



China Climbs the Global Value Chain for Medical Devices

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Abstract

This article discusses China's transition towards higher-value-added segments of the medical device global value chain (GVC) as observed through changes in both the composition of foreign direct investment (FDI) and in the technological complexity of its medical device exports. The period under review is primarily 2003–17.

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Introduction

Global value chains (GVCs) refer to the iterative steps that transform a product from conception to its eventual placement in the market.² More specifically, a GVC reflects the value-added contributions that are made at each stage of production.³ Activities in a GVC can be broadly categorized as low-value added (e.g., simple forms of manufacturing and assembly) or high-value added (e.g., research and development, more complex manufacturing, post-market services, etc.). Prior to 2009, China's medical device industry mostly resided in the low-value added spectrum of the GVC.⁴ This was largely reflected in both the type of foreign direct investment (FDI) that the country attracted and the relative lack of sophistication of China's medical device exports.

For example, during 2003–09, projects involving foreign investment into China's medical device sector were primarily directed towards manufacturing—the lowest value-added segment of the GVC—while exports were predominantly composed of low-technology (tech) devices. However, during 2010–17, the composition of FDI shifted into high-value-added activities, which include research and development (R&D), sales, and post-sales services. At the same time, China's medical device exports transitioned into mostly medium-to-high-tech categories.⁵

GVC analysis often makes use of world input/output tables, which catalogue both the trade and the value-added contributions made at each stage of production. However, these data are not available for the medical device industry. Instead, this article relies exclusively on greenfield FDI data⁶ from the *Financial Times* service, fDi Intelligence, along with trade data from IHS Markit's Global Trade Atlas to assess China's ascent up the medical device GVC. Evidence for the validity of this approach is given in a brief literature review later on in this paper.

Global Industry Overview

Medical devices range in complexity from relatively unsophisticated goods, such as bandages and other hospital supplies, to high-tech capital goods, such as diagnostic equipment. Studies have listed four major product groupings, ranging from least to most sophisticated: (1) disposables (bandages, surgical gloves, and plastic syringes); (2) surgical and medical instruments (devices used in surgeries and cosmetic procedures); (3) therapeutics (includes implantable devices like hearing aids and prosthetics and non-implantable devices such as ventilators and infusion pumps); and (4) diagnostic equipment (capital equipment that is technologically complex) (figure 1).

² Gereffi, "Global Value Chain," July 2016. (Duke Center on Globalization) source; OECD, *Mapping Global Value Chains*, December 2012.

³ Timmer, *User Guide to World Input-Output Database*, 2015.

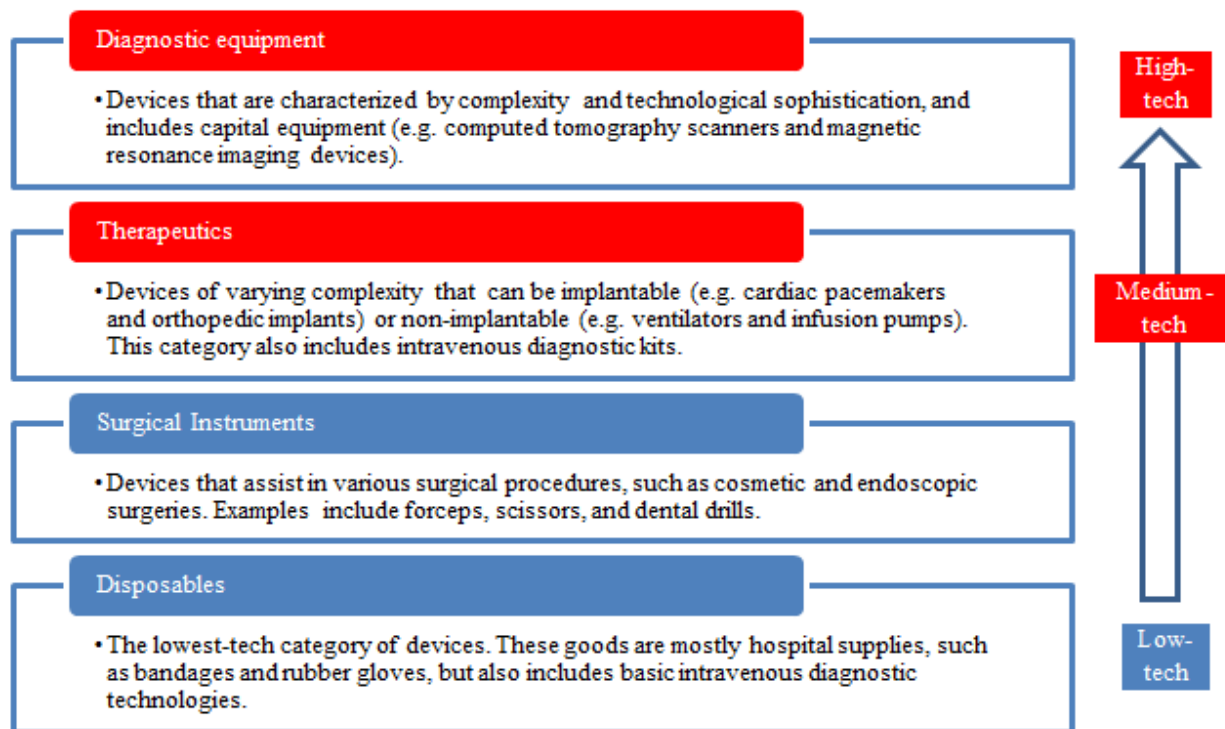
⁴ GVCs refer to the iterative steps that transform a product from conception to a finished good. Further, a GVC reflects the value-added contributions at various stages of production. Timmer, *User Guide to World Input-Output Database*, 2015.

