Duke Global Value Chains Center

Gender Dynamics and Upgrading in Global Value Chains: The Case of Medical Devices

Background Report for WBG-WTO Global Report on Trade and Gender:
How can 21st century trade help to close the gender gap?

Penny Bamber and Danny Hamrick

January 28, 2019

1. Introduction

Global value chain (GVC) integration and upgrading have become key goals of trade and investment policy in developing countries. GVC trade is seen as a channel for export revenue generation, knowledge and technology transfer; and importantly, boosting employment, particularly for women. GVC-related trade in sectors such as apparel, agriculture and electronics, has generated significant female employment, offering many women their first chance for waged employment (Bamber & Staritz, 2016; Lopez-Acevedo & Robertson, 2016; Staritz & Reis, 2013). Many emerging economies are now seeking to upgrade into increasingly higher value and/or more technologically sophisticated sectors.[1] While the economic imperative is clear, the gender implications of this strategic shift are more ambiguous (Kucera & Tejani, 2014; Saraçoğlu et al., 2018). In particular, important questions arise regarding the relative opportunities for men and women in these higher value GVCs, and what, if any, gender sensitive policies are required to enhance a country's competitiveness in these sectors.

While there is a growing literature on the nature of work across these different types of value chains (Fernandez-Stark & Bamber, 2018; Gereffi et al., 2011; ILO, 2016), research on gender and GVCs has primarily focused on labor-intensive and generally low-technology industries characterized by high levels of feminization. Much less research has been carried out on 'high tech' GVCs, or in value chain segments with higher technology intensity (Saraçoğlu et al., 2018). This study seeks to contribute to this gap in the gender and trade debate by analyzing the gender implications of, and impacts on trade and competitiveness in, a single high value manufacturing sector, medical devices.

The medical devices industry offers an interesting example of a high-tech and high-value manufacturing sector. It is characterized by strong and growing global demand as populations age and healthcare expenditure expands. High technological and regulatory barriers to entry reduce footloose investments and require a skilled and capable workforce. A diverse range of products, from relatively simple, low value items such as syringes and sutures to high-risk devices such as pacemakers, provides ample scope for product upgrading in the sector. Once dominated only by developed nations, it is rapidly globalizing, providing opportunities for a growing number of developing countries to join the industry, especially in production stages of the chain. At the same time, global employment is expanding, particularly in these new locations; a large share of these workers appears to be female.

This study utilizes a gendered GVC framework to analyze the dynamics of female participation in two emerging countries in the industry: Costa Rica and the Dominican Republic. Three key questions are addressed: (1) what is female intensity in the industry and how does it compare to the manufacturing sector as a whole; (2) does female intensity change over time as the sector grows and more technologically sophisticated products are manufactured in a particular location, and; (3) do changes in wages as a result of upgrading affect female intensity in different roles within the industry. Notably, the study uses firm-level data to isolate the employment effects of GVC-only activity from manufacturing oriented to the domestic economy; the research is also supported by stakeholder interviews.

Key findings from the study have relevant implications for policymakers seeking to use high tech GVC engagement to drive economic and social goals. First, the sector expanded quickly in both countries, contributing significantly to national export baskets, making it an attractive sector for GVC entry. Second, women account for over half of employment, considerably higher than their participation in the manufacturing sector as a whole, as well as export processing zones (EPZ). Third, this female participation holds steady as the sector grows, upgrades into new, higher value products and as wages rise; and forth, these predominantly female jobs are good quality jobs despite being primarily in production stages; that is, they are sustainable and characterized by permanent contracts and higher than average wages. Gender sensitive policies in both locations in terms of access to education and supportive maternity leave

[1] Made in China 2025 is emblematic of this shift in industrial policy amongst emerging economies.

approaches contributed to ongoing female participation, while industry characteristics for offering well-paying, long term, permanent employment were highly attractive for recruiting a growing number of single mothers in these countries. As such the sector offers both economic and social upgrading opportunities for its host locations, provided specific policy actions are taken.

The study is structured as follows. First, we present a brief overview of the existing literature on gender and GVC-trade, focusing on the benefits of a gendered GVC approach, followed by a discussion of the methodology used. Second, an overview of the medical device GVC is provided to highlight key global industry characteristics, particularly with respect to the nature of work in the industry. Next, we examine the experiences of the two countries cases, focusing on each nation's upgrading trajectory and gender dynamics within the industry. This is followed by a discussion of key factors raised in the literature which may explain the distribution of women/men seen in the two case studies. Finally, we conclude by considering the policy implications of our findings.

