THE DETERMINANTS OF HIGH-TECHNOLOGY EXPORT PERFORMANCE:

AN EMPIRICAL INVESTIGATION IN BRICT

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THE DETERMINANTS OF HIGH-TECHNOLOGY EXPORT PERFORMANCE:

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DECLARATION OF ORIGINALITY

I, Deniz Avşar, certify that

- I am the sole author of this thesis and that I have fully acknowledged and documented in my thesis all sources of ideas and words, including digital resources, which have been produced or published by another person or institution;
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ABSTRACT

The Determinants of High-technology Export Performance:

An Empirical Investigation in BRICT

In order to investigate the determinants of high-tech exports from BRIC and Turkey during the period 2006-2014, we built an empirical model based on national innovative capacity framework and High Tech Indicators conceptual model. Three panel data estimation methods with fixed effects were conducted: regression with Driscoll-Kraay standard errors, linear regression with panel-corrected standard errors and robust linear regression with a large dummy-variable set. Five clusters of measures were introduced to the empirical model respectively, and determinants related to innovation were reported to have the highest explanatory powers, followed by productive capacity, financial market development, national orientation and skilled labors. 5 integrated empirical models with more than 93 per cent explanatory power were subsequently introduced. The research concluded that the skilled labor variables (i.e. doctoral graduates and science and engineering graduates), human capital (i.e. researchers in R&D activities) and government R&D expenditures are all highly significant and positive in all the models, and some of them even exert the highest effect on high-tech exports in some models. For example, ceteris paribus, a 10% increase in government R&D expenditures and researchers will boost the share of high-tech exports in manufactured exports by 7.23% and 1.4%, respectively. Domestic innovative capacity does play an important role in the success of high-tech exports from BRIC and Turkey.

ÖZET

Yüksek Teknoloji İhracat Performansının Belirleyicilerini:

BRİC ile Türkiye Ülkeleri Üzerine Yapılan Ampirik İnceleme

2006 ile 2014 yılları arasında Türkiye ile BRİC ülkelerinden yapılan yüksek teknoloji ihracat performansının belirleyicilerini araştırmak için, ulusal yenilikçi kapasite çerçevesine ve yüksek teknoloji göstergeleri kavramsal modeline dayalı ampirik bir model oluşturduk. Sabit etkili üç panel veri kestirimi yöntemi uygulanmıştır: bunlar sırasıyla Driscoll-Kraay standart hata regresyonu, standart hataları düzeltilmiş panel doğrusal regresyonu ve büyük etkisiz-değişken kümeli sağlam doğrusal regresyon yöntemleridir. Ampirik model için beş adet ölçüm kümesi tanımlandı: inovasyon, üretken kapasite, finansal piyasaların gelişimi, ulusal yönelim ve nitelikli iş gücü olarak sıralanmaktadır. Bu kümelerin içinde en iyi açıklama gücüne sahip olan inovasyon ile ilgili belirleyiciler olarak belirlendi. Bunu takiben 93% açıklama gücüne sahip beş bütünleşik ampirik model tanımlandı. Nitelikli iş gücü (örneği: doktoralılar, bilim ve mühendislik dalından mezun olanlar), beşeri sermaye (örneği: Ar-Ge faliyetlerinde çalışan araştırmacılar) ve devletin Ar-Ge harcamaları tüm modellerde pozitif ve istatistiksel olarak anlamlı bulunmaktadırlar. Hatta bunlardan bazıları modellerde yüksek teknoloji ihracatında en büyük etkiyi ortaya koymaktadırlar. Örneğin; tüm diğer etkenler sabitken, devletin Ar-Ge harcamalarını ve araştırıcı sayısını 10% oranında arttırması yüksek teknoloji ihracatının ilkinde 7.23% ikincisinde ise 1.4% oranında artması sonucunu doğurur.

BRİC ve Türkiye'den yapılan yüksek teknoloji ihracatı başarısı üzerinde yerel yenilikçi kapasite önemli bir role sahiptir.

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CHAPTER 1

INTRODUCTION

1.1 High-technology exports and economic growth

According to Trabold (1995), international competitiveness is described as the nation's ability to export, to attract foreign direct investment [FDI], to upgrade its export structures and finally to achieve GDP growth. A lot of concepts (i.e. Cantwell, 1989; Dosi, Pavitt, & Soete, 1990; Leontief, 1953; Posner, 1961) also relate macroeconomic competitiveness to the nation's international trade. A nation`s openness to international competition is conducive to higher capital and labor productivity, technology transfers and access to new knowledge (Bernard, Jensen, Redding, & Schott, 2007), growth in macroeconomic competitiveness (Alcalá & Ciccone, 2004; Dollar & Kraay, 2003; Rodríguez & Rodrik, 2000), and ultimately economic growth (Fagerberg, 1996a; Fagerberg, Srholec, & Knell, 2007; Greenaway, Morgan, & Wright, 1999; Nicoletti & Scarpetta, 2003; Porter, Ketels, & Delgado, 2006)

During the last five decades, the developing countries with substantial export growth also achieved the most rapid economic growth. Researchers indicate that the rapid increase in export primarily contributes to faster productivity and economic growth of these developing countries (Bernard & Jensen 2004; Cooke & Watson, 2011; Madsen, 2009), such as the Newly Industrialized Countries (NICs) - Hong Kong, Singapore, South Korea, and Taiwan (Chow & Kellman, 1993), and four other Asian countries - Indonesia, Malaysia, Philippines, and Thailand (Sara, Cheng,

& Newhouse, 1995). For instance, South Korea had exports of $32 million in 1960, which increased to $65 billion in 1990, $172 billion in 2000, and shoot up to $572 billion in 2014 (United Nations Conference on Trade and Development [UNCTAD], 2015). Taiwan's exports also soared from $ 19 billion in 1980 to 313 billion in 2014 (UNCTAD, 2015).

While exports have been regarded as an engine of economic growth since the 1960s, export sophistication and structural change in exports are also emphasized for economic development (Hausmann, Hwang, & Rodrik, 2007; Rodrik, 2006; Srholec, 2007). In the last few decades, lots of countries experienced substantial economic growth by upgrading their export structure. For instance, Malaysia has moved from primary-product-based economy to a manufacturing-based economy. In 1960, while 90% of $1.2 billion of total exports were rubber, timber, palm oil and tin, manufactures exports had accounted for more than 80% of the $98.2 billion of total exports in 2000, and 61% of $234 billion in 2014. Malaysia is one of the world's largest exporters of semiconductor, whose global market share was up to 15% in 1990 and still maintained nearly 7% in 2013 (Abad, Amalu, Kitamura, & Simalabwi, 2015).

However, as the world has been entering a new economic system, named “digital economy”, “high-tech economy”, “information technology economy”, “knowledge-based economy”, or “network economy” (Tapscott, 1997), the competition between countries becomes so harsh which is described as “hyper competition”, "excessive competition", "destructive competition", and "cutthroat competition” (Brahm, 1995). Being the most dynamic and decisive factors in raising labor productivity and increasing the efficiency (Gökçe, Karatepe, & Karagöz, 2010), Schumpeter (1934) emphasized that in a long-run perspective technological progress is an important factor of a country's development. Science and technology are and will be the core-competitiveness of an economy (Ahuja, 2008; Antonell & De Liso, 1997; Archibugi & Michie, 1998; International Institute for Management Development [IMD], 1998, 1999, 2000; Johnson, Porter, Roessner, Newman, & Jin, 2010; Organization for Economic Co-operation and Development [OECD], 1999; Roessner, Porter, Fouts, Newman, & Jin, 2002). Scholars endeavor to understand the connection of technology, trade and overall economic performance (Eaton & Kortum 2001; Falk, 2009; Spulber, 2008; Zhang, 2007). Export activities and proliferating technology intensity are viewed as a crucial driver of economic growth (World Bank, 2009). Buiter and Kletzer (1995), Carolyn (2001), Hatzichronoglou (1997) and Lopez (2005) argued that dynamics of high-technology sectors dominates a big part of the export dynamics. For instance, despite the financial and economic crisis, during the period of 2005-2012, the production index for high-technology and medium-high technology industries of EU-27 increased by 26 % and 7%, respectively, while it shrunk by 5% and 6% for medium-low technology and low-technology production respectively (Jaegers, Lingua, & Amil, 2013). The average annual growth rate of high-tech industries was 3.3% (Jaegers et al., 2013).

Most of the innovations are produced by high-tech industries, including product innovation and process innovation, which lead to more efficient use of resources, expanded market share or even access to new markets for the firms (Seyoum, 2004). Additionally, exports of manufacturing products with higher technological contents are conducive to learning-by-doing and learning-by-exporting than in primary commodity trade (Herzer & Lehmann, 2006) and thus, increase the potential to benefit from export activity spillovers.

Many scholars have reported that specialization in technologically progressive industries are positively associated with the other economic activities, such as productivity growth (Fagerberg, 2000), economic growth (Eaton & Kortum, 2001; Falk, 2009; United Nations Industrial Development Organization [UNIDO], 2002; Yoo, 2008) and so on, especially in countries adopting export-led growth strategies (Hobday, 2001). Gouvea, Hranaiova, and Kassicieh (2002) concluded that a high-technology intensive export structure contributes to a higher level of export competitiveness. OECD (1999) showed that for the period 1986-1994 the top fifty innovative countries (such as Sweden, Japan, Korea, Finland, the United States and so on) (in terms of R & D intensity and number of scientists and engineers) experienced a three times higher growth rate than the rest of the world. While Peneder (2003) reported that GDP per capita level is positively correlated with exports of technology driven industries for OECD countries, Cuaresma and Wörz (2005) argued that the correlation exists only for non-OECD countries. Based on a panel data of 5-year averages for 22 OECD countries from 1980–2004, Falk (2009) conducted a dynamic growth model and also concluded that the export share of high-tech industries to total manufacturing exports highly significantly and positively affects the GDP growth.

These studies put forth the importance of high-tech industries in economic activities. Thus, it becomes easier to understand why many countries, developed and more recently developing countries, have been and are still devoting national resources and pursuing policies to promote the specialization in technologically intensive activities.

1.2 Definition

High technology usually refers to firms and industries whose products or services contain advanced, innovative and fast-changing technologies. Such firms depend on advanced scientific and technological expertise which requires higher research and development expenditures (Keeble & Wilkinson, 2000), and attempt to capitalize on product design (Lall, 2000).

In order to classify industries based on the use of technologies, numerous taxonomies using different criteria have been put forward in the literature (Abbott, 1991; Archibugi, 2001; Castellacci, 2004; Grupp, 1995; Guerrieri & Milana, 1995; Marsili, 2001; Peneder, 2003).

In order to classify manufactured products, Davis (1982) used the direct R&D spending relative to the value of shipments and indirect R&D embodied in the intermediate products in producing the product. The top ten products were identified as high-technology corresponding to the Standard Industrial Classification (SIC) of the US department of Commerce. Hatter (1985) mapped out a concordance between the SIC and Standard International Trade Classification (SITC, Rev. 1), which generalized the Davis's definition of high-technology products to other international data. However, the Davis-Hatter definition at a rather aggregate level is likely to overestimate the extent of exports of high-technology products from any country.

According to the sources of technology, the institutional sources, the nature of the technology produced in a sector, and the characteristics of innovating firms (e.g. size and principal activities), Pavitt (1984) classified industries into four categories: supplier dominated (e.g. textile industry), scale intensive (e.g. automobiles), science based (e.g. pharmaceuticals) and specialized suppliers (e.g. instruments, machinery). Nevertheless, since the analytical distinctions are unclear and there are large overlaps between categories, this definition is difficult to use (Srholec, 2007).

The OECD Secretariat also classified the industries according to technology intensity. Using direct R&D intensity (the ratio of R&D expenditure to output value) as criteria, in a sample of eleven countries, the industries were classified into 3 categories: high, medium and low technology (OECD, 1984). Later, OECD developed a more detailed and sophisticated specification with the collaboration of the OECD countries and the Statistical Office of the European Communities [Eurostat] (OECD, 1994), and then revised it in 1997 (Hatzichronoglou, 1997). 22 manufacturing industries were analyzed in 10 OECD countries, under a sectoral approach, based on direct R&D intensity, i.e. R&D expenditure intensity of value added and R&D expenditure intensity of the product, as well as indirect R&D expenditure embodied in purchased intermediate goods and investments. The manufacturing industries were divided into 4 categories at one to four-digit levels of the United Nations [UN] International Standard Industrial Classification (ISIC, Rev. 2): high-technology [HT], medium-high-technology, medium-low-technology and low-technology sectors. OECD (2003) updated the HT industries to ISIC Rev. 3., which comprises: aircraft and spacecraft (ISIC 353); pharmaceuticals (ISIC 2423); office, accounting, and computing machinery (ISIC 30); radio, TV and communication equipment (ISIC 32); medical, precision and optical instrument (ISIC 33). At a detailed product level at three-digit levels of the UN SITC Rev. 3 within the HT categories, based on R&D intensity (R&D expenditure divided by total sales) for approximately 130 products from six countries (Germany, Italy, Japan, the Netherlands, Sweden, and the United States), a list of high-technology manufactured products (services are excluded) is identified at three- to five-digit levels of SITC Rev. 3 (see Appendix A): aerospace (HT1), computers-office machines (HT2), electronics-telecommunications (HT3), pharmacy (HT4), scientific instruments (HT5), electrical machinery (HT6), chemistry (HT7), non-electrical machinery (HT8), armament (HT9). Since 1994, the five-digit OECD HT classification based on SITC Rev. 3 has been replaced by the six-digit Harmonized System classification and 252 product categories are identified as HT goods (Eberth, 2008), while Eurostat has also updated the HT products list based on SITC Rev. 4 using the same definition of Hatzichronoglou (1997). Hatzichronoglou pointed out that since many medium- or even low-tech products are manufactured by high-technology industrial sectors, due to the lack of detailed data, the product approach is preferred to the sectoral approach. The OECD definition (Hatzichronoglou, 1997) is preferable to the Davis's (1982), as the classification is defined corresponding to the SITC classification and thus the need for any concordance tables is obviated. However, Hatzichronoglou pointed the following limitations: (1) Only R&D intensity is taken into account in this methodology, while other characteristics of high technology such as scientific and technical personnel, know-how etc., also play a significant role; (2) High-tech products cannot be classified exclusively by quantitative methods since actual R&D intensities of individual products was not available at a lower aggregation level; (3) The product approach are not comparable with other industrial data such as value added etc., since they are available only at sector level.

Based on Pavitt (1984) and OECD (1994), Lall (2000) categorized the industries into 5 broad categories according to technology intensity at a 3-digit level of SITC Rev. 2: primary products, resource-based, low-technology, medium-technology, and high-technology manufactures. Lall (2000) split HT activities into 2 subgroups (see Appendix B). The first subgroup HT1 consists of products that can be described as light industrial products, whose final assembly stages are labor-intensive, including electronic and electrical products such as computers, computer components, audio-visual equipment, and office equipment; Subgroup HT2 consists of products such as pharmaceuticals, power generating equipment, aircraft, optical and other precision instruments, and measurement equipment, which remain rooted in economies with high levels of specialized technical skills, technology and denser local supply networks.

As Connolly (2012) argued, the aforementioned approaches have some obvious limitations. For instance, Lall (2000) and Hatzichronoglou (1997) classified deep-water oil extraction as resource-based product and medium-low technology respectively, for which the use of cutting-edge technology is often required, while some products that are identified by these classifications to be high-tech are obviously low-tech, such as basic personal computer systems. All the same, the aforementioned approaches do at least identify certain products which employ advanced and dynamic technologies, such as aerospace and pharmaceuticals.

Another important industry classification based on technology intensity is developed by National Science Board [NSB]. NSB (2014) used a modification of the measure adopted by the Bureau of Labor Statistics [BLS] (Hecker, 2005) in order to disaggregate the HT industries that are identified in the 2007 version of North American Industry Classification System [NAICS]. Based on the intensity of high-technology employment within an industry in technology-oriented occupation, the high-tech industries comprise 48 categories (include both manufactures and services) at four to six-digit NAICS level, such as petroleum refineries, electronic goods and equipment, industrial machinery manufacturing, etc. (NSB, 2014) (see Appendix C).

In this thesis, taking the availability of data into account, the OECD definition based on SITC Rev.3 is adopted.

1.3 Development of merchandise and manufactures exports in BRIC and Turkey

1.3.1 Brazil

During the period 1996-2014, merchandise exports of Brazil have risen by 9% (Compound Annual Growth Rate [CAGR]) (see Fig. D1 in Appendix D). Hereinto, the fastest growing product grouping is fuels increasing by 24.15%, which narrowed its trade deficit and comprised 9.17% of the total merchandise exports in 2014 (see Fig. D1 and Fig. D2 in Appendix D; see Appendix E for the detailed classification of merchandise exports). The non-fuel primary exports rose by 10.32%, which expanded its trade surplus to $102 billion, and its share in Brazil's total merchandise exports showed an increase trend which accounted for 54.27% in 2014, while the share of manufactures exports decreased from 57.37% in 2000 to 33.31% in 2014 (see Fig. D1 in Appendix D). With respect to the trade balance, the manufactures trade deficit was narrowed between 1996 and 2002, and the trade balance became positive between 2003 and 2006. However, it became negative again in 2007 and since then the manufactures trade deficit has expanded up to $89 billion (see Fig. D2 in Appendix D).

High- and medium-skill manufactures as well as high- and medium-tech manufactures account for a huge part of Brazil's manufactures exports. With respect to the degree of manufacturing groupings (see Table F1 in Appendix F for the detailed classification), high- and medium-skill manufactures exports have grown at the highest CAGR of 7.81% and 6.71% respectively during 1996-2014, and together accounted for from 54.47% in 1996 to 63.25% in 2014 (see Fig. D3 in Appendix D). From the view of technological intensity (see Table F2 in Appendix F for the detailed classification), high- and medium-tech manufactures exports have increased most by 9.82% and 6.95%, respectively. The manufactures exports are dominated by medium-tech manufactures, the share of which rose from 48.82% in 1996 to 60.53% in 2013 and dropped to 54.86% in 2014, while the share of high-tech exports soared from 6.82% in 1996 to 21.34% in 2001 and declined to 12.35% in 2014 (see Fig. D4 in Appendix D). The manufactures trade balance is significantly affected by these four groupings aforementioned. High-skill and high-tech manufactures have run a trade deficit during the period, and except 2003-2006, medium-skill and medium-tech manufactures have also experienced a trade deficit (see Fig. D5 and Fig. D6 in Appendix D).

1.3.2 China

China has been running a growing and massive merchandise trade surplus since 1996, which was $384 billion in 2014. Thereinto, although primary goods exports have increased by 10.32%, its trade deficit expanded from 1996 to 2011 and narrowed to a limited extent since 2012 (see Fig. D1 and Fig. D2 in Appendix D). The manufactures exports of China have risen at the highest CAGR of 17.16% accounting for 93.83% in 2014, and contribute most to the total merchandise trade surplus, which was $1055 billion in 2014.

The fastest growing manufactures exports are high-skill and high-tech manufactures exports at a CAGR of 20.1% and 21.75% respectively between 1996 and 2014, followed by medium-skill and medium-tech manufactures exports which have grown by 18.64% and 18.41%. The share of high-skill, medium-skill, high-tech and medium-tech manufactures exports has increased from 25.59%, 20.15%, 15.18% and 23.64% in 1996 to 39.99%, 25.25%, 30.32% and 28.6% in 2014, respectively (see Fig. D3 and Fig. D4 in Appendix D). However, in terms of technological intensity, low-tech manufactures still account for the largest part of total manufactures exports, exports of which have dropped from 54.76% in 1996 to 35.11% in 2014. Since 2006, high-skill, medium-skill, high-tech and medium-tech manufactures have run a trade surplus, although the value is quite small in contrast with the trade surplus of labor-intensive manufactures ($468 billion in 2014) and low-tech manufactures ($681 billion in 2014) (see Fig. D5 and Fig. D6 in Appendix D).

1.3.3 India

India has been running a growing merchandise trade deficit since 1996. Thereinto, although primary goods exports increased by 15.4%, trade deficit expanded and was more than $116 billion in 2014 (see Fig. D1 and Fig. D2 in Appendix D). Manufactures exports have risen by 12.81% and the average share in total merchandise exports has been around 57.46% during 1996-2014. Nevertheless, the manufactures trade surplus dropped from $3.77 billion in 1996 to $2.04 billion in 2005, the manufactures trade balance became negative in 2006 and this trade deficit expanded to $28.85 billion in 2008. Since 2007, the manufactures trade deficit narrowed and India started to run a manufactures trade surplus again since 2013, which was up to $11.66 billion in 2014.

The manufacturing sector in India has transformed from labor-intensive and resource intensive to high- and medium-skill manufacturing. During 1996-2014, high- and medium-skill manufactures exports have risen by 15.83% and 16.22% respectively, the share of which in total manufactures exports increased from 22.54% and 12.19% in 1996 to 36.25% and 20.86% in 2014, respectively. The share of labor-intensive and resource-intensive manufactures exports in manufactures exports dropped from 54.61% in 1996 to 27.1% in 2014 (see Fig. D3 in Appendix D). For technological intensity, high- and medium-tech manufactures exports have also grown at the highest CAGR of 17.15% and 15.95%, respectively, the share of which in total manufactures exports increased from 7.54% and 19.08% in 1996 to 14.88% and 31.29% in 2014, respectively. Low-tech manufactures exports, which declined from 62.7% in 1996 to 42.52% in 2014, still dominate the manufactures exports from India (see Fig. D4 in Appendix D). Additionally, while labor-intensive exports and low-tech exports enjoy a massive trade surplus, high-skill, medium-skill, high-tech and medium-tech manufactures have run a trade deficit during the whole period 1996-2014 (see Fig. D5 and Fig. D6 in Appendix D).

1.3.4 The Russian Federation

Since 1996, the merchandise trade surplus of the Russian Federation has increased to $211 billion by 2014, and the fuel exports contribute most whose trade surplus increased to $342 billion by 2014 (see Fig. D1 and Fig. D2 in Appendix D). While manufactures exports have risen by 7.19% since 1996, its share in merchandise exports has declined from 26.09% in 1996 to 16.23% in 2014, and the trade deficit was $153 billion in 2014.

The manufactures exports of Russian Federation have been dominated by low-skill, high-skill, medium-tech and low-tech exports, followed by medium-skill and primary manufactures exports, while the fastest growing manufactures exports are high-tech, high-skill and medium-skill manufactures exports at a CAGR of 8.72%, 9.08% and 7.2% respectively between 1996 and 2014. Considering technological intensity, during the period 1996-2014, the average share of medium-tech manufactures exports in total manufactures exports was up to 48.98%, followed by low-tech (23.92%), primary (15.38%) and high-tech exports (10.65%) in 2014 (see Fig. D4 in Appendix D). Considering the degree of manufacturing, high-skill manufactures exports have risen significantly since 2006, overtaken low-skill manufactures. High-skill manufactures became the largest part of the total manufactures exports in 2012, and the share was up to 40.95% in 2014 (see Fig. D3 in Appendix D). However, since 2005 low-skill manufactures exports have declined to 30.84% in 2014, while labor-intensive and medium-skill manufactures exports have maintained stable from 1996 to 2014. Moreover, since 2001, high- and medium-skill as well as high- and medium-tech manufactures have run a trade deficit, and the largest trade deficit resulted from medium-skill and medium-tech manufactures.

1.3.5 Turkey

While merchandise exports of Turkey have increased from $23.04 billion in 1996 to almost $158 billion in 2014, the trade deficit expanded from $19.88 billion in 1996 to $84.57 billion in 2014 (see Fig. D1 and Fig. D2 in Appendix D). Except food exports, all other product groupings have experienced a trade deficit, and the largest trade deficit results from manufactures which expanded from $15.53 billion in 1997 to $30.1 billion in 2013 and narrowed to $23.33 billion in 2014. Moreover, manufactures exports accounted for the largest part of merchandise trade, which increased from 73.84% in 1996 to 84.44% in 2004 and dropped to 76.88% in 2014.

Although from 2006 to 2014 high-skill and high-tech manufactures exports have grown at the highest CAGR of 9.27% and 9.4%, respectively, a large part of

Turkey's manufactures exports have consisted of labor-intensive and resource-intensive manufactures exports as well as medium- and low-tech manufactures exports. While the share of low-tech and labor-intensive and resource-intensive manufactures exports have decreased from 66.52% and 58.59% in 1996 to 46.77% and 32.7% in 2014 respectively, medium-tech and medium-skill manufactures exports have risen quickly and surpassed low-tech and labor-intensive manufactures exports in 2007, share of which reached 42.88% and 36.5%, respectively in 2014 (see Fig. D3 and Fig. D4 in Appendix D). However, during 1996-2014, high-tech and high-skill manufactures exports account for less than 6% and 15% of the total manufactures exports respectively, and high-skill, medium-skill, high-tech and medium-tech manufactures exports account for the largest part of the merchandise trade deficit (see Fig. D5 and Fig. D6 in Appendix D).

1.4 Development of high-tech exports in BRIC and Turkey

1.4.1 The standing in the world high-tech market

The high-tech exports[1] from China grew significantly by 20.48% during 2002-2014 which reached $648 billion in 2014 (Table 1), and its share in manufactured exports[2] has been stable since 2004 which is around 30% (see Fig. 1). Since 2006, China has surpassed the United States and became the largest high-tech product exporter in the

[1] High-tech exports refer to exports of high-tech products.
[2] The definition of manufactured exports is based on UNCTAD.

world (see Fig. 2), and comprised 22.59% of the world total high-tech exports (WTHTX) in 2014. Moreover, during 2002-2014, the top 10 high-tech exporters accounted for more than 67% of the WTHTX, and the total share of them shows an increase trend which was up to 70.79% in 2014 (see Fig. 3).

The high-tech exports of India and Turkey also boosted at a higher growth rate of 18.52% and 13.83% following China during 2002-2014, which is higher than the growth rate of WTHTX (see Table 1). However, in 2014, India and Turkey only accounted for 0.63% and 0.097% of WTHTX respectively, and the share of high-tech exports in manufactured exports has increased to a limited extent for India and Turkey (see Table 1 and Fig. 1).

Table 1 Major High-Tech Exporters in 2014

Rank	Country	Value (unit: $ billion)	HT market share (%)	2002-2014 CAGR (%)	2006-2014 CAGR (%)	2010-2014 CAGR (%)
1	China	648.67	22.59	20.48	11.41	8.11
2	USA	250.68	8.73	2.16	-0.97	2.95
3	China, Hong Kong SAR	241.50	8.41	13.56	10.32	9.08
4	Germany	209.87	7.31	6.93	3.16	5.73
5	Rep. of Korea	148.96	5.19	10.09	5.99	2.97
6	Singapore	142.41	4.96	6.79	1.61	2.01
7	France	119.29	4.15	6.90	4.80	3.56
8	Japan	106.63	3.71	0.86	-2.41	-4.63
9	Netherlands	88.52	3.08	8.27	3.07	4.23
10	United Kingdom	75.96	2.64	0.62	-5.51	4.39
24	India	18.20	0.63	18.52	17.82	14.82
30	Russia	10.24	0.35	6.09	12.83	18.66
31	Brazil	8.75	0.30	4.06	0.30	0.08
39	Turkey	2.77	0.09	13.83	9.21	9.78
	World	2871.09		7.86	4.58	5.32

Source: United Nations, Comtrade database, own calculation

Russia has been the fastest growing high-tech exporter during 2010-2014 at a CAGR of 18.66%, due to the exports of computer-office machinery, armament and pharmacy which rose by 99.31%, 66.34%, and 31.58% respectively. However, the share of Russia's high-tech exports to WTHTX and Russia's manufactured exports increased at a relatively slow pace (see Fig. 1and Fig. 2).

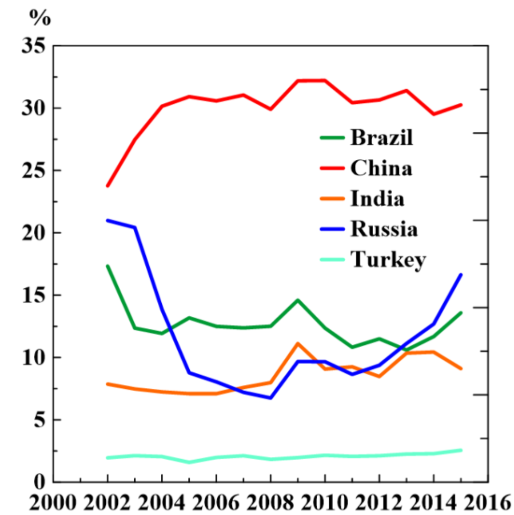


Fig. 1 High-tech exports as a % of manufactured exports
Source: United Nations, Comtrade database, own calculation

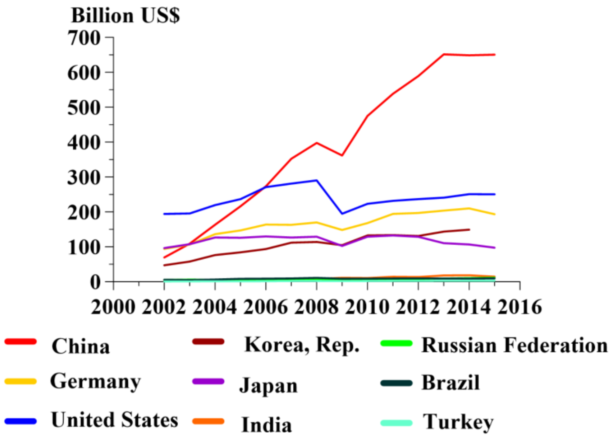


Fig. 2 High-tech exports from top high-tech exporters
Source: United Nations, Comtrade database, own calculation

Comparing with China, India, Russian Federation and Turkey, the share of Brazil's high-tech exports in WTHTX and Brazil's manufactured exports shows a decreasing trend until 2013 and began to pick up in 2014 (see Table 1, Fig. 1 and Fig. 2).

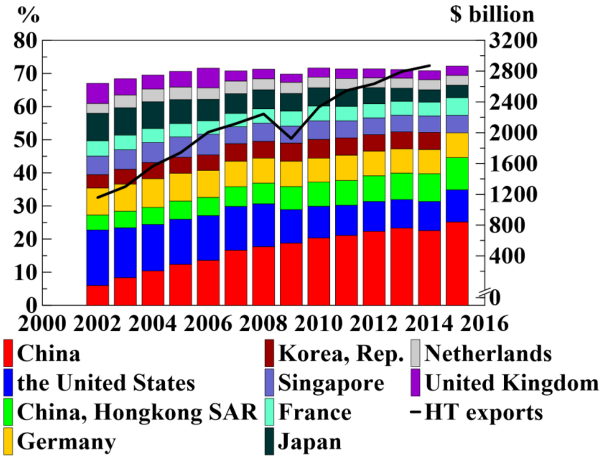


Fig. 3 World share of top 10 high-tech exporters
Source: United Nations, Comtrade database, own calculation

1.4.2 Structure of high-tech exports

From the view of production stage (see Table F3 and Table F4 in Appendix F for the detailed classification), although the share shows a decline during 2002-2014, capital goods still account for the largest part of high-tech exports from Brazil, China, Russia and Turkey (see Fig. 4). India experienced an increase in the exports of capital goods, which accounted for 40.57% of the total high-tech exports in 2014. While capital goods contribute the most to the trade surplus of China's high-tech exports, it dominates the trade deficit in high-tech products from India, Russian Federation and Turkey, and parts and components have run a trade deficit for all the five countries (see Fig. D7 in Appendix D).

When we take sectoral composition of high-tech exports into consideration, aerospace has dominated the high-tech exports of Brazil, the share of which grew from 50.97% in 2002 to 60.92% in 2014 (see Fig. 5). While the share of electronics exports dropped significantly from 27.35% in 2002 to 8.19% in 2014, the share of pharmacy and scientific instruments exports increased up to 7.44% and 5.96%, respectively. The share of chemistry exports had increased from 8.41% in 2002 to 15.04% in 2011 and dropped to 9.7% in 2014. Except exports of aerospace and armament, all other sectors have run a trade deficit. With regard to exports of electronics, the share of capital goods exports increased from 85.41% in 2002 to 94.23% in 2007 and then declined to 36.05% in 2014, while the share of parts and components rose from 12.72% in 2002 to 61.52% in 2014 (see Fig. D8 in Appendix D). The trade deficit in electronics is especially due to trade deficit of parts and components as well as the declining trade surplus during 2002-2008 and expanding trade deficit during 2009-2014 in capital goods (see Fig. D9 in Appendix D). Besides, electronics have the highest share in total high-tech trade deficit (see Fig. D10 in Appendix D).

As for China, although the share of scientific instruments exports has been increasing from 4.79% in 2002 to 8.22% in 2014, electronics and computers together still account for more than 84% of high-tech exports (see Fig. 5). The trade surplus in computers (for instance, $159.6 billion in 2014) has the highest share in the total high-tech trade surplus (see Fig. D10 in Appendix D), due to the massive trade surplus in capital goods comprising from 60.16% in 2002 to 85.35% of this high-tech sector in 2014 (see Fig. D11 and Fig. D12 in Appendix D). The trade deficit in electronics had narrowed since 2006 and its trade balance has become positive since 2013, due to the expanding trade surplus in capital goods and narrowing the trade deficit in parts and components (see Fig. D10 and Fig. D12 in Appendix D). The share of capital goods in electronics decreased from 61.02% in 2002 to 53.4% in

2014, while the share of parts and components increased from 34.23% in 2002 to 52.63% in 2013 and dropped to 46.24% in 2014 (see Fig. D11 in Appendix D).

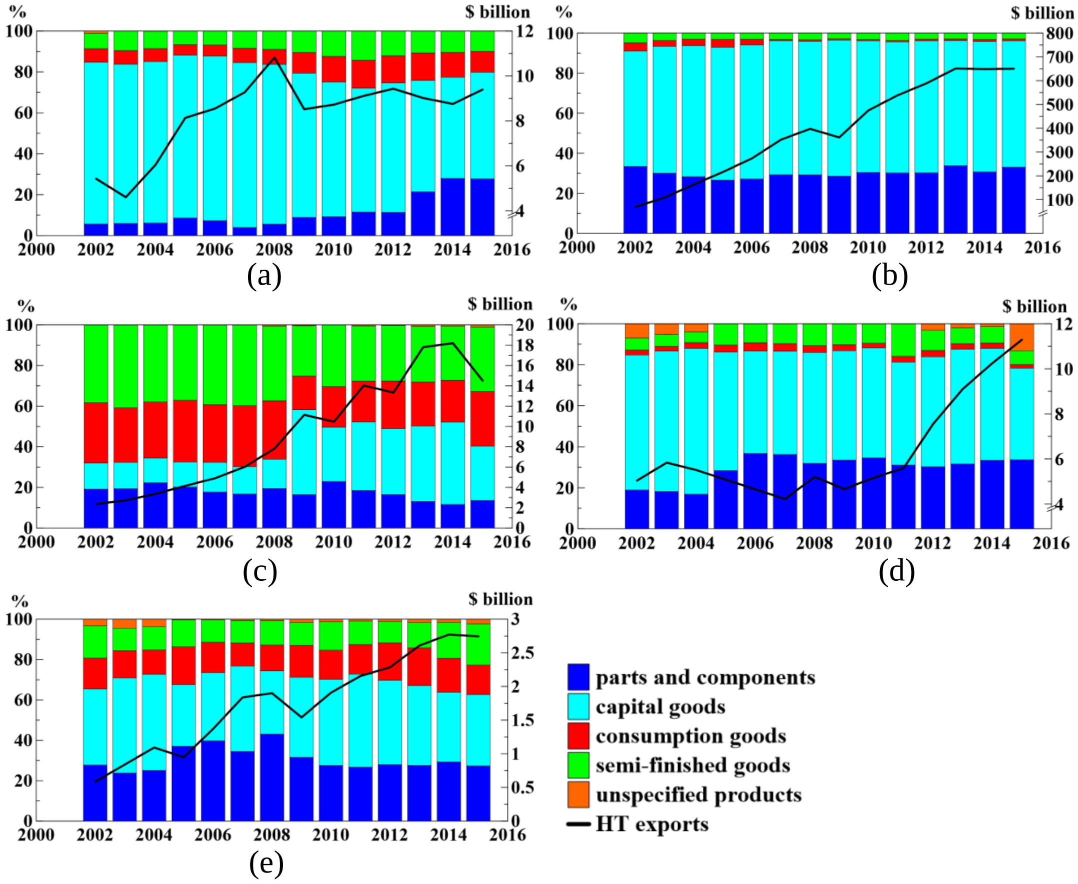


Fig. 4 High-tech exports by production stages: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: United Nations, Comtrade database, own calculation

Though both products showed a decreasing trend during 2002-2014, chemistry and pharmacy still dominate the high-tech exports from India, and the share of each is 26.08% and 19.54% in 2014, respectively (see Fig. 5). The share of electronics exports was stable between 2002 and 2008, soared to 43.85% in 2009 and then declined to 13.36% in 2014. Besides, the share of scientific instruments exports decreased from 10.96% in 2002 to 7.42% in 2014. Except chemistry and pharmacy, all other sectors have experienced a trade deficit (except aerospace during 2013-

2014) (see Fig. D10 in Appendix D). With regard to computers, the share of capital goods increased from 24.95% in 2002 to 62.19% in 2014, while the share of parts and components decreased from 75.05% in 2002 to 37.81% in 2014 (see Fig. D13 in Appendix D). As for electronics, the share of parts and components increased from 41.88% in 2002 to 67.67% in 2008, dipped to 21.82% in 2009 and rose to 57.07% in 2014, while the share of capital goods was stable during 2002 to 2008, soared to 77.14% in 2009 and decreased to 41.65% in 2014. Expanding trade deficit in capital goods of computers as well as the expanding trade deficit in capital goods and parts and components of electronics are the main sources for trade deficit in total high-tech products (see Fig. D10 and Fig. D14 in Appendix D).

The high-tech exports of Russian Federation became more diverse during 2002-2014, and the main products are aerospace and non-electrical machinery comprising 28.99% and 15.76% of high-tech exports respectively in 2014, followed by computer (16.92%), electronics-telecommunications (15.42%) and scientific instruments (9.45%) (see Fig. 5). The massive high-tech trade deficit owes the most to electronics and computers, due to the expanding trade deficit in capital goods of both sectors which account for a huge part of both sectors (see Fig. D10, D15 and Fig. D16 in Appendix D).

In comparison with BRIC, Turkey's high-tech exports seem more balanced and diverse (see Fig. 5). Except armament, all other sectors have run a trade deficit during 2002-2014 (see Fig. D10 in Appendix D). The high-tech trade deficit is mainly due to the expanding trade deficit in capital goods of electronics, aerospace and computers sectors (see Fig. D17 and Fig. D18 in Appendix D).