⁵ Also see Torsekar, "China's Changing Medical Device Exports," January 2018 for a discussion of how government policies and the domestic industry have contributed to these shifting exports.

⁶ Greenfield investments refer to new projects that are undertaken by a parent company. These projects can range from the erection of new manufacturing facilities to distribution centers, and headquarters.

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Figure 1: Medical device categories and their relative technological complexity



Source: Compiled by author from [Bamber and Gereffi, *Costa Rica in the Medical Devices Global Value Chain*, August 2013.](#)

The production of global medical devices is largely led by firms headquartered in the United States which, during 2017, boasted 9 of the world's top 15 producers and represented roughly one-quarter of global market share (table 1). Leading original equipment manufacturers (OEMs) of medical devices make a substantial portion of their sales in foreign markets. For example, U.S. medical device OEMs in recent years, have earned between 40 and 50 percent of their revenues outside the United States.⁷ Europe has accounted for roughly 30 percent of these sales. However, the rapidly growing healthcare markets in the Asia-Pacific region—especially in China—have attracted increasing levels of investment from OEMs, suggesting that these firms expect the region to generate significant future sales.⁸ From April 2009 through May 2017, the region captured the largest share of FDI for the medical device sector (figure 2). Every firm listed in table 1 has made investments in China.

⁷ S&P, *Healthcare: Products and Supplies*, February 2014, 19.

⁸ Ibid.

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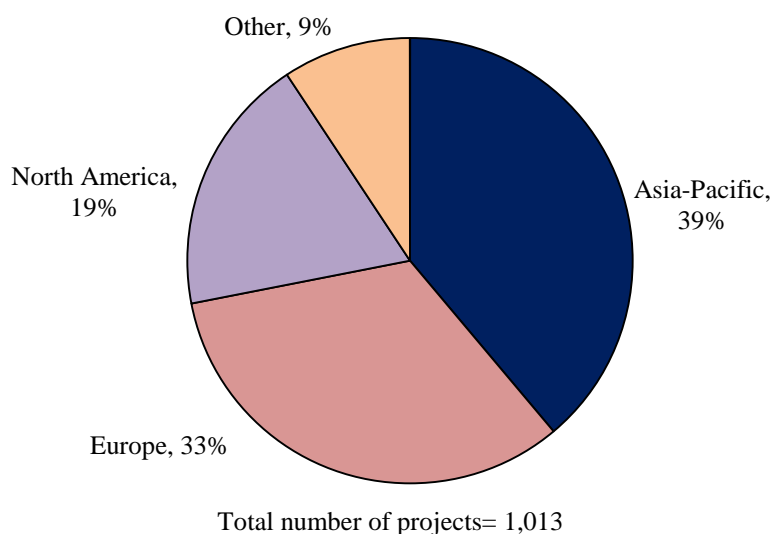
Table 1: The world's top 15 medical device manufacturers in 2017 by revenue, headquarters, and 2015 market share

Company	Headquartered	Revenue (\$ bn)	Global Market Share (%)
Medtronic	Ireland	28.8	8
Johnson & Johnson	United States	25.1	6
Siemens Healthineers	Germany	15.2	3
Becton Dickinson	United States	12.5	3
Cardinal Health	United States	12.4	3
Phillips HealthTech	The Netherlands	12.4	3
Stryker	United States	11.3	3
Baxter	United States	10.2	2
Abbot Laboratories	United States	10.1	2
Boston Scientific	United States	8.4	2
Danaher	United States	7.8	2
Zimmer Biomet	United States	7.7	2
Essilor	France	7.5	2
B.Braun	Germany	6.8	2
Top 15 totals	n/a	176.2	43

Source: Fenske, Barbella, and Brusco, "Top 30 Global Medical Device Companies," July 26, 2017; Snyder, *Healthcare Equipment and Supplies*, May 2017.

