and India at the firm level is meaningful and of great importance.

Finally, given the unbalanced development of Indian states, with the Indian firm level data at hand, complemented by state information, represents a natural way to further deepen the analysis of firms' technology investment, exporting, OFDI and productivity focusing on some regions or states, such as Maharashtra, Karnataka and West Bengal. Also, in light of the findings presented in Chapter 4 that technology intensive firms are less sensitive to internal funds, it would be plausible to look deeper into the relationship between financing sources and technology investment for firms in some technology intensive industries such as computer software.

Bibliography

Ackerberg, D., Caves, K. & Frazer, G. 2006. Structural Identification of Production Functions. *MPRA Paper*.

Aghion, P., Askenazy, P., Berman, N., Cette, G. & Eymard, L. 2012. Credit Constraints and the Cyclicality of R&D Investment: Evidence from France. *Journal of European Economic Association,* 10 (5)**,** 1001-1024.

Aiello, F. & Scoppa, V. 2008. Convergence and Regional Productivity Divide in Italy: Evidence from Panel Data. *MPRA Paper*.

Allen, F., Chakrabarti, R., De, S., Qian, J. Q. & Qian, M. 2012. Financing Firms in India. *Journal of Financial Intermediation,* 21 (3)**,** 409-445.

Allen, F., Qian, J. & Qian, M. 2005. Law, Finance, and Economic Growth in China. *Journal of Financial Economics,* 77 (1)**,** 57-116.

Almeida, H. & Campello, M. 2007. Financial Constraints, Asset Tangibility, and Corporate Investment. *Review of Financial Studies,* 20 (5)**,** 1429-1460.

Altomonte, C., Gamba, S., Mancusi, M. L. & Vezzulli, A. 2015. R&D Investments, Financing Constraints, Exporting and Productivity. *Economics of Innovation and New Technology***,** 1-21.

Álvarez, R. & Crespi, G. 2007. Multinational Firms and Productivity Catching-Up: The Case of Chilean Manufacturing. *International Journal of Technological Learning, Innovation and Development,* 1 (2)**,** 136-152.

Amiti, M. & Konings, J. 2007. Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia. *American Economic Review,* 97 (5)**,** 1611-1638.

Ariu, A. 2016. Services Versus Goods Trade: A Firm-Level Comparison. *Review of World Economics,* 152 (1)**,** 19-41.

Arnold, J. M., Javorcik, B., Lipscomb, M. & Mattoo, A. 2016. Services Reform and Manufacturing Performance: Evidence from India. *Economic Journal,* 126 (590)**,** 1-39.

Aw, B. Y., Roberts, M. J. & Winston, T. 2007. Export Market Participation, Investments in R&D and Worker Training, and the Evolution of Firm Productivity. *World Economy,* 30 (1)**,** 83-104.

Aw, B. Y., Roberts, M. J. & Xu, D. Y. 2011. R&D Investment, Exporting, and Productivity Dynamics. *American Economic Review,* 101 (4)**,** 1312-1344.

Ayyagari, M., Demirgüç-Kunt, A. & Maksimovic, V. 2010. Formal Versus Informal Finance: Evidence from China. *Review of Financial Studies,* 23 (8)**,** 3048-3097.

Baldwin, J. R. & Gu, W. 2004. Trade Liberalization: Export-Market Participation, Productivity Growth, and Innovation. *Oxford Review of Economic Policy,* 20 (3)**,** 372-392.

Barro, R. & Sala-I-Martin, X. 1997. Technological Diffusion, Convergence, and Growth. *Journal of Economic Growth,* 2 (1)**,** 1-26.

Barro, R. J. & Sala-I-Martin, X. 1992. Convergence. *Journal of Political Economy,* 100 (2)**,** 223-251.

Bartelsman, E. J., Haskel, J. & Märtin, R.-P. 2008. Distance to Which Frontiers? Evidence on Productivity Convergence from International Firm-Level Data. *CEPR Discussion Paper No. DP7032*.

Beck, T. & Demirguc-Kunt, A. 2006. Small and Medium-Size Enterprises: Access to Finance as a Growth Constraint. *Journal of Banking & Finance,* 30 (11)**,** 2931-2943.

Beck, T., Demirgüç-Kunt, A. & Maksimovic, V. 2005. Financial and Legal Constraints to Growth: Does Firm Size Matter? *The Journal of Finance,* 60 (1)**,** 137-177.

Beck, T., Demirgüç-Kunt, A. & Maksimovic, V. 2008. Financing Patterns around the World: Are Small Firms Different? *Journal of Financial Economics,* 89 (3)**,** 467-487.