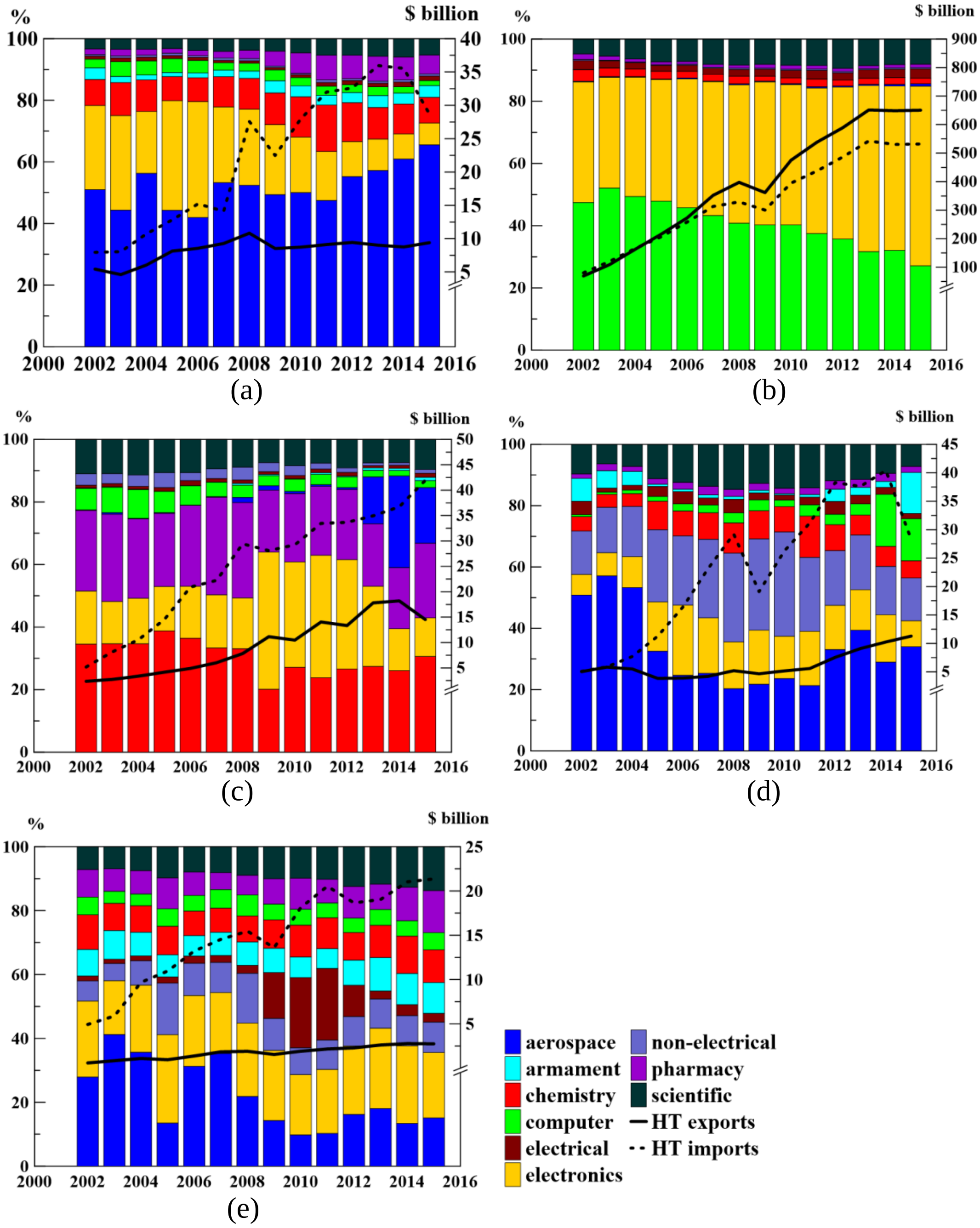


Fig. 5 Structure of high-tech exports: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey

Source: United Nations, Comtrade database, own calculation

1.4.3 Relative comparative advantage (RCA) of high-tech sectors

The Brazil's areas of specialization are aerospace (average RCA=2.23 during 2002-2014), armament (average RCA=1.95) and chemistry (average RCA=1.16) for exports of high-tech products, and its areas of weakness are computers and non-electrical machinery whose RCA on average during 2002-2014 is less than 0.1 (see Fig. D19 in Appendix D). China has a relatively comparative advantage in total high-tech exports (average RCA=1.8), especially in exports of computers (average RCA=3.5), electronics, electrical machinery, chemistry and scientific instruments. While India's strength in exports of chemistry (average RCA=3.02) is also immediately apparent, Turkey has been specialized in exports of armament and the RCA increased up to 2.57 in 2014. The Russian Federation has relative comparative advantages in exports of armament and non-electrical machinery.

A country's comparative advantages can be observed from its export share of a particular sector to the world exports. Brazil comprised more than 2.64% and 2.45% of world total exports of aerospace and armament in 2014, while Turkey and the Russian Federation accounted for 2.14% and 1.6% in the world total armament exports (see Fig. D20 in Appendix D). While the world share of chemistry exports from India was 5.56%, it was China that exported the most products of chemistry, computers, electrical machinery, electronics and scientific instruments in the world in 2014, the world share of which was 16.55%, 41.21%, 20.61%, 25.69% and 15.1% respectively.

Their comparative advantages can be also observed from the top 10 high-tech exports (see Fig. D21 and D22 in Appendix D). For example, as for Brazil, the total share of aeroplanes (weight>15000 and 2000<weight<15000) and parts for turbojets or turbopropellers rose from 38.47% in 2006 to 63.25% in 2015, and the total share of the top ten products rose up to 78.06% in 2015. While the top ten products of China, India and Russian Federation accounted for 68.8%, 63.63% and 75.9% of the total high-tech exports, Turkey's exports basket seems to be more diverse, since the top ten high-tech products only accounted for only 52.25% of total high-tech exports in 2015.

1.5 A close look into statistics: The case of China

Separability or modularity of production stages, falling transportation costs, declined barriers to trade, the reduction in communication costs and institutional change through liberalization all together enable the industrial value chain to be fragmented or broken up into finer, "portable" components (Ernst & Kim, 2002; Bonham, Gangnes & Van Assche, 2007; Jones, Kierzkowski, & Chen, 2005; Jones & Kierzkowski, 2005a, 2005b; Nonnenberg & Mesentier, 2012). For instance, while the manufacturing of pharmaceuticals, power generating equipment, aircraft, optical and other precision instruments, and measurement equipment usually requires the domestic production of higher value-added components, the final assemble stage of electronic equipment manufacturing, such as computers, computer components, audio-visual equipment, office equipment and so on, tends to be labor-intensive (Connolly, 2012). The fragmentation process went beyond the firm boundaries and even international borders in order to capitalize on local comparative advantage (Athukorala, 2006). Traditional product specialization has been replaced by “specializing in parts, components, and production procedures” (Xing, 2012, p: 7) or vertical specialization (Hummels, Ishii, & Yi, 2001).

Due to the prevalence of multinational enterprises (MNEs) and the evolution of integrated production networks (IPNs), many developing countries have experienced a surge in high-tech exports in absolute and relative terms. For example, many scholars and data sources (such as the World Bank, OECD STAT and World Trade Service database) have claimed that since 2005 China has surpassed Germany, the United States, Japan and Republic of Korea, and became the largest high-tech exporter, especially in information communication technology products, such as laptops, mobile devices, liquid crystal displays (LCDs) and integrated electronic circuits (Berger & Martin, 2011; Meri, 2009). Several scholars even contented that China’s export sophistication has been significantly upgraded beyond what is expected at its income level and its export basket increasingly resembles that of industrialized countries (Rodrik, 2006), such as OECD countries (Schott, 2008), due to the China’s industrial policies of promotion and protection.

Nevertheless, the extraordinary structural upgrading of exports in developing countries has been questioned by many economists, since the outstanding performance is surprisingly accompanied by a relatively low R&D performance and domestic technological capacity, especially in central European countries and Asian countries. For instance, despite their remarkable ranking of intra-EU high-tech exports, the Czech Republic, Hungary, Poland and Slovakia (the V4 countries) have a relative low synthetic intellectual capital asset value (Sember, 2013). Srholec (2006) reported that the R&D intensity (captured by R&D expenditures as share of value added) in high-tech electronics industries in Mexico, Poland, Slovakia, Hungary and the Czech Republic was far lower than the cut-off point in the OECD taxonomy between high tech and the rest of manufacturing which was around 20% in 1999 (OECD, 2003, p. 156). Developing an original index of high-tech industrial performance, Connolly (2012) identified that the high scores of the index have firmly accompanied with a fairly low R&D expenditure for most of the emerging Europe countries. For Asian countries, the disparity is most striking in the Philippines, whose high-tech exports accounted for 49% of manufactured exports in 2014, while more than 20% of manufactured exports from Kazakhstan, Vietnam and Thailand were high-tech exports. However, in all of these countries, the R&D expenditures were less than 0.5% of their GDP.

R&D expenditures and national innovative capacity (for instance, measured by new product output in the study of Fu, Wu, and Tang (2012)) are reported to be marginally significant factors in explaining the success of high-tech exports from developing countries such as China (Fu et al., 2011; Huang, Zhang, Zhao, & Varum, 2008; Xing, 2012) and the V4 countries (Sember, 2013). However, the surge of high-tech exports, such as exports of ICT products (Amighini, 2005; Andersson & Ejermo, 2008; Gaulier, Lemoine, & Kesenci, 2007a; Hummels *et al.*, 2001; Lemoine & Unal-Kesenci, 2002, 2004; Srholec, 2007; Yi, 2003) and other electronics products (Srholec, 2007), is largely due to their active participation in the low valued-added segments of the high-tech industries in the context of international vertical fragmentation of production (Andersson & Ejermo, 2008; Athukorala, 2009; Ernst & Kim 2002; Henderson, Dicken, Hess, Coe, & Yeung, 2002; Lall, 2000; Mani, 2000;

Mayer, Butkevicius, Kadri, & Pizarro, 2003; Srholec, 2007; Zeng, Liefner, & Si, 2011). For example, processing trade with imported parts and components (Huang et al., 2008; Xing, 2012) and foreign firms with few R&D efforts play important roles in China's leading position in high-tech exports. The rapid growth of high-tech exports also contributes little to the upgrading of local technological capabilities (Mayer et al., 2003; Srholec, 2006). The causes can be summarized as follows: Technologically intensive activities are argued to be highly concentrated in the home country of large MNEs (Cantwell & Iammarino, 1998; Le Bas & Sierra, 2002; Patel & Pavitt, 1991; Pavitt & Patel, 1999; Verspagen & Schoenmakers, 2004) and foreign subsidiaries hardly invest in R&D in contrast to state-owned and state-controlled enterprises such as in the Czech Republic (Srholec, 2005).

Considering the causality in the other way around, capability to manufacture and export high technology products, which is captured by the volume of high-tech exports (Furman, Porter, & Stern, 2002) or the share of high-tech exports (Lall, 2000), has been usually regarded as an important measurement of national innovation performance. However, according to the aforementioned findings and discussions, in the case of developing countries, the positive association between specialization in high-tech sectors and domestic technological progress cannot be taken for granted.

Lall (2000) and Srholec (2007) ask whether a surge of high-tech exports from developing countries is real or just a "statistical illusion". A deep analysis of China's high-tech exports is carried on in order to shed light on the question.

There are three characteristics of China’s high-tech exports. First, for the period of 2002-2015, electronics–telecommunications products and computers–office machines accounted for more than 84% of high-tech exports (see Fig. 5). Second, foreign direct investment has significantly upgraded China's export structure. Foreign invested enterprises comprised 86.3% of China’s high-tech exports in 2005 which dropped to 73.8% in 2014. Moreover, the share of high-tech exports by wholly foreign firms was 56.3%, though it has been decreasing since 2005 (see Fig. 6). While the share of state-owned firms has decreased since 2002, the share of joint venture and others started to increase since 2012 and 2002 respectively. Third, although the processing exports[3] showed a decreasing trend since 2002, this export mode still dominates the China’s high-tech exports, the share of which peaked at 89.3% in 2002 and declined to 66.5% in 2014 (see Fig. 7). More than 60% of the high-tech exports were attributable to imported parts and components during 2002-2014 (see Fig. 7). Last, unit values of Chinese exports are argued to be lower than that of similar products sold by more technologically advanced countries (Xu, 2007), such as by OECD countries (Schott, 2008). Hence, the quality of high-tech products of China has been doubted by some scholars. For instance, Amiti and Freund (2010) and Huang (2006) argued that the improvement of the scientific and technological content of China's capital-intensive products is due to processing trade led by foreign

[3] According to China Customs, processing trade uses both imported and domestically-produced parts and components as intermediate inputs, processes and assembles these them into finished products and re-exports the final products to the global market.

capital only, rather than domestic R&D activities or transfer of technology and cash management expertise from foreign enterprises to domestic enterprises.

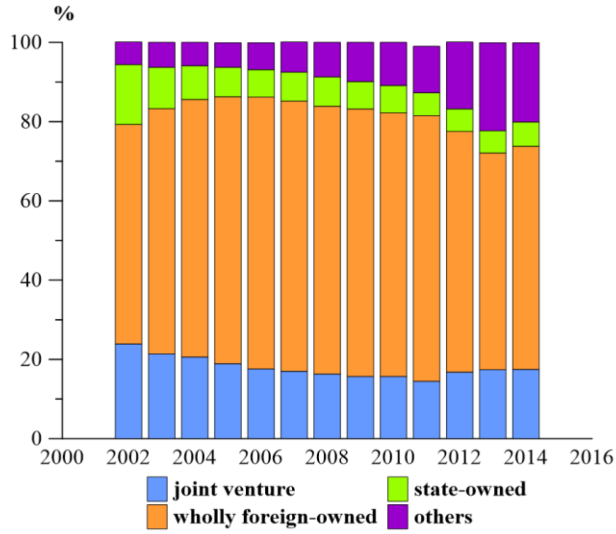


Fig. 6 China's high-tech exports by ownership (%)

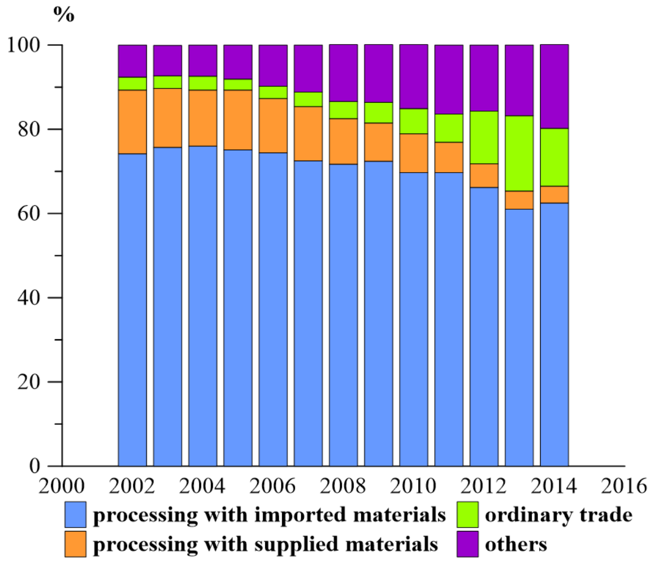


Fig. 7 China's high-tech exports by trade mode (%)

Up to the end of the nineties, China had depended heavily on FDI for its development of technology. However, since the most of China's high-tech imports were operated especially by wholly foreign-owned firms and some firms in sectors of new technology had substituted high-tech imports for R&D expenditure, the technology spillovers was limited from foreign firms to domestic firms (Gaulier, Lemoine, & Kesenci, 2007b; Hu, Jefferson, Guo, & Qian, 2005; Sigurdson & Jacquet, 2002). Since then, a series of efforts have been exerted in order to improve the national innovative capacity. First, after entering the WTO, the Chinese government was set out to define new Chinese standards in order to promote domestic industries and has been keeping updating these standards. The Chinese government is committed to the improvement of product quality through setting compulsory standards, strengthening innovation standards and so on in 2016 (Song, 2016). Second, a series of policies have been promulgated in order to encourage innovation and creativity. The National Plan for Science and Technology Talent Development (2010-20) was launched in 2010 in order to strengthen and cultivate skill labors for R&D personnel in the business sector. In the "12th Five-Year Development Plan for National Strategic Emerging Industries" released in 2012, seven strategic emerging industries were identified, consisting of energy-saving and environmental protection industry, new generation information technology industry, high-end equipment manufacturing, biotechnology industry, new energy industry, and new material industry (Lu, 2012). In order to support these industries, the plan includes the following policy measures: offering fiscal and financial policy support, perfecting technical innovation and talent policies, and building a desirable market environment (Lu, 2012). Besides these aforementioned measures and Technology Advanced Service Enterprise (TASE) program which was issued in 2013 and extended to December 2018, a series of tax incentives for new high tech enterprises (NHTEs) exclusively have been implemented at the national and provincial level since 2008, comprising up to 15% tax exemptions, staff training reimbursements, R&D expense rebates and so on (Shira, 2015). On December 29, 2014, the National Intellectual Property Rights (IPR) Strategy Action Plan (2014-2020) was issued so as to strengthen the utilization and protection of IPR (State Intellectual Property Office of the P.R.C. [SIPO], 2015). As the third effort in encouraging national innovation capacity, the Chinese government has established various regional clusters, pilot areas and demonstration zones to facilitate and promote R&D development, such as Zhongguancun Science Park in Beijing, the Tianjin Economic-Technological Development Area, Zhangjiang Hi-Tech Park in Shanghai, and so on (Marro, 2015).

Following governmental efforts, although the gap with developed countries remains large, China has realized significant technical and scientific advancements (see Fig. 8, Fig. 9, Fig. 10, and Fig. 11). The domestic R&D expenditure of China in 2014 was 2.04% of GDP, which was fairly low in contrast with the 4.29% of the Republic of Korea, 3.58% of Japan and 2.86% of Germany. However, with respect to the absolute level, total R&D in China in 2014 was $368.6 billion and became the second largest R&D investor following the United States (see Fig. 9). MNE's R&D activities also significantly contribute to upgrading China's value chain. Chinese government policies on technology transfer and changing global R&D strategies of MNEs affect the development of R&D activities in China (Gaulier et al., 2007b). The number of R&D centers built by MNEs rose significantly from around 700 in 2004 to more than 1300 in 2013, spanning aviation, information technology, life sciences, transportation and other sectors (Marro, 2015; Reddy, 2010). Most of the R&D activities involve product development and their adaptation to the domestic market guided by global R&D development. Recently, MNEs have organized the R&D facilities through local R&D development taking intellectual property generation into account (Marro, 2015). MNEs also involve in university agreements or university partnerships (such as company-sponsored textbooks, research laboratories, courses, and internship programs) to secure a reliable pool of talent for their local R&D operations.

Although the number of researchers in R&D is quite low compared with Korea, Japan and so on, China has made an impressive progress in the field of patent applications and grants as well as scientific and technical publication (see Fig. 10 and Fig. 11). With regard to publications, in 2014 China published 401,434 journal articles and was the second largest country in this area following the United States (412,541) (see Fig. 11).

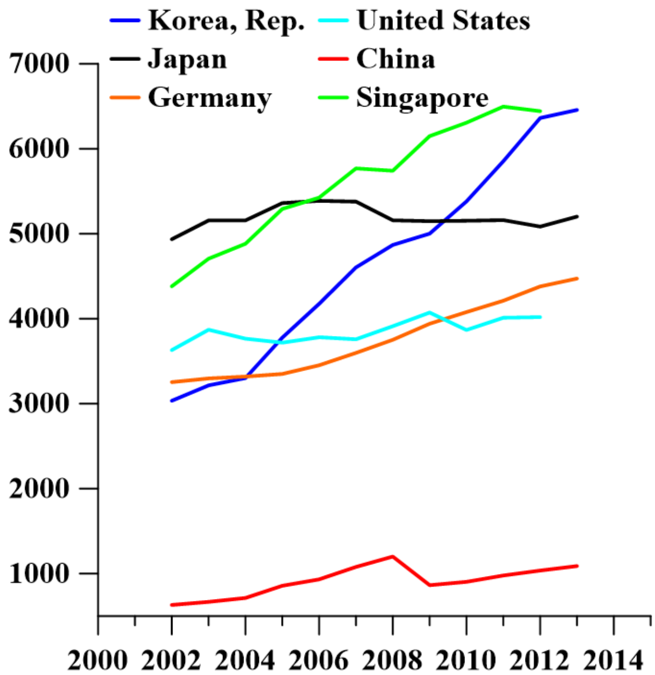
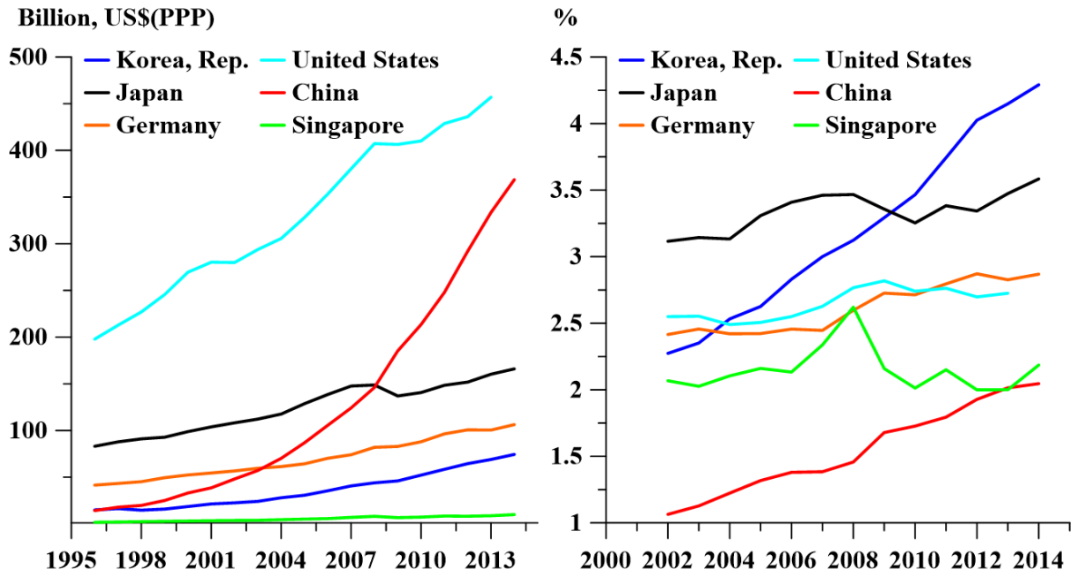
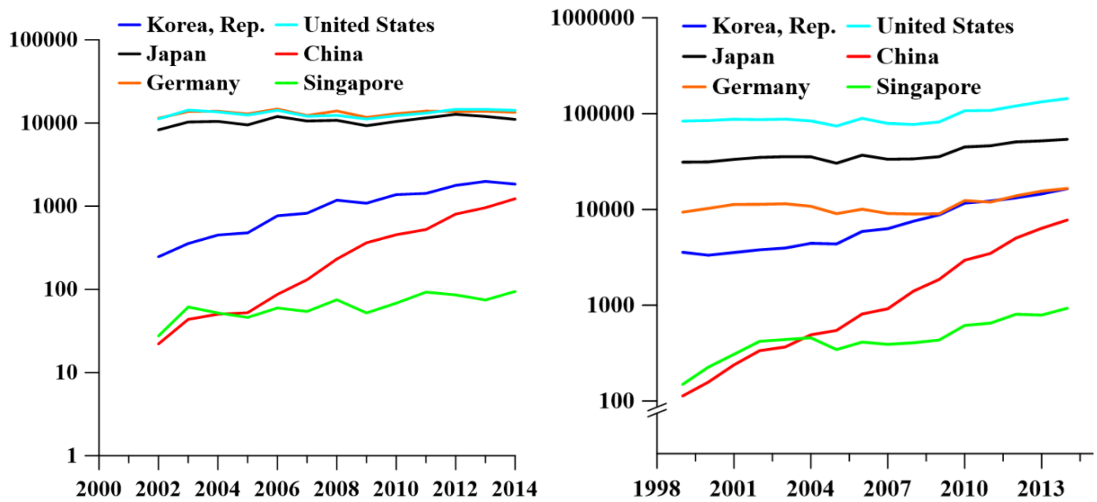


Fig. 8 Researchers in R&D (per million people)
Source: World Bank, World Development Indicators



(a) (b)

Fig. 9 (a) Gross domestic R&D expenditures [GERD] (Billion, US$ ppp); (b) GERD as a % of GDP
Source: The United Nations Educational, Scientific and Cultural Organization [UNESCO], Institute for Statistics



(a) (b)

Fig. 10 (a) Patents granted by EPO; (b) Patents granted by the USPTO
Source: OECD STAT

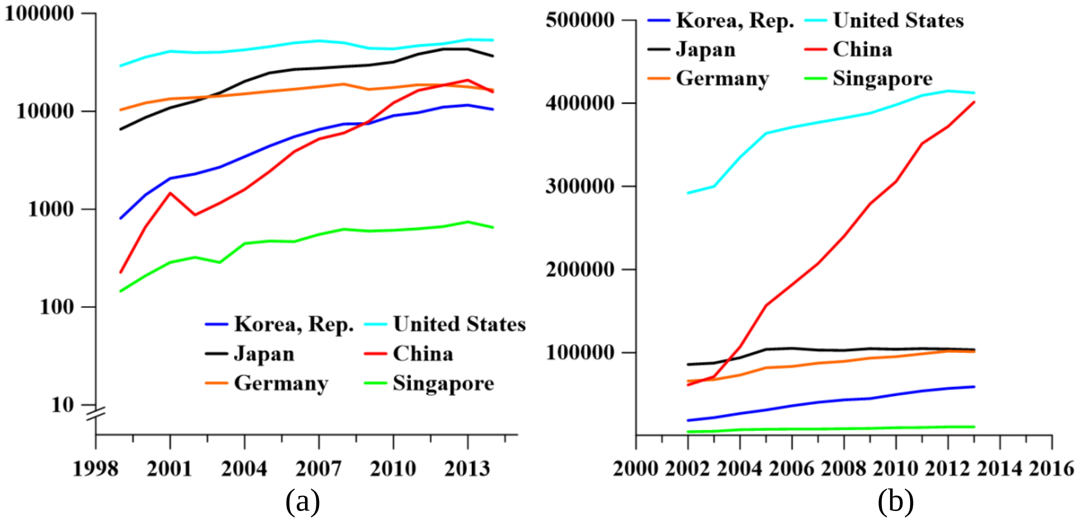


Fig. 11 (a) Patent application (PCT); (b) Scientific and technical journal articles
Source: OECD STAT

The technological progress has ultimately upgraded the domestic firms' position within the global value chain. Jarreau and Poncet (2009) claimed that the export structure of domestic firms operating in the ordinary sector has shifted from low-tech manufacturing to medium- and high-tech manufacturing such as machinery and electronics. In some highly competitive manufacturing industries, Chinese firms have increased their market shares and achieved upgrading along the value chain (UNCTAD, 2016). For instance, almost four fifths of the productions of smart phones in China were domestic brands (UNCTAD, 2016). As one of the top high-tech companies in China, Huawei filed the most patent applications (i.e. 3898) in 2015 at the firm level, and 45 of the world's top 50 telecom operators adopted its technology in 2015.

According to the value added method put forward by Xing (2014), the estimated value added of China's high-tech exports increased from 31% in 2002 to 45% in 2012 (see Fig. 12). Besides, the domestic content of processing high-tech exports has also increased from 25% in 2002 to 45% in 2012 (Xing, 2014).

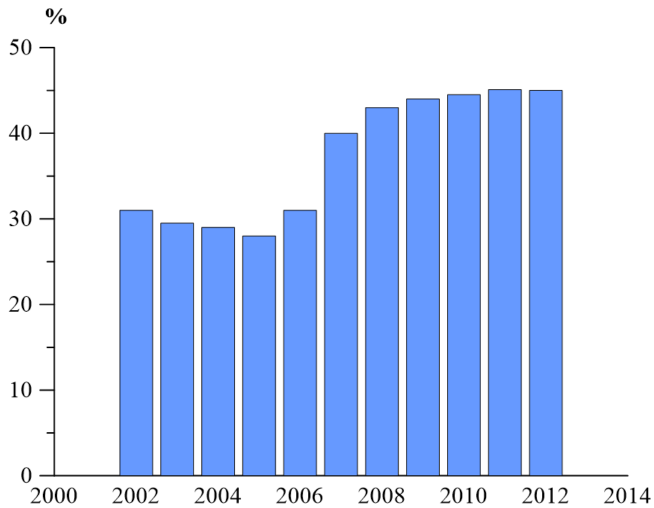


Fig. 12 Domestic value added in China’s high-tech exports (%)

CHAPTER 2

LITERATURE REVIEW

Assuming that the same technology set is available for every country, neoclassical economists have attempted to account for countries' export performance by their factor endowments. The underlying traditional theoretical framework generally takes income and price differentials as the determination of trade flows (Goldstein & Khan, 1985). However, many different empirical analyses show that trade flows usually prone to weak price effects (Bairam, 1988). Although price differences are the most obvious determinant of trade competitiveness, available empirical studies confirm the Kaldor Paradox which claims that in the post-war period, the countries in which relative unit labor costs and export prices increased faster than other countries grew faster in terms of exports and GDP, and vice versa (Kaldor, 1978; Kellman, 1983). Kaldor (1978) put forward the importance of so-called non-price factors' impact on exports. The new international trade literature (Grossman & Helpman, 1990; Krugman, 1989, 1990) also suggested that other than prices, factors such as product differentiation and increasing returns to scale on the supply side, and preference for variety on the demand side, affect market share as well. A bulk of non-price factors are often represented by Thirwall formula (Thirwall, 1979), which reveals income elasticity of exports and imports. For example, as growth of demand for HT products generally has a higher rate than the average, a higher income elasticity may reflect a higher quality of the exported goods (Amable, 1993; McCombie, 1992).

A set of 'non-price' factors includes the degree of innovation, quality, technical specification, design, advertising, marketing support, and value for money (Buxton, Mayes, & Murfin, 1994). A country's technological capability is a very important factor as pointed out by Kaldor (1981) and elaborated by Soete (1981). Technology-input (e.g. R&D expenditures and R&D employment) and technology-output measures (e.g. innovation counts and patents) are used to identify a country's technological capability. The endogenous growth theories (Aghion & Howitt, 1992; Grossman & Helpman, 1991, 1995; Howitt, 2000; Romer, 1990) and other theoretical literature (e.g. Krugman, 1983; Spencer & Brander, 1983)) also indicate that factors other than factor endowments, such as innovation, R&D, human capital and trade specialization, can be crucial determinants of trade flows.

From the perspective of the theory of fragmentation of production and global production network, multinational enterprises (MNEs) and positions of the firms in the integrated production networks (IPNs) play a crucial role in the export competitiveness of high-tech products (Connolly, 2012; Helleiner, 1981). Hence, several researchers also have attempted to explain HT exports' performance with HT imports (of both components and final products) and foreign direct investments (FDI) (both inward and outward). Thus, exploration of factors affecting the development of high-tech sectors became more and more complex.

2.1 Price factors

2.1.1 Labor cost

Several researchers have attempted to empirically quantify the relative importance of price and non-price factors in the determination of high-tech exports. Magnier and Bernate (1994) reported that, using an error correction model and allowing country and sector specific additive coefficients for the regressors, gross R&D expenditures and investment efforts (measured by gross fixed capital formation/value added) along with price competitiveness indicator (measured by relative export prices) significantly affect the HT export market shares in the five biggest OECD countries during 1971-1987. Amable and Verspagen (1995) also found that both the price (measured by unit labor cost) and non-price (measured by patent indicator) factors explain high-tech export performance of five industrialized countries and 18 industries. However, Fagerberg (1996b) conducted an analysis of data for 10 OECD countries and 22 industries in 1985, and suggested that export competitiveness is significantly determined by both direct R&D intensity (measured by direct business R&D divided by production) and indirect R&D acquired through purchase of capital goods and intermediates, while labor cost (measured by wage per worker) plays no role. Landesmann and Pfaffermayr (1997) reported that technology did not to be a determinant of export shares in all industries.

Clarysse, Muldur and Sloan (1999) conducted seemingly unrelated regression with fixed effects (SUR) on a set of 21 OECD countries over the period 1988-1996. They showed that price factor (measured by cost of employment divided by value added) has no impact on the percentage of HT products in the total exports of technology-intensive sectors, while EPO patents and physical capital investment (measured by gross fixed capital formation as a percentage of value added) come out to be a key factor. The findings hold across all the 7 science based sectors and corroborate the Kaldor Paradox (Kaldor, 1978) for the HT exports that high costs of labor combines with high level export performance.

Similar to Clarysse et al. (1999), Sember (2013) concluded that labor cost index exerts no impact on high-tech export competitiveness of EU-28 countries, while it does play a key role in the intra-EU trade of HT sectors for V4 countries (the Czech Republic, Hungary, Poland and Slovakia). Synthetic intellectual capital assets factor dominates the high-tech export performance of EU-28 countries, while technology input (measured by total intramural expenditures on R&D in euro per inhabitant) merely has a marginal effect for V4 countries. In addition, labor productivity as a percentage of EU27 total (based on PPS per employed person) is also a predictor of high-tech export performance for both country groups. The findings are consistent with Ferragina and Pastore (2007) but contrast to Braunerhjelm and Thulin (2008) who contend that productivity exerts no impact.

Since the exchange rate (ER) dynamics are likely to affect the unit labor costs and hence indicate general domestic production cost, some scholars also have taken the ER as one determinant of HT exports. Athukorala (1991) reported that the ER has an important impact on export behavior in the Brazilian case by confirming the study of Chircu and Mahajan (2009) and opposing Wallace (1990) who argued for the negligibility of ER fluctuations in market entry decisions. Tebaldi (2011) contended that while with respect to HT exports per worker, no response is found to exporter's exchange rate fluctuations which is consistent with the findings of Seyoum (2004), a depreciation of the exporter's local currency contributes to boost the HT exports as a percentage of manufactured exports, supporting the studies of Vogiatzoglou (2009) but yet with a merely marginal impact on ICT export specialization. Nevertheless, Ferragina and Pastore (2007) showed that a positive and dominant impact of foreign exchange liberalization (proxied by real effective exchange rate (REER) and REER volatility) and terms of trade on the export competitiveness of high-tech products from 84 developed and developing countries exist, and Zhang (2013) also argued that a rise of 10 percent in REER of import countries results in a 9 percent increase in Finnish high-tech exports, controlling for other variables. Zhang's findings are consistent with the several other studies analyzing the impact of exchange rates on overall manufactured exports for different economies (Cushman, 1983; Ghura & Grennes, 1993; Grobar, 1993).

2.1.2 Other trade cost factors

In all the literature, confirming the gravity model, distance between importer and exporter, be it direct-line or simple distance or other methodologies, is shown to be highly significantly and negatively associated with the value of high-tech exports (Liu & Lin, 2005; Abedini, 2013; Zhang, 2013). The common language is also likely to boost high-tech exports in a long run (Abedini, 2013; Zhang, 2013). These aforementioned findings indicate that transportation cost and information cost still have a non-negligible impact on the value of high-tech exports. With respect to the trade freedom, the results are controversial. Ferragina and Pastore (2007) concluded that the exporter's customs and other import duties in the percentage of tax revenue negatively and marginally influences the high-tech export performance of 84 middle-income countries, while the exporter's MFN rate on manufactured goods has a positive and marginal effect. However, Sara, Jackson, and Upchurch (2012) found no impact of exporter's tariffs and nontariff barriers on the share of high-tech exports in manufactured exports. With respect to the importer's trade regime, Abedini (2013) proved that raising the importer's tariff weakly significantly decrease the volume of high-tech exports from 11 emerging countries, but it tends to significantly boost the high-tech exports from 19 established countries, which is corroborated by Zhang (2013) in the case of Finland. Abedini's (2013) findings indicate that high-tech exports from the established exporters are more price sensitive than from the emerging countries.

2.2 Human capital

Torstensson (1998) analyzed the link between knowledge endowments (R&D intensity of industries which is measured by the share of technical personnel, e.g. scientists, engineers, and technicians) and high-tech export performance, using both absolute and relative measures covering 23 OECD countries in 1985, and strong correlation is found.

For the sake of investigating the role of factor conditions (human capital and physical infrastructure) and examining the relative importance of other variables, i.e. FDI inflows, domestic rivalry and demand conditions, in influencing a nation's export performance in HT industries, Seyoum (2004) developed an econometric model based on Porter's diamond theory and those of Cantwell (1999), Patel and Pavitt (1998) and Root (1992) on FDI and technology transfer. In the multiple regression on a data set for 54 developed and developing countries on the period 1996-1998, he found high-tech exports are positively determined by factor conditions constituting human capital (measured by the number of scientists and engineers per million people and level of math and science education), research collaboration and physical infrastructure (measured by telephone lines per employee), as well as by inward FDI and demand rivalry. Notably, the greatest predictor is inward FDI. However, demand conditions (measured by household consumption as per cent of GDP) are shown to negatively affect the value of high-tech exports, which was explained that "low home demand pressures firms into looking for market opportunities elsewhere" (p. 158). Later on, Vogiatzoglou (2009) revealed that ICT market size (measured by total ICT expenditure within a country) has a positive effect on ICT exports specialization.

Using a multiple regression with fixed effects on a panel dataset of 99 developed and developing countries from 1980 to 2008, Tebaldi (2011) identified that, the growth of high-tech exports per worker and the growth of high-tech exports as a percentage of manufactured exports (HTX intensity) can be obtained by fostering human capital stock (proxied by average schooling years in over 25 years and older) and opening the economy for inward flow of FDI and for international trade (captured by total trade as % of GDP, which is only marginally significant for HTX intensity). For example, an increase in inward FDI by 1 percent will lead to about 0.17 and 0.59 percent increase in high-tech exports per worker and HTX intensity. These results are supported by Zhang (2007), but contradictory to Braunerhjelm and Thulin (2008)'s conclusions. R&D expenditures are highly correlated with human capital, which indicates that international trade is conductive to speed knowledge transfer among countries and expand R&D activities (Zhu & Jeon, 2007) and therefore causes a higher level of high-tech export performance. Other factors such as inflation (a measure of macroeconomic volatility) and net migration, are found to have no effect on high-tech exports per worker and HTX intensity, implying that high-tech exports are associated with fundamental economic structures (such as human capital) rather than fluctuations in macroeconomic indicators (such as inflation).