Note: Market share data are presented for 2015, the most recent year for which these data were available.

Figure 2: Share of new FDI projects, by region, January 2009–August 2017



Source: Compiled by author from fDi Intelligence (date accessed October 12, 2017).

These investments reflect, in part, the growing healthcare markets within the Asia-Pacific region, which represent more than half of the world's population and roughly one-quarter of the global medical device market.⁹ High urbanization rates¹⁰ and growing disposable income in countries such as China and India, coupled with an aging population in China in particular, are creating a sizable demand for devices of varying complexity, including cardiac pacemakers and orthopedic implants.

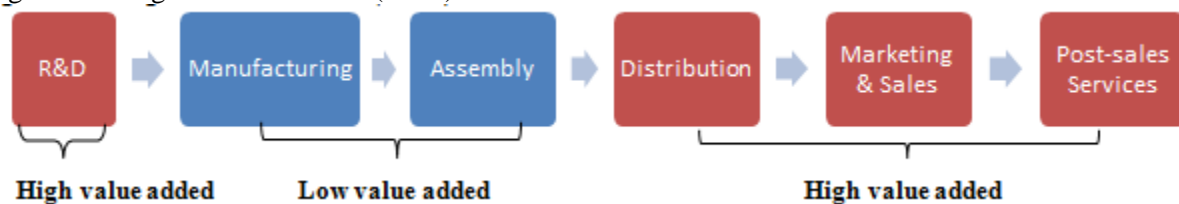
⁹ Agarwal, et al. *MedTech in Asia*, December 2015, 22.

¹⁰ Roxburgh, "Endless Cities," May 5, 2017.

The Global Value Chain for Medical Devices

The GVC for medical devices can be roughly broken down into six distinct phases of production, ranging from high-value-added activities, such as research and development (R&D), to the lower-value-added segments, such as the manufacturing and assembly of components (figure 3). The range of value-added activities has been said to resemble a “smile,” where the highest-value-added activities are close to the producer and the consumer at the very beginning and end of the GVC, while the production stages that occur in the middle are considered the lowest-value-added segment.¹¹

Figure 3: The global value chain (GVC) for medical devices



Source: Source: adapted from Bamber and Gereffi, “Costa Rica in the Medical Devices Global Value Chain,” August 2013.

R&D is the highest value segment of the GVC for medical devices and accounts for an estimated 60 percent of the final cost of medical device production.¹² This segment of the value chain includes product design, obtaining regulatory approval¹³ for sale in particular markets, and the determination of product pricing.¹⁴

As noted, manufacturing and assembly represent the lowest-value-added stages of the medical device GVC. As a result, much of the manufacturing-related FDI directed towards Asia largely reflects the low labor costs associated with this region.¹⁵ The activities related to this segment of the GVC include:

¹¹ The smile curve was first suggested in 1992 when the founder of a Taiwanese technology company reportedly observed that the ends of the value chain were associated with higher-value-added contributions than was the middle. It has since been used as a model to interpret value-added contributions of countries and industries. Degain, Meng, and Wang, “Recent Trends in Global Trade,” 2017, 54.

¹² Industry representative, interview by author, San Diego, CA, October 18, 2017.

¹³ Medical devices are commonly regulated according to a risk-based classification system; the stringency of a standard reflects its relative complexity and potential harm to consumers. The world’s leading medical device markets, (the United States, Japan, the European Union, and China) all use a similar classification system to regulate medical devices, though there are variations in the regulatory requirements across each market. The different regulatory regimes are reflected in the differences of time to market for various devices in these countries. For example, the European Union has the shortest approval time—on average—across all categories of devices among the leading markets. Torsekar, “U.S. Medical Devices,” June 2014; Emergo, “Compare the time,” 2017.

¹⁴ Bamber and Gereffi, *Costa Rica in the Medical Devices Value Chain*, August 2013; Rivers, “Navigating the 12 Steps of Medtech Development,” March 7, 2017.

¹⁵ In recent years, for example, China’s labor rates were estimated to be from 60 to 80 percent less than those observed in the United States. Notably, these labor cost advantages have been eroding relative to other regional suppliers. Crawford, “Asia’s Continued Manufacturing Evolution,” May 10, 2012.