Bellone, F., Musso, P., Nesta, L. & Schiavo, S. 2010. Financial Constraints and Firm Export Behaviour. *World Economy,* 33 (3)**,** 347-373.

Bernard, A. B. & Jones, C. I. 1996. Comparing Apples to Oranges: Productivity Convergence and Measurement across Industries and Countries. *American Economic Review,* 86 (5)**,** 1216-1238.

Blundell, R., Griffith, R. & Van Reenen, J. 1999. Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms. *The Review of Economic Studies,* 66 (3)**,** 529-554.

Blundell, R., Griffith, R. & Windmeijer, F. 2002. Individual Effects and Dynamics in Count Data Models. *Journal of Econometrics,* 108 (1)**,** 113-131.

Bond, S., Harhoff, D. & Reenen, J. V. a. N. 2005. Investment, R&D and Financial Constraints in Britain and Germany. *Annales d'Économie et de Statistique,* (79/80)**,** 433-460.

Bratti, M. & Felice, G. 2012. Are Exporters More Likely to Introduce Product Innovations? *World Economy,* 35 (11)**,** 1559-1598.

Brown, J. R., Martinsson, G. & Petersen, B. C. 2012. Do Financing Constraints Matter for R&D? *European Economic Review,* 56 (8)**,** 1512-1529.

Bustos, P. 2011. Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of Mercosur on Argentinian Firms. *American economic review,* 101 (1)**,** 304-340.

Cameron, G., Proudman, J. & Redding, S. 2005. Technological Convergence, R&D, Trade and Productivity Growth. *European Economic Review,* 49 (3)**,** 775-807.

Canepa, A. & Stoneman, P. 2007. Financial Constraints to Innovation in the UK: Evidence from Cis2 and Cis3. *Oxford Economic Papers*.

Cassiman, B., Golovko, E. & Martínez-Ros, E. 2010. Innovation, Exports and Productivity. *International Journal of Industrial Organization,* 28 (4)**,** 372-376.

Chaney, T. 2013. Liquidity Constrained Exporters. *National Bureau of Economic Research*.

Chen, J. J. 2004. Determinants of Capital Structure of Chinese-Listed Companies. *Journal of Business Research,* 57 (12)**,** 1341-1351.

Chen, M. & Guariglia, A. 2013. Internal Financial Constraints and Firm Productivity in China: Do Liquidity and Export Behaviour Make a Difference? *Journal of Comparative Economics,* 41 (4)**,** 1123-1140.

Chevalier, P.-A., Lecat, R. & Oulton, N. 2012. Convergence of Firm-Level Productivity, Globalisation and Information Technology: Evidence from France. *Economics Letters,* 116 (2)**,** 244-246.

Costantini, J. & Melitz, M. 2007. The Dynamics of Firm-Level Adjustment to Trade Liberalization. *The organization of firms in a global economy,* 107**,** 141.

Czarnitzki, D. & Fier, A. 2002. Do Innovation Subsidies Crowd out Private Investment? Evidence from the German Service Sector. *Applied Economics Quarterly,* 48 (1)**,** 1-25.

Damijan, J. P., Kostevc, Č. & Polanec, S. 2010. From Innovation to Exporting or Vice Versa? *World Economy,* 33 (3)**,** 374-398.

Das, L. & Raut, R. 2014. Impact of Changes in Service Sector in India in Shaping the Future of Business & Society. *Procedia Economics & Finance,* 11**,** 795-803.

De Loecker, J. 2007. Do Exports Generate Higher Productivity? Evidence from Slovenia. *Journal of International Economics,* 73 (1)**,** 69-98.

De Miguel, A. & Pindado, J. 2001. Determinants of Capital Structure: New Evidence from Spanish Panel Data. *Journal of Corporate Finance,* 7 (1)**,** 77-99.

Delcoure, N. 2007. The Determinants of Capital Structure in Transitional Economies. *International Review of Economics & Finance,* 16 (3)**,** 400-415.

Du, J. & Girma, S. 2012. Firm Size, Source of Finance, and Growth - Evidence from China. *International Journal of the Economics of Business,* 19 (3)**,** 397-419.

Ederington, J. & Mccalman, P. 2008. Endogenous Firm Heterogeneity and the Dynamics of Trade Liberalization. *Journal of International Economics,* 74 (2)**,** 422-440.

Efthyvoulou, G. & Vahter, P. 2016. Financial Constraints, Innovation Performance and Sectoral Disaggregation. *The Manchester School,* 84 (2)**,** 125-158.