2. Literature Review and Conceptual Framework

Over the past two decades, a growing body of literature has emerged on gender issues in developing country participation in GVCs. This research has focused primarily on the first industries to offshore production, that is, light manufacturing sectors, such as apparel, increased international trade in agriculture, and consumer electronics (1990s-mid-2000s). Global employment in these GVCs is characterized by high levels of female participation, which has led to theories of feminization of trade. Much less GVC research has been carried out on the gendered impacts of industries that have globalized since then. However, numerous export-oriented industrialization (EOI) studies have indicated that upgrading into these sectors results in declining female intensity, contributing to the emergence of a *feminization-defeminization* debate around trade (Kucera & Tejani, 2014; Saraçoğlu et al., 2018; Tejani & Milberg, 2016). This section briefly reviews these analyses before outlining the conceptual framework to be used in this study.

The early sectors to globalize were labor-intensive and cyclical in nature (Barrientos et al., 2011). Scholars have highlighted that countries entered into these light manufacturing and agricultural sectors in labor-intensive operations by tapping into large pools of previously unemployed female workers (Barrientos, 2014a; Kucera & Tejani, 2014; Pickles & Godfrey, 2012; Seguino, 2000). This resulted in high levels of female participation, particularly in sectors concentrated in export processing zones (Tejani, 2011); on average, 60-80% of apparel production jobs in the leading exporting countries are women (Barrientos, 2014a; Lopez-Acevedo & Robertson, 2016). Similarly, horticulture and floriculture GVCs have very large female shares (Christian et al., 2013). For many of these women, these industries provided them with their first opportunity to enter waged employment (Dolan & Sorby, 2003; Maertens & Swinnen, 2009; Pickles & Godfrey, 2012).

The high levels of female employment in these sectors prompted considerable research as to why (Barrientos, 2001; Barrientos & Kabeer, 2004; Bussolo & De Hoyos, 2009; Seguino, 1997). Findings from this work resulted in a persistent gender and GVC narrative arguing that women are overly represented in lower paying, labor intensive roles which rely on precarious conditions for female work to respond to fluctuations in global demand (Barrientos, 2014a; Fontana, 2006; UNCTAD, 2015). Key factors identified as contributing to this phenomenon are the gender wage gap, perceived flexibility and gender norms and stereotypes. Lower female wages meant women are more cost effective for low value stages of the value chain (Deere, 2005; Fussell, 2000; Seguino, 1997, 2000), while as secondary breadwinners, women were seen as being better positioned as flexible workers (Barrientos, 2014a; Barrientos et al., 1996; Seguino et al., 2010). Where women have failed to move into higher level positions in these industries, this has largely been attributed to lack of access to productive resources such as training and education, networks and access to finance (Fontana, 2011; Staritz & Reis, 2013).

Considerably less gender research has focused on the GVCs of industries that have offshored since the mid-2000s. These industries as a group are characterized by higher technology-, knowledge- or capital-intensity, such as aerospace, chemicals and information technology. With lower employment impacts than their labor-intensive predecessors, these industries have had a less pronounced impact on female employment in host countries. They have thus attracted less attention from scholars and policy makers alike. With the exception of knowledge-intensive sectors such as IT services (Powell & Chang, 2016; Sarkar & Mehta, 2018), few industry-specific gender analyses have been undertaken mapping the globalization of these industries.

Gendered analysis of participation in these sectors, rather, has been dominated by the export-led industrialization (EOI) literature. Collectively, the EOI studies have found that as countries upgrade their economies into high tech and capital-intensive industry segments/sectors for the export market, female intensity in employment declines; that is, the 'defeminization' of trade. Prominent scholars contributing to this theory include Caraway (2007) for East Asia; Kucera and Tejani (2014) for a sample of 36 countries,[2] Jomo (2009) in East Asia, Fussell (2000) in Mexico and Berik (2000) in Taiwan. Scholars attribute both inter and intra-industry declining female employment in high technology industries/segments to wage changes and gender differentiated access to productive resources (Saraçoğlu et al., 2018; Tejani, 2011). They argue as countries deepen their engagement in global industries, the gender wage gap declines due to labor market tightening, the cost advantages of hiring women are eroded and men tend to be favored over women (Ghosh, 2002; Kucera & Tejani, 2014).[3] As with the gender-GVC literature on low-value sectors, the productive resources access argument again posits that, as higher level of capital or technical expertise or networks are required, the barriers women face to access training and education prohibit them from advancing into more sophisticated activities within an industry or into higher technology sectors (Ahmed, 2013).