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- The production of components for low-tech products, such as the fabric used for mastectomy bras and the precision workings for metal stents.¹⁶
- The production of parts for medium- to high-tech products, including circuit boards and software for pacemakers and diagnostic equipment.

Many of these components often require the application of resins and coatings to prevent rusting and ensure proper functioning of the finished product.¹⁷

The three final stages of the medical device GVC (distribution, marketing and sales, and post-sales service) are considered high-value-added activities. Activities in this segment include coordination with the distributors or the end users to conduct sales. Low-tech products (disposables and surgical equipment) are generally marketed and sold in bulk to wholesale distributors, whereas high-tech products tend to be sold directly to hospital administrators or specialty care facilities.¹⁸ Post-sales services include the training and consulting activities that occur once a device (commonly high-tech equipment) has entered the market; they are intended to insure the proper use of the device.¹⁹

FDI and GVCs: Presentation of Data

As previously stated, because input/output data were not available for the medical device industry, this paper uses greenfield FDI data to determine China's position on the medical device GVC. Evidence for the validity of this approach is provided in a literature review on the ways that FDI influences both GVC activity and the composition of a country's exports (box 1).

¹⁶ Bamber and Gereffi, *Costa Rica in the Medical Devices Value Chain*, August 2013.

¹⁷ Isenberg and Coates, "Using Supply Chains," November 20, 2015.

¹⁸ Bamber and Gereffi, *Costa Rica*, August 2013

¹⁹ Ghemawat, "Managing Differences," March 2007.

Box 1. Foreign Direct Investment (FDI), Global Value Chains (GVCs), and Export Composition: A Brief Literature Review

The role of FDI in influencing both a country's contribution to global value chains and the composition of its exports has been explored in a number of recent publications. For example, the European Central Bank (2017) found an indirect association between policies that encourage FDI and a host economy's participation in GVCs. The research also pointed to the role that foreign investors play in shaping a country's exports.^a Further, the World Bank (2015) cited FDI as the principal means through which countries engage in GVCs.

More specifically, Amador and Cabral (2014) found that FDI plays a critical role in arranging GVCs operated by multinational corporations (MNCs). Nikolovová's (2013) examination of data for the 27 countries then making up the European Union found a positive correlation between FDI growth at the sectoral level and demand for intermediate goods.^b

Other researchers have concluded that FDI plays an important role in reconfiguring a given country's economic and export structure (Damijan, Kostevc, and Rojec, 2013). Further, Bajgar and Javorcik (2016) noted that FDI may translate into higher-value-added exports from domestic firms due to the strength of backward linkages^c, as local suppliers compete to produce high-quality parts to meet the needs of MNCs.

^a Buelens and Tirpák, *Reading the Footprints: How Foreign Investors Shape Countries' Participation in Global Value Chains*, May 2017, 3.

^b GVCs are characterized by the trade of intermediate goods, otherwise known as parts or inputs.

^c Backward linkages can refer to the ability of domestic firms to acquire inputs from other domestic firms.

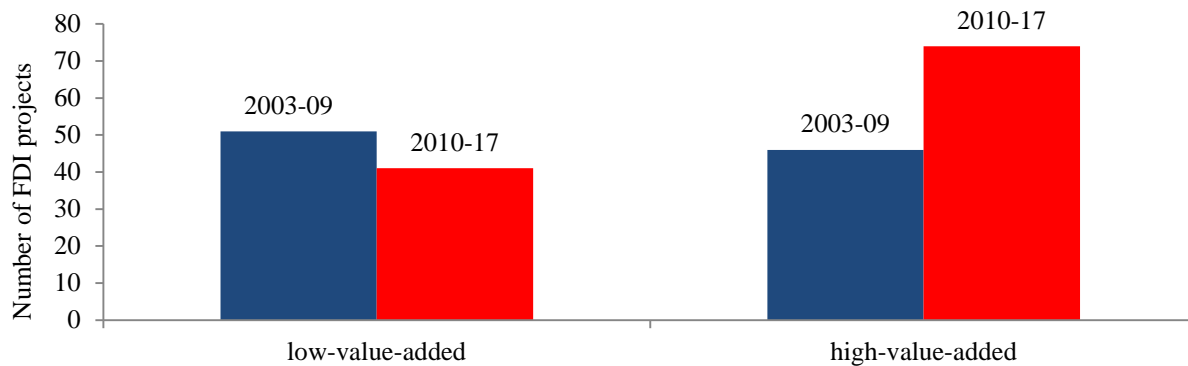
During 2003–17, greenfield foreign direct investment (FDI) in China's medical device sector totaled \$1.9 billion. The world's largest medical device manufacturers contributed more than one-third of this total and more than one-quarter of the total number of projects.²⁰ From 2003 to 2009, foreign investors were especially driven to supply China's burgeoning medical device market, encouraged by the opportunity to achieve lower production costs.²¹ For this reason, investments during this time were largely oriented towards manufacturing. During 2010–17, however, the pattern of investment projects shifted away from low-value-added activities (manufacturing and assembly) and towards high-value-added segments (R&D, distribution, marketing and sales, and post-market services) (figure 4).