El-Said, H., Al-Said, M. & Zaki, C. 2015. Trade and Access to Finance of SMEs: Is There a Nexus? *Applied Economics,* 47 (39)**,** 4184-4199.

Esteban, J. 2000. Regional Convergence in Europe and the Industry Mix: A Shift-Share Analysis. *Regional Science and Urban Economics,* 30 (3)**,** 353-364.

Esteve-Pérez, S. & Rodríguez, D. 2013. The Dynamics of Exports and R&D in Smes. *Small Business Economics,* 41 (1)**,** 219-240.

Fariñas, J. C. & Ruano, S. 2005. Firm Productivity, Heterogeneity, Sunk Costs and Market Selection. *International Journal of Industrial Organization,* 23 (7–8)**,** 505-534.

Fazzari, S. M., Hubbard, R. G., Petersen, B. C., Blinder, A. S. & Poterba, J. M. 1988. Financing Constraints and Corporate Investment. *Brookings Papers on Economic Activity,* 1988 (1)**,** 141-206.

Feenstra, R. C., Li, Z. & Yu, M. 2013. Exports and Credit Constraints under Incomplete Information: Theory and Evidence from China. *Review of Economics and Statistics,* 96 (4)**,** 729-744.

Ferrando, A. & Ruggieri, A. 2015. Financial Constraints and Productivity: Evidence from Euro Area Companies. *ECB Working Paper No. 1823*.

Francois, J. & Hoekman, B. 2010. Services Trade and Policy. *Journal of Economic Literature,* 48 (3)**,** 642-692.

Frank, M. Z. & Goyal, V. K. 2003. Testing the Pecking Order Theory of Capital Structure. *Journal of Financial Economics,* 67 (2)**,** 217-248.

Frank, M. Z. & Goyal, V. K. 2007. Trade-Off and Pecking Order Theories of Debt. *Available at SSRN 670543*.

Girma, S. & Kneller, R. 2005. Convergence in the UK Service Sector: Firm Level Evidence, 1988–1998. *Scottish Journal of Political Economy,* 52 (5)**,** 736-746.

Girma, S. & Vencappa, D. 2014. Financing Sources and Firm Level Productivity Growth: Evidence from Indian Manufacturing. *Journal of Productivity Analysis***,** 1-10.

Goldberg, P. K., Khandelwal, A. K., Pavcnik, N. & Topalova, P. 2010. Imported Intermediate Inputs and Domestic Product Growth: Evidence from India. *Quarterly Journal of Economics,* 125 (4)**,** 1727-1767.

Gorodnichenko, Y. & Schnitzer, M. 2013. Financial Constraints and Innovation: Why Poor Countries Don't Catch Up. *Journal of the European Economic Association,* 11 (5)**,** 1115-1152.

Greenaway, D. & Kneller, R. 2007. Firm Heterogeneity, Exporting and Foreign Direct Investment. *Economic Journal,* 117 (517)**,** F134-F161.

Griffith, R., Redding, S. & Simpson, H. 2009. Technological Catch-up and Geographic Proximity. *Journal of Regional Science,* 49 (4)**,** 689-720.

Guariglia, A. & Liu, P. 2014. To What Extent Do Financing Constraints Affect Chinese Firms' Innovation Activities? *International Review of Financial Analysis,* 36**,** 223-240.

Guariglia, A., Liu, X. & Song, L. 2011. Internal Finance and Growth: Microeconometric Evidence on Chinese Firms. *Journal of Development Economics,* 96 (1)**,** 79-94.

Hall, B. H. & Lerner, J. 2010. The Financing of R&D and Innovation. *Handbook of the Economics of Innovation , 1,* 609-639.

Hall, B. H., Mairesse, J., Branstetter, L. & Crepon, B. 1998. Does Cash Flow Cause Investment and R&D?: An Exploration Using Panel Data for French, Japanese, and United States Scientific Firms. *IFS Paper,* (W98/11)**,** 98-260.

Harhoff, D. 1998. Are There Financing Constraints for R&D and Investment in German Manufacturing Firms? *Annales d'Économie et de Statistique,* (49/50)**,** 421-456.

Harris, R. & Moffat, J. 2011. R&D, Innovation and Exporting. *SERC Discussion paper 73*.

Hogan, T. & Hutson, E. 2005. Capital Structure in New Technology-Based Firms: Evidence from the Irish Software Sector. *Global Finance Journal,* 15 (3)**,** 369-387.

Howitt, P. 2000. Endogenous Growth and Cross-Country Income Differences. *American Economic Review,* 90 (4)**,** 829-846.