In both sets of literature, gender norms and stereotypes are highlighted as major contributors to this *feminization-defeminization* paradigm, while at the same time, women's reproductive responsibilities are emphasized as a major constraint to their potential to respond to opportunities in expanding export-oriented economic activities. In many parts of the world, women are viewed as preferential for certain jobs that require high levels of dexterity, or jobs that are considered to be female – such as sewing, food preparation and housekeeping, while men are favored for machine operation and maintenance (Bamber & Fernandez-Stark, 2013; Barrientos, 2001). Meanwhile, their ability, or interest, in pursuing roles with more responsibility is said to be dampened by time constraints due to their primary responsibility for reproductive, care and unpaid work, such as domestic work, childcare, and caring for the sick and elderly (Ferrant et al., 2014). Consequently, women may opt out of promotions or leadership positions, and in some cases, completely exit the industry, creating a leaking talent pipeline (Cabrera, 2009).

Despite the growing literature, this research to date remains somewhat inconclusive. This is, in part, the result of two important limitations: lack of specificity, on one hand, and lack of generalizability, on the other. First, much of the existing quantitative work is done on the aggregate level due to poor data availability or disaggregation. A large number of these studies utilize UNIDO INDSTAT national employment data at the ISIC 2D level.[4] This limits the ability to unpack export-oriented jobs versus

[2] Kucera and Tejani (2014) find that technological upgrading within industries has a particularly strong effect on defeminization, which is intensified if countries move out of the labor-intensive apparel sector and into those characterized by metal fabricated products.
[3] Jomo (2009) argues that this was not the case for East Asian countries, and that the trends were in fact independent of each other.
[4] Including Caraway (2007); Jomo (2009); Kucera and Tejani (2014); Saraçoğlu et al. (2018); Tejani and Milberg (2016).

domestically focused employment; to understand how specific manufacturing GVCs may operate and the impact of the lead firms that drive them; or the differential effects at different stages of a GVC (e.g. production versus processing; engineering versus assembly).[5] The approach also assumes spillovers from export operations into domestic manufacturing industry in terms of employment practices and trends; this is often not the case in GVCs in developing countries where EPZ based firms remain fairly isolated (Farole, 2011). Second, GVC case studies have focused on gender dynamics in specific countries in globalizing industries, yet these gendered GVCs have been limited to select labor-intensive industries (Caraway, 2007): apparel, electronics, horticulture, tourism and offshore services (Barrientos, 2014a; Christian et al., 2013; Fontana, 2006; Staritz & Reis, 2013). As a result, the literature lacks a generalizability of findings. More specifically, gender dynamics in high value manufacturing GVCs remains underexplored.

This study seeks to contribute to this literature by taking a high-tech sector-specific approach and analyzing the gender implications of, and impacts on, trade and competitiveness in a single high value manufacturing sector, medical devices. This study utilizes a gendered GVC framework based on firm-level data to isolate the employment effects of GVC-only activity. Three key questions are addressed: (1) what is female intensity in the industry and how does it compare to the manufacturing sector as a whole; (2) does female intensity change over time as the sector grows and more technologically sophisticated products are manufactured in a particular location, and; (3) do changes in wages as a result of upgrading affect female intensity in different roles within the industry. This gendered GVC mapping approach can be replicated across countries and sectors.[6]

A gendered GVC approach is particularly useful to develop a nuanced understanding of how countries participate in these industries and their impact on men and women. Specifically, the GVC framework[7] maps globalized industries into segments and roles/activities and analyzes which firms, countries and workers undertake each of these activities (Gereffi & Fernandez-Stark, 2016). A gendered GVC framework examines how men and women are distributed across these activities, helping to identify why they may be concentrated in particular nodes or jobs and thus providing insights as to how to mitigate potential bottlenecks to trade and competitiveness (Bamber & Staritz, 2016). At the same time, by analyzing which firms undertake each activity, it allows policymakers to better understand how the organization of lead firms, whose decisions drive the industry, may impact gender outcomes. These lead firms dampen or reinforce gender norms through activities such as recruitment, promotion, skill development, knowledge transfer, procurement, working conditions and possibilities to combine work and family life (Bamber & Staritz, 2016).