²⁰ fDi Intelligence, October 13, 2017).

²¹ During 2003–07, the two most commonly cited motives for FDI were China's market growth and low labor costs. fDi Intelligence (accessed October 13, 2017).

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Figure 4: FDI projects in China's medical device sector during 2003–09 were concentrated in low-value added activities; this pattern reversed during 2010–17.



Source: Compiled by author from fDI Intelligence (date accessed October 13, 2017).

Note: Low-value added activities refer to announced FDI directed towards manufacturing and assembly. High-value added activities include projects related to design and testing; distribution; logistics and transport; marketing and sales (including customer support); post-market services, encompassing business services; education and training, headquarters, shared services center, and technical support center.

FDI into China's medical device sector during 2003–17 were concentrated in two provinces (Guangdong and Jiangsu), as well as two municipalities (Beijing and Shanghai) in Eastern China (figure 5). Collectively, these destinations accounted for three-quarters of all of the sector's FDI projects in the country and for \$1.3 billion of the \$1.9 billion of the capital investments into China over this period. Not surprisingly, a substantial amount of manufacturing for industries related to medical device production occurs at some of these locations, which have been identified as manufacturing clusters (table 2).²²

For example, some of the activities that occur at these locations are manufacturing for electronics and electrical equipment, as well as the establishment of centers for industrial machinery and information technology. These activities suggest that foreign OEMs operating in China may be able to acquire inputs from domestic producers (defined earlier as backward linkages).²³ Moreover, these locations are associated with strong transportation networks, access to shipping ports, and the country's greatest concentration of high-end hospitals.²⁴

In addition, China's 2014 introduction of a policy aimed at supporting domestic innovation has especially benefitted companies operating in Beijing, Shanghai, Guangdong, Jiangsu, and Zhejiang. Collectively, these areas have accounted for 80 percent of all the devices that have been selected for expedited approvals under this policy.²⁵

²² Clusters, as defined by Michael E. Porter are geographically concentrated interconnected entities operating within a particular industry. Porter, "Clusters," November-December 1998.

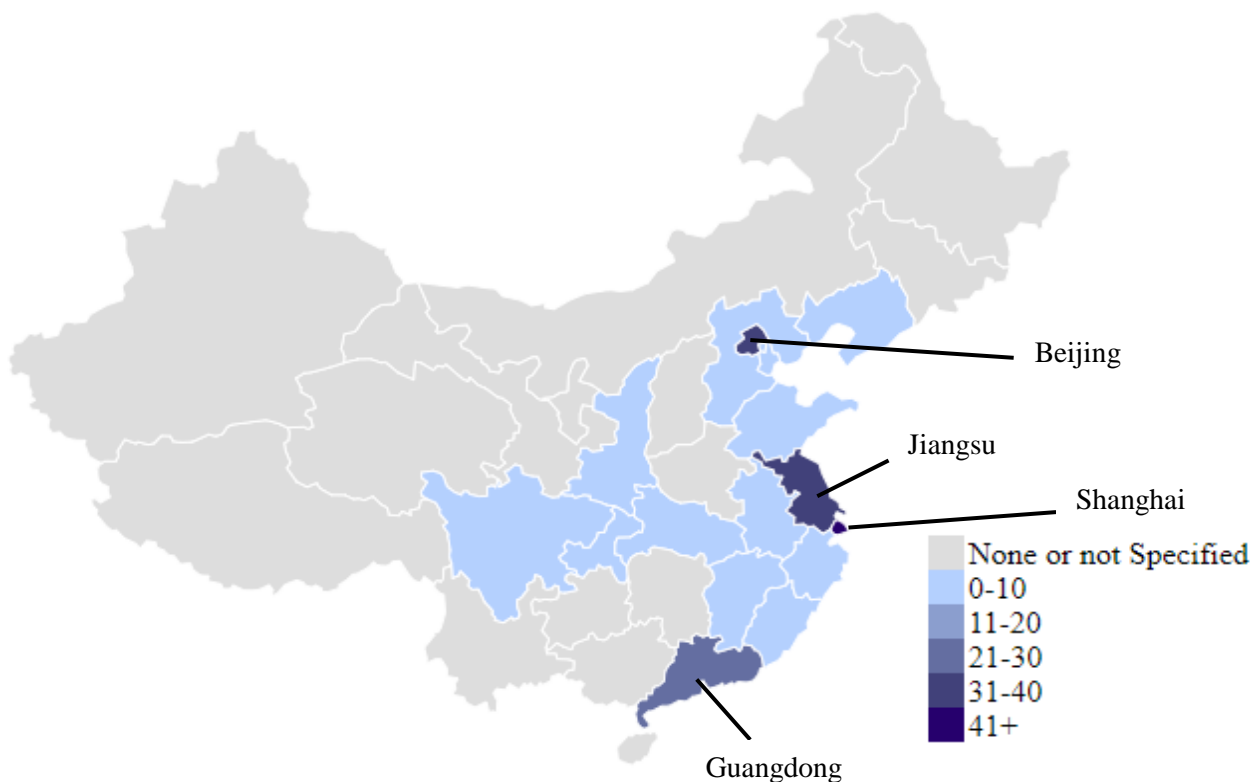
²³ According to one source, China's medical device manufacturing sector boasted an abundance of "...second- and third-tier suppliers to support [device] manufacturing." Crawford, "Asia's Continued Manufacturing Evolution," May 10, 2012; IBISWorld, *Medical Device Manufacturing in China*, July 2017, 17.