Iacovone, L. & Crespi, G. A. 2010. Catching up with the Technological Frontier: Micro-Level Evidence on Growth and Convergence. *Industrial and Corporate Change,* 19 (6)**,** 2073-2096.

Kaplan, S. N. & Zingales, L. 1997. Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints? *Quarterly Journal of Economics,* 112 (1)**,** 169-215.

Khandelwal, A. & Topalova, P. 2011. Trade Liberalization and Firm Productivity: The Case of India. *Review of Economics and Statistics,* 93 (3)**,** 995-1009.

Kraus, A. & Litzenberger, R. H. 1973. A State-Preference Model of Optimal Financial Leverage. *The Journal of Finance,* 28 (4)**,** 911-922.

Lachenmaier, S. & Wößmann, L. 2006. Does Innovation Cause Exports? Evidence from Exogenous Innovation Impulses and Obstacles Using German Micro Data. *Oxford Economic Papers,* 58 (2)**,** 317-350.

Lancheros, S. & Demirel, P. 2012. Does Finance Play a Role in Exporting for Service Firms? Evidence from India. *World Economy,* 35 (1)**,** 44-60.

Lee, J. 2009. Trade, Fdi and Productivity Convergence: A Dynamic Panel Data Approach in 25 Countries. *Japan and the World Economy,* 21 (3)**,** 226-238.

Levinsohn, J. & Petrin, A. 2003. Estimating Production Functions Using Inputs to Control for Unobservables. *Review of Economic Studies,* 70 (2)**,** 317-341.

Lileeva, A. & Trefler, D. 2010. Improved Access to Foreign Markets Raises Plant-Level Productivity…For Some Plants. *Quarterly Journal of Economics*, 125 (3)**,** 1051-1099.

Liu, Q. & Lu, Y. 2015. Firm Investment and Exporting: Evidence from China's Value-Added Tax Reform. *Journal of International Economics*.

López Rodríguez, J. & García Rodríguez, R. M. 2005. Technology and Export Behaviour: A Resource-Based View Approach. *International Business Review,* 14 (5)**,** 539-557.

López-Gracia, J. & Sogorb-Mira, F. 2008. Testing Trade-Off and Pecking Order Theories Financing SMEs. *Small Business Economics,* 31 (2)**,** 117-136.

Máñez, J. A., Rochina-Barrachina, M. E., Sanchis-Llopis, J. A. & Vicente, 2014. Financial Constraints and R&D and Exporting Strategies for Spanish Manufacturing Firms. *Industrial and Corporate Change,* 23 (6)**,** 1563-1594.

Männasoo, K. & Meriküll, J. 2015. The Impact of Firm Financing Constraints on R&D over the Business Cycle. *Eesti Pank. Working Paper Series*.

Manova, K., Wei, S.-J. & Zhang, Z. 2015. Firm Exports and Multinational Activity under Credit Constraints. *Review of Economics and Statistics,* 97 (3)**,** 574-588.

Melitz, M. J. 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica,* 71 (6)**,** 1695-1725.

Minetti, R. & Zhu, S. C. 2011. Credit Constraints and Firm Export: Microeconomic Evidence from Italy. *Journal of International Economics*, 83 (2)**,** 109-125.

Miranda, A. 2010. Bivariate Dynamic Probit Models for Panel Data. *Stata Users Group, Mexican Stata Users' Group Meetings 2010*.

Modigliani, F. & Miller, M. H. 1958. The Cost of Capital, Corporation Finance and the Theory of Investment. *The American Economic Review,* 48 (3)**,** 261-297.

Myers, S. C. 1984. The Capital Structure Puzzle. *Journal of Finance,* 39 (3)**,** 574-592.

Myers, S. C. & Majluf, N. S. 1984. Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have. *Journal of Financial Economics,* 13 (2)**,** 187-221.

Newman, A., Gunessee, S. & Hilton, B. 2011. Applicability of Financial Theories of Capital Structure to the Chinese Cultural Context: A Study of Privately Owned SMEs. *International Small Business Journal*.

Nishimura, K. G., Nakajima, T. & Kiyota, K. 2005. Productivity Convergence at the Firm Level. *University of Tokyo MMRC Discussion Paper No. 39.*

Olley, G. S. & Pakes, A. 1996. The Dynamics of Productivity in the Telecommunications Equipment Industry. *Econometrica,* 64 (6)**,** 1263-1297.

Parameswaran, M. 2010. International Trade and R&D Investment: Evidence from Manufacturing Firms in India. *International Journal of Technology and Globalisation,* 5 (1-2)**,** 43-60.