Alinsunurin (2014) examined the impact of telecommunications infrastructure as well as human capital on economies' high-tech exports as a percentage of total exports of goods and services on a panel data of 100 countries with a panel size of 25 years. Under the generalized least squares (GLS) method with random effects model, the coefficients of telephone, internet and mobile phone densities are positive and highly statistically significant at 1% level. For instance, as the strongest telecommunications infrastructure factor, every additional telephone made available for every hundred people increases the share of the high-tech exports by 0.23%. Internet and mobile phone densities are also quadratically, negatively and highly significantly affect the HTX intensity, indicating non-linear effects and diminishing marginal effects beyond the optimal density ratios, namely 35.23 and 54.16 per 100 persons respectively. In the model, the quadratic form of telephone densities plays no significant role. As the key determinant, a 1% increase in the human capital stock (measured by Barro and Lee's Human 2010 capital index) leads to a 3.4-5.8% increase in the HTX intensity, implying that an ample human capital investment may overwhelmingly complement the economic benefits created by infrastructure investments. Economic openness (measured by trade as percent of GDP) is a positive and significant determinant for the share of high-tech exports in total exports of goods and services as well, further validating the previous studies that value and supply chains of high tech goods and services are enhanced by liberal trade regimes. The other factors, life expectancy (a proxy for health) and the share of the urban population, seem not to be correlated with the growth of high-tech exports.

Using fully-modified ordinary least square regression on a panel data of EU-15 countries for the period 1995-2010, Gökmen and Turen (2013) showed that in the long run high-tech exports per capita is highly significantly (at 0.01 significance level) and positively influenced by economic freedom measured by Index of Economic Freedom Score by the Heritage Foundation, human development level measured by Human Development Index (HDI) and inward FDI per capita. For instance, one percent increase in inward FDI per capita, IEF and HDI are associated with an increase of 0.44%, 27.28% and 4.77% in high-tech exports per capita, respectively. The conclusions are almost similar to the study of Tebaldi (2011) with different economic indicators. The Grangers causality test reveals that a significant long-term causal impact runs from each of HDI, IFDI, IEF to high-tech exports per capita, and the causality between HDI and high-tech exports per capita indicates the importance of human capital in high technology export oriented economic growth model.

2.3 Technology capabilities

2.3.1 R&D expenditures

Several researchers reported that the technological factors have an important and significant impact on a country's trade performance in technologically advanced industries (Vernon, 1966), such as patent (Fagerberg, 1988; Soete, 1981) and R&D expenditures (Daniels, 1993; Fagerberg, 1988; Kalafsky & MacPherson, 2001; Le, 1987; Lee & Stone, 1994; OECD, 1995; Stern & Maskus, 1981; Zhao & Li, 1997). Most of the previous empirical studies focused on the dataset of a single country at the sectoral level (Fagerberg, 1995; Kalafsky & MacPherson, 2001; Lacroix & Scheuer, 1976; Le, 1987; Lee & Stone, 1994; Stern & Maskus, 1981; Zhao & Li, 1997), while others conducted a cross-sectional analysis of several countries using a time series model (Amable & Verspagen, 1995; Carlin, Glynn & Reenen, 1998; Daniels, 1993; Magnier & Toujas-Bernate, 1994; Soete, 1981). For instance, supporting Fagerberg's (1996b) study, Ioannidis and Schreyer (1997) reported that an increase in technology-related factors, proxied by R&D stock, R&D embodied in intermediate goods and in investment goods, is likely to boost market share in total exports from ten developed countries both in segmented and fragmented industries of the high technology sector. Industrial competition is largely driven by product innovation and vertical differentiation in segmented HT industries and by process innovation in fragmented HT industries.

Lall (2000) argued that HT exports require advanced technology infrastructure, large R&D investment and close link between universities, research institutions and firms.

With the similar model and country group in the study of Seyoum (2004), Seyoum (2005) investigated the link between the value of high-tech exports in 1999 and with some economic indicators: total R&D expenditures per capita, human capital, inward FDI and the sophistication level of the buyer which measures the knowledgeable and demanding extent of a country’s buyers. All these factors are revealed to highly statistically significant stimulate high-tech exports. Inward FDI has the highest explanatory power with a coefficient of 0.628 at the 0.01 level of significance. For many countries with low indigenous technological capability, such as Malaysia and Singapore, foreign multinationals have established the requisite expertise, such as advanced manufacturing, design and development capabilities, to enable them to extend the range of high technology products. These results are also confirmed by the findings of Srholec (2007).

Gökçe et al. (2010), using panel data Granger causality analysis for 27 EU countries and Turkey for annual time series over the period, 1997-2007, tested a long run relationship from R&D expenditures intensity to the share of high-tech exports in total exports (Sara et al., 2012; D’Angelo, 2012), confirming the “R&D expenditures led High-Tech Exports” hypothesis. Sandu and Ciocanel (2014) further supported the view that the innovation growth strategy (the growth of R&D investments in both public and private sectors) can strengthen the competitiveness of medium and high-tech products export (complex exports) with variability across 27 EU countries. A 1 % increase in R&D expenditure in the business sector (as % of GDP) will quasi-simultaneously raise the high-tech exports and complex exports as a percentage of total exports by 9.16% and 3.68%, with all other variables held constant. With regard to the public expenditure for R&D (GovRD, as % of GDP), a 1 % increase in GovRD boosts the share of high-tech exports in total exports by 14.42% and 16.07%, with a 5 and 7 year delay (lag) respectively, ceteris paribus. So for the short-term gain, more R&D expenditure can be directed at the private sector. Nevertheless, a 1% increase in the employment in knowledge-intensive sectors (products and services) as a percentage of total employment decrease the share of complex exports by 2.83% in the same year. It is partially as a result of the recoil effect of exports led by the efforts of integrating, training and adapting the new workforce in medium and high technology sectors.

Using linear regression on 40 OECD countries, Shelton, Fadel, and Foland (2015) concluded that R&D investment (including business expenditure on R&D and overall gross expenditure on R&D), particularly by the business sector, has an overwhelmingly positive impact on high-tech exports and value-added high-tech manufacturing outputs. Business researchers, papers SCI and patents are also highly correlated with high-tech exports and value-added high-tech manufacturing outputs. Shelton et al. (2015) also pointed out that the multinational companies' choice of the location of manufacturing seems to largely affect the relationship between R&D investments and high-tech exports.

In the case of developing countries, Alemu (2013) conducted system GMM estimator for dynamic panel data of 11 countries of East Asia during the period 1994-2010. The empirical results reveal that the ability of a country to specialize in high-tech product exports is positively determinate by a nation's state of scientific infrastructure such as the ratio of R&D expenditures to real GDP and skilled R&D human resources (measured by the number of R&D researchers), physical capital (measured by gross fixed capital formation/GDP), physical infrastructure (measured by telephone per 100 people), education (measured by the secondary school enrollment ratio) and inward FDI. Assuming that all other factors are constant, a 1% increase in each of the aforementioned factors raises the high-tech exports of a country by approximately \$397 million, \$67 million, \$109 million, \$295 million, \$332 million and \$412 million per year, respectively. Moreover, the results indicate that high-tech exports from countries with significant high-tech exports in the past are exceedingly path dependent. The findings of Fugazza (2004) and Limão and Venables (2001) put forward as well that the physical infrastructure (measured by telephone per 1000 people) is a significant determinant in explaining complex exports.

2.3.2 Patent

In order to investigate the effect of domestic innovative capacity on high-tech performance, Furman et al. (2002) developed an empirical model based on the concept of national innovative capacity, which depends on the strength of a nation's common innovation infrastructure, the environment for innovation in nation's industrial clusters and the strength of linkages between these two. Technology specialization is also considered which refers to the relative concentration of innovative output in chemical, electrical, and mechanical patent classes granted by United States patent and trademark office (USPTO), adopting E–G index (Ellison & Glaeser, 1997). Adopting the NAICS industry classification and conducting a simple regression on panel data of 17 OECD countries during 1973-1995, Furman et al. (2002) reported that the cumulative knowledge stock of a country (measured by patent stock) and size of an economy (GDP and population) play an important role in the high-tech export competitiveness. These factors explain nearly 80% of the idiosyncratic variance in a country's market share in all the 17 OECD countries, implying that countries are likely to attain higher national shares of worldwide high-tech exports by accumulating advanced knowledge stocks. High-tech market share is also influenced by other measures of national innovative capacity, such as R&D inputs (measured by full-time scientists & engineers in all sectors), government's resource commitment (measured by the share of GDP spent on secondary and tertiary education), policy choices (measured by openness to international trade and investment), cluster-specific innovation environment (measured by the ratio of private R&D expenditures to total R&D expenditures and technology specialization) as well as the quality of the linkage between industrial clusters and the national innovation system (measured by ratio of R&D expenditures by universities to total R&D expenditures). On the other hand, the results demonstrate that the scientific output (measured by the number of publications in international academic journals) per se contributes little to stepping up national shares in worldwide HT markets in the short run. It is noteworthy that the R&D expenditures in all sectors are negatively associated with HT performance (Furman et.al, 2002). With regard to trade openness, Liu and Lin (2005) revealed that the more open the importing country, the more the exports of the three knowledge-intensive industries (i.e. the semiconductor, the information and the communications equipment industries) for Taiwan, confirming the conclusions of Deardorff (1995).

Montobbio and Rampa (2005) focused on 9 large developing countries and reported that export gain in HT industries is influenced by the growth of innovation activities, FDI inflows, productivity, and the initial level of technical skills.

Contradicting the findings of Montobbio and Rampa (2005), Braunerhjelm and Thulin (2008) conducted a multiple regression on a panel data of 19 OECD countries during 1981-1999, and stated that as a key determinant, a 1% increase in the ratio of R&D expenditures to GDP magnifies the share of high-tech exports by approximately 3%, ceteris paribus. The technological balance of payments and expenditure on education sectors have a negative and significant impact on the share of high-tech exports in total exports and the factor of production (measured by capital per worker) as well as FDI outflows play no role.

Sara, et al. (2012) conducted an empirical analysis of 120 countries and revealed that the innovative capability of a country overwhelmingly contributes to the share of high-tech exports as a percentage of total manufactured exports. However, the quality of existing technologies and infrastructure, business sophistication, business freedom and quality of training and education of a country’s labor force are not shown to be relevant with the HTX intensity. However, Robson, Haugh and Obeng (2009) studied 496 entrepreneurs in Ghana and concluded that level of education positively associates with innovation. Meo and Usmani (2014) also identified patents and R&D expenditure intensity influence high-tech exports.

Sun, Li, and Chen (2014) drew on Georgia Tech High Tech Indicators (HTI) conceptual model to develop a varying coefficient model on a panel data of BRICS countries during 2000-2010. For the sake of correcting cross-sectional heteroscedasticity and serial autocorrelation, the seemingly unrelated regression (SUR) estimator is conducted to examine the relationship between high-tech exports from BRICS countries to the United States and several factors: resident patent filings (PAT) (proxy for productive capacity), the ratio of R&D expenditure to GDP (proxy for technological infrastructure), Scientific and Technological Cooperation Fund (TEC) (proxy for national orientation) and inward FDI (proxy for socio-economic infrastructure). They showed a significant heterogeneity across high-tech exports from BRICS to the United States with respect to the four factors. Patent indicator is highly significant. It contributes largely for Brazil, India and Russia (coefficients=1.45, 1.03 and 0.79, respectively) but little for China (coefficient=0.05) and South Africa (coefficient=0.0056). The R&D investment plays the most important role in the export competitiveness of high-tech products to the United State for all the BRICS countries. With regard to the inward FDI indicator, though the impacts of FDI on high-tech exports to the United State are more significant for China and South Africa (coefficients= 0.192 and 0.101 respectively) than for Brazil, Russia and India (significance is less than 0.1), the impacts are quite marginal for all the BRICS countries. Nevertheless, in the case of China, Zhao (2013) argued that at the product level positive foreign export spillovers and crowding-in effect are identified. In other words, the presence of surrounding foreign exporting firms helps domestic exporters to boost HT exports. Besides, high-tech cooperation among BRICS countries also significantly enhances the high-tech export competitiveness (the significance in order is China, South Africa, India, Brazil, Russia), which not only promote technical exchanges but also economic and trade exchanges between them. For instance, ceteris paribus, a 1 unit increase in TEC of China can boost its high-tech exports to the United States by 0.758 units.

2.4 Demand and market scale factors

Income per capita, domestic or foreigners', plays an important role in the growth of high-tech exports (Abedini, 2013; Alemu, 2013; Ferragina & Pastore, 2007; Liu & Lin, 2005; Meo & Usmani, 2014). Abedini (2013) also pointed out that the larger the income per capita gap between the trade partners, the higher the value of high-tech exports. With regard to market scale (measured by GDP and population), most of the literature confirms the new economic geography theory that the market sizes of importers and exporters have a very important impact on a country's export competitiveness of high-tech products (Abedini, 2013; Ferragina & Pastore, 2007; Liu & Lin, 2005; Sember, 2013; Srholec, 2007; Torstensson, 1998; Zhao, 2013). For example, Furman et al. (2002) reported that a 10% increase in exporter's GDP will boost the share of high-tech exports in the global market by nearly 10%; Ferragina and Pastore (2007) also identified the share of high-tech exports in total manufactured exports has a higher income elasticity of world demand (captured by world GDP) (coefficient above 1). In addition, Abedini (2013) argued that although the magnitude is small, emerging countries can benefit from trading with a country with the similar GDP or with a small GDP gap. However, the GDP gap has no role in the high-tech export performance of developed countries. In oppose to that, Braunerhjelm and Thulin (2008) did not identify any significant effect of the exporter’s market size gauged by share of world GDP on the share of high-tech exports in total exports from 19 OECD countries, which is consistent with the findings of Fagerberg (1995) and validates the traditional trade theory explanations instead of economic geography explanations. Braunerhjelm and Thulin (2008) offered a possible explanation:

> Knowledge may be so specialized that it can be highly localized, simultaneously as economies of scale are exploited through exports and FDI by firms located in small countries. Similarly, product differentiation and vertical specialization could generate a structure where the smaller countries specialize in certain niches and stages of high-technology production. (p. 107)

Meanwhile, Nsiah, Wu, and Mayer (2012) examined determinants of the export performance of the 48 contiguous U.S. states in the 24 Asian export markets. They showed that the countries with higher income (measured by GDP) have stronger demand for HT products imports. Moreover, the importer’s population has a negative and insignificant impact which may indicate a "self-sufficiency" effect argued by Zarzoso and Lehmann (2003) and the exporter’s size (gauged by GDP and population) is not significant and crucial which can be explained by the fact that the high-tech exports from America are largely not labor intensive or not from industries with high economies of scale. Finland's high-tech exports are even highly significantly and negatively influenced by its own GDP, which indicates that as the domestic demand becomes weaker, the Finnish HT sectors shift from domestic market to overseas (Zhang, 2013). This may be because the Finnish market had become a highly competent and efficient high tech producer during the estimation period according to Zhang (2013).

2.5 Nation's industrial technological capacity (ITC)

Zhang (2007) investigated the link between complex exports (CXs) and nation's industrial technological capacity (ITC) as well as general economic factors. Here ITC is defined as its ability and capacity of producing complex products (high- and medium-tech products), measured by complex manufacturing value added per capita, or by complex manufacturing's product share in total manufacturing value added. Using ordinary least-squares regression on cross-country data for 87 countries, the results indicate that ITC is closely associated with a nation's complex exports per capita as well as complex exports' share in total manufactures during 1985-1998 Indeed, Zhang confirmed Lall's (2000) and UNIDO's (2002) studies that based on the traditional and new trade theories, the higher level of ITC in a nation, more CXs it has, due to economies of scale and comparative advantage. The growth in the per capita and share of CXs in total manufactures are also mainly stimulated by the increase in ICT. Inward FDI is positively correlated only with CXs per capita. Regarding the effects of human capital, the study does not find strong link between skill labors and CXs, although a positive link between skilled labor and complex export per capita for the 1990s is observed. Nevertheless, Keeble and Wilkinson (2000) emphasized the importance of highly skilled scientists and engineers in high-tech product competitiveness. Fugazza (2004) and Greenhalg (1990) also stated that a higher level of human capital can significantly strengthen the productivity and export competitiveness of an industry. Nevertheless, Zhang (2007)'s empirical analysis likely suffers from issues such as specification and endogeneity which usually plague OLS estimates.

Supporting Zhang (2007)'s findings, Vogiatzoglou (2009) concluded that, using a multiple regression with one-way fixed-effects upon 28 countries for 2000-2005, R&D intensity (measured by RD/GDP), human capital (measured by researchers in R&D per million people) and public infrastructure such as ICT-related telecommunication infrastructure significantly strengthen the cross-country ICT export specialization, being consistent with Seyoum (2004, 2005). However, new economic geography (NEG) deterministic factors, such as international market access (measured by share of total trade in GDP - Trade/GDP) and agglomeration economies or industrial infrastructure (measured by manufacturing value added) have stronger causal effects on the ICT export specialization.

In order to investigate the relationship between skilled labor (measured by the Harbison Myers Index and indices for science and engineering enrollment in tertiary education) and the nation's competitiveness (measured by the share of high-tech exports in total manufactured exports), Onsomu, Ngware and Manda (2010) estimated a panel data on 84 developing countries for the period 1999–2003. They found both of the skilled labor measures as well as income level (measured by GDP per capita, ppp) and inward FDI positively and significantly affect the high-tech export performance.

Abedini (2013) conducted the specific GMM (generalized method of moments) instrumental variable–based estimation on a panel data over the period of 1995-2008 including 19 developed and 11 emerging countries separately, and reported that high-tech exports for these two groups are strongly path dependent which is consistent with Alemu (2013)'s study. Industrial technological capacity (MAN, indicated by share of manufacturing), participation in the international production chain of high-tech goods (captured by the total import of HT goods) and skilled labor (gauged by share of secondary education enrollment) play a more important role in the growth of high-tech exports for the two groups than factors related to common technological capacity such as research and development efforts. The other structural variables have different effects on the high-tech export competitiveness across the established and emerging exporters of high-tech goods. The emerging countries' high-tech exports are significantly affected by FDI inflows and located mainly at the lowest value added segment of the production chains: processing and assembling. High-tech exports from the established exporters are negatively affected in a long run with respect to inward FDI. Indeed, the two export patterns show a significantly convergent trend over time in terms of the impact of inward FDI, MAN, R&D efforts, and institutional quality in the importing country, while the patterns diverge with respect to export concentration and institutional quality in the exporting country.

2.6 Institutional quality, business environment and export concentration factors

Ferragina and Pastore (2007) offer an economic analysis of whether a country's high-tech exports (as a share of total manufactured exports) could be explained by institutional quality, business environment and export or product concentration as measured by the Herfindahl-Hirschman Industrial Concentration Index (HHI) in order to capture industry-level competition. On a data set of 84 developed and developing countries over the period 1994-2003, a panel data analysis with fixed effects reveals that technology capability (measured by RD/GDP), export diversity, total factor productivity and human capital (measured by the secondary school enrollment ratio on net enrollment) play a significant and a prominent role in the technological upgrading of a country’s exports. On the other hand inward FDI and gross fixed capital formation as a percentage of GDP have insignificant impact on high-tech exports. The findings confirm the statement of World Bank (2006) that total export performance will be improved by increasing the quality in the export product mix through higher exports and corroborate the opinion that high-tech activities are human capital intensive, not physical capital intensive (Barlevy, 2004). A sound political environment (measured by World Bank governance indicators) and a friendly investment climate (measured by house of freedom) would complement trade and foreign exchange reforms in strengthening the high-tech export competitiveness. Contradicting with Ferragina and Pastore (2007), Abedini (2013) showed that high-tech exports of the traditionally leading exporters are positively affected by export diversification and exporters’ institutional quality, while export concentration and the importer’s institutional quality dominate high-tech exports from the emerging countries. As for political institutions factor, Tebaldi (2011) did not identify a direct influence on the performance of a country’s high-tech industry in the global market, but it might have an indirect link with high-tech sectors via its impact on proximate factors such as human capital and inflows of foreign direct investments.

Similar to the study of Ferragina and Pastore (2007), Chircu and Mahajan (2009) argued that the internal factors such as industrial policy guidance, industry hatching input, industrial technology innovation, and external factors FDI and export policy constraints dominate the high-tech industry development.

Nsiah et al. (2012) also investigated the relationship between the business environment and export performance of the U.S. states in the 24 Asian export markets. The probit regression with random effects demonstrates that a state's business vitality, manufacturing union density (UDEN), legal system (measured by State liability systems index score), pollution abatement capital expenditures (POLEXP), employment density (EDEN), and regional location significantly strengthen the global competitiveness of U.S states in high-tech exports. The findings of the study are consistent with the following earlier studies: Berkowitz, Moenius, & Pistor (2005), Bennett and Kaufman (2008), Doucouloagos and Laroche (2004) for UDEN indicator, Porter and Linde (1995) for POLEXP indicator and Combes (2000) for EDEN indicator. For instance, a 1 unit improvement in a state's business vitality and liability systems raises the probability that it outperforms its estimated high-tech manufacturing export potential by 3.7% and 0.2%, respectively. Besides, the state corporate tax seems not to matter for the economic performance of the states, similar to Mead (2001) and Lynch (2004). Furthermore, the results reveal that surprisingly the growth of Chinese exports does highly significantly enhance the high-tech export performance of all states. However, estimated by the instrumental variable estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998), autocorrelation problem is identified, while a significant time trend in high-tech exports is not observed.

With respect to employment regulation, Zhang (2013) also pointed out that lower level of unemployment raises Finland's high-tech exports to a great extent. On the other hand, Allen and Aldred (2011) argued that employment regulations, such as low level of employee participation, high level of the labor force share with tertiary education and high level of employment rigidity, are not universally sufficient to explain the high-tech export competitiveness of all the countries in CEE.

As regards state corporate tax, Braunerhjelm and Thulin (2008) reported that the institutional setting, i.e. the implicit tax pressure, captured by the share of government expenditures to GDP negatively and weakly correlates with HT exports. It means a negative crowding out effect, implying that a viable institution setting is able to mediate and facilitate the utilization and commercialization of knowledge for incumbent firms and entrepreneurs. It may complement R&D investments in enhancing exports of high-technology products.

2.7 Property rights

Ivus (2010) conducted a difference-in-difference estimation to explore the link between the strength of developing countries' property rights (PRs) and dynamics of HT exports from the developed countries. He found a relative relation. The effect is strongest for patent-sensitive industries, such as medicinal and pharmaceutical products and professional and scientific equipment. For example, strengthening the PRs (captured by Ginarte and Park index) response to the 1994 agreement Trade-Related Aspects of Intellectual Property Rights (TRIPs) adds $35 billion (2000 US dollars) to the patent-sensitive export from 24 developed countries to 18 developing countries. Liu and Lin (2005) followed Smith's model and used a gravity model estimated by pooled data analysis on industry-level data of Taiwan over the period 1989-2000. They argued that the FPRs (foreign PRs, captured by Ginarte and Park index) overwhelmingly raise (lower) Taiwan's exports through the market expansion (power) effect, as the importing country displays characteristics of a strong (weak) threat of imitation. Exports of semiconductor and ICT industries from Taiwan to a country with stronger R&D abilities than Taiwan can be boosted, particularly, when the importing country's PRs protection improves. Nevertheless, Zhang (2013) reported that for Finland, the share of importer's R&D expenditures in GDP highly and negatively correlated with high-tech export performance which is in line with the economic principles. However, the exporter's own strength of protection for intellectual property (IP) has a non-significant effect on the market share of high-tech exports in 17 OECD countries, probably due to the imprecise estimation (Furman et al., 2002).

2.8 Financial development

The neo-institutionalists argue that financial development would reduce costs of economic transactions such as selling and distribution costs, especially for high-tech sectors because of high degree of market uncertainties and information asymmetry (North, 1990; Willianson, 1985). Kletzer and Bardhan (1987) showed that a higher level of financial development drives comparative advantages in sophisticated manufactured products. Drawing on the corporate governance and employment regulation issues from the varieties of capitalism paradigm and employing a fuzzy-set qualitative comparative analysis of 10 Central and Eastern Europe (CEE) countries for 2008, Allen and Aldred (2011) revealed that a relatively high level of financial markets (measured by stock market capitalization as a percentage of GDP and domestic credit to private sector as a percentage of GDP), foreign investors (measured by FDI inflows as a percentage of GDP) and a low level of business regulations (measured by ease of doing business index) constitute a causal combination, which is sufficient for success in high-tech export markets (measured by the share of high-tech exports in manufactured exports). The findings indicate that companies in the region, be it foreign-owned subsidiaries or domestic firms, were able to establish or develop their own advanced organizational capabilities and competitive competencies. These not only enable them to absorb technologies developed elsewhere, but also develop their own innovation capabilities. On the contrary, Nölke and Vliegenthart's (2009) claim that multinational corporations "prefer to keep the most innovation-heavy activities at the headquarters" (p. 678).

Indeed, results driven by Allen and Aldred (2011) also contradict to Bohle and Greskovits's (2007) contention:

> In the less developed part of the world, neoliberalism is likelier to spell the fast decline of the most innovative industries, as these will be the first victims of the global competition with their advanced country rivals. (p. 111)

Zhao (2013) also claimed that the efficiency of financial sectors or level of financial development (measured by the share of all deposits and loans in all Chinese domestic financial institutions to GDP), as well as the region's population, transportation infrastructure, inward FDI, government R&D expenditure and fixed asset investment, significantly and positively determine high-tech export competitiveness of different provinces in China. In addition, Ferragina and Pastore (2007) reported that HT exports of the middle income countries are weakly significantly affected by financial development (captured by the ratio of Money and quasi money (M2) to GDP).

2.9 Global integration in the international industrial value chain

Srholec (2007) used several empirical analyses, and estimated a parsimonious model for a panel of 111 countries. In comparison with other predictive factors related to indigenous technological capabilities gauged by enrollment in tertiary education, granted ICT patents per capita and access to a computer, the position in the global production networks (measured by import of high-tech components, HTM) plays a much more important role in the electronics exports. However, the propensity to import final products negatively correlates with the high-tech exports, at least as far as electronics is concerned, which indicates a substitution relation with exports of the same industry. Due to the fragmented international high-tech production, a precautionary use of standard industry-based taxonomies in broad cross-country comparative studies are suggested, particularly in comparing countries at largely different levels of development. Instead, conducting analysis on company level data is recommended.

Alvarez and Marin (2013) also investigated the impact of national technological capacities, namely, technology creation capabilities (captured by patent and royalty receipt indicators), absorption capacities and technology acquisition (measured by royalty payment), and the global integration level (measured by FDI inward stock and outward stock and the ratio of HT imports to total imports, HTM/TIMP), on a country's international competitiveness in high-tech industries. With system GMM estimator on a panel data of two groups, 41 developing countries (middle-income economies) and 34 developed countries during 1996-2010 are taken into consideration. The empirical analysis reports that, the integration in the industrial international value chain together with outward FDI dominates the dynamics of the high-tech exports from both country groups. This would reflect the intra-industry trade activities in the case of developed countries. For example, ceteris paribus, a 1% increase in the ratio of high-tech imports raises their share of high-tech exports in total manufactured exports by almost 0.99% for developing and 0.76% for developed economies. The result of outward FDI from developing countries supports the studies of Cazurra (2007) and Gammeloft, Barnard, and Madhok (2010) who argued that the potential of developing economies as a source of MNE may relate to the high-tech performance of these countries. However, as for inward FDI stock, the presence of foreign MNE negatively affects the high-tech export competitiveness of developing countries but exerts no impact for developed countries, which can be explained that foreign subsidiaries in emerging economies are mainly local market-oriented and active in more traditional industries instead of high-tech industries. Vogiatzoglou (2009) also argued that countries with a lower level of inward FDI as a percentage of GDP exhibit higher ICT export specialization, implying that most of the inward FDI stock might be diverted into the non-ICT sectors. In terms of technological capacities, regarding developing countries, the acquisition of technology and the development of absorptive capacities constitute a suitable framework for the generation of positive effects in the HT competitiveness shifts. Patent has non-significant effect, but royalty receipts have a significant and negative impact on the high-tech export competitiveness, indicating the scarce role of developing countries as technology creators argued by Athreye and Cantwell (2007). Nevertheless, for developed countries, technology creation capabilities play an important role in the improvement of their competitiveness in high-tech markets. On the other hand, technology absorptive capacities and acquisition have no noticeable impact. Meanwhile, as Sandu and Ciocanel (2014) put forward, the result of R&D activities may indicate that the different impact of R&D according to a country's specialization in high-tech subsectors. For example, in the United States and Europe, where aerospace industry is developed, R&D exert a stronger impact on HT exports, whereas in information technology industry, dominated by MNC, HT exports are weakly influenced by national RD investments and activities.

CHAPTER 3

THEORETICAL FRAMEWORK

This thesis adopts an eclectic approach and builds an empirical model based on Furman, Porter, and Stern (2002), and Porter, Newman, Roessner, Johnson, and Jin (2009).

3.1 National innovative capacity

Furman et al. (2002) argued that high-technology export competitiveness is to be significantly boosted by national innovative capacity. Here, innovative capacity is defined as a country's potential to produce a flow of commercially relevant innovations in the long run (Furman et al., 2002). A country's innovative productivity depends on: (1) the strength of a nation's common innovation infrastructure tools, such as national investments, resource commitment, policy choices and institutions, which have impacts on the incentives to take part in innovative activities (see Fig. 13), (2) conditions in the industry and innovative environment in national industrial clusters that influences the enterprises' R&D productivity, (3) the quality of linkages between these two components that determine whether a given common innovation infrastructure will lead to more productive innovative outcomes in industrial clusters (Furman et al., 2002). In order to examine the factors of the common innovation infrastructure, Furman et al. (2002) built a conceptual framework based on ideas-driven growth theory or new growth theory (Romer, 1990) and national innovation systems (Nelson, 1993).

Ideas-driven endogenous growth theory argued that economic growth is endogenously determined by the ideas-generating sector of the economy (Grossman & Helpman, 1991; Jones, 1995, 1998; Porter & Stern, 2000; Romer, 1990). Romer (1990) also suggested that the innovative productivity depends on a country's historical stock of knowledge and the extent of efforts (human capital and financial resources) committed to the production of new technologies.

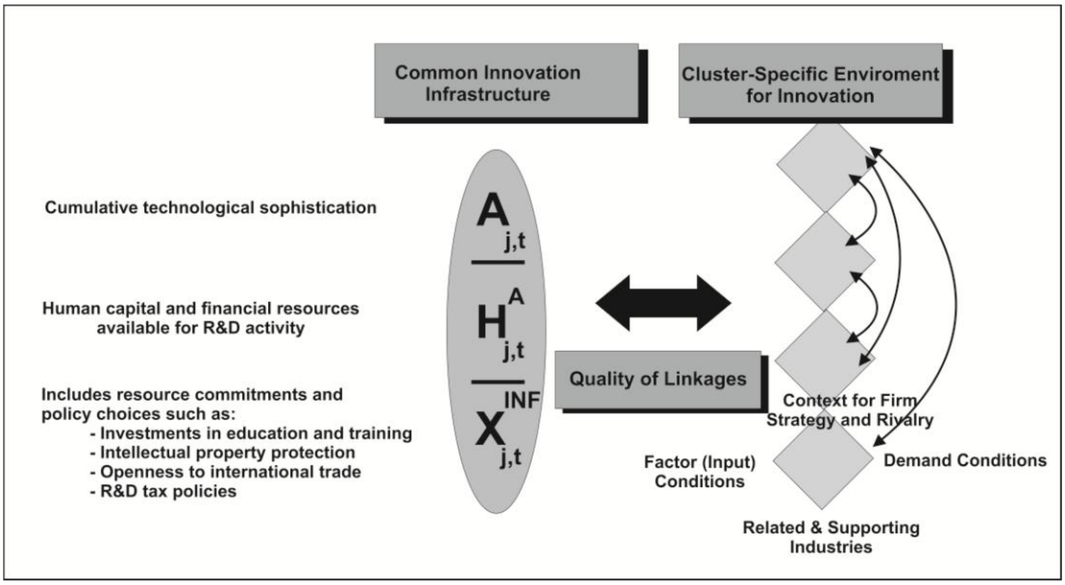


Fig. 13 National innovative capacity framework

Criticizing the new growth literature for oversimplifying the firms and the lack of addressing the required institutions, the national innovation systems emphasize the importance of national policies and investments, such as intellectual property protection, openness to international competition, expenditures on higher education and so on (Dosi, Freeman, Silverberg, & Soete, 1988; Edquist, 1997; Freeman, 1987; Lundvall, 1992; Nelson, 1993). Nelson (1993) reported an over-arching impact of these factors on national innovativeness across different sectors. Besides, following the national innovation systems approach, Furman and Hayes

(2004) incorporate the constellations of different actors who affect the nature and extent of innovative output in an economy, such as private firms, universities, public and quasi-public research organizations as well as the institutions, legal authorities and so on. This perspective also underscores iterative learning, detailed search efforts and relationships among the aforementioned actors which contribute to the technical development (Lundvall, 1992; Nelson & Winter, 1982).

Rosenberg (1963) and Porter (1990) proposed microeconomic models of national industrial competitive advantage focusing on the national industrial clusters. While the common innovation infrastructure provides resources that influence all innovation-oriented sectors throughout an economy, it is ultimately the individual firms and industrial clusters that produce and commercialize those innovations. Furman et al. (2002) directly employed “diamond” framework developed by Porter (1990) who proposed four key attributes of the microeconomic environment (see Fig. 14 and the diamonds on the right-hand side of Fig. 13) – the presence of high-quality and specialized factors of production such as skilled labor, sophisticated home-market demand, related and supporting industries that are internationally competitive, as well as an environment that encourages investment, innovation and intensive domestic rivalry. Moreover, the potential for productivity-enhancing knowledge spillovers also exists across industrial clusters (represented by the lines connecting the diamonds on the right-hand side of Fig. 13).

Furman et.al (2002) concluded that indigenous research efforts such as financial and human capital investment in R&D play an important role in determining national innovative capacity as well as innovation-enhancing policies and infrastructures. Nevertheless, the study of Furman et al. (2002) mainly focused on domestic sources of innovation without taking international technology spillover sources such as royalty and license purchased from abroad into account.

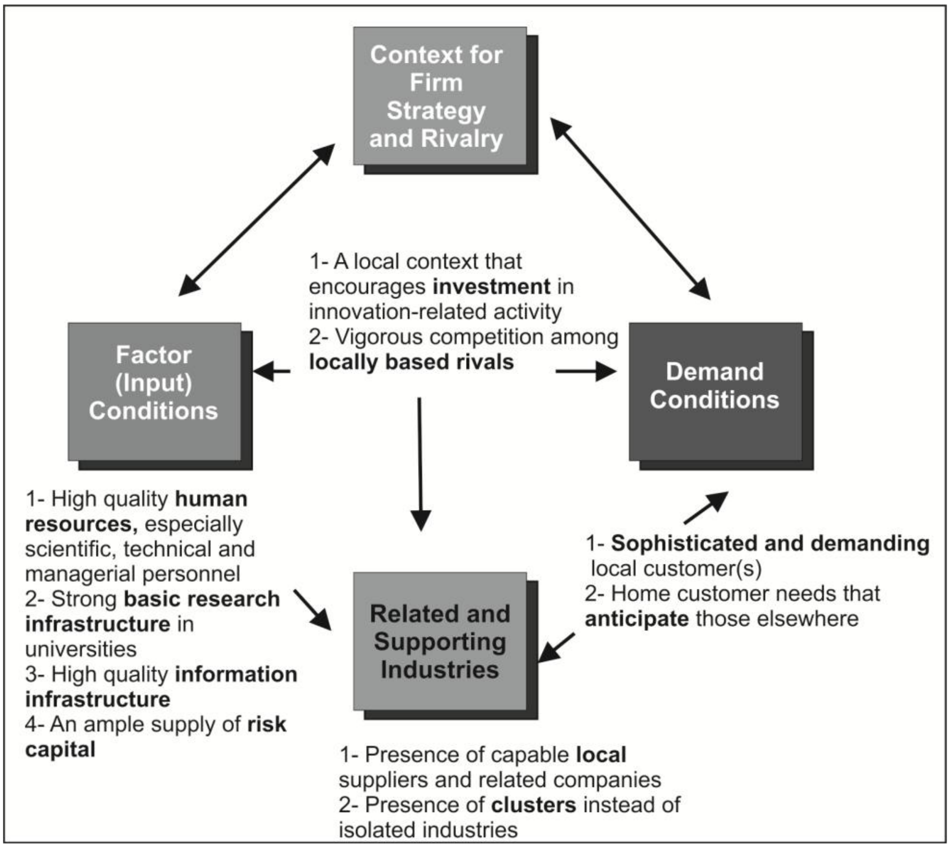


Fig. 14 The innovation orientation of national industry clusters

3.2 High-Tech Indicators

The enhancement of high-technology competitiveness is due to “the complex interaction of social, political and economic forces that affect the creation and commercialization of high technologies” (Johnson et al., 2010, p. 281). In order to measure the present and future high- technology competitiveness of rapidly industrializing countries, Georgia Tech compiled national “High Tech Indicators” [HTI] in 1987. While the traditional HTI is based on both statistical data and expert panel judgments (Porter, Newman, Jin, Johnson, & J. David Roessner, 2008a), the HTI (statistics only) combines statistical components from the HTI-traditional model with various international statistical sources (Porter, Newman, Jin, Johnson, & Roessner, 2008b). The conceptual model analyzes national technology-based competitiveness in the long term (15-year time horizon) and captures the output, “Technological Standing” depending on four inputs or “leading components”. (Roessner, Porter, & Newman, 1997). The inputs are national orientation, socio-economic infrastructure, technological infrastructure and productive capacity (Porter et al., 2009). Figure 16 sketches the relationships among the components (Porter et al., 2009). Technological infrastructure and productive capacity are expected to exert more proximate influences on future technological standing than national orientation and socio-economic infrastructure (Porter et al., 2008a). The components are defined as follows:

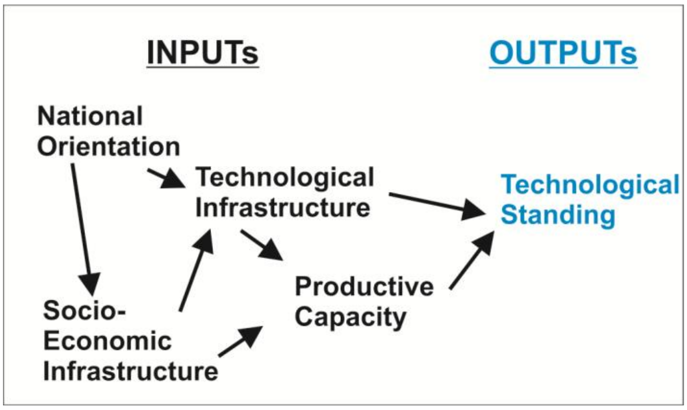


Fig. 15 Georgia Tech High Tech Indicators conceptual model

National orientation reflects a country's commitment to achieve national technological competitiveness along a series of dimensions such as entrepreneurial spirit, political stability, and government policy. (Porter et al., 2009). National orientation is measured by intellectual property protection effectiveness, ease of starting a business and 5-year investment risk assessment index in the HTI (statistics only) (Porter et al., 2008b).

Socioeconomic infrastructure concerns mobility of capital, laws and policies on foreign investments, and the social and economic institutions (such as the nation's educational system, financial market and so on) (Porter et al., 2009). These aspects support and maintain the physical capital, skill labors, organizational and economic resources which are essential to the development of a knowledge-based economy.