²⁴ IBISWorld, *Medical Device Manufacturing in China*, July 2017, 17.

²⁵ EIU, *Medtech in China*, 2017.

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Figure 5: Most FDI projects during 2003–17 have been aimed at Eastern China, especially Shanghai



Source: Compiled by author from fDi Intelligence (accessed October 12, 2017).

Note: There were 212 FDI projects announced during 2003–17. Shanghai accounted for 31 percent; Jiangsu, 19 percent; Beijing, 15 percent ; and Guangdong, 10 percent of all these projects over this period.

Table 2: China’s prominent manufacturing clusters

Manufacturing cluster	Industries served
Beijing	Automotive, chemicals, pharmaceuticals, metals, industrial machinery, information technology
Changshu	Automotive, industrial machinery and parts, pharmaceuticals
Shanghai	Automotive, biotechnology, electronics and electrical equipment, transportation and logistics
Suzhou	Chemical and pharmaceutical, industrial machinery and parts, information technology

Source: Dezan Shira & Associates, map, “Breakdown of Professional Clusters in China,” in “China’s Industry Clusters,” February 23, 2012, <http://www.china-briefing.com/news/wp-content/uploads/2012/02/Clusters-Large-1024x763.jpg>.

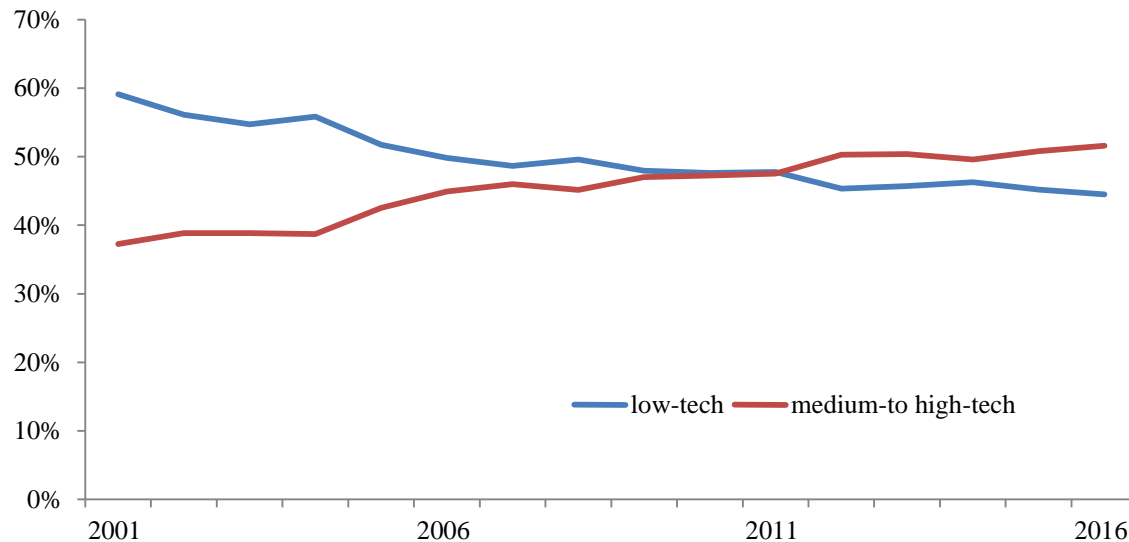
China’s Transition into High-Tech Exports