The framework allows for dynamic analysis over time as countries change the way they participate within a particular industry; this is broadly referred to as ‘upgrading’ (Bamber & Staritz, 2016; Gereffi & Fernandez-Stark, 2016; ILO, 2016). A number of upgrading strategies have been identified in the GVC literature to date, covering both economic and social dimensions of chain participation (Gereffi & Fernandez-Stark, 2016). Economic upgrading strategies include improving efficiencies via technology and production advancements (process upgrading); producing higher value or more sophisticated products (product upgrading); expansion or shifting into new stages of the value chain (functional upgrading) amongst others (Humphrey & Schmitz, 2002). Social upgrading strategies focus on creating more and better

[5] Tejani and Milberg (2016) use 2D ISIC codes to analyze whether wage gaps and differential education outcomes account for lower female shares in more technologically advanced sectors, arguing that technological intensity matter more than export intensity based on broad manufacturing data. However, they mention that such broad categorizations of manufacturing could mask sector and country specific experiences.
[6] See Frederick (2019) for further details on this GVC mapping approach.
[7] GVC analysis focuses on understanding the nature of the global fragmentation of industries into order to maximize benefits from the increasing integration of the world economy. It examines geographically dispersed operations performed by workers of varying skill, located around the world, but intrinsically linked as a single system.

jobs with good working conditions and opportunities for advancement (ILO, 2016). A gendered GVC framework further unpacks these dynamic economic and social upgrading elements to identify whether these are associated with differential outcomes for men and women.

Building on the variables detailed for a gendered GVC framework presented in Bamber and Staritz (2016) (see Annex 1), the discussion of the resulting gender distribution in this high-tech sector is framed around five key issues that emerge in the existing literature. Collectively, these five issues are important from a policy perspective in terms of promoting practices that encourage female empowerment while driving trade competitiveness. (1) Do differing work conditions exist between men and women within a high-tech industry and if so, do these contribute to gender roles.[8] (2) Could differential access by men and women to relevant productive resources (Barrientos, 2014a, 2014b; Fontana, 2011) – in this case, education -- result in poor participation of women in sectors with higher technology requirements (e.g. Tejani and Milberg (2016), Kucera and Tejani (2014)). (3) Is there a gender wage gap effect? Lower female costs helps to explain females predominance in low-value, labor-intensive segments of many GVCs, such as assembly activities (Barrientos, 2001), are these replicated in high tech sectors as well? (4) Do reproductive responsibilities impact women's ability to work in high-tech GVCs and what policies may support their retention in the workforce. In order to empower females, policies such as maternity leave and programs to facilitate breastfeeding and childcare are often needed. (5) Are gender norms at play in the industry? Along the GVC, multiple and sometimes divergent norms operate. For example, the norms of lead firms, such as commitments to equality and diversity are seen as driving the chain. However, these operations are embedded into multiple local contexts where the chains touchdown. Gender norms, such as perceived ability in detail-oriented tasks, demands for higher level of care work and reproductive responsibilities can limit female participation and opportunities (Bamber & Staritz, 2016; Staritz & Reis, 2013; Tejani, 2011).

3. Methodology

A mixed methods approach was used to develop this analysis, including both quantitative and qualitative sources. Quantitative sources include national trade statistics published for both countries in UN Comtrade database for 2004-2016 and firm-level trade and employment statistics for each country for firms in the sector gathered in the Annual Census of Export Processing Zones; in the case of Costa Rica, this data was then cross-referenced with data from Banco Central de Costa Rica, filtering for firms registered as medical supplies and equipment manufacturers (AE80).[9] Firm-level trade data included exports (HS2002, 6D, value, 2000-2016 Costa Rica, 2012-2016 Dominican Republic) and imports for limited years. For Costa Rica, employment data (number of workers, total wages) was available at the firm level for 2000-2016, although gender segregated data was only available between 2004-2011, somewhat limiting the sample. For the Dominican Republic, employment and gender data (number of workers in production, technical and professional roles; wages for production and technical workers) were available for 2006-2016. The resulting dataset for analyzing female intensity included 19 firms in Costa Rica and 25 firms from the Dominican Republic, although entry years differ.[10] While the number of firms overall is small, limiting analytical methods, firms accounted for >85% of sector exports in the relevant years for both countries.

Firms were first mapped onto the GVC by segment and product type using the value chain and product categories identified in Bamber and Gereffi (2013). Value chain segment was determined by the

[8] This has been a key trend in light manufacturing, agriculture and tourism industries (Barrientos, 2001, 2014b; Christian et al., 2013; UNCTAD, 2014).
[9] AE80 is approximately equivalent to ISIC Rev 3 code 3250. ISIC Rev. 4 further divides medical device manufacturing into two codes, including 3250 and 2660.
[10] A breakdown of the division of these firms is available in the Annex.

composition of firm exports as components manufacturers and assemblers.[11] In Costa Rica, following the methodology of Frederick (2017), assembly firms were then further defined by the specific types of products exports using HS-2002 classifications based on a 50% share of exports, allowing for analysis of sophistication of output. In the Dominican Republic, the majority of exports are categorized under one HS code regardless of output making additional analysis difficult. Available employment and gender data were then analyzed. Finally, data analysis was complemented by 28 semi-structured interviews with firms, educational institutions and public sector agencies in both countries carried out at intervals between July 2012 and November 2018. Firm interviews were conducted primarily with general/plant managers and human resources managers to understand how plants undertake economic upgrading, the characteristics of the workforce and firm approach to human capital development. It should be taken into account that no workers were interviewed for this study.