As a metric of a nation's technological development, technological infrastructure captures the strength and contributions of a nation's physical and human capital, economic investment for technology absorption and utilization, and technology creation capabilities to develop, produce and market new technology (Porter et al., 2009). The HTI (statistics only) measures this component using electronic data processing equipment purchases, scientists & engineers in R&D, R&D expenditures, royalty and receipts payments, ICT access, patent applications and research publication (Porter et al., 2008b).

Productive capacity measures the efforts devoted to building resources to manufacture technology-intensive products and the efficiency of these resources, using local supplier quality, production process sophistication, imports of HT goods and services, manufacturing value added and electronics production (Porter et al., 2009).

As the output of the model, technological standing measures a country's current success in exporting HT products. The indicator equals to the average mean of HT exports, electronics exports, royalty/license fees and export of computer, communications and other services in HTI (statistics only) (Porter et al., 2009).

CHAPTER 4

MEASURES

According to the study of Furman et al. (2002) and Porter et al. (2009), as well as different innovation indexes (such as the composite innovation indicator by European Commission, the global innovation index by the World Intellectual Property Organization, etc.), we choose the following variables in our study and the rationale for each independent variable is as follows.

4.1 Dependent variable

In the literature, the competitiveness of HT exports is measured by the value of HT exports, HT exports as percent of total exports, and HT exports as a percent of manufactured exports. This thesis aims to analyze the HT exports of BRIC and Turkey. The value of HT exports differs significantly among Brazil, China, India, Russian Federation and Turkey. For example, in 2014, the value of HT exports from China was $648.7 billion, while it was $8.8, $18.2, $10.2, and $2.8 billion from Brazil, India, Russian Federation and Turkey respectively. Moreover, in the case that the HT exports as a share of total exports is taken into consideration, fuel exports account for a large share of merchandise exports in the Russian Federation (for instance, it was 69.5% in 2014), which results in underestimation of high-tech export performance of the country. Therefore, in this thesis, HT exports as a percent of manufactured exports (htx) is adopted as the dependent variable.

4.2 Independent variables

4.2.1 National orientation

In order to identify a nation's government, business and cultural oriented actions to achieve technological improvements, following indices are used as variables: labor freedom, political stability and absence of violence, government spending, trade freedom, openness to trade.

Radical innovation is known as a sine qua non for the competitiveness of high-tech industries (Allen et al., 2006; Casper, 2009; Casper & Whitley, 2004; Hall & Soskice, 2001). Institutional framework, that resembles the neo-liberal market model especially being related to corporate governance and employment regulations, is favorable to radical innovation (Casper & Whitley, 2004; Hall & Soskice, 2001). This can be explained as follows: First, a higher economic freedom [EF] fosters open and fierce market competition (Miller & Kim, 2011), which promotes innovation and entrepreneurship as well as a higher level of coordination and cooperation efforts between research and industry circles (Freeman, 2002; Kim, 1997; Salmenkaita & Salo, 2002). Next, achievement of technology accumulation, which is critical to innovative capability, necessitates constant technology-oriented investments (domestic and foreign). EF affects inward FDI accumulation (Bengoa & Sanchez-Robles, 2003; Caetano & Caleiro, 2009; Kapuria, 2007; Quazi, 2007; Ramirez, 2010; Wheeler & Mody, 1992), especially through the country selection decision of foreign investors (Gökmen, Turen, & Dilek, 2012; Turen, Gökmen, & Dilek, 2012a). EF also offers a favorable environment for domestic capital investment (Gokmen & Turen, 2013).

In this thesis, we hypothesize that EF is positively associated with performance of HT exports. It is measured by labor freedom, government spending and trade freedom from the Heritage Foundation, political stability and absence of violence from World Bank Governance Indicators and trade openness indicator from World Bank.

According to Heritage Foundation, government spending comprises government consumption and all transfer payments related to various entitlement programs. Excessive government spending is likely to bring about both misallocation of resources, chronic budget deficits, the accumulation of public debt and loss of economic efficiency (The Heritage Foundation, 2016), and thus distort incentive structures and hinder entrepreneurship and innovation as well (Fölster & Henrekson, 2001; Fölster & Trofimov, 1998; Kirzner, 1997).

Labor freedom indicator measures the legal and regulatory framework of a country's labor market, taking into account regulations related to minimum wages, laws inhibiting layoffs, severance requirements, and measurable regulatory restraints on hiring and hours worked as well as the labor force participation rate. (The Heritage Foundation, 2016)

Trade freedom measures the tariff barriers and non-tariff barriers that influence international trade of goods and services (The Heritage Foundation, 2016). Studies show that a higher level of trade freedom accelerates knowledge transfer

(Sara, Jackson and Upchurch, 2012) and ensures the market operation (Gwartney, Lawson, & Holcombe, 1999; Kirzner, 1997).

Political stability and absence of violence index measures the likelihood of political instability and/or politically motivated violence, including terrorism (see the definition of World Bank).

Openness to trade, defined as a percent of GDP (Awokuse, 2008; Miller & Upadhyay, 2000; Sarker & Jayasinghe, 2007; Yanikkaya, 2003), captures the extent of domestic market opening to the world and dependence of economic development on the international trade.

4.2.2 Socio-economic infrastructure

4.2.2.1 Financial market development

Financial resources are viewed as a key factor for the national technology development (Bell & Albu, 1999; Kuruvilla, Erickson, & Hwang, 2002; Psacharopoulos & Ng, 1992), especially for financially dependent industries (Rajan & Zingales, 1998). A well-developed financial market and financial institutions promote the production of capital-intensive and technology-intensive products via capital accumulation and technical advancement (Qi, 2005; Qi, Wang, Shi, & Sheng, 2011) by increasing savings rate, pooling and mobilizing savings, delivering timely investment information, optimizing capital allocation, facilitating and encouraging foreign capital inflows, trade and diversification (Čihák, Kunt, Feyen, & Levine, 2012; Department for International Development, 2004). While financial development is defined as the value of all financial assets over GNP by Goldsmith (1969), generally researchers simplify this definition and measure financial development with the value of all financial assets as percent of GDP. In this study, domestic credit provided by bank and financial sector (as % of GDP), the ratio of stock market capitalization of indigenous companies to GDP as well as gross domestic savings (as % of GDP) are chosen to capture financial development.

4.2.2.2 Foreign direct investment

The FDI inflows to BRIC and Turkey had upward trend between 1996 and 2009 (see Fig. 16). Although these countries suffered a severe decrease in FDI inflows in 2009, the trend has been maintained in the later years, except Russian Federation whose economy hampered by falling oil prices and sanctions. Due to the national recession, FDI flows to Brazil (the 8th world largest FDI recipient) slipped 12% year on year to $65 billion in 2015, while FDI equity investment increased by 4% year on year such as in the automotive industry and health care (UNCTAD, 2016). China, the 3rd world largest FDI recipient, absorbed $136 billion FDI (up nearly 6% from 2014), thereinto, 61% in services sector particularly in retail, transportation and finance and 31% in manufacturing sector which was 6% down in comparison with 2014 due to rising labor costs and production costs in China (UNCTAD, 2016). Moreover, FDI into China shifts from efficiency seeking to market seeking (UNCTAD, 2016). For example, in the automotive industry, MNEs have increasely taken Chinese car market- the largest in the world- as central to their global strategy (UNCTAD, 2016). FDI flows to India reached $44 billion in 2015, which makes India the tenth world largest FDI recipient in the world. FDI into India primarily flows to the automotive industry, which accounted for 20% of India's manufacturing value added. In the last decade, FDI flows to Russian Federation soared from $15 billion in 2004 to $69 billion in 2013, and the country became the 5th world largest FDI recipient. However, since inward FDI concentrated in energy and natural-resources related sectors, due to falling oil prices and geopolitical tensions, FDI flows into the Russian Federation dipped to $21 billion in 2014 and halved to $9.8 billion in 2015, and FDI in manufacturing and banking sectors slumped sharply (UNCTAD, 2016). Turkey, as the largest FDI recipient in West Asia and the 20th world largest FDI recipient, received $17 billion FDI up by 36% in 2015 compared to 2014. Thereinto, the manufacturing sector received the largest proportion of FDI inflows, followed by financial services and transportation sectors ("Investment Support and Promotion Agency of Turkey", 2016)

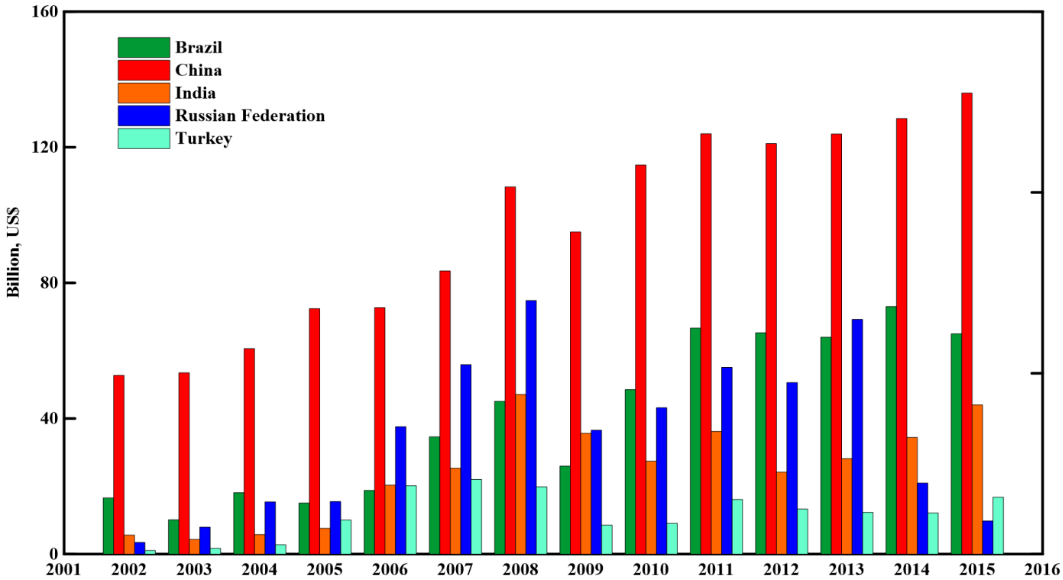


Fig. 16 Inward FDI from 2002 to 2015 (current $billion)
Source: UNCTAD

In the related literature, scholars concluded that inward investment is likely to promote the export competitiveness of the host economy through inward technology transfer (Blomström & Kokko, 1997; Globerman, 1979; Razin & Sadka, 2007; Turen, Gökmen, & Dilek, 2012b), managerial know-how transfer (Dunning, 1998; Potterie & Lichtenberg, 2001; Zhang, 2006), advanced manufacturing capabilities built by multinational firms (Borensztein, De Gregorio & Lee, 1998; Buckley & Clegg, 1991; De Mello, 1999; UNCTAD, 1999), financial sources offered by FDI (Huang & Xian, 2010), and access to global marketing networks (Huang & Xian， 2010; Mayneris & Poncet, 2011; Potterie & Lichtenberg, 2001; United Nations, 1999). Besides, there are findings of a positive association between inward FDI and export performance. United Nations (1999) concluded that FDI inflows are likely to boost manufactures exports in 52 countries, such as in Ireland and the Philippines over the last few years, and also pointed out that the higher the technology intensity of exports, the more significant the impact of FDI. He (2010) argued that inward FDI has a significant export creation effect in Brazil, China and India, but not in Russia. Moreover, wholly foreign owned firms accounted for a huge part of high-tech exports from China, which was 68.6% in 2006 and dropped to 54.7% in 2013 according to the Ministry of Science and Technology of the People's Republic of China (2014).

However, the findings show that the positive effects of inward FDI do not always extend to long term development of developing countries. Blomström and Kokko (1997), Globerman (1979), Kokko (1994), Kokko and Blomström (1995), Razin and Sadka (2007) argued that over the long term inward FDI is harmful to the economic growth of developing nations. In some cases, the national resources of the host economy may be controlled and exploited by the home country of FDI, which would be used by firms of the host country (Cardoso, 1973; Cardoso & Dornbusch, 1989; Evans, 1979; Fan, 2002). In another case, for the eight investigated transition economies, technology transfer only occurs from the headquarters to direct subordinate firms and positive intra-industry spillovers from FDI to domestic firms are not observed. (Damijan, Knell, Majcen, & Rojec, 2003)

In this thesis, we expect a positive relationship between FDI inflows and high-tech export competitiveness. Inward FDI as a percent of gross fixed capital formation is adopted.

4.2.2.3 Skilled labor

Technology, one of the key factors for high tech manufacturing and export, can be obtained through domestic research and development (R&D) and other innovation activities. The quality of human capital[4] is crucial in these processes, as well as in the production of high-tech products and in the processes of global marketing and sales (Tebaldi, 2011).

Technology can also be acquired by technology transfer. FDI is viewed as a cheap, easy but one of the most efficient ways of technology transfer (Gokmen & Turen, 2013). Sufficient absorptive capacity of host nation or the sector (such as

[4] Bontis (2004, p. 7) defined human capital as "the knowledge, education and competencies of individuals in realizing national tasks and goals".

human capital) is also prerequisite to mediate and ultimately realize this process (Archibugia & Cocoa, 2005; Barkley, Dahlgran, & Smith, 1988; Edwards, 1998; Ferragina & Pastore, 2007; Kathuria, 2002; Kinoshita, 2000; Papaconstantinou, 1997; Purlys, 2007; Rasiah, 2004; Wooster & Diebel, 2010; Xu, 2000; Yokota & Tomohara, 2010), and lower level discrepancy of human capital between the home party and host party can catalyze this process (Gokmen *et al*., 2012). For instance, Xu (2000), being supported by Sinani and Klaus (2004), claimed that U.S. MNEs' positive effect on productivity growth of host nation can only be traced in developed countries, and those technologies transferred by these MNEs cannot be absorbed until the host nation's human capital reach a minimum threshold level. Yokota and Tomohara (2010) concluded that knowledge spillovers in high-tech industries is likely to be absorbed by nations with highly skilled labor force, while nations with a lower level of human capital can only absorb the spillovers in low-tech industries.

In this study, we expect a positive relationship between skilled labor and high-tech export performance. Tertiary graduates (including undergraduates, graduates and doctorate graduates), tertiary graduates of science and engineering programs, as well as graduation at the doctoral level are used as proxies for skilled labor. Besides, to measure the effort made by the country to attract and retain top talent, the brain drain indicator is also taken into account.

4.2.3 Innovation

In the knowledge age, competition among countries becomes ultimately the competition of technological innovation (Spulber, 2008). Innovation is conducive to the development of cutting-edge products and processes and thus, helps national firms to enhance their competitiveness (Porter, 1990; Montobbio & Rampa, 2005). The McKinsey Quarterly (2006) even reported that it is the most important way for firms to sustain competitive advantage, and Sala-I-Martin et al. (2008) also argued that innovation is the only way to upgrade an economy's competitive position in global markets, in the long term.

4.2.3.1 R&D expenditures

In order to measure innovative capacity, R&D expenditures, which are considered as the innovation input, are used.

R&D expenditures are expenses of state and private businesses on innovative work. R&D activities, which consist of basic research, applied research as well as experimental development (World Bank definition), are systematically undertaken to enhance knowledge, including knowledge of humanity, culture, society, and knowledge for new applications (OECD, 2002).

R&D activities contribute to enhancement of firms' competitiveness through productivity improvement (Crepon, Dugest, & Mairesse, 1998), labor saving (Johnston, 1966), creation of increasing returns to scale (Romer, 2001), cost reductions (Johnston, 1966; Blind, 2001; Rodriguez & Rodriquez, 2005), new product development (Grossman & Helpman, 1990; Krugman, 1979; Mucuk, 2005) and increase in the absorptive capacity (Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van den Oord, 2008; De Jong & Freel, 2010). Domestic R&D expenditures and the transferred foreign technology are reported to be an important driver of high-tech exports of several developing countries, especially East Asian economies (Alem, 2013). Srithanpong (2014) argued that in Thailand, the government aid on R&D significantly enhances the productivity in the manufacturing exports.

R&D intensity (defined as R&D expenditures as a percentage of GDP, GERD) indicates a nation's innovation capacity and investment efforts at high-tech industries (Falk, 2009). According to World Bank, the R&D intensity of EU-28 was around 2% for the period of 2003-2013, when the target was 3%. In the same period, it was more than 4% for Israel, and between 3%-4% for Sweden, Finland and Japan. As for Germany, Denmark, France, Austria, Iceland, South Korea and United States, the R&D intensity maintained between 2%-3%. The R&D intensity of BRIC and Turkey shows an increasing trend in the period of 2002-2013 (see Fig. 17). China's R&D intensity reached 2% in 2013, while it was around 1.1% for Brazil and Russia. Turkey significantly increased its R&D spending, but the ratio was still less than 1% in 2014. As for India, the level of R&D spending was stable and nearly 0.8% of GDP. The share of government expenditures in GERD accounts for more than 50% for Brazil, India, the Russian Federation, while it accounts for less than 35% for China and Turkey since 2008 and the ratio is still decreasing for both countries (see Fig. 18). However, the government R&D expenditures are still increasing in Brazil and the Russian Federation (since 2010 it has been more than 70% of GERD for the Russian Federation), while it is decreasing for India although the ratio is still much higher than for China and Turkey.

In this thesis, gross domestic expenditure on R&D as percent of GDP, government expenditure on R&D as a percent of GDP and business expenditure on R&D as percent of GDP are taken into models.

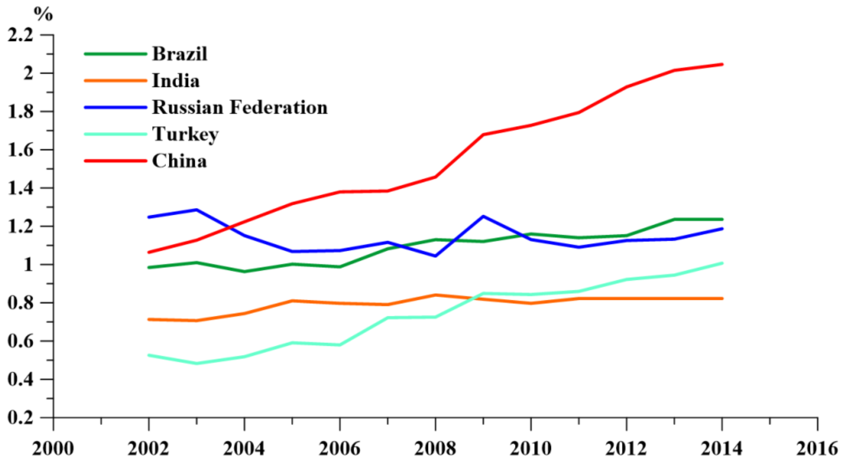


Fig. 17 R&D intensity from 2002-2014
Source: Brail: RICYT; China, Russia, Turkey: OECD, Main Science and Technology Indicators; India: UNESCO;

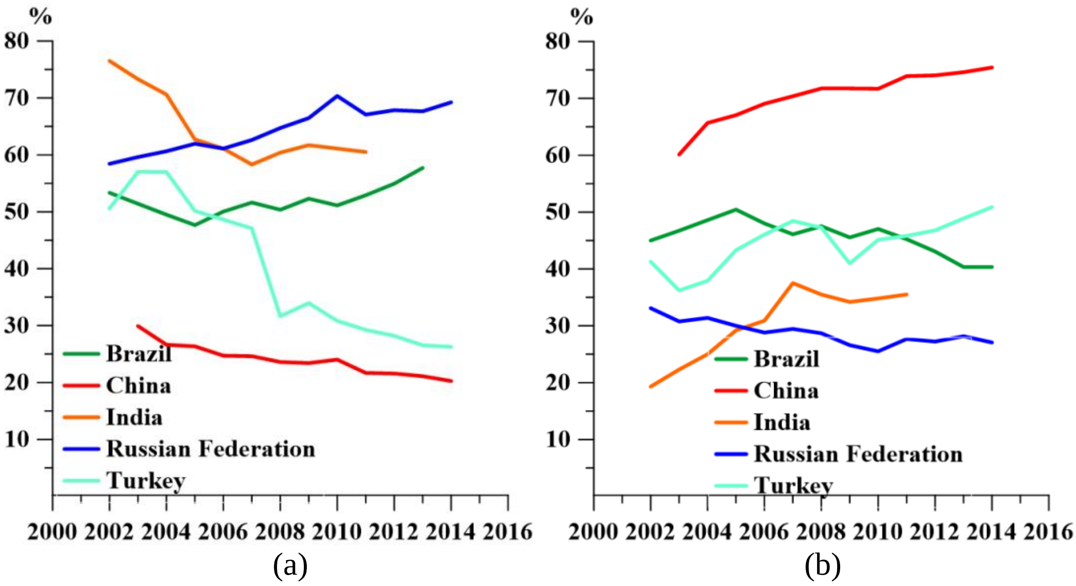


Fig. 18 (a) GERD financed by government; (b) GERD financed by business enterprise
Source: Brail: RICYT; China, Russia, Turkey: OECD, Main Science and Technology Indicators; India: UNESCO;

4.2.3.2 Other innovation measures

In order to measure the companies' capacity for innovation, the sub-indicators of the Global Competitiveness Report (GCR) are used. In addition, the number of researchers in R&D, which is considered as another innovation input, is also used. As for domestic innovation output, patent applications per million residents and scientific and technical journal articles are chosen. Technological development can also be gained through foreign technology transfer and acquisition, which is regarded as a better way to achieve greater productivity growth in comparison with internal development (Seyoum, 2005). Here, royalty and license fees payments are used. Moreover, university and industry research collaboration, as the innovation indicator of GCR, is also included in order to measure the quality of linkage between industrial clusters and common innovation infrastructure. Indeed, weak linkage quality is argued to result in stagnated technology development (Bell & Albu, 1999; Kuruvilla et al., 2002; Psacharopoulos & Ng, 1992).

4.2.4 Productive capacity

Besides human capital, inward FDI and R&D activities, a productive and efficient manufacturing base is another important component of high-tech exports. Productive capability can be boosted by domestic firms' own efforts on development of cluster and innovation, acquisitions of technologically sophisticated machinery and equipment (for instance, ICT goods) (Lopez-Pueyo, Sanau, & Barcenilla, 2009), or participations in the international industry value chain. Integrating into the global production value chain is conducive to technological advancement of the local manufacturing base (Lemoine & Unal-Kesenci, 2004； Liu, 2008; Todo & Miyamoto, 2006). Development of ICT sector in China can be seen as an illustrating case (Fan, 2008; Gaulier et al., 2007a). Additionally, export diversification may increase national productivity (Feenstra & Kee, 2004) and boost economic growth by minimizing investment risks and enhancing resistance to idiosyncratic sectoral shocks (Acemoglu & Zilibotti, 1997).

Manufacturing value added, ICT goods imports (percent of total goods imports), computer, communications and other services as percent of commercial service imports, high-tech parts and components imports, semi-finished goods imports, and capital goods imports are taken into the models in this thesis. A positive relation between high-tech export performance and each aforementioned factor can be expected. Moreover, state of cluster development is also included in this study to measure the quality of the linkages between firms and suppliers. In order to represent the exports diversification and concentration, Hirschamn-Herfindhal indices are also included.

The variables (see Table 2) are clustered into 5 groups as follows:

Table 2 Five Clusters of Determinants of High-Tech Exports

Categories	Variables
National orientation	Labor freedom, political stability and absence of violence, government spending, trade freedom, openness to trade
Financial market development	Domestic credit to private sector by banks as % of GDP, Domestic credit to private sector by financial sector as % of GDP, stock market capitalization as % of GDP, Gross domestic savings as % of GDP
Skill labors	Tertiary graduates, tertiary graduates of Science and Engineering programs, graduation at doctoral level, brain drain
Innovation	Gross domestic expenditure on R&D (GERD) as % of GDP, GERD financed by government as % of GDP, GERD financed by the business enterprise as % of GDP, researchers, full-time equivalence (FTE) (per million population), scientific and technical journal articles, patent applications per million residents, charges for the use of intellectual property, payments (BOP), university/industry research collaboration, capacity for innovation
Productive capacity	Manufacturing, value added, ICT goods imports (% total goods imports), computer, communications and other services as % of commercial service imports, HT parts and components import, state of cluster development, exports diversification index

CHAPTER 5

THE DETERMINANTS OF HIGH-TECH EXPORTS

5.1 Methodology

In this study, we try to understand the determinants of high-tech exports from BRIC and Turkey. Based on the data availability of the variables (see Table G1 in Appendix G), the period 2006-2014 is considered.

Since the abnormal distribution of residuals usually results from skew distribution in dependent variable (Stock & Watson, 2007), the normality of the dependent variables is considered in order to enhance the validity of the result, and both numeric and graphic displays are as follows. Identity, square root, log and inverse square root all yield distributions that are not significantly different from normal (See Fig. 19). However, log transformation of htx has the smallest chi square and is not significantly non-normal (p=0.193) (see Table 3). Hence, the natural logarithm of dependent variable htx is used. Since the independent variables have different measurement units (see Table G1 in Appendix G), the natural logarithms of all the independent variables will be used except the dummy variables. Descriptive statistics are shown in Table H1 in Appendix H.

Panel data estimation is used in this study, since it can effectively control heterogeneity through allowing for individual-specific variables, provide more degrees of freedom and less collinearity among the variables and be suitable to check dynamic adjustment process (Gujarati, 2004, p. 637; Baltagi, 2005, p. 1-3; Brooks, 2008, p. 488). The panel here is highly balanced.

Table 3 Transformation of htx

Transformation	Formula	Chi2(2)	P(chi2)
cubic	htx^3	10.19	0.006
square	htx^2	8.43	0.015
identity	htx	7.21	0.027
square root	sqrt(htx)	5.09	0.078
log	log(htx)	3.29	0.193
1/(square root)	1/sqrt(htx)	8.45	0.015
inverse	1/htx	12.44	0.002
1/square	1/(htx^2)	15.41	0.000
1/cubic	1/(htx^3)	17.61	0.000

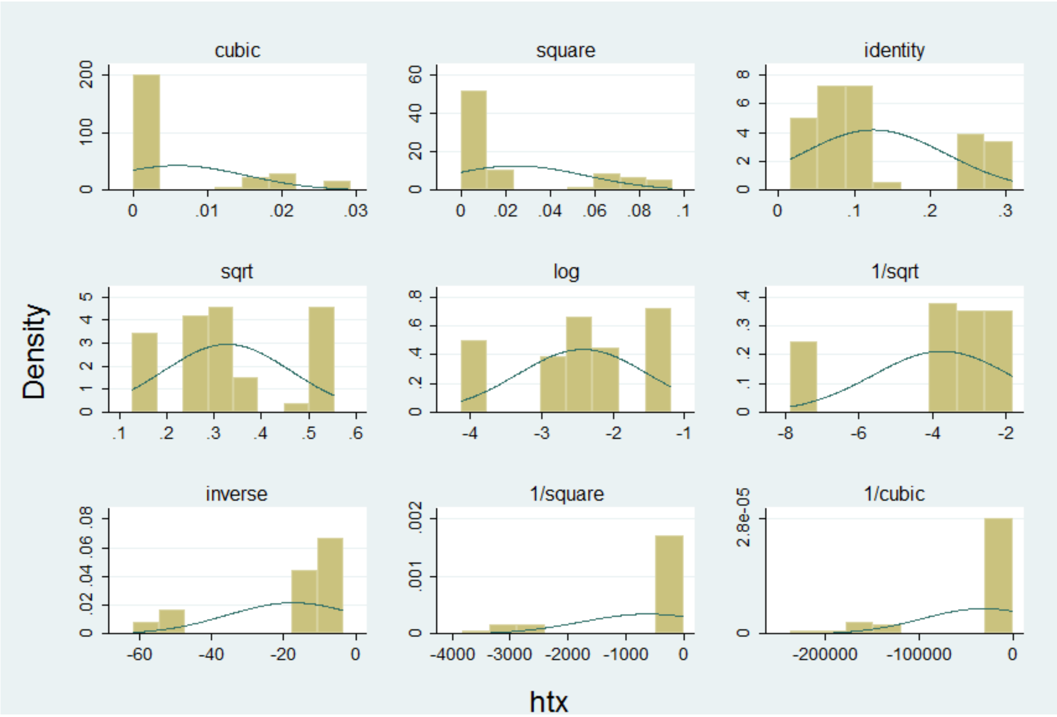


Fig. 19 Graphic display of the distribution of all htx formulas

To avert fallacious regressions and co-integration in regression analysis due to non-stationary variables (Baltagi, 2005, p. 237), the common unit root test Levin, Lin and Chu (LLC) (2002), Im, Pesaran and Shin (IPS) (2003), the augmented Dickey-Fuller-Fisher χ^2 (ADF-Fisher) and the Phillips-Perron-Fisher χ^2 (PP-Fisher) are used to check non-stationarity of all variables (see Table G1 in Appendix G). As a result, the tests indicate that any of the variables do not have a unit root and are stationary or trend stationary in level (see Table H2 in Appendix H).

Stepwise multiple linear regression is applied to five clusters of determinants using STATA 12 (see Table 2; Table H3 in Appendix H). In order to reveal the appropriate panel specification, Hausman test, Robust Hausman test (Colin & Trivedi, 2005), Mundlak approach (Greene, 2012) and robust Hausman test with Driscoll and Kraay standard errors are conducted (Hoechle, 2007) (see Table 4). The Hausman tests for all the models significantly reject the null hypothesis that the individual specific effects are uncorrelated with the regressors. Thus, the fixed effects are chosen in this study. The variance inflation factor (VIF) is also conducted in order to check the multicollinearity of the models. For all the models, the maximum VIF is below the upper limit of ten, which indicates that all the models do not suffer a multicollinearity problem (see Table 4). The modified Wald statistic for groupwise heteroskedasticity (Greene, 2000, p. 598) is employed and the results indicate that heteroskedasticity exists in all of the models (see Table 4). Other important potential problems of using panel data are panel correlation and serial autocorrelation. Breusch-Pagan LM test for cross-sectional dependence (Greene, 2000, p. 601) and Durbin-Watson Autocorrelation test (Shehata & Mickaiel, 2015) are conducted. Except model 1, 3, 14 and 16, all other models suffer the panel correlation problem (see Table 4). Additionally, autocorrelation exists in all models (see Table 4).

Since the panel dataset studied is a long panel ($N=5 < T=9$), regression with Driscoll-Kraay standard errors [xtscc] (Driscoll & Kraay, 1998), linear regression with panel-corrected standard errors [xtpcse] (Greene, 2012) and robust linear regression with a large dummy-variable set [areg] are used. In the xtscc estimation, the Driscoll-Kraay error is "assumed to be heteroskedastic, autocorrelated up to some lag, and possibly correlated between the groups (panels)" (Hoechle, 2007, p. 286), while xtpcse assumes the error is heteroskedastic, autocorrelated in first-order, or cross-sectional correlation. Due to global financial crisis during the period 2007-2008, European sovereign debt crisis in 2010 and Russian financial crises in 2014, the year dummies are taken into consider in the aforementioned estimations.

Table 4 Test of Multicollinearity, Heteroskedasticity, Panel Correlation and Autocorrelation for Empirical Models

	VIF test		Modified Wald test	Hausman test	Breusch-Pagan LM test for cross-sectional dependence	Durbin-Watson Autocorrelation test
	mean VIF	max VIF	Probability	Probability	Probability	
model 1	1.32	1.43	0.0000	0.0000	0.9445	.7431763**
model 2	1.68	2.03	0.0000	0.0000	0.0336	.2013185**
model 3	3.34	5.59	0.0000	0.0000	0.1914	.1998051**
model 4	1.08	1.77	0.0000	0.0000	0.0088	.3084083**
model 5	1.12	1.122	0.0000	0.0090	0.0166	.1574122**
model 6	1.23	1.24	0.0000	0.0037	0.0008	.1409077**
model 7	3.11	4.19	0.0000	0.0003	0.0071	.2743617**
model 8	4.42	6.36	0.0000	0.0001	0.0044	.2380387**
model 9	1.82	2.33	0.0000	0.0000	0.0091	.3719036**
model 10	2.59	4.06	0.0000	0.0000	0.0157	.3266379**
model 11	4.09	7.99	0.0000	0.0000	0.0141	.326974**
model 12	4.06	7.58	0.0000	0.0000	0.0005	.4187085**
model 13	1.76	2.26	0.0001	0.0000	0.0086	1.234722*
model 14	1.68	2.24	0.0000	0.0000	0.6306	1.068086**
model 15	1.61	1.95	0.0000	0.0000	0.0354	1.083253**
model 16	3.99	8.35	0.0000	0.0000	0.3099	1.073293**

5.2 Results of empirical models

Table 5 indicates that the variables of national orientation cluster explain 75.2% of the variance. Trade freedom is negative, but not significant. Besides, except trade openness, labor freedom, political stability and government spending indicators are statistically significant in all the estimation methods. For example, ceteris paribus, a 1% increase in the labor freedom indicator will boost the share of high-tech exports in manufactured exports [HT intensity] by 2.8%.

As for financial market development, except stock market capitalization, gross domestic savings and domestic credit to the private sector by banks significantly affect the high-tech export performance of BRIC and Turkey (See Model 2 in Table 6), which is consistent with the study of Allen and Aldred (2011). However, when domestic credit to the private sector by financial sector is included in the model, domestic credit to the private sector by bank becomes non-significant and domestic credit to the private sector by financial sector is significant at the 5 percent level, and the adjusted R2 of the regression rises from 75.9% to 77.9%. (Model 3 in Table 6) For instance, controlling other variables, a 10% increase in domestic credit to the private sector by financial sector and gross domestic savings as a percentage of GDP is associated with 5.87% and 8.63% increase in the HT intensity of BRIC and Turkey, respectively.

Skilled labor also plays an important role in the export competitiveness of high-tech, such as tertiary graduates, tertiary graduates of science and engineering programs and graduation at doctoral level in order of importance as well as the capability of retaining and attracting talented people (captured by brain drain) (see Table 7). For instance, in model 5, ceteris paribus, a rise in science and engineering graduates by 10% will bring about a 4.62% increase of HT intensity four years later. In model 6, ceteris paribus, a 10% increase in tertiary graduates will boost the HT intensity by 5.94% four years later. Indeed, the tertiary graduates and the brain drain together explain 74.3% of the variance (see model 6 in table 7).

Table 5 Results of Empirical Models for National Orientation Cluster

	model 1		
	xtscc	areg_year	xtpcse
lnlabfre	2.803**	2.857***	2.444***
	(0.650)	(0.419)	(0.508)
polistabi	1.745**	1.999***	1.461***
	(0.371)	(0.294)	(0.292)
lngovspen	1.613**	1.409*	1.146*
	(0.328)	(0.524)	(0.498)
lntradefre	-0.318	-0.563	-0.281
	(0.439)	(0.385)	(0.294)
lnopen	0.706	1.092**	0.598
	(0.462)	(0.395)	(0.418)
year	0.0444**		
	(0.0117)		
2006.year			0
			(.)
2007.year			0.197
			(0.186)
2008.year			-0.0208
			(0.208)
2009.year			0.335
			(0.229)
2010.year			0.476
			(0.247)
2011.year			0.323
			(0.248)
2012.year			0.351
			(0.253)
2013.year			0.439
			(0.252)
2014.year			0.188
			(0.243)
_cons	-106.7**	-15.31***	-14.77***
	(25.25)	(3.428)	(3.195)
F	356.3***	40.67***	
chi2			60.01***
r2	0.786	0.824	0.715
r2_adjusted	0.752	0.750	0.596
rho			.445744241
rss		6.049	4.590
rmse	0.440	0.442	0.385
year effects	14.50**		8.548
N	45	45	45

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 Results of Empirical Models for Financial Market Development Cluster

	model 2	model 3
	xtpcse	xtpcse
lnscapital_gdp	0.412	0.182
	(0.229)	(0.183)
lncrebank_gdp	0.782**	0.159
	(0.239)	(0.369)
lngds	0.816***	0.863**
	(0.238)	(0.279)
lncrefin_gdp		0.587*
		(0.287)
year		
2006.year	0	0
	(.)	(.)
2007.year	-0.163***	-0.0942
	(0.0437)	(0.0754)
2008.year	-0.400***	-0.236
	(0.114)	(0.132)
2009.year	-0.335	-0.118
	(0.225)	(0.211)
2010.year	-0.389*	-0.226
	(0.171)	(0.182)
2011.year	-0.436***	-0.309
	(0.130)	(0.164)
2012.year	-0.533**	-0.343
	(0.190)	(0.199)
2013.year	-0.396*	-0.244
	(0.176)	(0.193)
2014.year	-0.318	-0.195
	(0.166)	(0.196)
_cons	-0.424	-0.812**
	(0.229)	(0.305)
chi2	108.8***	53.72***
r2	0.819	0.839
r2_adjusted	0.759	0.779
rho	.694170534	852321097
rss	1.846	1.013
rmse	0.236	0.178
year effects	586.3***	14.22
N	45	45

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7 Results of Empirical Models for Skilled Labors Cluster

	model 4	model 5	model 6	model 7	model 8
	xtscc	xtpcse	xtpcse	xtpcse	xtpcse
L4.lnphd	0.630***			0.143	0.0555
	(0.0610)			(0.178)	(0.163)
lnbraindrain	2.475**	0.724	0.474	1.147*	0.741
	(0.674)	(0.495)	(0.451)	(0.573)	(0.513)
L4.lnse_grad		0.462***		0.370***	
		(0.0421)		(0.111)	
L4.lntert_grad			0.594***		0.559***
			(0.0548)		(0.136)
year	-0.0345				
	(0.0167)				
2006.year		0	0	0	0
		(.)	(.)	(.)	(.)
2007.year		-0.118***	-0.120***	-0.146***	-0.135***
		(0.0163)	(0.0153)	(0.0296)	(0.0252)
2008.year		-0.222***	-0.242***	-0.265***	-0.265***
		(0.0323)	(0.0304)	(0.0463)	(0.0374)
2009.year		-0.101***	-0.136***	-0.163*	-0.166**
		(0.0300)	(0.0302)	(0.0652)	(0.0513)
2010.year		-0.150***	-0.210***	-0.183***	-0.225***
		(0.0182)	(0.0231)	(0.0386)	(0.0263)
2011.year		-0.272***	-0.360***	-0.322***	-0.380***
		(0.0197)	(0.0279)	(0.0618)	(0.0413)
2012.year		-0.299***	-0.378***	-0.355***	-0.403***
		(0.0292)	(0.0345)	(0.0626)	(0.0438)
2013.year		-0.242***	-0.354***	-0.271***	-0.363***
		(0.0279)	(0.0379)	(0.0540)	(0.0390)
2014.year		-0.193***	-0.331***	-0.237**	-0.343***
		(0.0328)	(0.0437)	(0.0795)	(0.0549)
_cons	57.60	-9.182***	-11.38***	-9.905***	-11.74***
	(33.92)	(0.746)	(0.884)	(0.897)	(0.795)
F	205.4***				
chi2		132.9***	124.8***	176.7***	176.7***
r2	0.688	0.784	0.801	0.757	0.782
r2_adjusted	0.665	0.721	0.743	0.676	0.710
rho		.790303335	.780989895	.700917534	.710947053
rss		1.719	1.629	2.444	2.143
rmse	0.512	0.225	0.219	0.272	0.255
year effects	4.273	122.1***	125.7***	260.1***	196.2***
N	45	45	45	45	45

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The national innovative capacity is another indispensable component for high-tech exports. Model 9 (see Table 8) shows that R&D expenditures by government or business enterprises are highly significantly (at the significance level of 0.001) determinants of HT intensity, supporting the study of Sandu and Ciocanel (2014) and Furman et al (2002). Capacity for innovation of the domestic companies and research collaboration between university and industry can also boost HT intensity at the significance level of 0.05, which support the argument of Sara et al (2012) and Furman et al (2002) respectively. For instance, ceteris paribus, a 10% increase in R&D expenditures by business enterprises (lagged by 1 year) will increase the HT intensity by 8.18% (see model 9 in Table 8). When including innovation outputs indicators such as patent applications and scientific and technical journals (lagged by 2 years) in this study, the GCR indicators University/industry research collaboration and capacity for innovation become non-significant (see model 10 in Table 8), while government R&D expenditures (lagged by 3 years) and innovation output indicators are associated with high-tech performance at the significance level of 0.001. Foreign technology plays an even more important role than the domestic innovative capacity for the success of high-tech exports from BRIC and Turkey, as model 11 and model 12 in Table 8 show. For example, in model 12, ceteris paribus, a 10% increase in the acquisition of intellectual property from abroad (lagged by 3 years) and government R&D expenditures will increase the HT intensity by 5.03% and 3.92% respectively. However, in model 12, the GCR innovation indicators become non-significant and business enterprises R&D expenditures only influence the HT intensity at the significance level of 0.5. The model 12 has a high explanatory power which is more than 96%.