In addition to changing patterns of FDI, China’s rise along the medical device GVC is also reflected in the composition of the country’s medical device exports. For most of the past two decades, those exports were predominantly low-tech medical goods. During 2001–11, for example, disposable devices were China’s largest category of medical device exports, accounting for more than one-quarter of the sector’s overall exports over that period. However, by 2012, medium- to high-tech devices had emerged as China’s largest share of medical device exports (figure 6). Two categories have driven much of this transition: therapeutic devices have been

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China's largest medical device export category since 2012, while diagnostic equipment registered the highest growth rate of any of the remaining categories since 2001.

Figure 6: China's medical device exports have transitioned from low-tech into medium-to high-tech during 2012–16.



Source: Compiled by author from IHS Markit, Global Trade Atlas database (accessed October 12, 2017).

Note: Devices that have been categorized as low tech include disposables, surgical instruments, intravenous diagnostic technologies, and parts of various products; medium- to high-tech devices include therapeutic and diagnostic equipment. Devices that could not be clearly identified as low- or high-tech were categorized as "other." These goods, which largely consisted of wheelchairs, were not included in the figure above, but accounted for less than 6 percent in each of the years covered. For the data used in this figure, please see Torsekar, "China's Changing Medical Device Exports," *JICE*, January 2018.

Conclusion

During 2003–17, China gradually transitioned away from low-end segments of the medical device GVC, towards high-end activities. This shift is reflected in the types of FDI made during this time. For the first six years of this period, FDI was principally directed to manufacturing and assembly—the lowest value-added segments of the GVC. In contrast from 2009 through 2017, the majority of investments were geared towards R&D, distribution, marketing and sales, and post-market services; all of these activities are considered high-value added. This shift along the GVC has also been reflected in the changing technological complexity of China's exports from low-tech to mostly medium-and-high-tech medical devices. Notably, foreign multinationals remain the leading suppliers of China's high-tech medical device market. However, China's advancement along the medical device GVC and increased domestic production of higher-tech medical devices may portend a reduced reliance on foreign producers.

Bibliography

- Agarwal, Amit, Axel Baur, Shan He, Franck Le Deu, Satsheel Shrotriya, and Florian Then. *MedTech in Asia: Committing at Scale to Raise Standards of Care for Patients*. McKinsey & Company, December 2015.
<https://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/~media/98d2e02830e84e0f9cbb330e622a64e1.ashx> (registration required).
- Amador, João, and Sónia Cabral. *Global Value Chains Surveying Drivers and Measures*. European Central Bank Working Paper Series no. 1739, October 2014.
<https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1739.en.pdf?99f9f032cf940af4996a661341669745>.
- Bajgar, Matej, and Beata Javorcik. *Climbing the Rungs of the Quality Ladder: FDI and Domestic Exporters in Romania*. Organisation for Economic Co-operation and Development (OECD). July 26, 2017.
- Bamber, Penny, and Gary Gereffi. *Costa Rica in the Medical Devices Global Value Chain*. Duke Center on Globalization, Governance and Competitiveness, August 2013.
<https://globalvaluechains.org/publication/costa-rica-medical-devices-global-value-chain-opportunities-upgrading>.
- Buelens, Christian, and Marcel Tirpák. *Reading the Footprints: How Foreign Investors Shape Countries' Participation in Global Value Chains*. European Central Bank (ECB). ECB Working Paper Series No. 2060, May 2017.
<https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2060.en.pdf>.
- Center for Financial Research and Analysis (CFRA). *Health Care Equipment and Supplies*, May 2017 (fee required).
- Crawford, Mark. "Asia's Continued Manufacturing Evolution." *Medical Product Outsourcing (MPO)*, May 10, 2012. https://www.mpo-mag.com/issues/2012-05/view_features/asias-continued-manufacturing-evolution/.
- Damijan, Jože, Črt Kostevc, and Matija Rojec. *FDI, Structural Change and Productivity Growth: Global Supply Chains at Work in Central and Eastern European Countries*, 2013. www.grincoh.eu/media/...growth.../grincoh_wp1.07_damijan_kostevc_rojec.pdf.
- Degain, Christophe, Bo Meng, and Zhi Wang. "Recent Trends in Global Trade and Global Value Chains." Chap. 2 in World Bank et al., *Measuring and Analyzing the Impact of GVCs on Economic Development*, World Bank, 2017.
<http://www.worldbank.org/en/topic/trade/publication/global-value-chain-development-report-measuring-and-analyzing-the-impact-of-gvcs-on-economic-development>.