4. The Global Medical Device Industry

The medical devices industry[12] is a high-tech and high-value manufacturing sector[13] with strong global female employment that deviates from widespread norms of high male dominance of manufacturing. It is a global growth industry; with trade reaching US$203B in 2016 (UN Comtrade, 2018).[14] Global demand is driven by populations that are growing (emerging markets) and aging (mature markets), rising incomes and expanding access to health care (BMI Research, 2018; CFRA, 2018).[15] The production of these devices is concentrated in a relatively small number of global lead firms, which account for more than half of the world's market share. These firms historically focused their production in developed countries with solid technical capabilities and intellectual property protection (Bamber & Gereffi, 2013). Nonetheless, increasing price pressure from buyers (BD, 2018; Boston Scientific, 2018; Medtronic, 2018), has spurred the industry to globalize and outsource production, first to increase economic efficiencies, but also to harness qualified human capital abroad and access new markets (Brocca et al., 2017).

Numerous countries from Latin America, Asia and the Middle East have developed industrial policies to attract and/or develop these firms (Bamber & Frederick, Forthcoming; BMI Research, 2018; Field Research, 2018; World Bank, 2011). Several characteristics of the offshoring patterns of this industry make it particularly attractive. First, investments tend to be long-term in nature as a result of long-transfer times, and relatively low competition. Barriers to entry are considerable due to the high costs of research and product development (R&D) and regulatory compliance, while installation of new product lines can take up to three years. Second, investment sustainability is facilitated by steady demand; driven by evolving healthcare needs, demand is relatively predictable and correlated with growing and aging populations and healthcare spending plans. Third, the sector covers a diverse range of products, from relatively simple, low value items such as syringes and sutures with low regulatory coverage to high-risk devices such as pacemakers, which require strict regulatory controls and technical know-how. This wide range of product

[11] Services firms were not included in the data analysis. In Costa Rica, in 2014, the largest share of services in the medical devices sector was the payment for royalties, accounting for over half of services included (Frederick, 2017).
[12] The medical devices industry covers a wide spectrum of products including "all instruments, appliances and materials that are designed for diagnostic and/or therapeutic purposes to monitor, treat, prevent or alleviate disease, injuries or handicap and that do not strictly achieve their action by pharmacological, immunological or metabolic means" (WHO, 2017).
[13] Based on OECD (2011) Technology Intensity Definition.
[14] See Bamber & Frederick (Forthcoming) for industry definition. 2016 was the latest available comprehensive data at the time of publication
[15] From 2004-2016, global imports of medical devices grew 120% with developing countries, particularly those in Asia, being the fastest growth markets with significant long-term potential (UN Comtrade, 2018).

offerings provides ample scope for entry and product upgrading in the sector – even in basic assembly operations. Finally, companies typically expand production operations as plant capabilities improve, allowing countries to functionally upgrade across value chain segments.[16] As a result, the sector offers a more sustainable alternative to that in GVCs such as apparel or electronics, with high potential for long term product, process and functional upgrading over time.

These characteristics have important implications for sector employment. While the size of the global medical device workforce is still small, estimated at 1.5-2M in total (UNIDO, 2018), it is growing rapidly, particularly in offshore production locations. Headcounts in manufacturing hubs, including Costa Rica, Singapore and China, grew by over 50% between 2008-2015, as medical devices firms have expanded into new destinations. Workforce quality plays a critical role in the industry's globalization. Human capital has been identified in certain cases as the single most important factor driving site selection in the sector (Field Research, 2012; Kimelberg & Nicoll, 2012). The workforce consists of skilled and semi-skilled workers who hold permanent jobs within firms as opposed to contractual labor arrangements seen in other industries (Bamber & Frederick, forthcoming). Approximately one third of roles require either a two-year degree, technical or vocational training, while the remaining two-thirds require a minimum of high school and a few months to a year of on the job training (BLS, 2018; O*Net OnLine, 2018).

Globally, the benefits of employment in the medical device industry appear to cross gender lines. Analysis of available gender disaggregated employment data for the industry shows that the medical devices GVC is characterized by sector-wide gender equity, and the female share of the workforce tends to be higher as compared to the manufacturing sector as a whole. Table 1 details female employment in the sector for the 16 countries reporting to UNIDO INDSTAT, together with the United States (US). These countries collectively account for 33% of medical devices exports in 2016 (UN Comtrade, 2018). Female employment accounts for 49%, compared to 39% in manufacturing. Leading exporters of these products (US, China, and Mexico) have similar shares of male and female employment. In 2015, 44% of the US medical devices workforce was female (BLS, 2018); in China, 50% (UNIDO, 2018), while in Mexico, the share was slightly higher with 59% (INEGI, 2018).