Pascual, A. G. & Westermann, F. 2002. Productivity Convergence in European Manufacturing. *Review of International Economics,* 10 (2)**,** 313-323.

Peri, G. & Urban, D. 2006. Catching-up to Foreign Technology? Evidence on the "Veblen–Gerschenkron" Effect of Foreign Investments. *Regional Science and Urban Economics,* 36 (1)**,** 72-98.

Potterie, B. V. P. D. L. & Lichtenberg, F. 2001. Does Foreign Direct Investment Transfer Technology across Borders? *Review of Economics and Statistics,* 83 (3)**,** 490-497.

Rahaman, M. M. 2011. Access to Financing and Firm Growth. *Journal of Banking & Finance,* 35 (3)**,** 709-723.

Roberts, M. J. & Tybout, J. R. 1997. The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs. *American Economic Review,* 87 (4)**,** 545-564.

Roper, S. & Love, J. H. 2002. Innovation and Export Performance: Evidence from the UK and German Manufacturing Plants. *Research Policy,* 31 (7)**,** 1087-1102.

Sahoo, P. & Dash, R. K. 2014. India's Surge in Modern Services Exports: Empirics for Policy. *Journal of Policy Modeling,* 36 (6)**,** 1082-1100.

Sasidharan, S., Jijo Lukose, P. J. & Komera, S. 2015. Financing Constraints and Investments in R&D: Evidence from Indian Manufacturing Firms. *Quarterly Review of Economics and Finance,* 55**,** 28-39.

Shingal, A. 2014. The Services Sector in India's States: A Tale of Growth, Convergence and Trade. *World Economy,* 37 (12)**,** 1773-1793.

Shyam-Sunder, L. & C. Myers, S. 1999. Testing Static Tradeoff against Pecking Order Models of Capital Structure1. *Journal of Financial Economics,* 51 (2)**,** 219-244.

Silva, F. & Carreira, C. 2010. Financial Constraints: Are There Differences between Manufacturing and Services? : GEMF-Faculdade de Economia, Universidade de Coimbra.

Sirilli, G. & Evangelista, R. 1998. Technological Innovation in Services and Manufacturing: Results from Italian Surveys. *Research Policy,* 27 (9)**,** 881-899.

Solow, R. M. 1956. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics,* 70 (1)**,** 65-94.

Stiebale, J. 2011. Do Financial Constraints Matter for Foreign Market Entry? A Firm-Level Examination. *World Economy,* 34 (1)**,** 123-153.

Strebulaev, I. A. 2007. Do Tests of Capital Structure Theory Mean What They Say? *The Journal of Finance,* 62 (4)**,** 1747-1787.

Tirole, J. 2006. *The Theory of Corporate Finance,* Princeton, Princeton University Press.

Van Biesebroeck, J. 2005. Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms. *Journal of International Economics,* 67 (2)**,** 373-391.

Villaverde, J. & Maza, A. 2008. Productivity Convergence in the European Regions, 1980–2003: A Sectoral and Spatial Approach. *Applied Economics,* 40 (10)**,** 1299-1313.

Vogel, A. & Wagner, J. 2012. Exports, R&D and Productivity in German Business Services Firms: A Test of the Bustos-Model. University of Lüneburg Working Paper Series in Economics.

Wagner, J. 2014. Credit Constraints and Exports: A Survey of Empirical Studies Using Firm-Level Data. *Industrial and Corporate Change,* 23 (6)**,** 1477-1492.

Wang, Z. & Yu, Z. 2012. Trading Partners, Traded Products and Firm Performances of China's Exporter-Importers: Does Processing Trade Make a Difference? *World Economy,* 35 (12)**,** 1795-1824.

Westhead, P. & Storey, D. J. 1997. Financial Constraints on the Growth of High Technology Small Firms in the United Kingdom. *Applied Financial Economics,* 7 (2)**,** 197-201.

Yang, C.-H., Chen, J.-R. & Chuang, W.-B. 2004. Technology and Export Decision. *Small Business Economics,* 22 (5)**,** 349-364.

Zellner, A. 1962. An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias. *Journal of the American Statistical Association,* 57 (298)**,** 348-368.

Zellner, A. 1963. Estimators for Seemingly Unrelated Regression Equations: Some Exact Finite Sample Results. *Journal of the American Statistical Association,* 58 (304)**,** 977-992.

Zellner, A. & Huang, D. S. 1962. Further Properties of Efficient Estimators for Seemingly Unrelated Regression Equations. *International Economic Review,* 3 (3)**,** 300-313.