Table 8 Results of Empirical Models for Innovation Cluster

	model 9	model 10	model 11	model 12
	xtscc	xtscc	xtscc	xtscc
L.lnberd	0.818***			0.148*
	(0.0576)			(0.0552)
L3.lngovrd	0.549***	0.708***	0.337***	0.392***
	(0.108)	(0.0939)	(0.0450)	(0.0663)
lnunivindcol	1.973*	1.217	0.909*	0.346
	(0.767)	(0.701)	(0.331)	(0.396)
lninnovcapa	1.246*	0.978	0.954	0.826
	(0.499)	(0.435)	(0.530)	(0.385)
L3.lnroyalpayment			0.655***	0.503***
			(0.0495)	(0.0928)
lnpatent_mil		0.224***	0.00638	
		(0.0232)	(0.0128)	
L2.lnjournal		0.344***		0.146*
		(0.0236)		(0.0437)
year	-0.0685***	-0.0896***	-0.144***	-0.128***
	(0.0132)	(0.0117)	(0.0152)	(0.0128)
_cons	138.5***	174.2***	273.1***	243.8***
	(25.41)	(22.85)	(30.28)	(24.82)
F	1473.0***	8605.9***	2675.2***	19636.4***
r2	0.924	0.944	0.969	0.974
r2_adjusted	0.914	0.935	0.964	0.969
rmse	0.259	0.226	0.168	0.157
year effects	27.14***	58.54***	90.50***	99.62***
N	45	45	45	45

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

With respect to productive capacity, model 13 (see Table 9) confirms that the domestic own productive capacity cannot be overlooked. The manufacturing value added exerts the highest effect on the high-tech export performance in model 13, ceteris paribus, a 10% increase of which will cause a 7.74% increase in HT intensity. The state of cluster development is negative but non-significant (see model 13 in Table 9). However, as model 14 and model 15 indicate, imports of ICT goods and parts and components also significantly affect the high-tech exports from BRIC and Turkey, and the latter has a higher explanatory power than the former according to model 16. In model 16, ceteris paribus, a 10% increase in parts and components import and total export diversification will bring about 4.27% and 20.26% increase in HT intensity, and the model can explain 88% variance.

Table 9 Results of Empirical Models for Productive Capacity Cluster

	model 13	model 14	model 15	model 16
	areg_year	xtscc	xtscc	xtscc
lnmanuva	0.774***			
	(0.0625)			
lnictserv_im	0.720**	0.423*	0.447	0.430
	(0.244)	(0.177)	(0.254)	(0.269)
lncluster	-0.343	0.0538	0.320	0.363
	(0.394)	(0.523)	(0.390)	(0.415)
lnec	-0.168*	-0.248*		
	(0.0695)	(0.0747)		
lnictim		1.223***		0.268
		(0.196)		(0.313)
lnparts			0.522***	0.427***
			(0.0302)	(0.0805)
lnediv			2.356*	2.026*
			(0.921)	(0.656)
year		0.0364*	-0.0449**	-0.0303
		(0.0112)	(0.0119)	(0.0131)
_cons	-21.90***	-72.61*	77.42*	50.51
	(1.780)	(23.01)	(23.41)	(24.44)
F	88.64***	4382.3***	1521.4***	6216.9***
r2	0.900	0.869	0.894	0.896
r2_adjusted	0.862	0.852	0.880	0.880
rss	3.447			
rmse	0.328	0.340	0.306	0.307
year effects		10.62*	14.29**	5.318*
N	45	45	45	45

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3 Integrated models

According to the aforementioned discussion, 5 integrated models are built (see Table H3 in Appendix H), and the data tests as well as the results are given in Table 10 and Table H4 (see Appendix H), respectively. All the Hausman tests are highly significant and support the fixed effects (see Table 10). Except model 17, the maximum of VIF for all other models are less than 10, which means that the models do not suffer the multicollinearity problem. The error of all the models is heteroskedastic, and except model 18 all other models suffer from autocorrelation problem. Moreover, except model 18 and model 20, cross-sectional correlation exists in all other 3 models.

Table 10 Test of Multicollinearity, Heteroskedasticity, Panel Correlation and Autocorrelation for Integrated Models

	VIF test		Modified Wald test	Hausman test	Breusch-Pagan LM test for cross-sectional dependence	Durbin-Watson Autocorrelation test
	mean VIF	max VIF	Probability	Probability	Probability	
model 17	6.79	14.61	0.0000	0.0000	0.0031	.694344**
model 18	4.57	6.39	0.0000	0.0000	0.3062	1.477624
model 19	2.68	4.09	0.0265	0.0000	0.0001	1.079238*
model 20	5.83	7.02	0.0000	0.0000	0.1440	1.095729*
model 21	3.04	5.48	0.0000	0.0000	0.0008	.777207**

The results show that the means for the success of high-tech exports from BRIC and Turkey are diversified. From the perspective of domestic own innovative capacity, model 17 (see Table H4 in Appendix H) indicates that high-tech exports from a country are tied to political stability, ample skilled labor such as doctoral graduates, adequate business R&D expenditure and a higher export diversification. In model 17, while the number of journal publications and ICT service imports are not significant, business R&D expenditures is significant at the 5% level consistent with the studies of Furman et al (2002) and Sandu and Ciocanel (2014), political stability and export concentration are significant at 1%, and the number of doctoral graduates is highly significant at the 0.1% level. For example, ceteris paribus, when the number of doctoral graduates rises by 10%, the HT intensity will grow by 5.09%. The adjusted R2 of model 17 is 94.7%, which reflects that this model can fit and simulate the panel data with satisfaction.

A country can also improve its high-tech exports via ample financial capital (here, i.e. domestic credit provided by financial sector), government R&D expenditures, skilled labor (here, i.e. doctoral graduates) and patent applications as well as enough ICT goods imports (see model 18 in Table H4 of Appendix H). In the model 18 with an explanatory power of 93.8%, while trade freedom and export diversification do not significantly affect the performance of high-tech exports and ICT imports are significant at the 1% level , other variables highly significantly (at the 0.1 % level) boost the high-tech exports. For instance, ceteris paribus, when the government R&D expenditures increase by 10%, the HT intensity will increase by 6.08%, supporting Sandu and Ciocanel' (2014) study. Moreover, the number of patent applications also significantly boosts high-tech exports, which is consistent with Sun et al (2014) but contrast with the conclusion of Alvarez, and Marin (2013).

A country can also enhance its competitiveness of high-tech exports through a higher level of trade freedom, plenty government R&D expenditures, enough researchers in R&D activities (consistent with the study of Alemu (2013) and Vogiatzoglou (2009)) and higher manufacturing value added (consistent with the study of Vogiatzoglou (2009)) (see model 19 in Table H4 in Appendix H). While domestic credit is not significant, all other variables are positive and highly significant at the 0.1% level. For example, ceteris paribus, a 10% increase in government R&D expenditures, manufacturing value added and researchers will boost the HT intensity by 7.23%, 6.07% and 1.4%, respectively. The model 19 can explain more than 97% of the variance.

When taking foreign technology (see model 20 in Table H4 in Appendix H) into consideration, ceteris paribus, a 10% increase in government R&D expenditures, acquisition of intellectual property and total export diversification will boost the high-tech exports by 3.35%, 5.02% and 2.2%, respectively, and all these variables are significant at the 0.1% level. A 10% increase in the number of doctoral graduates can boost the HT intensity by 1.23%, but this variable is significantly significant at the 1% level. Moreover, except patent application and ICT goods imports which are not significant, trade freedom affects the high-tech exports at the significance level of 0.05. This model also can fit the sample data very well with an adjusted R2 of 97.9%.

In model 21 (see Table H4 in Appendix H), except ICT service imports, all other variables are highly significantly significant, and the adjusted R2 is as high as 97.8%. this model indicates that instead of developing their own domestic innovative capacity, BRIC and Turkey can also boost their high-tech exports through absorbing inward FDI, improving labor market flexibility and technology absorptive capacities (captured by ample science and engineering graduates), and purchasing intellectual property from abroad. For example, ceteris paribus, a 10% rise in acquisition of intellectual property (consistent with the study of Alvarez and Marin (2013)), labor freedom, inward FDI (contrast with the study of Alvarez and Marin (2013), but consistent with most of the literature), exports diversification (contrast with the study of Ferragina and Pastore (2007), but consistent with the study of Abedini (2013)) and science and engineering graduates will lead to an increase of HT intensity by 6.59%, 5.94%, 3.55%, 3.54% and 1.37%, respectively.

CHAPTER 6

CONCLUSIONS AND IMPLICATIONS

Merchandise exports of BRIC and Turkey have grown by more than 9% during the period 1996-2014. Nevertheless, except for China, whose share of manufactures exports in merchandise exports increased from 84.11% to 93.83% between 1996 and 2014, the share of manufactures exports showed a decreasing trend for Brazil, India, Russia, Turkey which was 33.31%, 54.93%, 16.23% and 76.88% respectively in 2014. However, the value of manufactures exports has risen by 6.26%, 12.81%, 7.19% and 11.52% during this period for Brazil, India, Russia, and Turkey, respectively. Fuel exports of Russia increased by 13.02% during the period, and it comprised 69.53% of Russian merchandise exports in 2014.

From the view of degree of manufacturing, the total share of high- and medium-skill manufactures exports in total manufactures exports from BRIC and Turkey has increased up to 63.25%, 59.85%, 57.1%, 65.24% and 51.15% respectively in 2014. From the view of technology intensity, although the low-tech sectors still account for the largest part in China, India and Turkey (the share of low-tech sectors was 35.11%, 42.52% and 46.77% for China, India and Turkey, respectively), the total share of high- and medium-tech sectors in manufactured exports has risen up to 58.92%, 46.17% and 46.14%, respectively. High- and medium-tech sectors in Brazil and the Russian Federation constitute a huge share of manufactured exports between1996 and 2014, which has increased during the period up to 67.2% and 60.26% by 2014 for Brazil and Russia, respectively. Moreover, high-skill, medium-skill, high-tech and medium-tech sectors have grown at the highest CAGR during 1996-2014.

In the manufactured exports, between 2002 and 2014, the exports of high-tech products have increased by 4.06%, 6.09%, 18.52%, 20.48% and 13.83% for BRIC and Turkey, respectively. Except for Brazil, the share of high-tech exports in manufactured exports has increased during the period. China has surpassed the United States and became the largest high-tech exporter in the world. China’s high-tech exports accounted for 22.6% of the world total high-tech exports in 2014, which was 0.30%, 0.63%, 0.35% and 0.09% for Brazil, India, the Russian Federation and Turkey, respectively.

Capital goods comprise the largest part of manufactured exports for all the countries, although this share has declined in recent years. Aerospace has dominated the high-tech exports of Brazil, the share of which grew from 50.97% in 2002 to 60.92% in 2014. The main exports of high-tech products from China are electronics and computers, together comprising more than 84% of high-tech exports in 2014. The largest part of high-tech exports from India are occupied by chemistry and pharmacy products which together account for 45.62% of the total high-tech exports. As for the Russian Federation, the dominant high-tech sectors are aerospace and non-electrical machinery, the share of which together was 57.23% in 2013 and dropped to 44.75% in 2014. In contrast with BRIC, Turkey’s high-tech exports seem more diverse, and the share of main high-tech products, aerospace and electronics together, has declined to 37.67% in 2014, while the share of armament, chemistry, non-electrical machinery and scientific instruments have shown an increase trend during 2002-2014.

Brazil has a relatively higher comparative advantage in exports of aerospace (average RCA=2.23 during 2002-2014), armament (average RCA=1.95) and chemistry (average RCA=1.16). China's areas of specialization are in exports of computers (average RCA=3.5), electronics, electrical machinery, chemistry and scientific instruments. While India's strength in exports of chemistry (average RCA=3.02) is immediately apparent, Turkey has specialized in exports of armament and the RCA increased up to 2.57 in 2014. The Russian Federation has relatively specialized in exports of armament and non-electrical machinery. Brazil accounted for more than 2.64% and 2.45% in world total exports of aerospace and armament in 2014, while Turkey and Russian Federation comprised 2.14% and 1.6% in world total armament exports. While India exported 5.56% of world total chemistry products, it was China that exported the most products of chemistry, computers, electrical machinery, electronics and scientific instruments in the world in 2014, the world share of which was 16.55%, 41.21%, 20.61%, 25.69% and 15.1% respectively.

The surge of high-tech exports from developing countries, especially from China, has been questioned by many scholars since 2000. The high-tech exports of China are highly correlated with imports of parts and components (the correlation coefficient is 0.7114) and imports of capital goods (the correlation coefficient is 0.7554). Foreign invested enterprises accounted for the largest part of China's high-tech exports, which was 73.8% in 2014, and wholly foreign firms alone exported 56.3% of China's total high-tech products. Meanwhile, the processing exports dominate the China's high-tech exports, the share of which was 66.5% in 2014. More than 60% of the high-tech exports were processed with imported parts and components during 2002-2014. However, in 2014 total R&D expenditures in China were $368.6 billion whose ratio in GDP was 2.04%, and became the second largest R&D investor following the United States. MNEs also tend to build R&D centers in China, the number of which rose significantly from around 700 in 2004 to more than 1300 in 2013. With respect to innovation output indicators, patent granted by the USPTO and EPO, patent application under the PCT as well as scientific and technical journals have dramatically increased during 2002-2014. Therefore, it is not surprising to question whether the success of high-tech exports from China before 2014 is real or just a "statistical illusion".

In this thesis, in order to analyze the determinants of high-tech exports from BRIC and Turkey during 2006-2014, the independent variables have been categorized into 5 groups to generate 16 models. They are national orientation (model 1), financial market development (model 2 and model 3), skilled labors (model 4, model 5, model 6, model 7 and model 8), innovation (model 9, model 10, model 11 and model 12) and productive capacity (model 13, model 14, model 15 and model 16). The 16 models are conducted with a multiple linear regression estimated by xtscc, PCSEs and robust linear regression with year dummies. The results indicate that innovation indicator has the highest explanatory power, followed by productive capacity, financial market development, national orientation and skilled labors. This finding is consistent with the study of Porter et al. (2008a).

Ultimately, 5 integrated models are constructed based on the 16 empirical models aforementioned. The results indicate that the paths to the success of high-tech exports from BRIC and Turkey are not unique. From the perspective of domestic own innovative capacity, a country can improve its development of high-tech exports through political stability, ample skilled labors such as doctoral graduates, adequate business R&D expenditure and a higher export diversification; or through ample financial capital (i.e. domestic credit provided by financial sector), government R&D expenditures, a huge pool of skilled labors (i.e. doctoral graduates) and a great deal of patent application as well as enough ICT goods imports; or through higher trade freedom, plenty government R&D expenditures, enough researchers in R&D activities and higher manufacturing value added. When taking foreign technology into consideration, a country can enhance its competitiveness of high-tech exports via higher trade freedom, adequate government R&D expenditures, ample doctoral graduates, acquisition of intellectual property from abroad and lower export concentration; or via higher labor freedom, a huge pool of science and engineering graduates, ample inward FDI, acquisition of intellectual property from abroad and higher export diversification. One point to which we must pay attention is that the skilled labor variables (i.e. doctoral graduates and science and engineering graduates), human capital (here, i.e. researchers in R&D activities), government R&D expenditures are all highly significant and positive in all the models, and some of them even exert the highest effect on high-tech exports in some models, such as doctoral graduates in model 17 and government R&D expenditures in model 18 and model 19. All of the integrated models have a very high explanatory power whose adjusted R2 is more than 93%.

All in all, domestic innovative capacity does play an important role in the success of high-tech exports from BRIC and Turkey, although inward FDI and foreign technology acquisition with trade freedom, science and engineering graduates and export diversification can explain 97.8% of the variance. In order to improve high-tech exports, besides attracting FDI inflows and acquiring foreign technology, all the five countries should build a favorable economic environment, especially with regard to labor freedom, political stability and trade freedom. Strengthening education to enlarge the pool of skilled labors and thus improving the pool of human capital for R&D activities, and increase R&D expenditures (government or business enterprises) and diversify the exports basket are the most important policies to be followed.

CHAPTER 7

CONTRIBUTIONS AND LIMITATIONS

We included labor freedom, trade freedom and political stability-sub indicators of Index of Economic Freedom from different institutions or organizations, which were tested to have the most effect on high-tech exports. Instead of enrollment, we took into account tertiary graduates of science and engineering programs, graduates at doctoral level in order to measure skilled labor indicators. In order to capture the financial market development, domestic credit to private sectors by financial sectors was considered, which has not yet been used in the literature. In addition, similar to Srholec (2007), we also included import of high-tech components and parts. These measures are all reported significantly and positively associations with high-tech exports.

As for limitation, since the structure of high-tech exports is so different among the BRIC and Turkey, panel data estimation with random-coefficients is preferable to estimator with fixed coefficients. However, due to the data availability, the period investigated was limited between 2006 and 2014, and the observation numbers were relatively small. Thus, we could not obtain desirable results from Swamy (1970) random-coefficients model and seemingly unrelated regression model, and had to choose the estimation methods with fixed estimation though expected results were obtained.

Another potential limitation is that inward FDI, human capital variables and innovation variables at sectoral level are not available for BRIC. In the future study, instead of the aggregate value, high-tech exports at sectoral level can be investigated to further understand the development of high-tech exports from BRIC and Turkey.

APPENDIX A

OECD HIGH-TECHNOLOGY PRODUCTS LIST (SITC REV.3)

1. Aerospace

792 = Aircraft and associated equipment, excluding 7928, 79295, 79297

714 = Airplane motors, excluding 71489, 71499

87411 = Other navigational instruments

2. Computers - office machines

75113 = Word-processing machines

7513 = Photo-copying apparatus excluding 75133, 75135

752 = Computers: excluding 7529

75997 = Parts and accessories of group 752

3. Electronics - telecommunications

76381 = Video apparatus

76383 = Other sound reproducing equipment

764 = Telecommunications equipment, excluding 76493, 76499

7722 = Printed circuits

77261 = Electrical boards and consoles 1000V

77318 =Optical fiber cables

77625 =Microwave tubes

77627 =Other valves and tubes

7763 = semiconductor devices

7764 = Electronic integrated circuits and microassemblies

7768 =Piezo-electric crystals

89879 =Numeric recording stays

4. Pharmacy

5413 = Antibiotics

5415 = Hormones and their derivatives

5416 = Glycosides, glands, antisera, vaccines

5421 = Medicaments containing antibiotics or derivatives thereof

5422 = Medicaments containing hormones or other products of heading 5415

5. Scientific instruments

774 = Electro-diagnostic apparatuses for medicine or surgery and radiological apparatuses

871 = Optical instruments and apparatuses

87211 = Dental drill engines

874 = Measuring instruments and apparatuses excluding 87411, 8742

88111 = Photographic cameras

88121 = Cinematographic cameras

88411 = Contact lenses

88419 = Optical fibers other than those of heading 7731

8996 = Orthopedic appliances excluding 89965, 89969

6. Electrical machinery

7786 = Electrical capacitors, fixed, variable or adjustable excluding 77861, 77866, 77869

7787 = Electrical machines having individual functions

77884 = Electric sound or visual signaling apparatus

7. Non-electrical machinery

71489 = Other gas turbines

71499 = Part of gas turbines

7187 = Nuclear reactors and parts thereof, fuel elements etc..

72847 = Machinery and apparatus for isotopic separation

7311 = Machine-tools working by laser or other light or photon beam, ultrasonic electro-discharge or electro-chemical processes

7313 = Lathes for removing metal, excluding 73137, 73139

73153 = Other milling machines, numerically controlled

7316 = Machine-tools for deburring, sharpening, grinding, lapping, etc., excluding 73162, 73166, 73167, 73169

73312 = Bending, folding, straightening or flattening machines, numerically controlled

73314 = Shearing machines, numerically controlled

73316 = Punching machines, numerically controlled

7359 = Parts and accessories of 731- and 733-

73733 = Machines and apparatuses for resistance welding of metal fully or partly automatic

73735 = Machines and apparatuses fir arc, including plasma arc welding of metal; fully or partly automatic

8. Chemistry

52222 = Selenium, tellurium, phosphorus, arsenic and boron

52223 = Silicon

52229 = Calcium, strontium and barium

52269 = Other inorganic bases

525 = Radioactive materials

531 = Synthetic organic coloring matter and color lakes

57433 = Polyethylene terephthalase

591 = Insecticides, disinfectants

9. Armament

891 = Arms and ammunition

APPENDIX B

HIGH-TECHNOLOGY MANUFACTURES ACCORDING TO LALL'S (2000) TECHNOLOGICAL CLASSIFICATION (SITC 3, REV. 2)

HT1: Electronic and electrical products

716 Rotating electric plant

718 Other power-generating machinery

751 Office machines

752 Automatic data PROC EQUIP

759 Parts and accessories suitable for use solely or principally with office machines and automatic data-processing machines

761 Television receivers

764 Telecommunications equipment, n.e.s., and parts, n.e.s., and accessories of apparatus falling within division 76

771 Electric power MACHY NES

774 ELECTRO-MEDCL, XRAY EQUIP

776 Transistors, valves, etc.

778 Electrical machinery NES

HT2: Other

524 Radioactive etc material

541 Medicinal and pharmaceutical products

712 Steam engines, turbines

792 Aircraft, etc.

871 Optical instruments

874 Measuring, controlling instruments

881 Photo apparatuses, EQUIPT NES

Note: Excludes ‘special transactions’ like electric current, cinema film, printed matter, special transactions, gold, works of art, coins, pets.

APPENDIX C

NAICS CODES THAT CONSITITUTE HIGH-TECHNOLOGY INDUSTRIES

2002 NAICS code	2007 NAICS code	Industry
1131	1131	Timber track operations
1132	1132	Forest nurseries and gathering of forest products
2111	2111	Oil and gas extraction
2211	2211	Electric power generation, transmission, and distribution
3241	3241	Petroleum and coal products manufacturing
3251	3251	Basic chemical manufacturing
3252	3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing
3253	3253	Pesticide, fertilizer, and other agricultural chemical manufacturing
3254	3254	Pharmaceutical and medicine manufacturing
3255	3255	Paint, coating, and adhesive manufacturing
3259	3259	Other chemical product and preparation manufacturing
3332	3332	Industrial machinery manufacturing
3333	3333	Commercial and service industry machinery manufacturing
3336	3336	Engine, turbine, and power transmission equipment manufacturing
3339	3339	Other general purpose machinery manufacturing
3341	3341	Computer and peripheral equipment manufacturing
3342	3342	Communications equipment manufacturing
3343	3343	Audio and video equipment manufacturing
3344	3344	Semiconductor and other electronic

		component manufacturing
3345	3345	Navigational, measuring, electromedical, and control instruments manufacturing
3346	3346	Manufacturing and reproducing magnetic and optical media
3353	3353	Electrical equipment manufacturing
3364	3364	Aerospace product and parts manufacturing
3369	3369	Other transportation equipment manufacturing
4234	4234	Professional and commercial equipment and supplies, merchant wholesalers
4861	4861	Pipeline transportation of crude oil
4862	4862	Pipeline transportation of natural gas
4869	4869	Other pipeline transportation
5112	5112	Software publishers
5161	na	Internet publishing and broadcasting
na	519130	Internet publishing and broadcasting and Web search portals
5171	5171	Wired telecommunications carriers
5172	5172	Wireless telecommunications carriers (except satellite)
5173	na	Telecommunications resellers
5174	5174	Satellite telecommunications
5179	5179	Other telecommunications
5181	na	Internet service providers and Web search portals
5182	5182	Data processing, hosting, and related services
5211	5211	Monetary authorities, central bank
5232	5232	Securities and commodity exchanges
5413	5413	Architectural, engineering, and related services
5415	5415	Computer systems design and related services
5416	5416	Management, scientific, and technical consulting services
5417	5417	Scientific research and development services

5511	5611	Management of companies and enterprises
5612	5612	Facilities support services
na	561312	Executive search services
8112	8112	Electronic and precision equipment repair and maintenance

NOTES: na = not applicable. Data on high-tech industries for 2008 and earlier years were compiled using the 2002 NAICS codes. Data for 2009 and 2010 were compiled using the 2007 NAICS codes.

APPENDIX D

EXPORT DATA

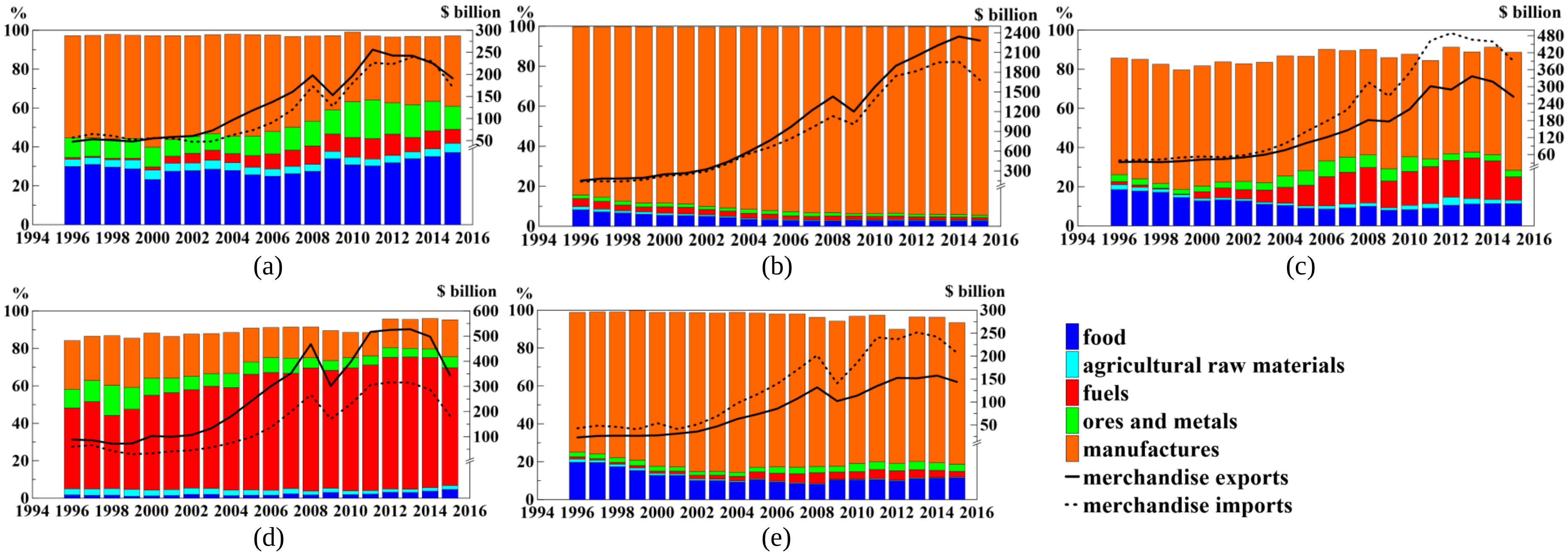


Fig. D1 Merchandise exports by product group: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: UNCTAD, data center

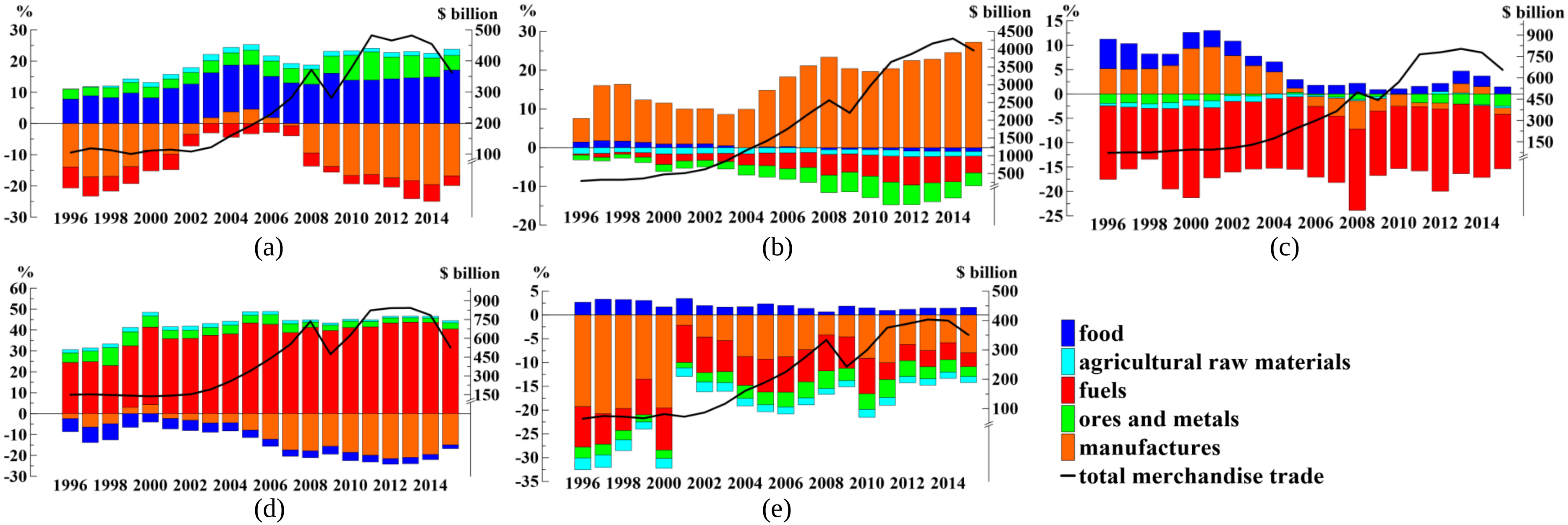


Fig. D2 Merchandise trade balance by product group as a % of total merchandise trade: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: UNCTAD data center, 2016

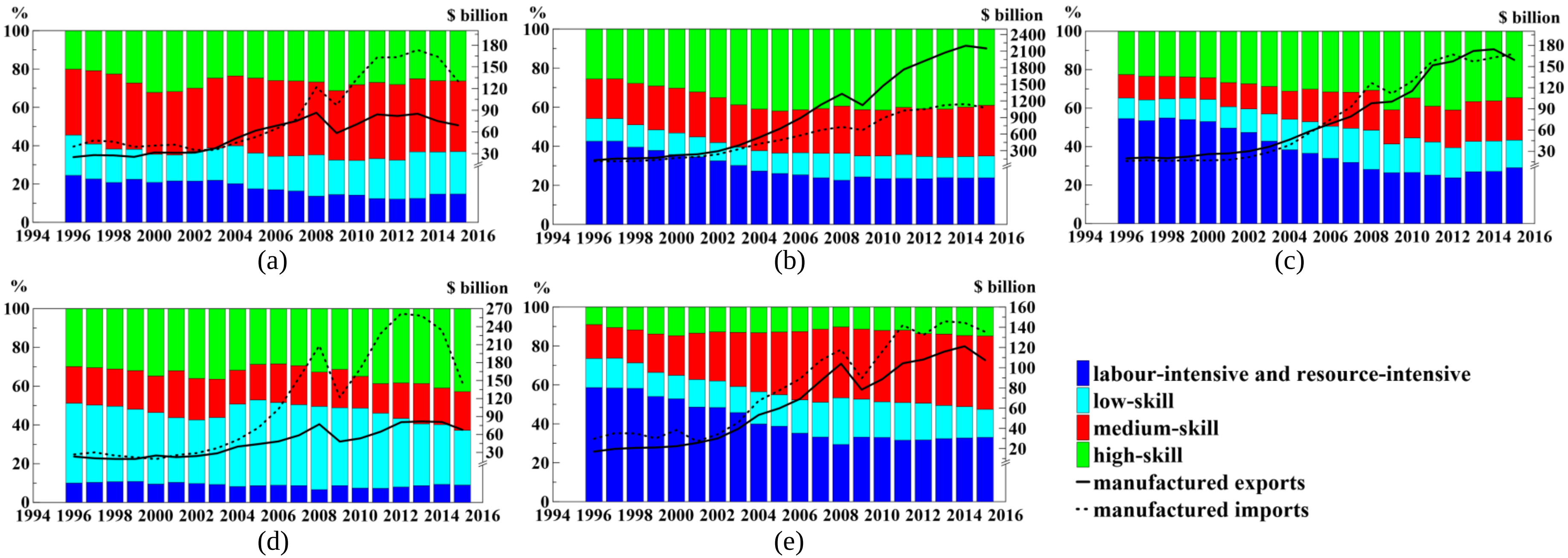


Fig. D3 Manufactures exports by degree of manufacturing groupings: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: UNCTAD

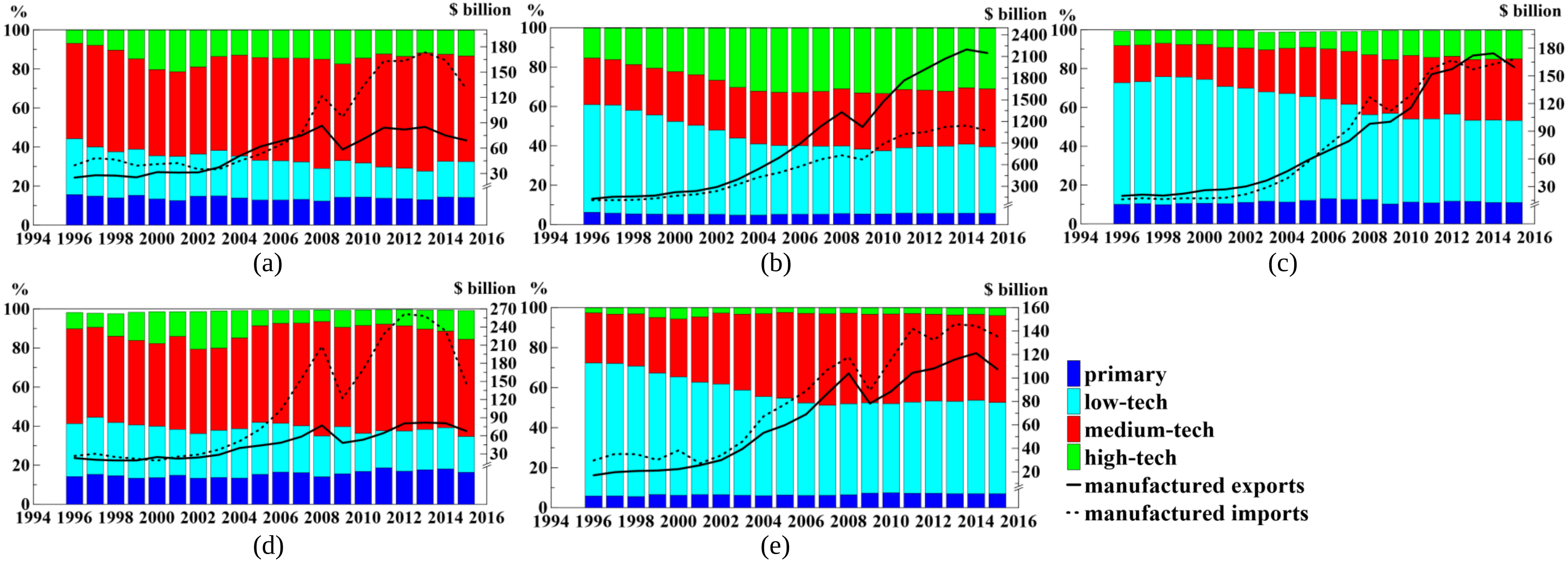


Fig. D4 Manufactures exports by technology intensity: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: United Nations, Comtrade database, own calculation

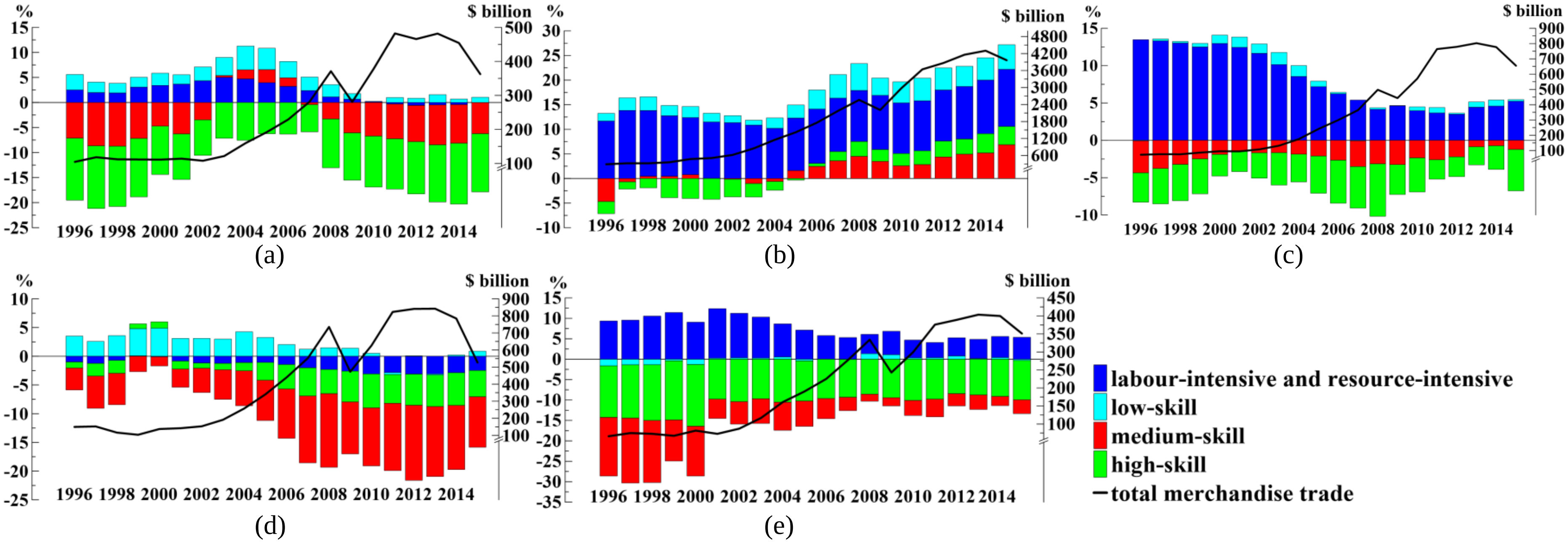


Fig. D5 Manufactures trade balance by degree of manufacturing groupings as a % of total merchandise trade: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey

Source: UNCTAD

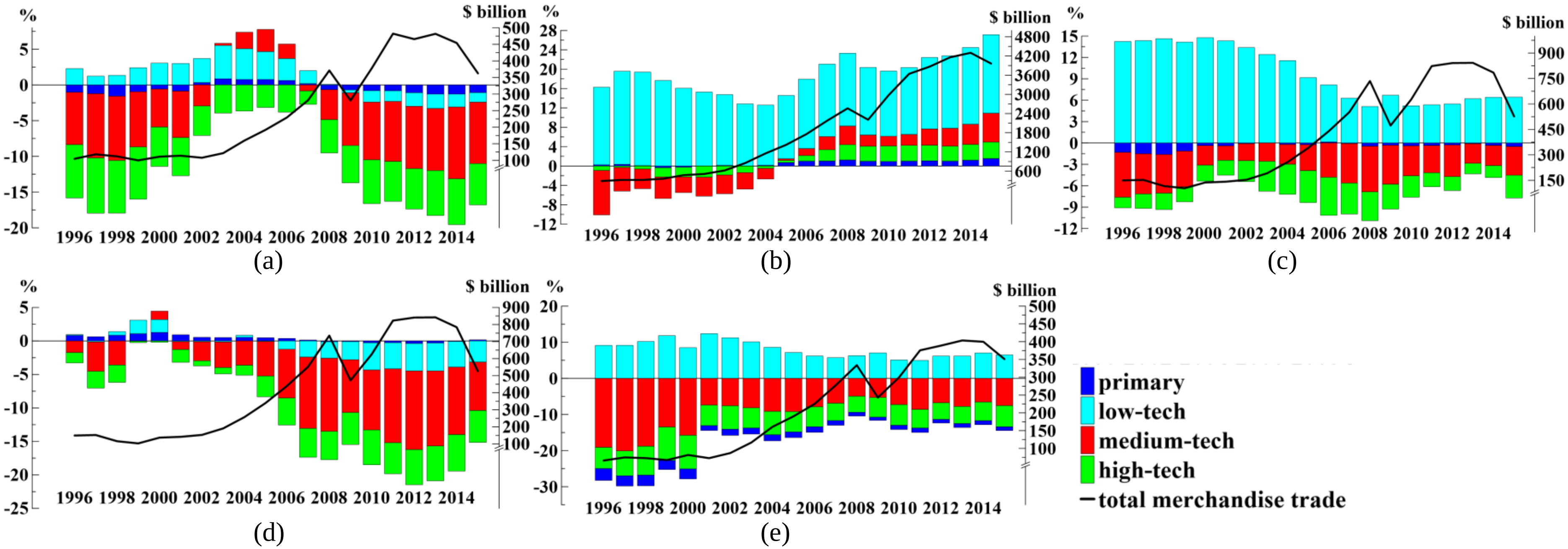


Fig. D6 Manufactures trade balance by technology intensity as a % of total merchandise trade: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: United Nations, Comtrade database, own calculation

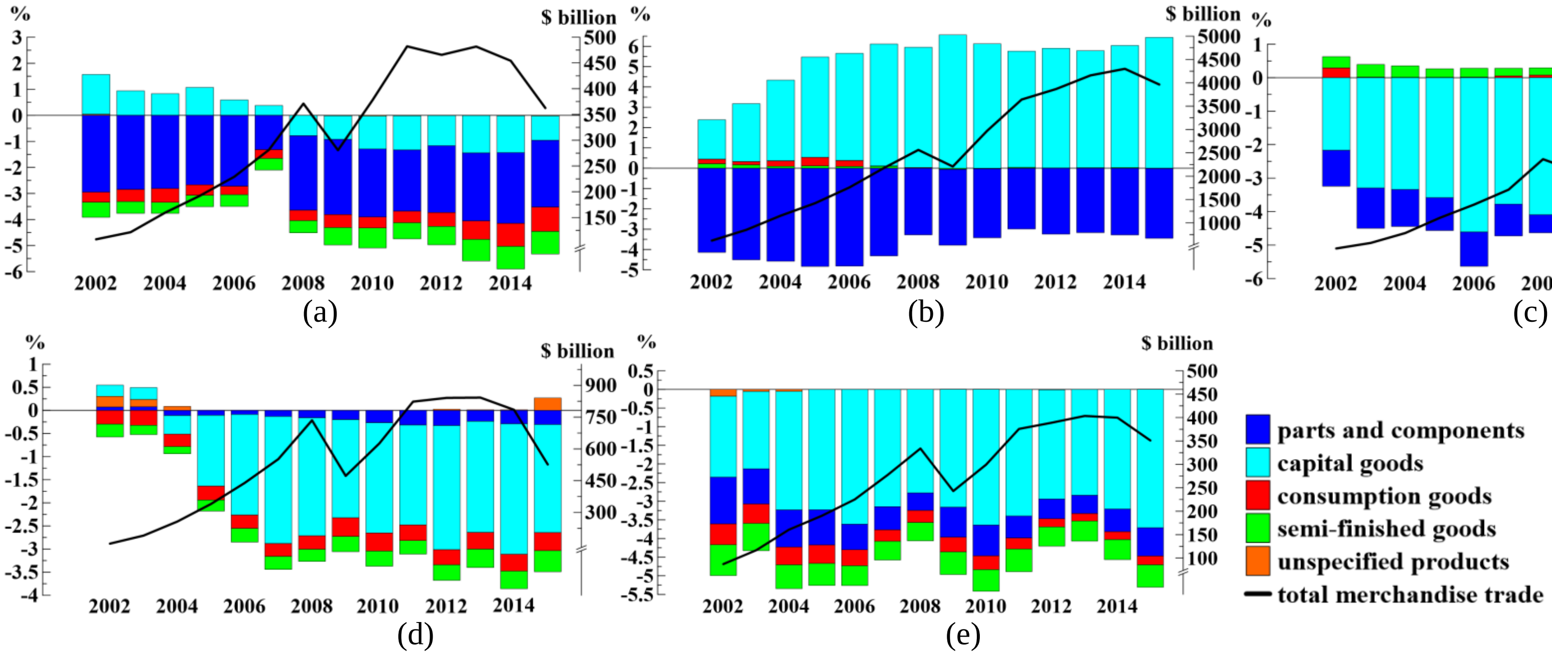


Fig. D7 High-tech trade balance by production stage as a % of total merchandise trade: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey

Source: United Nations, Comtrade database, own calculation

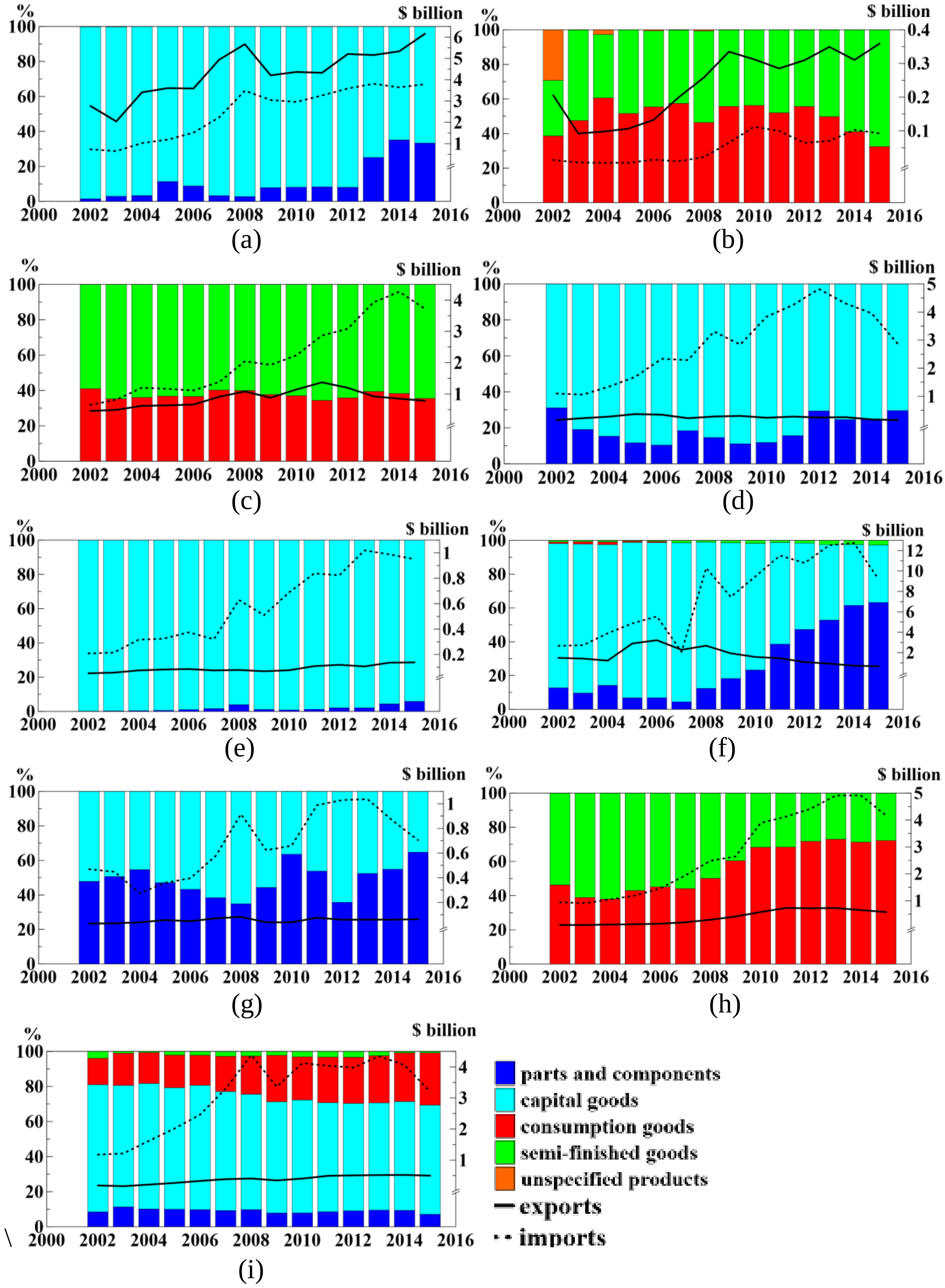
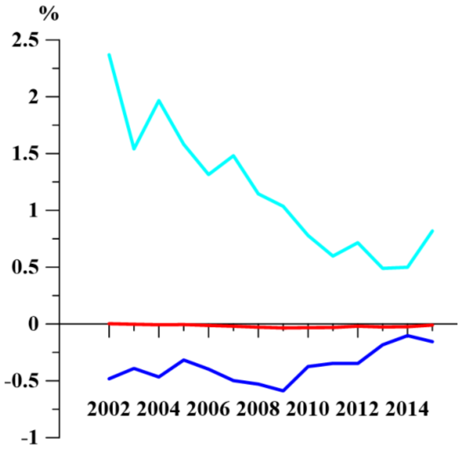
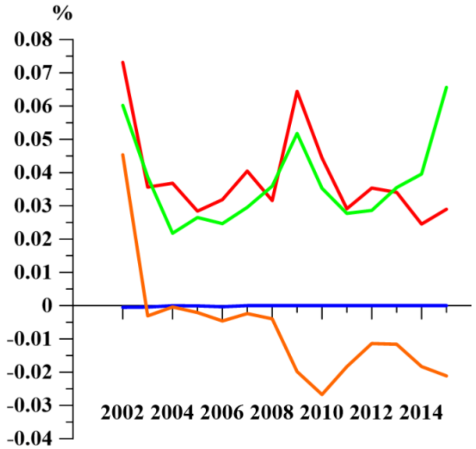


Fig. D8 The exports of Brazil's high-tech sectors by production stage: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

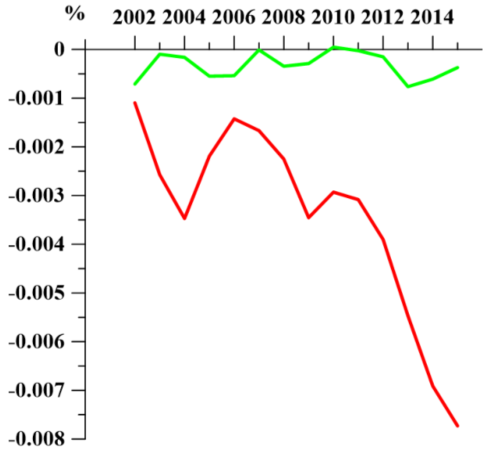
Source: United Nations, Comtrade database, own calculation


%
2.5
2
1.5
1
0.5
0
-0.5
-1
2002 2004 2006 2008 2010 2012 2014

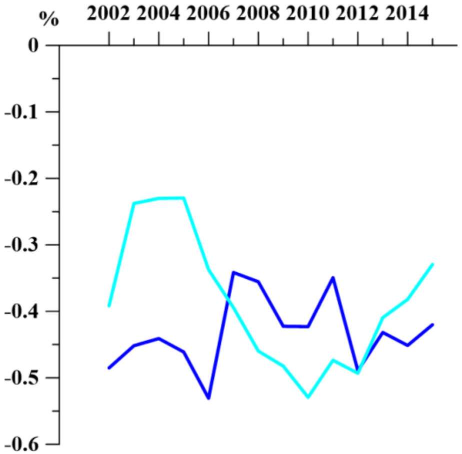
(a)


%
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
2002 2004 2006 2008 2010 2012 2014

(b)


%
2002 2004 2006 2008 2010 2012 2014
0
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
-0.007
-0.008

(c)


%
2002 2004 2006 2008 2010 2012 2014
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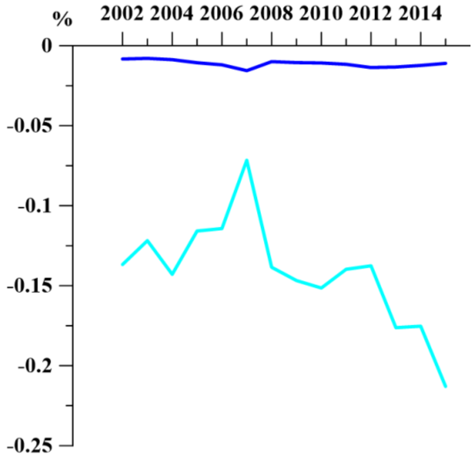
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6

(d)


%
2002 2004 2006 2008 2010 2012 2014
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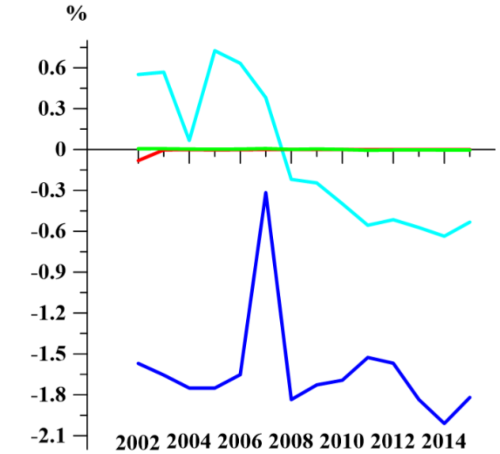
-0.05
-0.1
-0.15
-0.2
-0.25

(e)


%
0.6
0.3
0
-0.3
-0.6
-0.9
-1.2
-1.5
-1.8
-2.1
2002 2004 2006 2008 2010 2012 2014

(f)

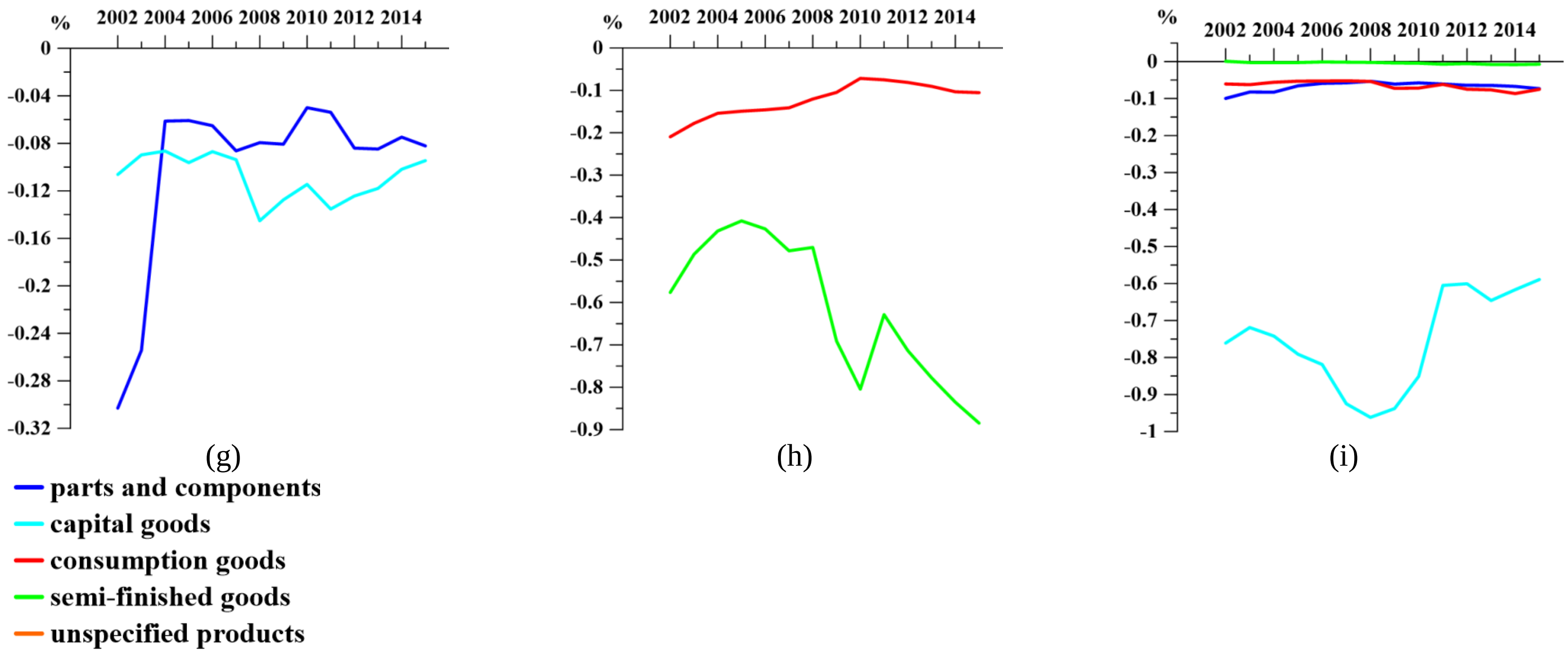


Fig. D9 The trade balance of Brazil's high-tech sectors by production stage as a % of total merchandise trade: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation

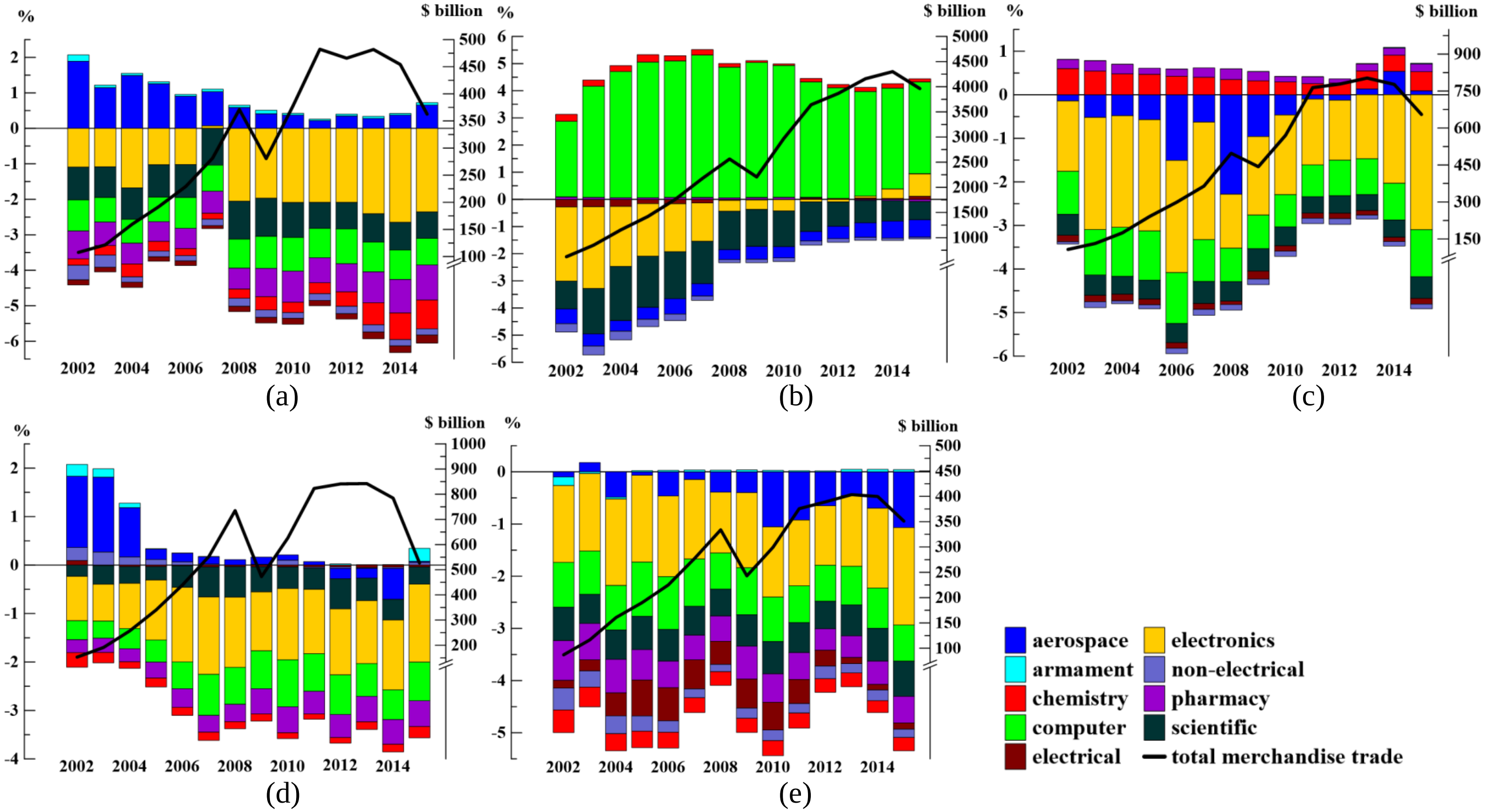


Fig. D10 The trade balance of high-tech sectors as a % of total merchandise trade: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey

Source: United Nations, Comtrade database, own calculation

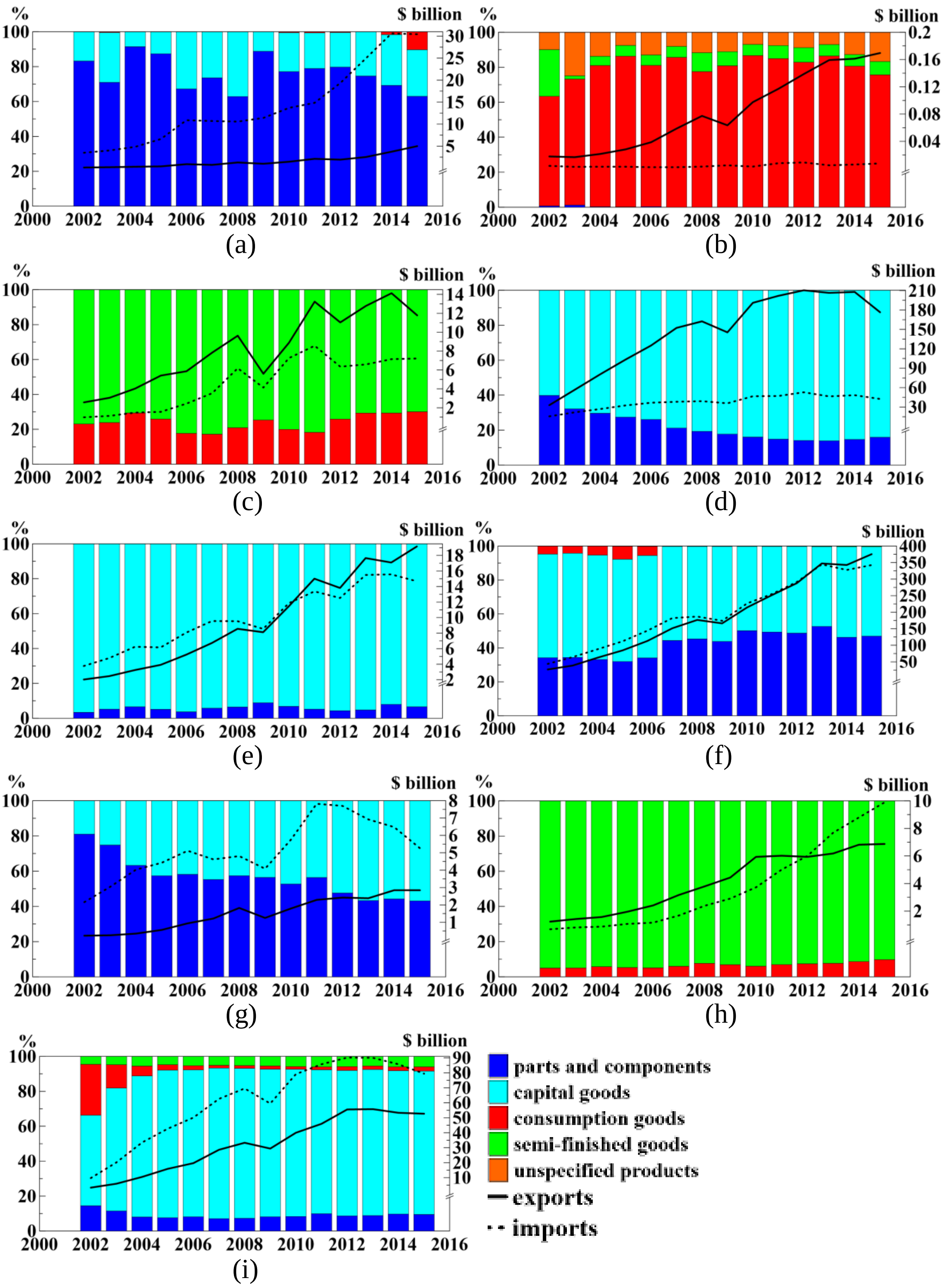
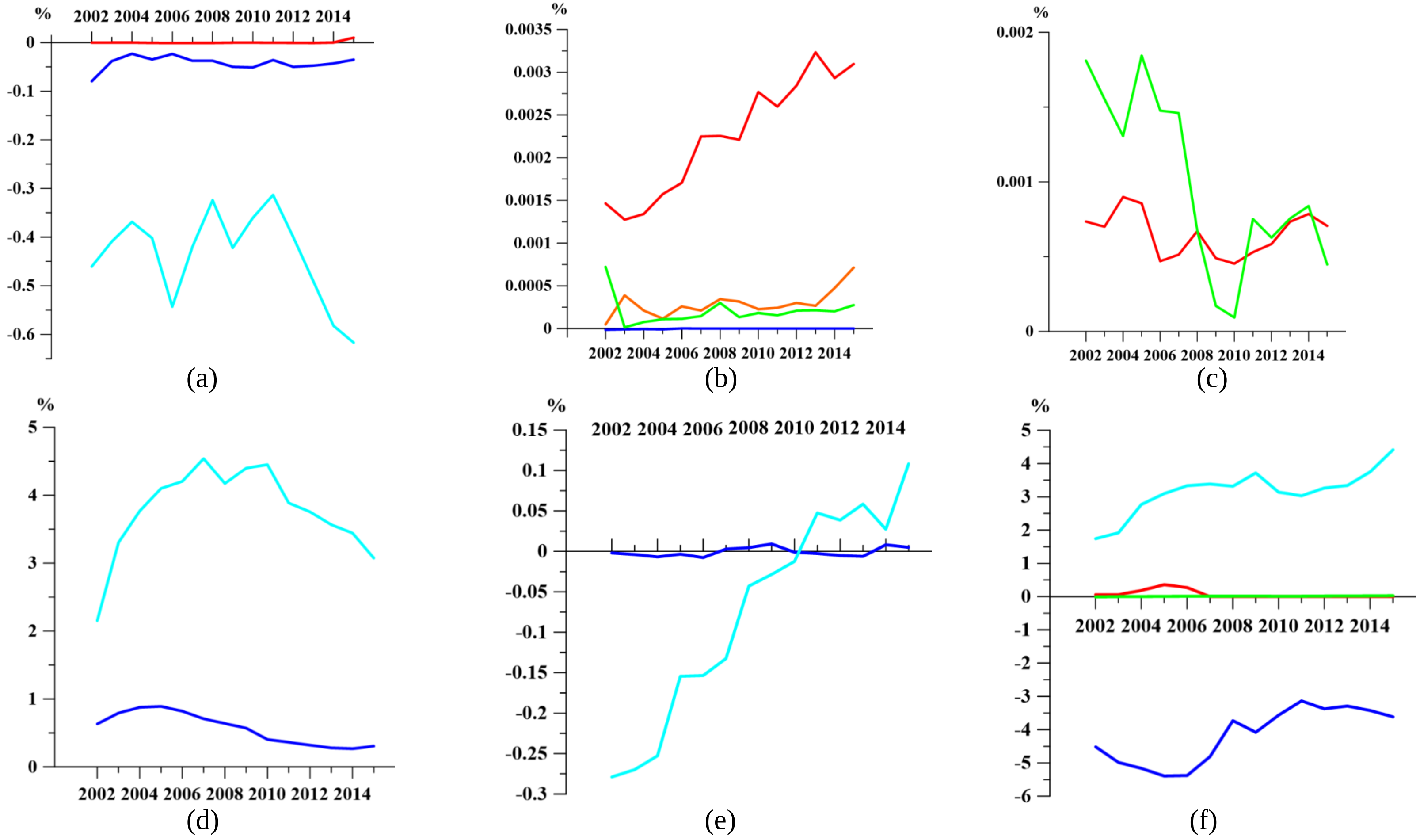


Fig. D11 The exports of China's high-tech sectors by production stage: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation



%
2002 2004 2006 2008 2010 2012 2014
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
(a)
%
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2002 2004 2006 2008 2010 2012 2014
(b)
%
0.002
0.001
0
2002 2004 2006 2008 2010 2012 2014
(c)
%
5
4
3
2
1
0
2002 2004 2006 2008 2010 2012 2014
(d)
%
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
2002 2004 2006 2008 2010 2012 2014
(e)
%
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
2002 2004 2006 2008 2010 2012 2014
(f)

Fig. D12 The trade balance of China's high-tech sectors by production stage as a % of total merchandise trade: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation

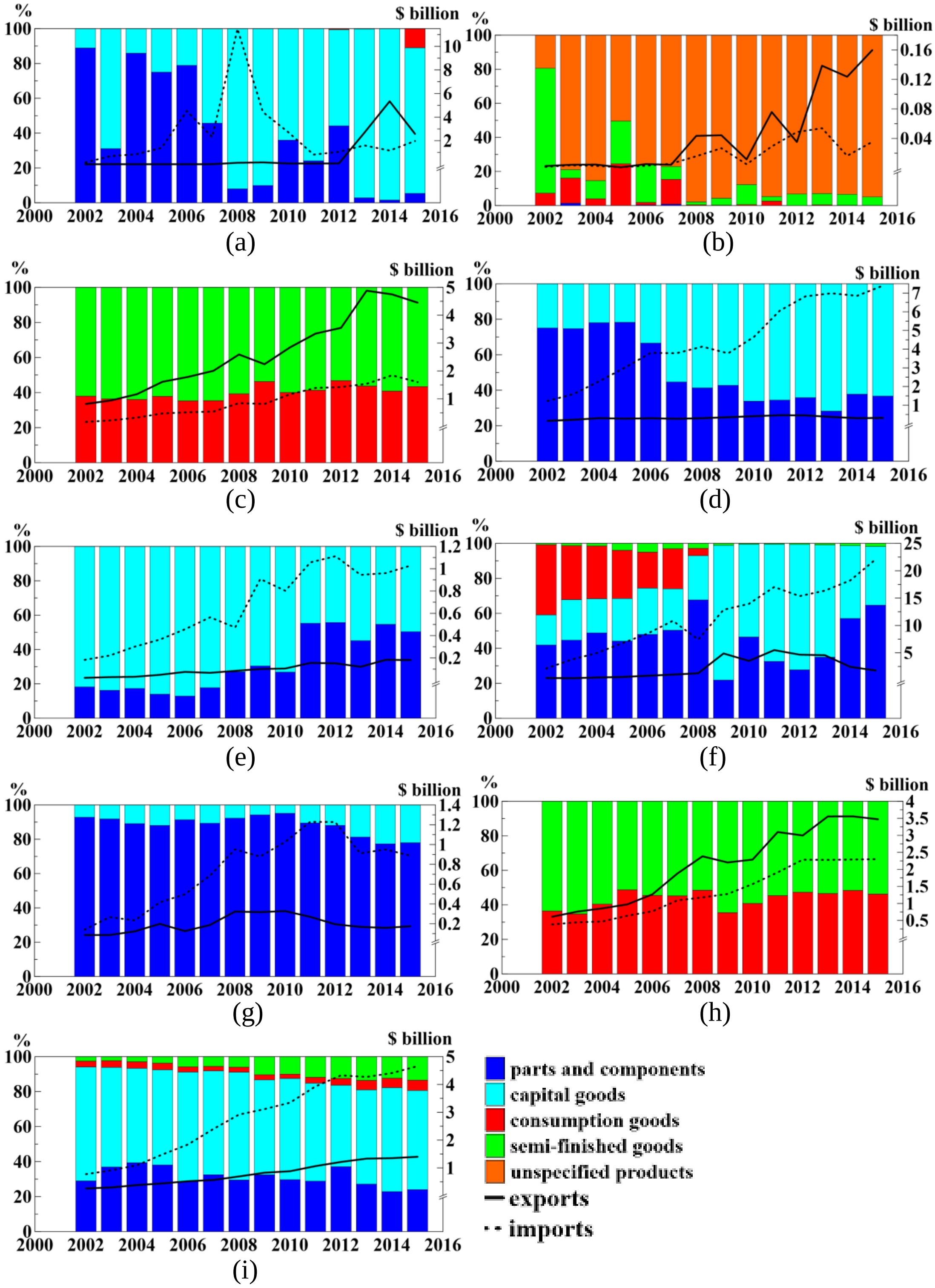
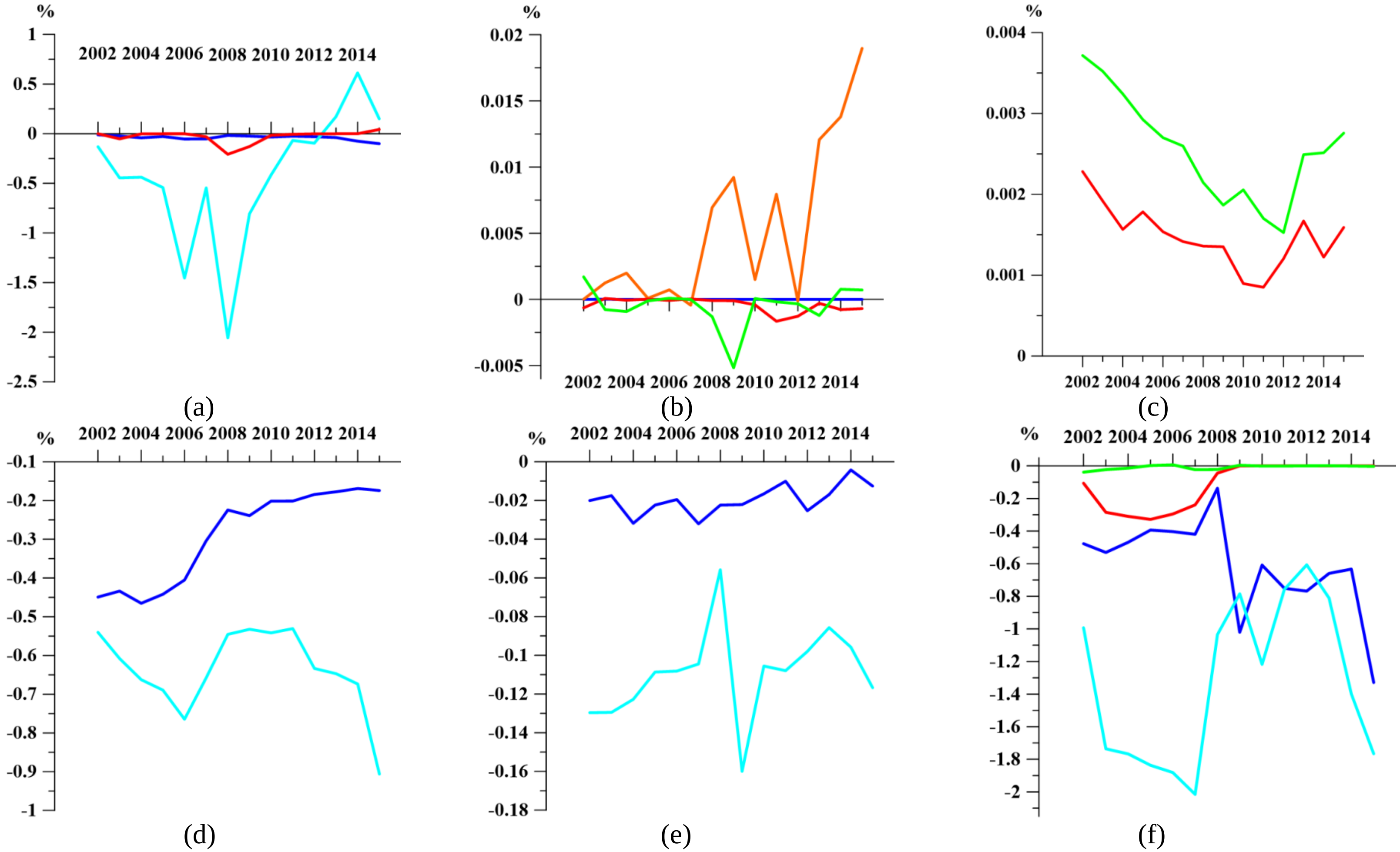