Table 1. Female Employment in Medical Devices Manufacturing, by Country

	All Medical Devices			**All Manufacturing**			**Difference in Female Intensity**
	Total	**Female**		**Total**	**Female**		
Reporter	**Employees**	**Employees**	**Share**	**Employees**	**Employees**	**Share**	
China	409,457	203,067	50	83,403,475	33,566,689	40	10
United States*	309,200	134,600	44	12,335,167	3,359,417	27	17
Mexico	111,796	65,429	59	3,442,108	1,197,544	35	24
Turkey	22,242	7,680	35	3,427,395	805,576	24	11
Malaysia	19,594	11,047	56	2,088,001	688,368	33	23
Viet Nam	17,721	12,141	69	6,097,051	3,695,916	61	8
Others	10,536	4,189	40	3,366,831	876,657	26	14
Total	**900,546**	**438,153**	**49**	**114,160,028**	**44,190,167**	**39**	**10**

Source: BLS (2018); UNIDO (2018)

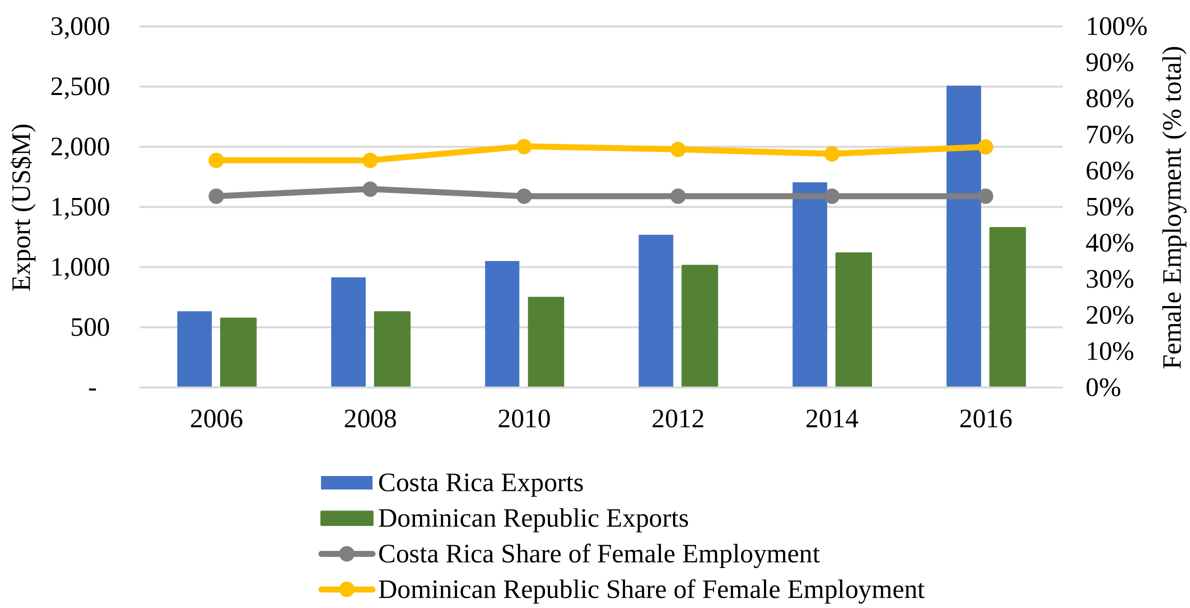
[16] While high value segments of the GVC – namely R&D, have remained close to headquarters, various stages of production have been offshored. Assembly tasks for low-value items were the first to be relocated with lower cost countries offering skilled labor at a considerable discount, with more sophisticated products and then components manufacturing, distribution and sales following, capitalizing on long term engagement with lead firms.