China Climbs the Medical Device Global Value Chain

Dezan Shira & Associates. “China’s Industry Clusters.” China Briefing, February 23, 2012. <http://www.china-briefing.com/news/2012/02/23/chinas-industry-clusters.html>.

Economist Intelligence Unit (EIU). *Medtech in China: Growth and Policy Uncertainty*, 2017.

Emergo Group (Emergo). “Compare the Time, Cost and Complexity of Getting Regulatory Approval for Medical Devices.” Emergo interactive table, updated December 2017. <https://www.emergogroup.com/resources/worldwide/global-regulatory-comparison-tool>.

fDi Intelligence. fDi Markets Database. <https://www.fdiintelligence.com/Info/About-us> (fee required) (accessed October 12, 2017).

Fenske, Sean, Michael Barbella, and Sam Brusco. “Top 30 Global Medical Device Companies.” Medical Product Outsourcing (MPO), July 26, 2017. https://www.mpo-mag.com/heaps/view/3670/1/?nav=top_nav.

Gereffi, Gary, Karina Fernandez-Stark. *Global Value Chain Analysis: A Primer*. Duke Center on Globalization, Governance and Competitiveness. July 2016. https://gvcc.duke.edu/wp-content/uploads/Duke_CGGC_Global_Value_Chain_GVC_Analysis_Primer_2nd_Ed_2016.pdf. Sean Fenske, Michael Barbella, and Sam Brusco. “Top 30 Global Medical Device Companies.” *Medical Product Outsourcing*. July 26, 2017. https://www.mpo-mag.com/heaps/view/3670/1/?nav=top_nav.

Ghemawat, Pankaj. “Managing Differences: The Central Challenge of Global Strategy.” *Harvard Business Review*. March 2007. <https://hbr.org/2007/03/managing-differences-the-central-challenge-of-global-strategy>.

IBISWorld. *Medical Device Manufacturing in China*. July 2017. <https://www.ibisworld.com/industry-trends/international/china-market-research-reports/manufacturing/special-equipment-machinery/medical-device-manufacturing.html>. (fee required).

IHS Markit. Global Trade Atlas database (accessed October 12, 2017).

Isenberg, Daniel, and Timothy Coates. “Using Supply Chains to Grow Your Business.” *Harvard Business Review*, November 20, 2015. <https://hbr.org/2015/11/using-supply-chains-to-grow-your-business>.

Nikolovová, Pavla. “Sourcing Patterns of FDI Activity and Their Impact on the Domestic Economy.” *Czech Journal of Economics and Finance* 63, no. 3 (July 2013): 288–302.

Organisation for Economic Co-operation and Development (OECD). *Mapping Global Value Chains*, December 4-5, 2012.

Porter, Michael E. “Clusters and the New Economics of Competition.” *Harvard Business Review*. November–December 1998. <https://hbr.org/1998/11/clusters-and-the-new-economics-of-competition>.

China Climbs the Medical Device Global Value Chain

Rivers, Dorine. “Navigating the 12 Steps of Medtech Development.” *Medical Product Outsourcing (MPO)*, March 7, 2017. https://www.mpo-mag.com/issues/2017-03-01/view_features/navigating-the-12-steps-of-medtech-development-264519/.

Roxburgh, Helen. “Endless Cities: Will China’s New Urbanisation Just Mean More Sprawl?” *The Guardian*. May 5, 2017. <https://www.theguardian.com/cities/2017/may/05/megaregions-endless-china-urbanisation-sprawl-xiongan-jingjinji>.

Snyder, Keith. *Healthcare Equipment & Supplies*. Standard and Poor’s Global. May 2017.

Timmer, Marcel P., Erik Dietzenbacher, Bart Los, Robert Stehrer, and Gaaitzen J. de Vries. “An Illustrated User Guide to the World Input-Output Database: The Case of Global Automotive Production.” *Review of International Economics* 23, no. 3 (August 2015): 575–605. doi:10.1111/roie.12178.

Torsekar, Mihir. “China’s Changing Medical Device Exports.” *Journal of International Commerce and Economics*, January 2018.

U.S. International Trade Commission (USITC). *Medical Devices and Equipment: Competitive Conditions Affecting U.S. Trade in Japan and Other Principal Foreign Markets*. Publication No. 3909. Washington, DC: USITC, March 2007. <https://www.usitc.gov/publications/332/pub3909.pdf>.