Fig. D13 The exports of India's high-tech sectors by production stage: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation


%
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
2002 2004 2006 2008 2010 2012 2014
(a)
%
0.02
0.015
0.01
0.005
0
-0.005
2002 2004 2006 2008 2010 2012 2014
(b)
%
0.004
0.003
0.002
0.001
0
2002 2004 2006 2008 2010 2012 2014
(c)
%
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
2002 2004 2006 2008 2010 2012 2014
(d)
%
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
2002 2004 2006 2008 2010 2012 2014
(e)
%
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
2002 2004 2006 2008 2010 2012 2014
(f)

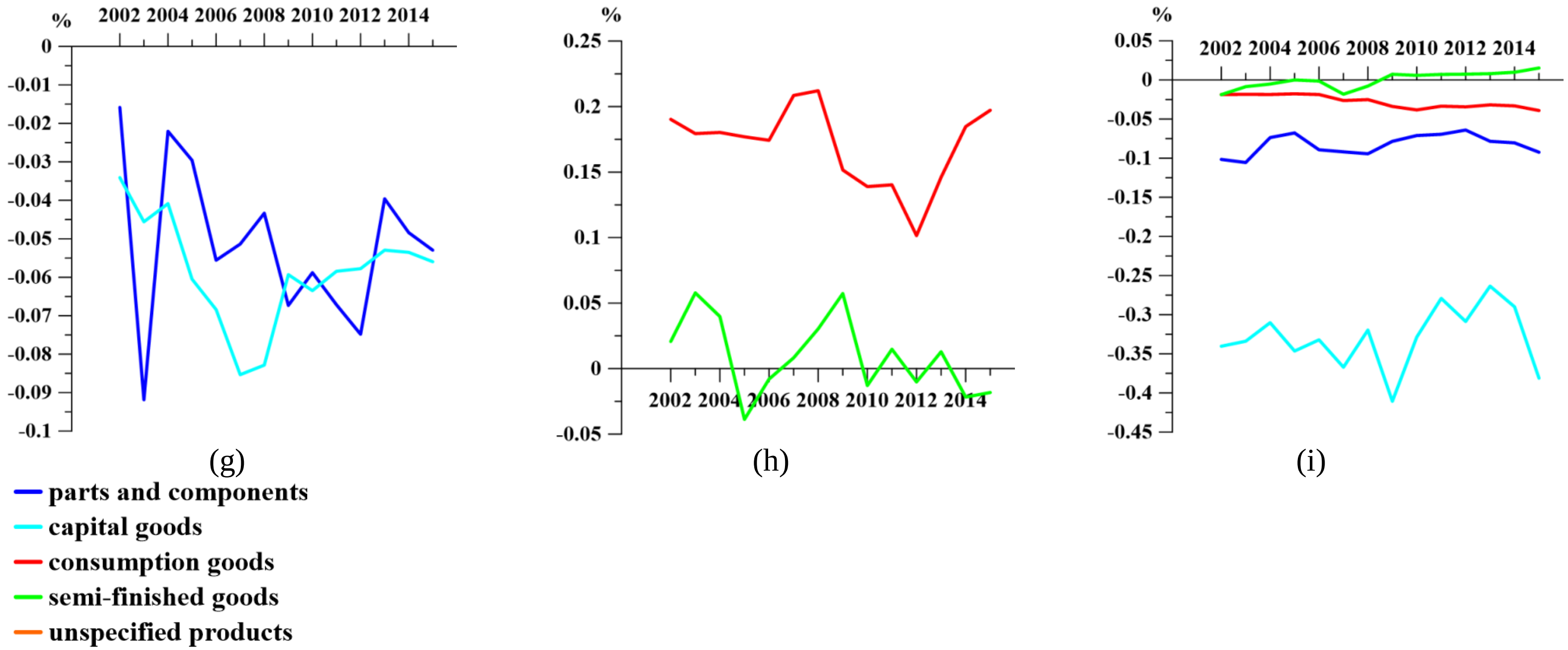


Fig. D14 The trade balance of India's high-tech sectors by production stage as a % of total merchandise trade: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation

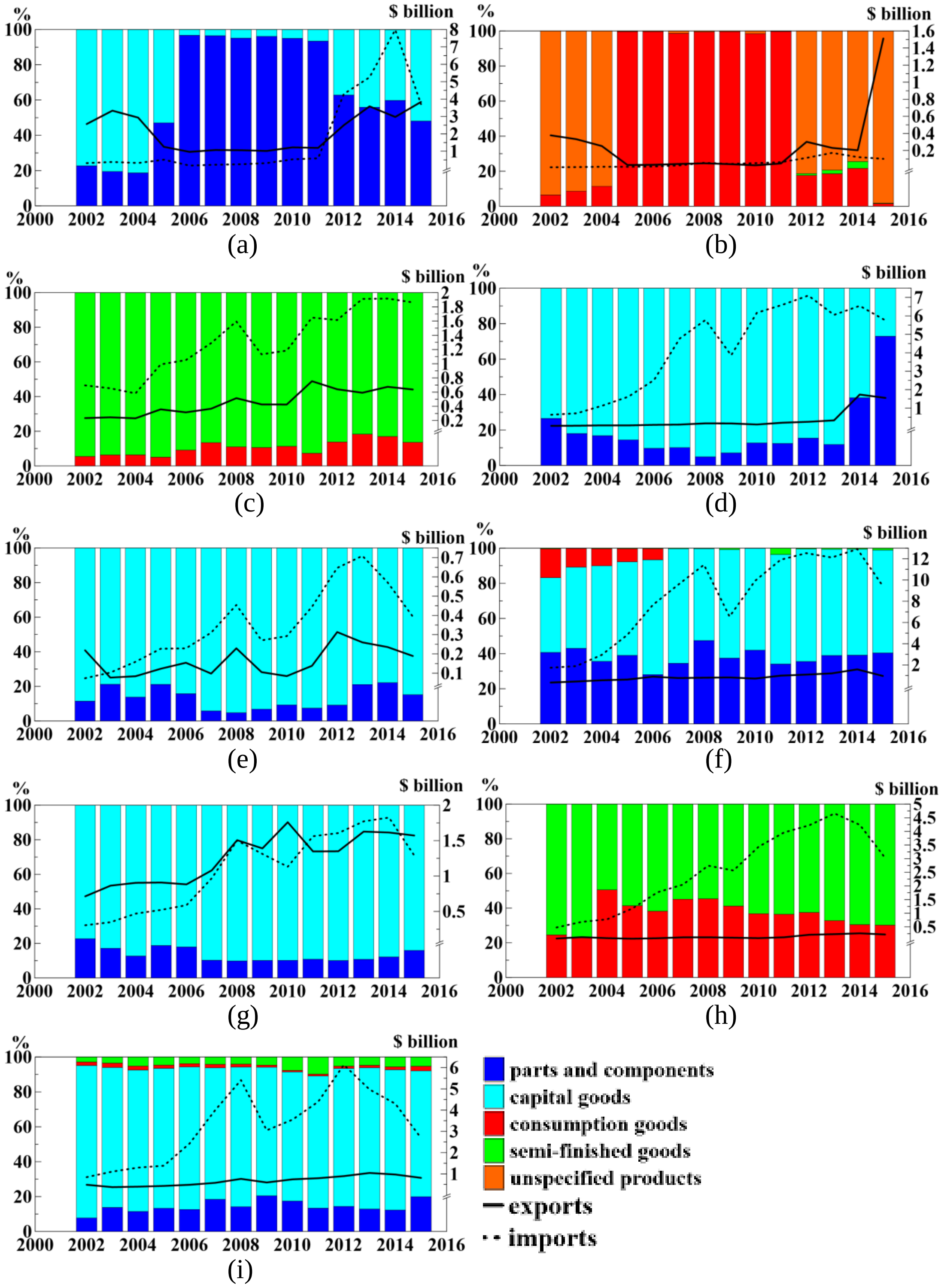
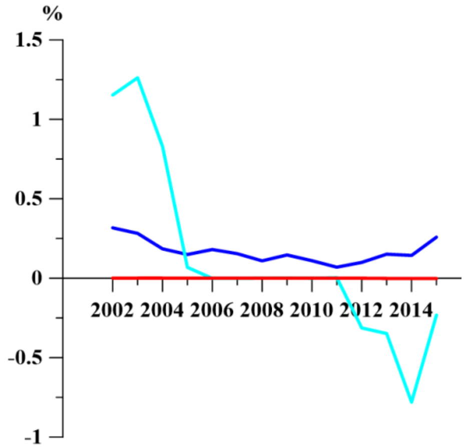
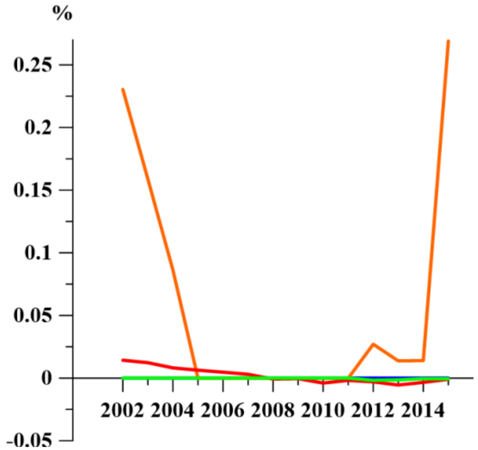
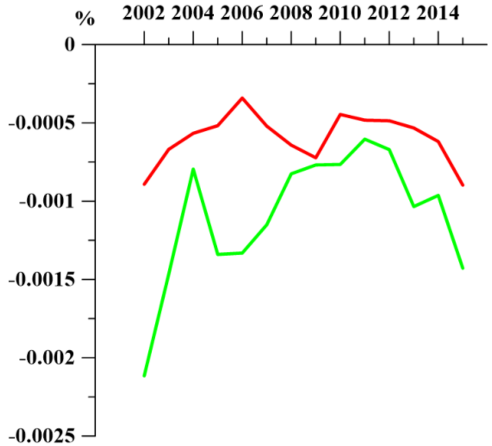


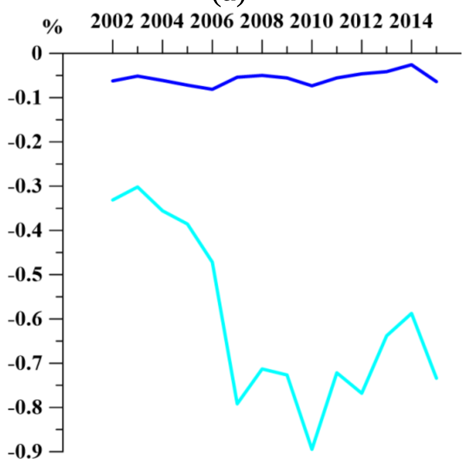
Fig. D15 The exports of Russia's high-tech sectors by production stage: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

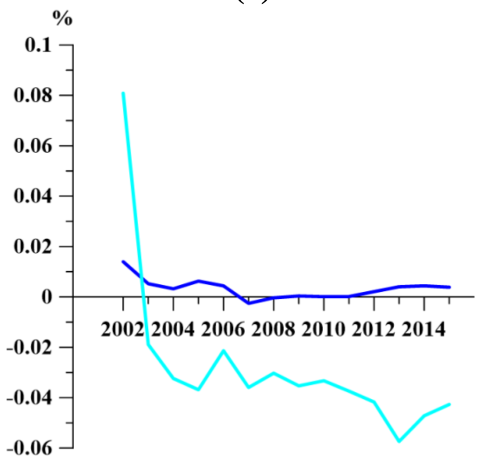
Source: United Nations, Comtrade database, own calculation

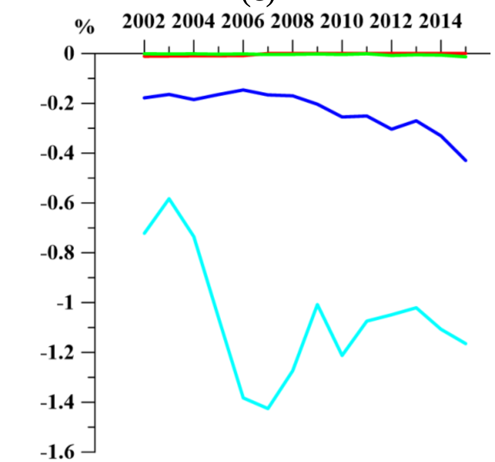

%
1.5
1
0.5
0
-0.5
-1
2002 2004 2006 2008 2010 2012 2014
(a)


%
0.25
0.2
0.15
0.1
0.05
0
-0.05
2002 2004 2006 2008 2010 2012 2014
(b)


%
2002 2004 2006 2008 2010 2012 2014
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
(c)


%
2002 2004 2006 2008 2010 2012 2014
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
(d)


%
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
2002 2004 2006 2008 2010 2012 2014
(e)


%
2002 2004 2006 2008 2010 2012 2014
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
(f)

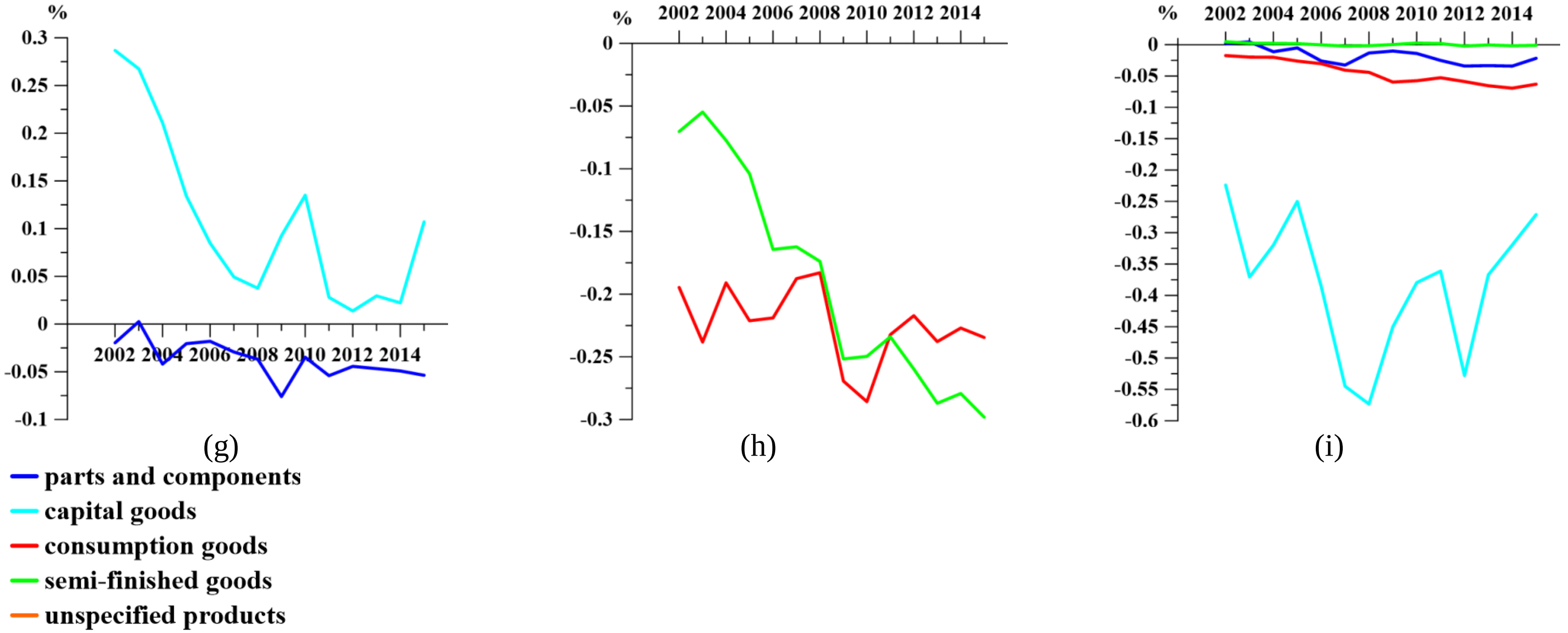


Fig. D16 The trade balance of Russia's high-tech sectors by production stage as a % of total merchandise trade: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments
Source: United Nations, Comtrade database, own calculation

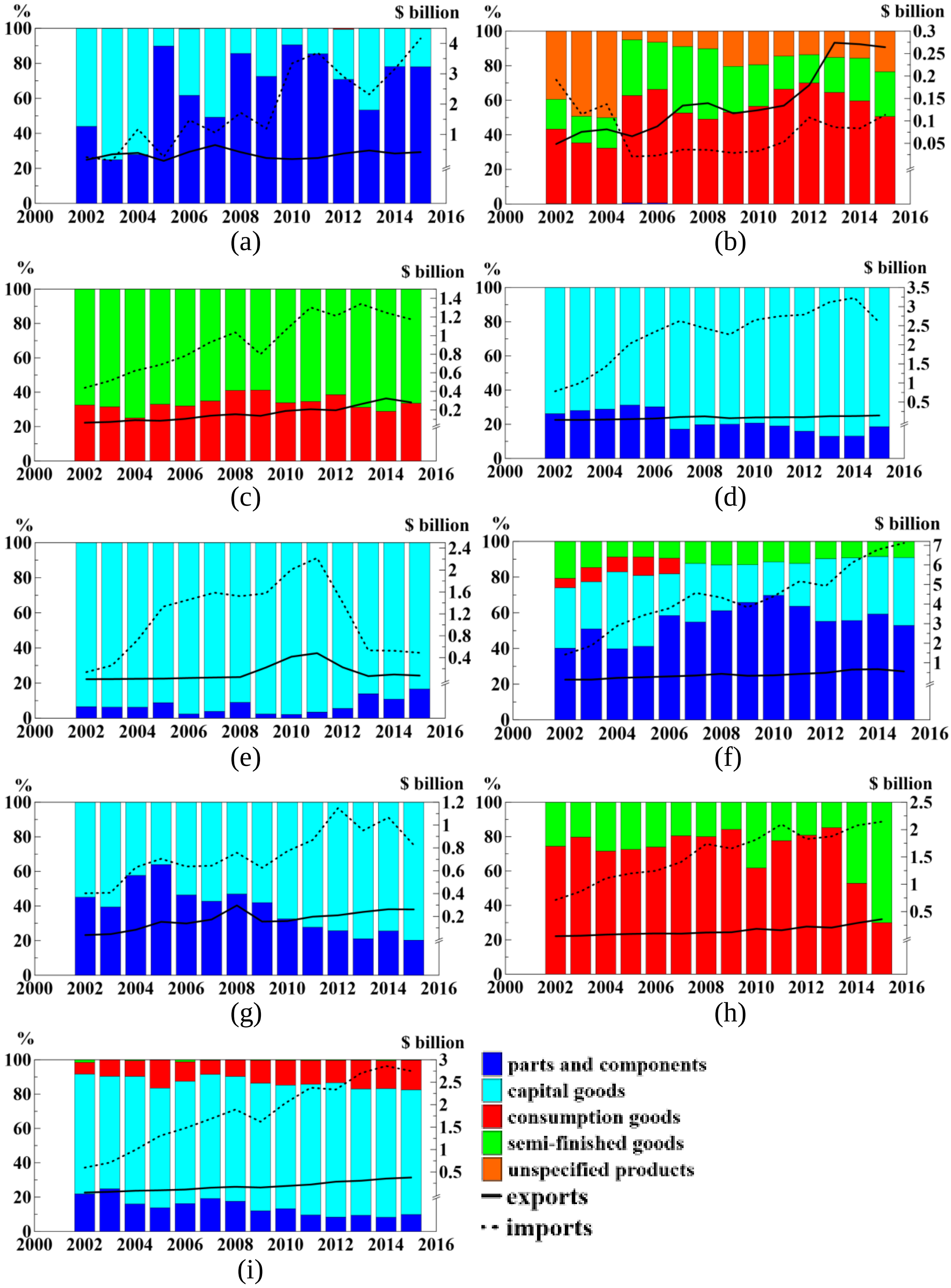
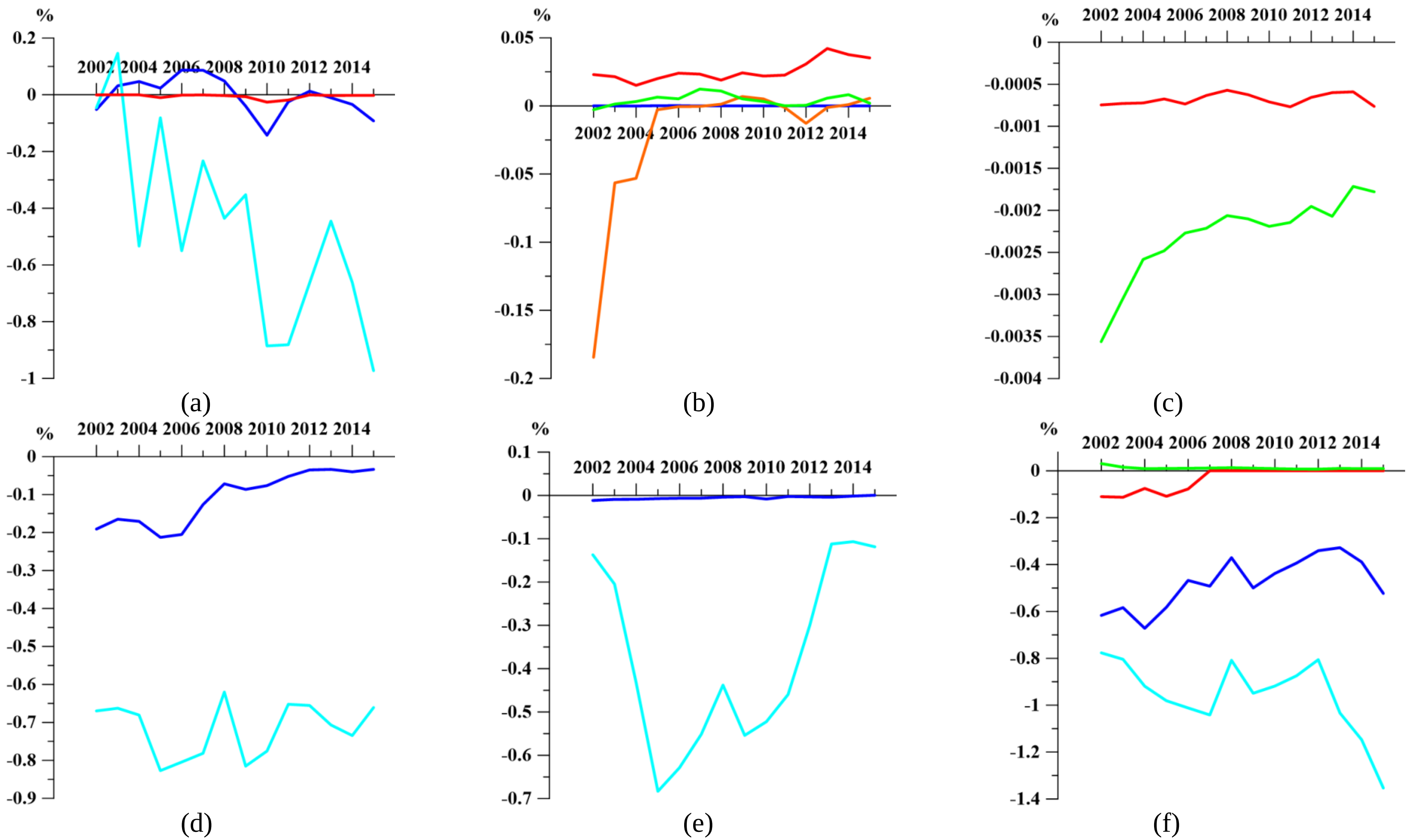


Fig. D17 The exports of Turkey's high-tech sectors by production stage: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation


%
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
2002 2004 2006 2008 2010 2012 2014
(a)
%
0.05
0
-0.05
-0.1
-0.15
-0.2
2002 2004 2006 2008 2010 2012 2014
(b)
%
0
-0.0005
-0.001
-0.0015
-0.002
-0.0025
-0.003
-0.0035
-0.004
2002 2004 2006 2008 2010 2012 2014
(c)
%
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
2002 2004 2006 2008 2010 2012 2014
(d)
%
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
2002 2004 2006 2008 2010 2012 2014
(e)
%
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
2002 2004 2006 2008 2010 2012 2014
(f)

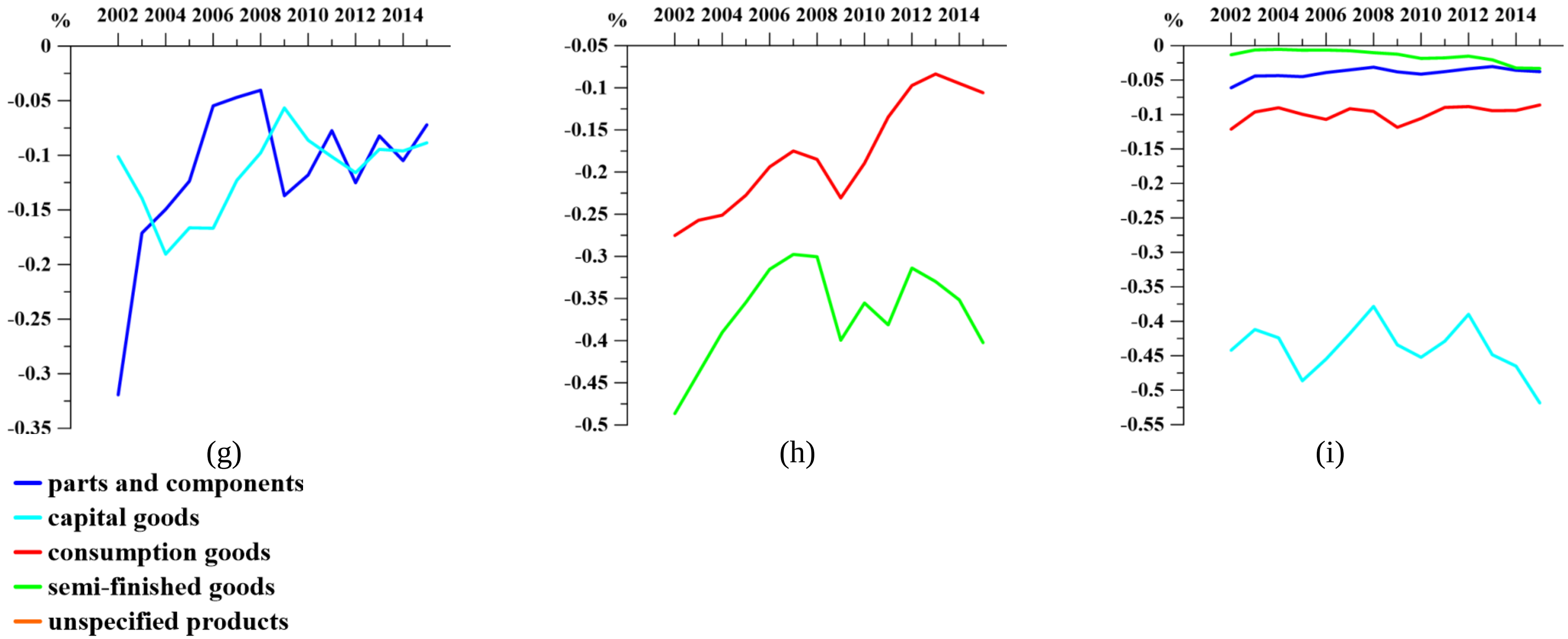


Fig. D18 The trade balance of Turkey's high-tech sectors by production stage as a % of total merchandise trade: (a) aerospace; (b) armament; (c) chemistry; (d) computer; (e) electrical machinery; (f) electronics and telecommunications; (g) non-electrical machinery; (h) pharmacy; (i) scientific instruments

Source: United Nations, Comtrade database, own calculation

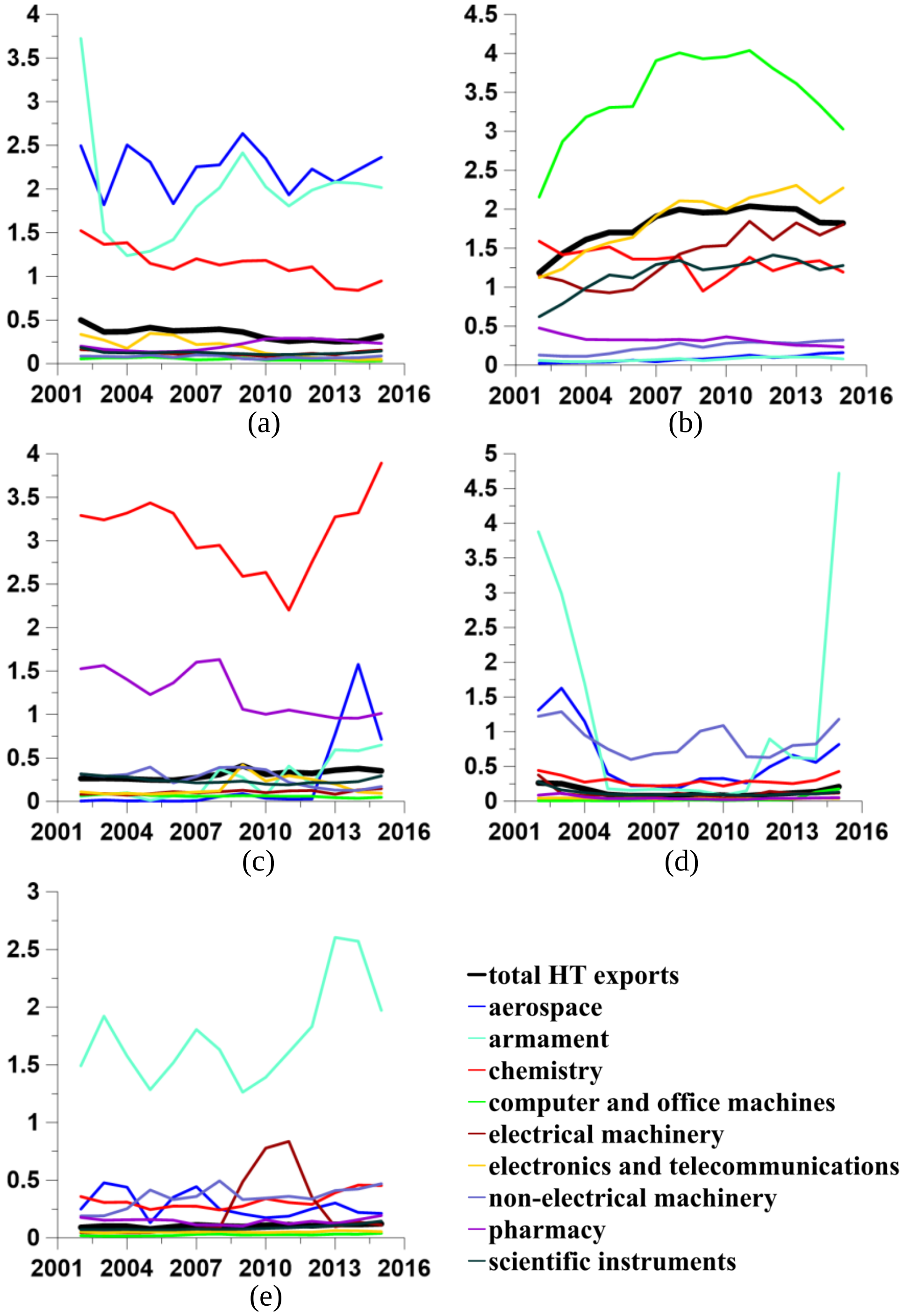


Fig. D19 Relative specialization indices (RCA) for high-tech exports by sector: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey
Source: United Nations, Comtrade database, own calculation
Notes: Relative Comparative Advantage are calculated as the ratio of the export share of a country in the world exports for a particular sector (product) to the export share of a country on the world export for all products (sectors).

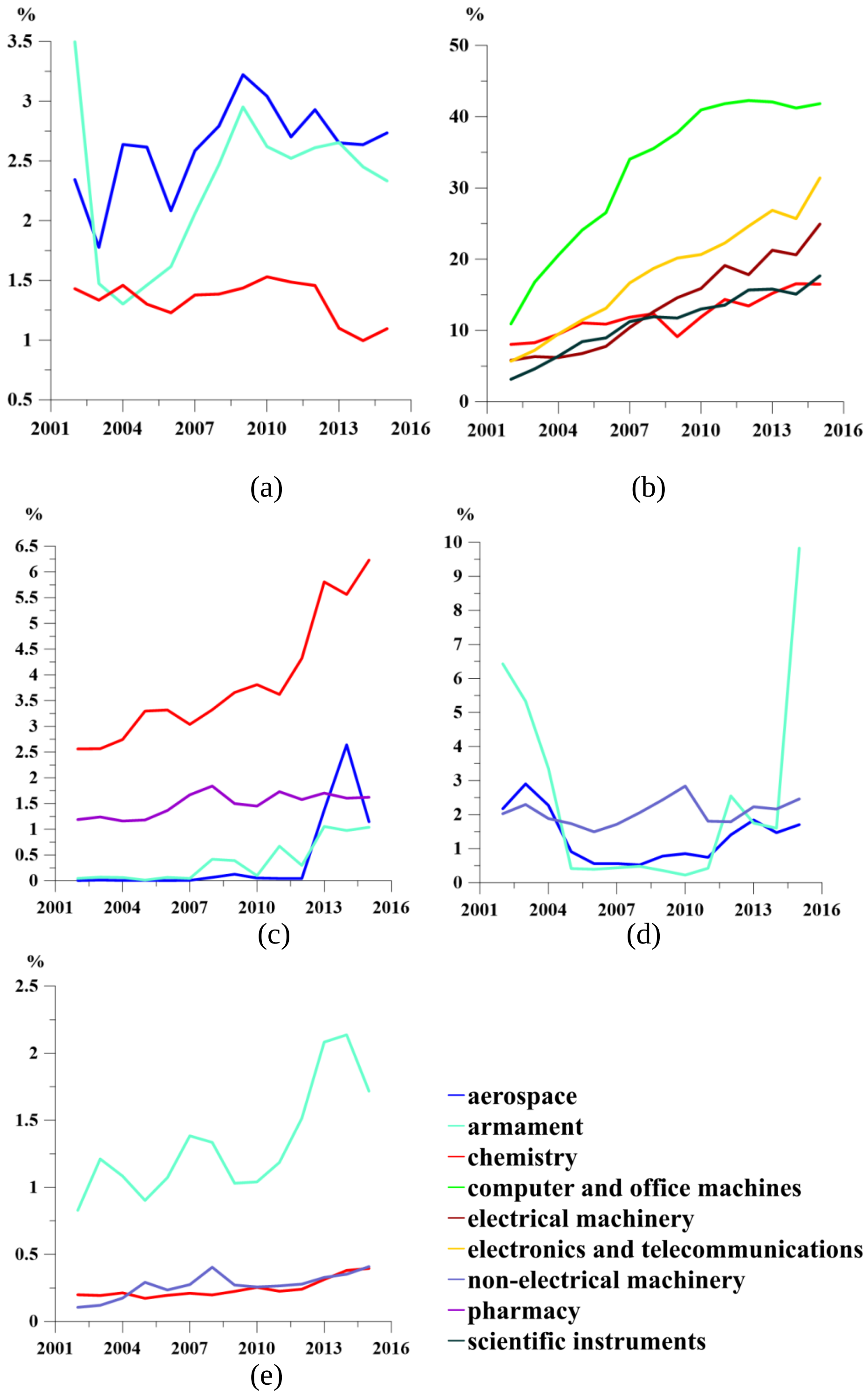
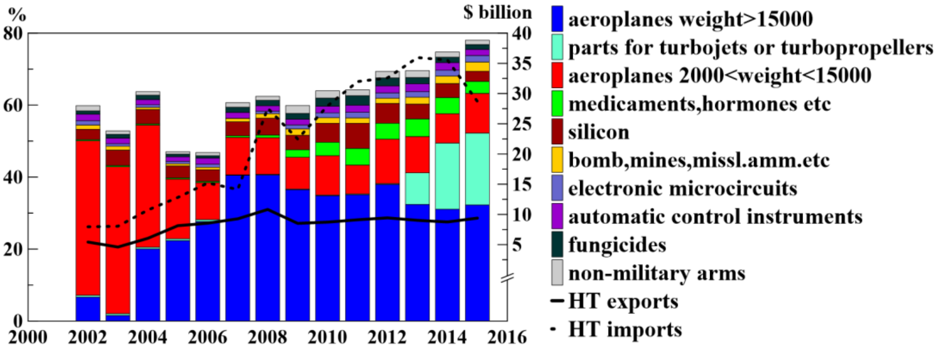
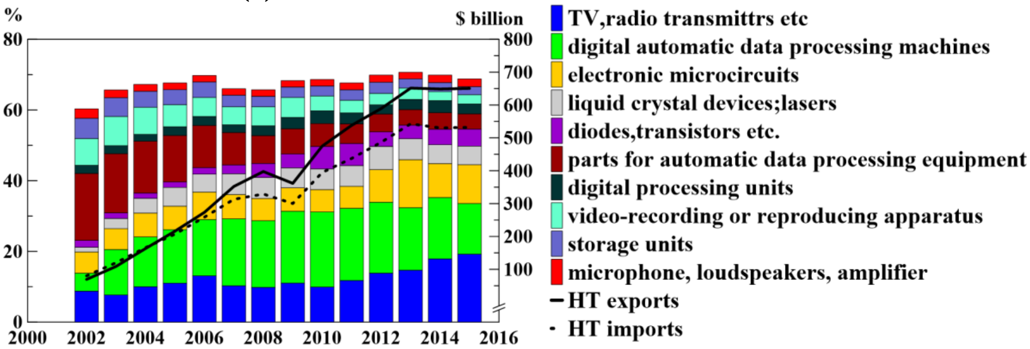


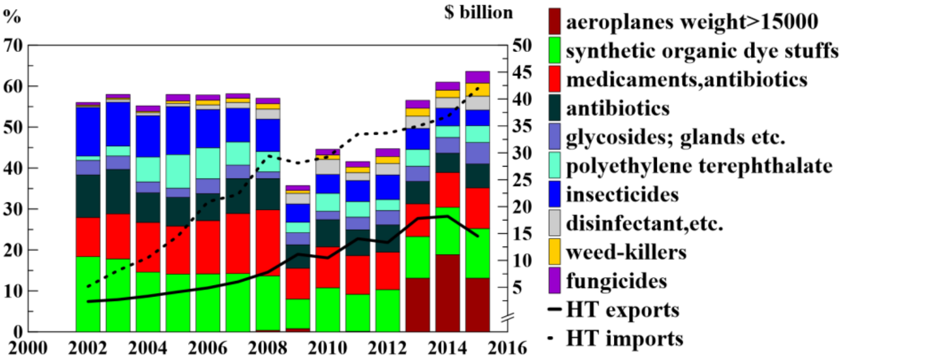
Fig. D20 The world share of high-tech exports with higher RCA by sector: (a) Brazil; (b) China; (c) India; (d) Russian Federation; (e) Turkey
Source: United Nations, Comtrade database, own calculation