Notes: All Medical Devices, based on ISIC Rev. 4 4D: 2660 Irradiation/electro medical equipment & 3250 Medical and dental instruments and supplies. All Manufacturing, C. European countries account for approximately 1/3 of global employment in the sector, however, they do not report female intensity.
*US Employment statistics based on NACIS 3391, Employment, Hours and Earnings, Current Employment Survey

5. Gender Dynamics in the Medical Devices GVC: Costa Rica and the Dominican Republic

To explore how gender dynamics may evolve in medical devices GVC trade and the roles of different firms in driving these changes, we look at the experience of two countries, Costa Rica (CRI) and the Dominican Republic (DRI). Each is an emerging producer within the industry, although with over a decade of experience. The medical devices industry is considered a priority sector for investment agencies in both CRI and DRI as part of their efforts to diversify exports and upgrade. Further, each nation is growing and upgrading into new value chain activities and/or product categories. From 2006 to 2016, sector exports from Costa Rica and the Dominican Republic grew at 296% and 131% respectively (UN Comtrade, 2018). Both countries have maintained high levels of female participation over time, despite this considerable export growth (Figure 1). An overview of participation in the GVC is provided for each country, followed by analysis of gendered distribution of roles and how this has changed as the countries have upgraded.

Figure 1. Costa Rica & Dominican Republic Exports in the Medical Devices GVC, 2006-2016



Source: CNFZE (2017); PROCOMER (2012); UN Comtrade (2018).

Costa Rica's participation in the medical devices industry dates back to 1985, when the first device companies - Baxter Healthcare and Abbott - established operations there. Export growth began in the early 2000s, picking up as the industry globalized. By 2016, medical devices exports reached US$2.5B, 1.2% of global medical devices exports and 17% of the country's merchandize exports. Just a year later, the sector surpassed Costa Rica's agricultural industry to become the largest export sector (Alvarado, 2018; Lo, 2018; UN Comtrade, 2018).[17] In 2016, medical devices in the country employed just 16,417 people; 53% of these

[17] This is due both to sector growth, as well as the closure of Intel's plant in 2014.

were women (PROCOMER, 2016).

The Costa Rican medical devices sector consists of a consolidating base of foreign firms producing increasingly sophisticated products. This includes local subsidiaries of global lead firms serving an array of healthcare markets, such as Boston Scientific and St. Jude Medical, as well as a number of smaller firms focused on single segments such as cardiovascular and neurology. There is only one domestically owned original equipment manufacturer in the country; other local firms in the industry are concentrated in supporting activities. 70% of firms are concentrated in the manufacturing of components and assembly of final goods. Numerous firms run vertically integrated operations, carrying out all production related activities from sourcing of raw materials, through component manufacture and assembly to sterilization. In 2017 and 2018, a number of firms also established offshore service operations to serve global functions in human resources, and accounting, as well as carry out product related complaints management for both products manufactured in Costa Rica and abroad.[18]

The Dominican Republic entered the medical devices industry a little later than Costa Rica (late 1990s), however, the industry only gained significant momentum after 2006. Over the past decade, the sector has grown in importance to become one of the leading exports, worth over US$1.3B in 2016, 0.5% of the global medical device market and 12% of national export basket (UN Comtrade, 2018).[19] Insertion in this GVC marks a departure from the country's previous dependence on the comparatively volatile textile and apparel (T&A) industry (World Bank, 2017c). Today, medical devices production is one of the most advanced manufacturing industries in the country. While firms generally export devices in the surgical instruments product category (HS9018), output in fact covers a wide range of devices from sutures to ostomy bags and IV sets as well as parts for capital equipment. Sectoral employment doubled between 2006-2016, reaching approximately 20,695;[20] women account for 67% of these jobs (CNFZE, 2017).

As in Costa Rica, GVC participation is based primarily on investments of global lead firms. Six of the top ten global firms had established operations in the country by 2016 and 72% of accumulated investment (US$1.1B) in the sector entered the Dominican Republic since 2008 (CNFZE, 2017). These firms are located in EPZs which account for 100% of the country's exports in the industry (Bamber & Frederick, 2018). The majority (90%) of these products are destined to the US, although Asia is the fastest growth market for the country (Hamrick & Bamber, 2019). Activities primarily focus on labor-intensive assembly and packaging, with the more established firms carrying out sustaining engineering to support productivity improvements; 22 firms carry out assembly-only operations, while 3 firms export components.

Notably, firm-level data analysis reveals a high degree of correlation between exports and employment in both countries (2016: Costa Rica, r= 0.79 (r^2=0.89); Dominican Republic, r=0.94, (r^2=0.62) as a result of the more labor-intensive production stage in which both countries primarily operate.