%
$ billion
aeroplanes weight>15000
parts for turbojets or turbopropellers
aeroplanes 2000<weight<15000
medicaments,hormones etc
silicon
bomb,mines,missl.amm.etc
electronic microcircuits
automatic control instruments
fungicides
non-military arms
HT exports
HT imports

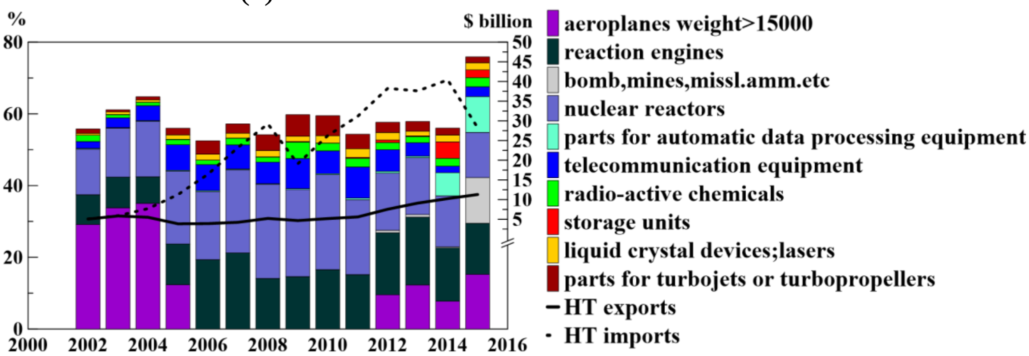
(a)


%
$ billion
TV,radio transmittrs etc
digital automatic data processing machines
electronic microcircuits
liquid crystal devices;lasers
diodes,transistors etc.
parts for automatic data processing equipment
digital processing units
video-recording or reproducing apparatus
storage units
microphone, loudspeakers, amplifier
HT exports
HT imports

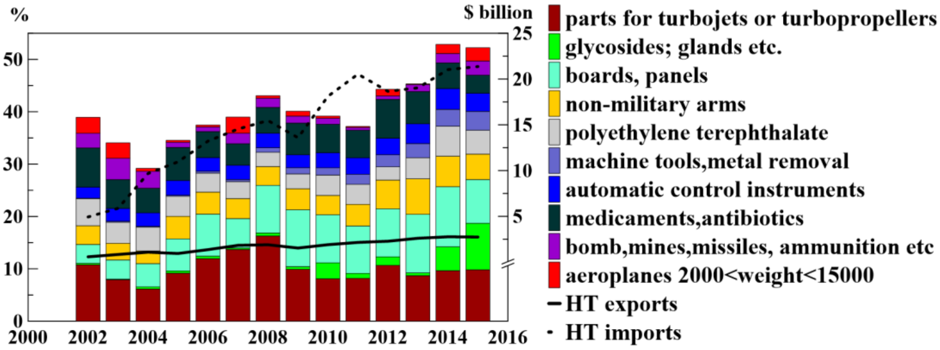
(b)


%
$ billion
aeroplanes weight>15000
synthetic organic dye stuffs
medicaments,antibiotics
antibiotics
glycosides; glands etc.
polyethylene terephthalate
insecticides
disinfectant,etc.
weed-killers
fungicides
HT exports
HT imports

(c)


%
$ billion
aeroplanes weight>15000
reaction engines
bomb,mines,missl.amm.etc
nuclear reactors
parts for automatic data processing equipment
telecommunication equipment
radio-active chemicals
storage units
liquid crystal devices;lasers
parts for turbojets or turbopropellers
HT exports
HT imports

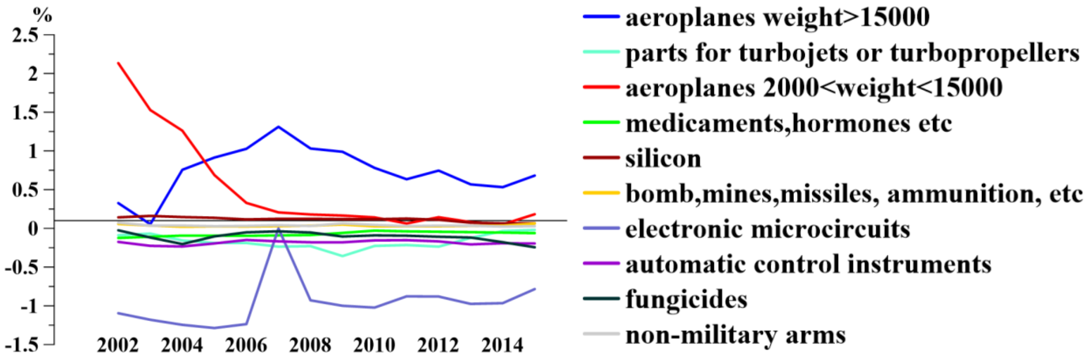
(d)



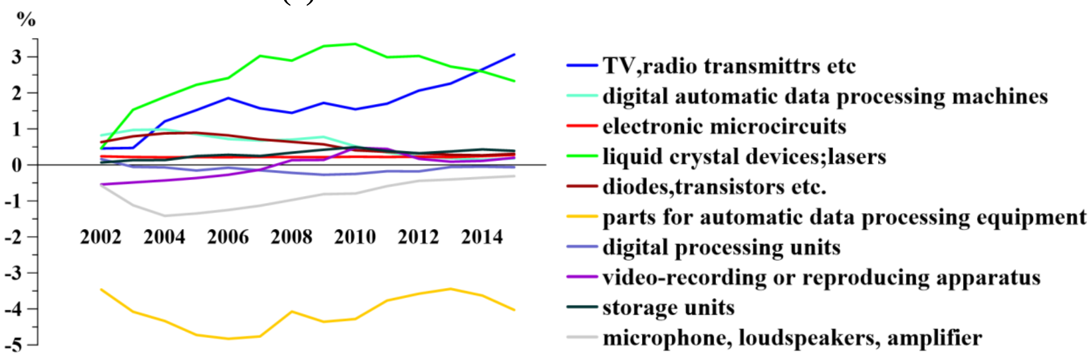
(e)

Fig. D21 Top ten high-tech exports: (a) Brazil; (b) China; (c) India; (d) The Russian Federation; (e) Turkey

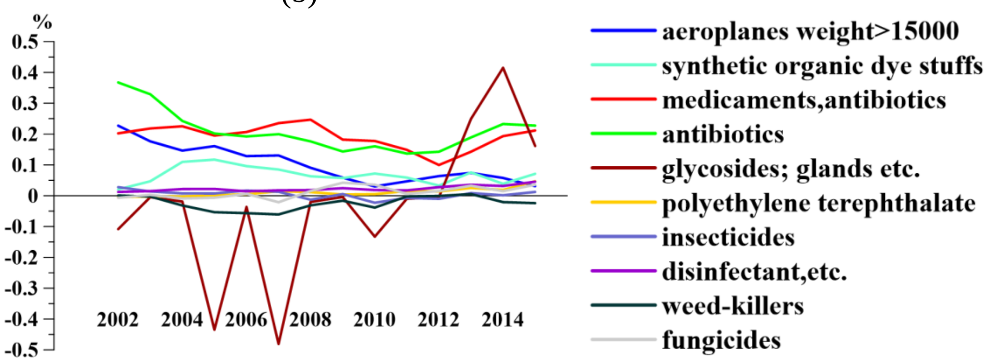
Source: United Nations, Comtrade database, own calculation



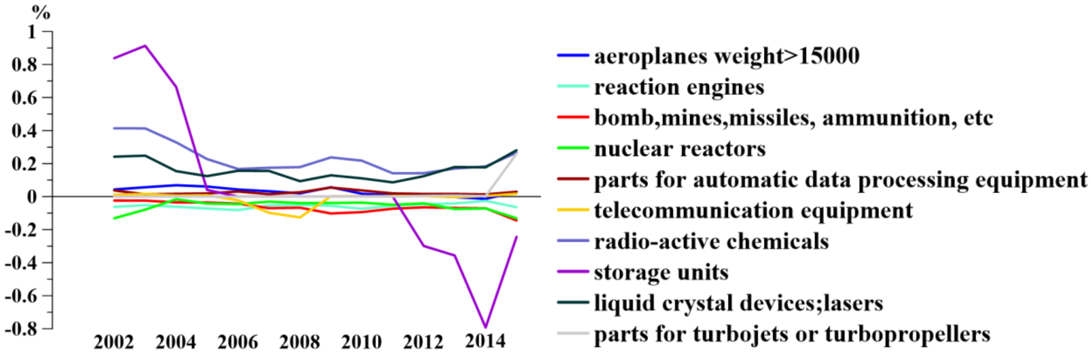
(a)



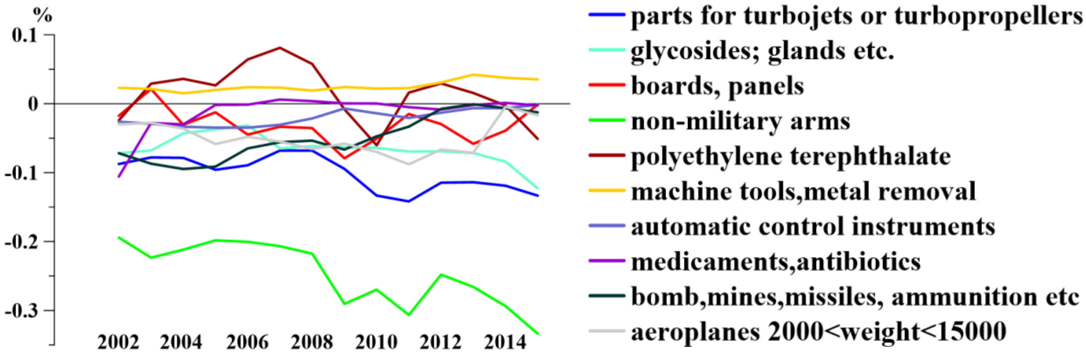
(b)



(c)



(d)



(e)

Fig. D22 Trade balance of top ten high-tech exports as a % of total merchandise trade: (a) Brazil; (b) China; (c) India; (d) Russian Federation; (e) Turkey
Source: United Nations, Comtrade database, own calculation

APPENDIX E

UNCTAD PRODUCT GROUPINGS AND COMPOSITION (SITC REV. 3)

Agricultural raw materials consist of SITC section 2 (crude materials, except fuels) excluding divisions 22 (Oil seeds and oleaginous fruits), 27 (crude fertilizers and crude minerals, excluding coal, petroleum, and precious stones), and 28 (metalliferous ores and scrap).

Food consists of SITC sections 0 (food and live animals), 1 (beverages and tobacco), 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels).

Ores and metals consist of SITC section 27 (crude fertilizer, minerals n.e.s.), 28 (metalliferous ores, scrap) and 68 (non-ferrous metals).

Fuels consist of SITC section 3 (mineral fuels).

Primary goods consist of SITC section 0, 1, 2, 3, 4, and division 68, i.e. (i) Food; (ii) Agricultural raw materials; (iii) Ores and metals; (iv) fuels.

Non-fuel primary goods consist of SITC section 0, 1, 2, 4, and division 68, i.e. (i) Food; (ii) Agricultural raw materials; (iii) Ores and metals.

Manufactures consist of SITC section 5 (chemicals), 6 (basic manufactures), 7 (machinery and transport equipment), and 8 (miscellaneous manufactured goods), excluding division 68 (non-ferrous metals) and division 667 (pearls, precious and semi-precious stones)

APPENDIX F

VARIOUS CLASSIFICATIONS OF MANUFACTURES EXPORTS

Table F1 Manufactured Goods by Degree of Manufacturing Groupings (SITC Rev. 3)

Type of manufactures	SITC sections
Labor-intensive and resource-intensive manufactures	611, 612, 613, 633, 634, 635, 641, 642, 651, 652, 653, 654, 655, 656, 657, 658, 659, 661, 662, 663, 664, 665, 666, 821, 831, 841, 842, 843, 844, 845, 846, 848, 851
Low-skill and technology-intensive manufactures	671, 672, 673, 674, 675, 676, 677, 678, 679, 691, 692, 693, 694, 695, 696, 697, 699, 785, 786, 791, 793, 895, 899
Medium-skill and technology-intensive manufactures	621, 625, 629, 711, 712, 713, 714, 716, 718, 721, 722, 723, 724, 725, 726, 727, 728, 731, 733, 735, 737, 741, 742, 743, 744, 745, 746, 747, 748, 749, 771, 772, 773, 774, 775, 778, 781, 782, 783, 784, 811, 812, 813, 893, 894
High-skill and technology-intensive manufactures	751, 752, 761, 762, 763, 759, 764, 776, 511, 512, 513, 514, 515, 516, 522, 523, 524, 525, 531, 532, 533, 541, 542, 551, 553, 554, 562, 571, 572, 573, 574, 575, 579, 581, 582, 583, 591, 592, 593, 597, 598, 792, 871, 872, 873, 874, 881, 882, 883, 884, 885, 891, 892, 896, 897, 898

Source: UNCTAD

Table F2 Technological Classification of Manufactures Exports (SITC Rev. 3)

Type of manufactures exports	SITC sections
Resource-based manufactures exports	511, 514, 515, 516, 522, 523, 524, 531, 532, 551, 592, 621, 625, 629, 633, 634, 635, 641, 661, 662, 663, 664
Low-tech manufactures exports	612, 613, 642, 651, 652, 654, 655, 656, 657, 658, 659, 665, 666, 673, 674, 675, 676, 677, 679, 691, 692, 693, 694, 695, 696, 697, 699, 821, 831, 841, 842, 843, 844, 845, 846, 848, 851, 893, 894, 895, 897, 898, 899
Medium-tech manufactures exports	512, 513, 533, 553, 554, 562, 571, 572, 573, 574, 575, 579, 581, 582, 583, 591, 593, 597, 598, 653, 671, 672, 678, 711, 712, 713, 714, 721, 722, 723, 724, 725, 726, 727, 728, 731, 733, 735, 737, 741, 742, 743, 744, 745, 746, 747, 748, 749, 761, 762, 763, 772, 773, 775, 778, 781, 782, 783, 784, 785, 786, 791, 793, 811, 812, 813, 872, 873, 882, 884, 885
High-tech manufactures exports	525, 541, 542, 716, 718, 751, 752, 759, 764, 771, 774, 776, 792, 871, 874, 881, 891

Source: UNIDO (2011)

Table F3 Production Stage According to the BEC Classification

3 stages	5 stages	code BEC	Title BEC
Primary goods		111	Food and beverages mainly for industry
		21	Industrial supplies, n.e.s., primary
		31	Fuels and lubricants, primary
Intermediate goods	Semi-finished goods	121	Food and beverages, processed, mainly for industry
		22	Industrial supplies, n.e.s., processed
		322	Fuels and lubricants, processed
	Parts & components	42	Of capital goods, except transport equipment
		53	Parts and accessories of transport equipment
Final goods	Capital goods	41	Capital goods, except transport equipment
		521	Other industrial transport equipment
	Consumption goods	112	Food & beverage, primary, mainly for household consumption
		122	Food & beverage, primary, processed, for household consumption
		51	Passenger motor cars
		522	Other non-industrial transport equipment
		61	Durable consumer goods n.e.s.
		62	Semi-durable consumer goods n.e.s.
		63	Non-durable consumer goods n.e.s.

Source: Gaulier et al. (2005)

Table F4 Exports Of High-tech Products by Stage According to the BEC Classification

3 stages	5 stages	code BEC	SITC divisions
Primary goods		21	52517
Intermediate goods	Semi-finished goods	22	54222, 52222, 52223, 52229, 52269, 525-52517, 531, 5413, 5415, 5416, 54211, 54212, 54221, 57433, 77318, 88419, 89122, 89123, 89193, 89195
	Parts & components	42	71878, 7359, 75997, 76491, 76492, 7722, 77261, 77625, 77627, 7763, 7764, 7768, 77423, 77429, 77879, 87119, 87139, 87149, 87199, 8741-87411-87413, 87439, 87454, 87456, 87469, 87479, 8749, 89121,
		53	714-71489-71499, 71489, 71499, 7929-79295-79297
Final goods	Capital goods	41	7187-71878, 72847, 7311, 7313-73137-73139, 73142, 73144, 73151, 73153, 7316-73162-73166-73167-73169, 73312, 73314, 73316, 73733, 73735, 75113, 7513-75133-75135, 76381, 764-7649, 774-77423-77429, 7786-77861-77866-77869, 7787-77879, 77884, 871-87119-87139-87149-87199-87111, 87211, 87413, 874-8741-8742-8749-87439-87454-87456-87469-87479, 88121, 87411, , 752-7529
		521	792-7922-7928-7929
	Consumption goods	522	7922
		61	76383, 87111, 88111, , 8996-89965-89969, 8913
		62	89879
		63	591, 54213, 54219, 54223, 54224, 54229, 88411,
Goods not elsewhere specified		7	8911, 89124, 89129, 89191, 89199

Source: own calculation according to the correspondence table of BEC and SITC Rev. 3 offered by the United Nations Statistics Division.

APPENDIX G

VARIABLES

Table G1 List of Variables

Variables	Description	Period	Measurement	Source
lnhtx	High-technology exports (as a % of manufactured exports)[5]	2006-2014	%	World Bank, the World Development Indicators (WDI)
National Orientation				
lnlabfre	Labor freedom	2006-2014		The Heritage Foundation
polistabi	Political Stability and Absence of Violence /Terrorism	2006-2014		World Band, the Worldwide Governance Indicators
lngovspen	Government spending	2006-2014		The Heritage Foundation
lntradefre	Trade freedom based on the trade-weighted average tariff rate and Non-tariff barriers (NTBs)	2006-2014		The Heritage Foundation
lnopen	Trade as a % of GDP	2006-2014	%	World Bank, WDI
Socioeconomic Infrastructure				
lnifdi_gfcf	Foreign direct investment as % of gross fixed capital formation	2006-2014	%	UNCTAD
Financial market development				
lncrebank_gdp	Domestic credit to private sector by banks as a % of GDP	2006-2014	%	World Bank, WDI
lncrefin_gdp	Domestic credit provided by the financial	2006-2014	%	World Bank, WDI

[5] According to the World Bank, manufactured products are commodities classifi ed in SITC revision 2 sections 5–8 excluding division 68.

	sector as % of GDP			
lnscapita_gdp	Stock market capitalization as a % of GDP	2006-2014	%	World Bank Global Financial development
lngds	Gross domestic savings as a % of GDP	2006-2014	%	World Bank, WDI
Skill labors				
L4.lntert_grad	Tertiary graduates (both sexes), lagged by 4 years	2002-2014	Unit	Brazil: OECD Main Science and Technology Indicators, the Ibero-American and Inter-American Network for Science and Technology Indicators (RICYT) database, own calculation; China: the Ministry of Education, China; India: University Grants Commission (UGC), University Development in India: Basic facts and figures (Examination results), UGC Annual Report, India, own calculation; Russia and Turkey: UNESCO, Institute for Statistics
L4.lnse_grad	Tertiary graduates of Science and Engineering programs, lagged by 4 years	2002-2014	Unit	Brazil: OECD Main Science and Technology Indicators, RICYT, own calculation; China: the Ministry of Education, China, own calculation; India: UGC, University Development in India, UGC Annual Report, India, own calculation; Russia and Turkey: UNESCO Institute for Statistics, own calculation
L4.lnphd	Graduation at doctoral level, lagged by 4 years	2002-2014	Unit	Brazil: OECD Main Science and Technology Indicators, RICYT; China: the Ministry of Education, China; India: UGC, University Development in India, UGC Annual Report, India; Russia and Turkey: UNESCO Institute for Statistics
lnbraindrain	Brain drain	2006-2014		The Global Competitiveness Report
Innovation				
L3.lngovrd	Gross domestic expenditure on R&D (GERD) financed by government as a % of GDP, lagged by 3 years	2003-2014	Innovation input	Brazil: RICYT; China, Russia, Turkey: OECD, Main Science and Technology Indicators; India: UNESCO;

L.lnberd	GERD financed by the business enterprise as a % of GDP, lagged by 1 years	2005-2014	Innovation input	Brazil: RICYT; China, Russia, Turkey: OECD, Main Science and Technology Indicators; India: UNESCO;
lnresearchers	Researchers, full-time equivalence (FTE) (per million population)	2002-2013	Innovation input	China, Russia, Turkey: OECD, Main Science and Technology Indicators; Brazil, India: UNESCO
L2.lnjournal	Scientific and technical journal articles in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences, lagged by 2 years	2004-2014	Domestic innovation output	World Bank, WDI
lnpatent_mil	Patent applications per million residents	2006-2014	Domestic innovation output	World Bank, WDI
L3.lnroyalpayment	Charges for the use of intellectual property, payments (BoP), lagged by 3 years	2003-2014	Current US$	World Bank, WDI
lnunivindcol	University/industry research collaboration	2006-2014		The Global Competitiveness Report
lninnovcapa	Capacity for innovation	2006-2014		The Global Competitiveness Report
Productive Capacity				
lnmanuva	Manufacturing, value added	2006-2014	Current US$	World Bank, WDI
lnictim	ICT goods imports (as a % total goods imports)	2006-2014	%	World Bank, WDI
lnictserv_im	Computer, communications and other services as % of commercial service imports	2006-2015	%	World Bank, WDI
lnparts	Imports of HT parts and components	2006-2015	Current US$	United nations Comtrade database
lnediv	Export Diversification Hirschamn-Herfindhal index (HHI)	2006-2015		UNCTAD
lnec	Export Concentration HHI	2006-2014		UNCTAD
lncluster	State of cluster development	2006-2014		The Global Competitiveness Report

APPENDIX H

DATA ANALYSES AND EMPIRICAL MODELS

Table H1 Descriptive Statistics of Variables (annual data 2006-2014, 45 observations)

Variable	Mean	Std. Dev.	Min	Max
lnhtx	-2.521	0.884	-4.125	-1.187
lnopen	-0.814	0.307	-1.508	-0.434
lngovspen	4.236	0.183	3.884	4.496
lnlabfre	4.043	0.183	3.658	4.307
lntradefre	4.219	0.216	3.178	4.464
polistabi	-0.731	0.393	-1.328	0.164
lngds	-1.306	0.420	-1.978	-0.664
lnscapital_gdp	-0.629	0.423	-1.536	0.246
lncrefin_gdp	-0.309	0.505	-1.536	0.526
lncrebank_gdp	-0.567	0.443	-1.349	0.349
lnresearchers	6.662	0.993	4.891	8.097
lnpatent_mil	3.878	1.401	1.588	6.375
lnictim	-2.482	0.544	-3.263	-1.344
lnictserv_im	-1.184	0.505	-3.434	-0.684
lnec	-1.474	0.741	-2.411	-0.424
lnediv	-0.675	0.122	-0.861	-0.424
lnparts	23.12	1.675	21.32	26.59
lnmanuva	26.43	0.992	25.23	28.68
lnunivindcol	1.332	0.101	1.163	1.526
lninnovcapa	1.316	0.0900	1.099	1.459
lnbraindrain	1.314	0.142	1.030	1.526
lncluster	1.391	0.154	1.099	1.589
$lngovrd_{t-3}$	-5.867	0.740	-7.794	-5.111
$lnberd_{t-1}$	-5.263	0.554	-6.215	-4.171
$lnjournal_{t-2}$	10.77	0.887	9.646	12.83
lnfdi_gfcf	2.119	0.545	1.031	3.021
$lnphd_{t-4}$	9.635	0.899	7.813	10.82
$lntert\_grad_{t-4}$	14.26	1.017	12.46	16.05
$lnse\_grad_{t-4}$	12.74	1.176	11.10	14.89
$lnroyalpayment_{t-3}$	21.35	1.052	18.93	23.41

Table H2 Unit Root Tests

	LLC		IPS		ADF-Fisher		PP-Fisher	
Variables	Without trend	With trend	Without trend	With trend	Without trend	With trend	Without trend	With trend
lnhtx	-3.2563	-4.2262	-3.1003	-2.5464	33.2063	40.2039	27.0797	27.0684
	(0.0006)	(0.0000)	(0.0010)	(0.0054)	(0.0003)	(0.0000)	(0.0025)	(0.0025)
lnopen	-3.8821	-2.6219	-0.4462	-0.9123	31.2508	36.3665	29.5474	31.9569
	(0.0001)	(0.0044)	(0.3277)	(0.1808)	(0.0005)	(0.0001)	(0.0010)	(0.0004)
lngovspen	-2.4550	-3.8542	-1.1317	-1.9075	16.8040	34.1037	17.2443	17.9438
	(0.0070)	(0.0001)	(0.1289)	(0.0282)	(0.0788)	(0.0002)	(0.0691)	(0.0559)
lnlabfre	1.7838	-3.3733	3.3382	-1.9278	33.3615	23.1634	4.6590	4.7354
	(0.9628)	(0.0004)	(0.9996)	(0.0269)	(0.0002)	(0.0102)	(0.9128)	(0.9081)
lntradefre	-3.1862	-6.3490	-2.5081	-3.3193	30.3516	38.5262	16.1840	43.6493
	(0.0007)	(0.0000)	(0.0061)	(0.0005)	(0.0008)	(0.0000)	(0.0945)	(0.0000)
polistabi	-2.8368	-3.6984	-2.4691	-2.7062	3.3338	6.7603	3.4534	2.5571
	(0.0023)	(0.0001)	(0.0068)	(0.0034)	(0.0004)	(0.0000)	(0.0003)	(0.0053)
lngds	-6.9153	-8.1674	-2.2222	-81.9974	22.3329	33.6457	28.5780	17.4168
	(0.0000)	(0.0000)	(0.0131)	(0.0000)	(0.0135)	(0.0002)	(0.0015)	(0.0656)
lnscapital_gdp	-4.5005	-5.1763	-2.5854	-4.5929	44.5274	36.9433	31.1887	13.9237
	(0.0000)	(0.0000)	(0.0049)	(0.0000)	(0.0000)	(0.0000)	(0.0005)	(0.1765)
lncrefin_gdp	-3.5810	-4.2807	-4.1656	-1.0371	83.3381	23.0864	31.3105	19.9285
	(0.0002)	(0.0000)	(0.0000)	(0.1498)	(0.0000)	(0.0104)	(0.0005)	(0.0299)
lncrebank_gdp	-3.4188	-5.5416	-0.8428	-1.9772	9.4009	23.6045	15.7517	18.8024
	(0.0003)	(0.0000)	(0.1997)	(0.0240)	(0.4945)	(0.0087)	(0.1070)	(0.0428)
lnresearchers	-4.1008	-7.2109	-4.8939	-5.3486	82.0467	93.4745	9.3787	6.5619
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.4966)	(0.7661)
lnpatent_mil	-2.8517	-3.0969	-1.4014	-1.1505	1.2845	5.5561	3.9128	4.0203
	(0.0022)	(0.0010)	(0.0805)	(0.1250)	(0.0995)	(0.0000)	(0.0000)	(0.0000)
lnictim	-2.8313	-2.4910	-2.4648	-2.3983	1.8886	6.1716	7.1322	6.1716
	(0.0023)	(0.0064)	(0.0069)	(0.0082)	(0.0295)	(0.0000)	(0.0000)	(0.0000)
lnictserv_im	-3.1643	-3.8897	-2.5694	-3.3909	5.8888	5.6928	5.8888	5.6928
	(0.0008)	(0.0001)	(0.0051)	(0.0003)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
lnec	-3.6430	-5.6581	-2.3827	-4.8645	24.9961	29.9628	25.6224	19.2248
	(0.0001)	(0.0000)	(0.0086)	(0.0000)	(0.0054)	(0.0009)	(0.0043)	(0.0375)
lnediv	-3.8030	-4.1432	-5.6691	-26.5274	75.4930	162.6835	15.0238	11.6611
	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.1312)	(0.3084)
lnparts	-5.0791	-15.4287	-2.5712	-4.3069	67.9519	33.2470	16.9305	14.3923
	(0.0000)	(0.0000)	(0.0051)	(0.0000)	(0.0000)	(0.0002)	(0.0759)	(0.1558)
lnmanuva	-3.5628	-0.7361	-2.3811	3.1384	3.5102	7.2699	3.5102	-1.7817
	(0.0002)	(0.2308)	(0.0086)	(0.9992)	(0.0002)	(0.0000)	(0.0002)	(0.9626)
lnunivindcol	-10.2842	-11.7741	-5.2945	-4.1775	24.2009	33.0303	10.7786	30.2921
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0071)	(0.0003)	(0.3750)	(0.0008)
lninnovcapa	-9.9474	-6.0887	-1.8705	-2.4847	72.2001	35.8877	31.3756	43.9795
	(0.0000)	(0.0000)	(0.0307)	(0.0065)	(0.0000)	(0.0001)	(0.0005)	(0.0000)
lnbraindrain	-4.6495	-3.4272	-3.5677	-0.4267	54.2403	26.9500	14.3721	11.4483
	(0.0000)	(0.0003)	(0.0002)	(0.3348)	(0.0000)	(0.0027)	(0.1567)	(0.3237)
lncluster	-3.2513	-3.5134	-0.9086	0.0017	15.9768	4.5503	-0.1560	-1.7514
	(0.0006)	(0.0002)	(0.1818)	(0.5007)	(0.0000)	(0.0000)	(0.5620)	(0.9601)
lngovrd	-2.8565	-3.6412	-1.7012	-1.9256	57.8212	45.7821	2.3778	1.4011
	(0.0021)	(0.0001)	(0.0445)	(0.0271)	(0.0000)	(0.0000)	(0.0087)	(0.0806)
lnberd	-4.2761	-2.9737	-4.1831	-2.5897	43.9363	44.5419	34.7348	2.6863
	(0.0000)	(0.0015)	(0.0000)	(0.0048)	(0.0000)	(0.0000)	(0.0001)	(0.0036)
lnjournal	-6.8900	-3.1861	-2.5929	-2.9154	44.9561	45.1257	44.9561	31.6552
	(0.0000)	(0.0007)	(0.0048)	(0.0018)	(0.0000)	(0.0000)	(0.0000)	(0.0005)
lnfdi_gfcf	-2.5300	-5.7457	-2.7573	-2.0389	2.7499	5.8372	2.7499	1.8196
	(0.0057)	(0.0000)	(0.0029)	(0.0207)	(0.0030)	(0.0000)	(0.0030)	(0.0344)
lnphd	-4.2387	-7.1612	-2.7976	-2.7976	-6.0313	7.9266	9.8554	2.7119
	(0.0000)	(0.0000)	(0.0026)	(0.0026)	(0.0000)	(0.0000)	(0.0000)	(0.0053)
lntert_grad	-2.1595	-4.8675	-2.3391	-3.5351	11.7682	8.7682	14.8862	3.3847
	(0.0154)	(0.0000)	(0.0097)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0004)
lnse_grad	-2.6152	-6.9982	-0.9063	-3.6255	10.4027	3.4101	10.4027	13.6663
	(0.0045)	(0.0000)	(0.1824)	(0.0001)	(0.4059)	(0.0003)	(0.4059)	(0.18888)
lnroyalpayment	-3.8850	-5.5368	-3.1181	-2.1869	39.4064	33.2153	114.7193	3.5603
	(0.0001)	(0.0000)	(0.0009)	(0.0144)	(0.0000)	(0.0003)	(0.0000)	(0.0002)

Table H3 Empirical Models

Model	Multiple regression
model 1	$lnhtx=\alpha+\beta_1 lnlabfre+\beta_2 polistabi+\beta_3 lngovspen+\beta_4 lngtradefre+\beta_5 lnopen+\varepsilon$
model 2	$lnhtx=\alpha+\beta_1 lnscapital\_gdp+\beta_2 lncrebank\_gdp+\beta_3 lngds+\varepsilon$
model 3	$lnhtx=\alpha+\beta_1 lnscapital\_gdp+\beta_2 lncrebank\_gdp+\beta_3 lngds+\beta_4 lncrefin\_gdp+\varepsilon$
model 4	$lnhtx=\alpha+\beta_1 lnphd_{t-4}+\beta_2 lnbraindrain+\varepsilon$
model 5	$lnhtx=\alpha+\beta_1 lnse\_grad_{t-4}+\beta_2 lnbraindrain+\varepsilon$
model 6	$lnhtx=\alpha+\beta_1 lntert\_grad_{t-4}+\beta_2 lnbraindrain+\varepsilon$
model 7	$lnhtx=\alpha+\beta_1 lnphd_{t-4+}\beta_2 lnse\_grad_{t-4}+ \beta_2 lnbraindrain+\varepsilon$
model 8	$lnhtx=\alpha+\beta_1 lnphd_{t-4+}\beta_2 lntert\_grad_{t-4}+\beta_2 lnbraindrain+\varepsilon$
model 9	$lnhtx=\alpha+\beta_1 lnberd_{t-1}+\beta_2 lngovrd_{t-3}+\beta_3 lnunivindcol+\beta_4 lninnovcapa+\varepsilon$
model 10	$lnhtx=\alpha+\beta_1 lnjournal_{t-2}+\beta_2 lngovrd_{t-3}+\beta_3 lnunivindcol+\beta_4 lninnovcapa+ \beta_5 lnpatent\_mil+\varepsilon$
model 11	$lnhtx=\alpha+\beta_1 lnroyalpayment_{t-3}+\beta_2 lngovrd_{t-3}+\beta_3 lnunivindcol+\beta_4 lninnovcapa+\beta_5 lnpatent\_mil+\varepsilon$
model 12	$lnhtx=\alpha+\beta_1 lnberd_{t-1}+\beta_2 lngovrd_{t-3}+\beta_3 lnunivindcol+\beta_4 lninnovcapa+\beta_5 lnroyalpayment_{t-3}+\beta_6 lnjournal_{t-2}+\varepsilon$
model 13	$lnhtx=\alpha+\beta_1 lnmanuva+\beta_2 lnictserv\_im+\beta_3 lncluster+\beta_4 lnec+\varepsilon$
model 14	$lnhtx=\alpha+\beta_1 lnictim+\beta_2 lnictserv\_im+\beta_3 lncluster +\beta_4 lnec+\varepsilon$
model 15	$lnhtx=\alpha+\beta_1 lnparts+\beta_2 lnictserv\_im+\beta_3 lncluster+\beta_4 lnediv+\varepsilon$
model 16	$lnhtx=\alpha+\beta_1 lnictim+\beta_2 lnparts+\beta_3 lnictserv\_im+\beta_4 lncluster+\beta_5 lnediv+\varepsilon$
model 17	$lnhtx=\alpha+\beta_1 lnphd_{t-4}+\beta_2 lnberd_{t-1}+\beta_3 lnictserv\_im+\beta_4 lnjournal_{t-2}+\beta_5 lnec+\varepsilon$
model 18	$lnhtx=\alpha+\beta_1 lntradefre+\beta_2 lncrefin\_gdp+\beta_3 lnphd_{t-4}+\beta_4 lngovrd_{t-}$ $3+lnpatent\_mil+\beta_6 lnictim+\beta_7 lnediv+\varepsilon$
model 19	$lnhtx=\alpha+\beta_1 lntradefre+\beta_2 lndcredit\_gdp +\beta_3 lnresearchers+\beta_4 lnmanuva+\varepsilon$
model 20	$lnhtx=\alpha+\beta_1 lntradefre+\beta_2 lnphd_{t-4}+\beta_3 lngovrd_{t-3}+\beta_4 lnpatent\_mil+\beta_5 lnroyalpayment_{t-3+}\beta_6 lnictim+\beta_7 lnec+\varepsilon$
model 21	$lnhtx=\alpha+\beta_1 lnlabfre+\beta_2 lnse\_grad_{t-4}+\beta_3 lnroyalpayment_{t-3}+\beta_4 lnifdi\_gfcf+\beta_5 lnictserv\_im+\beta 6lnec+\varepsilon$

Note: α refers to the constant; β refers to the coefficient of the independent variables; ε refers to the error term.

Table H4 Results of Integrated Models

	model 17	model 18	model 19	model 20	model 21
	xtscc	xtpcse	areg_year	areg_year	areg_year
lnlabfre					0.594^{***}
					(0.161)
polistabi	0.496^{**}				
	(0.118)				
lntradefre		0.339	0.462^{***}	0.352^{*}	
		(0.175)	(0.103)	(0.130)	
polistabi					
lndcredit_gdp			0.0440		
			(0.146)		
lncrefin_gdp		0.594^{***}			
		(0.177)			
L4.lnphd	0.509^{***}	0.244^{***}		0.123^{**}	
	(0.0844)	(0.0663)		(0.0350)	
L4.lnse_grad					0.137^{**}
					(0.0420)
lnresearchers			0.140^{***}		
			(0.0298)		
L3.lngovrd		0.608^{***}	0.723^{***}	0.335^{***}	
		(0.0903)	(0.0488)	(0.0617)	
L.lnberd	0.389^{*}				
	(0.122)				
lnpatent_mil		0.157^{***}		0.0214	

	(1)	(2)	(3)	(4)	(5)
		(0.0452)		(0.0345)	
L2.lnjournal	0.0440				
	(0.102)				
L3.lnroyalpayment				0.502***	0.659***
				(0.0738)	(0.0402)
lnifdi_gfcf					0.355***
					(0.0759)
lnmanuva			0.607***		
			(0.0585)		
lnictim		0.378**		0.178	
		(0.119)		(0.115)	
lnictserv_im	0.106				0.0662
	(0.0938)				(0.0590)
lnediv		0.191			
		(0.643)			
lnec	-0.448**			-0.220***	-0.354***
	(0.100)			(0.0563)	(0.0440)
year	-0.0441**				
	(0.00882)				
2006.year		0			
		(.)			
2007.year		-0.0387			
		(0.0975)			
2008.year		-0.134			
		(0.100)			
2009.year		-0.202			
		(0.117)			
2010.year		-0.338*			
		(0.134)			
2011.year		-0.478**			
		(0.146)			
2012.year		-0.578***			
		(0.145)			
2013.year		-0.569***			
		(0.160)			
2014.year		-0.590***			
		(0.158)			
_cons	82.66**	-1.774	-17.19***	-13.90***	-21.95***
	(17.09)	(1.197)	(1.750)	(2.000)	(0.875)
F	7477.9***		311.0***	657.1***	551.7***
chi2		1105.9***			
r2	0.955	0.959	0.979	0.986	0.985
r2_adjusted	0.947	0.938	0.970	0.979	0.978
rho		.236324336033			
rss		0.941	0.727	0.468	0.527
rmse	0.204	0.180	0.153	0.127	0.133
year effects	25.02**	27.94***			
N	45	45	45	45	45

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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