5.1. Mapping the Participation of Women in the Medical Devices Industry[21]

The medical devices sector in both countries is characterized by strong female participation that deviates

[18] These include Allergan, Boston Scientific, ICU Medical (former Hospira), Medtronic, and Hologic amongst others (Zolezzi, 2018).
[19] Based on an estimated US$8.7B in exports (UN Comtrade, 2018).
[20] Export, employment and investment information in this project proposal is based on data published by the Dominican Republic *Consejo Nacional de Zonas Francas de Exportación (CNZFE)*.
[21] Data analysis in this segment is limited to firms with available employment statistics for both countries (Costa Rica, n=19, Dominican Republic n=25).

from national manufacturing norms. This deviation is consistent with the global trends noted in Table 1. Female intensity is significantly higher than that of EPZs,[22] national manufacturing sectors (approximately a 20% margin) and overall labor force participation in both nations (Table 2). In Costa Rica, it is the only EPZ sector in which women account for the majority of employment (PROCOMER, 2012), while in the Dominican Republic, the only sector that employs a higher share of women is apparel (INEC, 2017).[23]

Table 2. Female Intensity of Medical Devices Employment, EPZ, and Manufacturing

	Medical Devices [a]		EPZs [a]		Manufacturing [b]		Labour Force [c]	
	2006	2016	2006	2016	2006	2016	2006	2016
Costa Rica	50*	53	40**	40	32	34	36	38
Dominican Republic	65	67	52	49	35***	31	38	41

Sources: a) PROCOMER (2015, 2016); Own calculation based on CNFZE (2017) b) World Bank (2017b), c INEC (2017) (BCDR, 2017)
Notes: *2004, **2010, ***2008.

Female intensity is high across the value chain; however, this falls slightly with participation in upstream production stages of the chain (Table 3). During the periods analyzed, both countries primarily participated in two stages of the value chain, assembly and components manufacturing. Employment is concentrated in firms undertaking assembly activities which account for >98% in both countries. In Costa Rica, however, many assembly firms are vertically integrated upstream into the production of some components for final goods exports. Components production typically requires more technical expertise and draws on more traditional manufacturing sector competencies. This vertical integration potentially contributes to Costa Rica's lower female intensity relative to the Dominican Republic, which has very limited component production.

Table 3. Female Intensity by Value Chain Stage

	Total		Females	
	Employees	Share (%)	Employees	Share (%)
Costa Rica (2011)	10,272		5,472	
Components Exporters	115	1	54	47
Final Goods Exporters (assembly)	10,157	99	5,418	53
Dominican Republic (2016)	20,695			
Components Exporters	405	2	259	64
Final Goods Exporters (assembly)	20,290	98	13,534	67

Source: CNFZE (2017); PROCOMER (2012)
Note: Firms are categorized by their final exports; final goods exporters therefore include those firms that are vertically integrated into the components segment of the chain.

Table 4 below details the gender disaggregation of production, technical and professional roles in the Dominican Republic allowing for further analysis of the types of roles undertaken by men and women in both segments of the chain.[24] There is a clear gendered division of labor that is consistent across both components manufacturing and assembly stages of the GVC. In both stages, female employment is concentrated in production roles. These roles usually include line jobs such as putting together components

[22] The other sectors in which these countries participate via EPZs include Costa Rica: Services, Plastics, Metalworks, Electrical & Electronics, Food and Textiles & Apparel; Dominican Republic: Services, Textile & Apparel, Footwear, Jewelry, Agri-processing and Tobacco, Electrical & Electronics.
[23] The high levels of female intensity identified by using firm-level data differ significantly from those indicated through national manufacturing statistics that were used in earlier EOI studies. This suggests that using the latter as a proxy for female participation in trade could be misleading.
[24] Comparable data was not available for Costa Rica.

or final goods. Comparatively, women are underrepresented in technical roles, such as machine operators. While male employment is also concentrated in production, a larger share of male employees can be found in technical and professional jobs.

Female intensity, or share of female participation in the workforce, is also highest in production jobs (74% assembly, 67% components), but is closer to gender parity in technical and professional roles, particularly in components manufacturing where women account for 47% and 52% respectively. Women feature particularly in professional roles such as industrial engineering, and transversal functions such as finance and human resources. However, there are very few women in firm leadership positions. In the Dominican Republic in 2017, only 3 firms had female in senior leadership (General Manager/Plant Manager) (Field Research, 2017).

Table 4. Gender Composition of Workforce, by Job Type and Value Chain Segment in the Dominican Republic

	Total Employment		Employment by Gender		Share, Job Type (%)		Female Intensity (%)
	Total	**Share**	**Male**	**Female**	**Male**	**Female**	
Assembly							
Production	15,927	78	4,486	11,776	65	85	74
Technical	2,700	13	1,581	1,164	23	8	43
Professional	1,663	8	835	853	12	6	51
Total	20,290		6,902	13,793	100	100	68
Components							
Production	335	83	110	225	75	87	67
Technical	45	11	24	21	16	8	47
Professional	25	6	12	13	8	5	52
Total	405		146	259	100	100	64

Source: CNFZE (2017); PROCOMER (2012).

Finally, female intensity is associated with firm employment size. Small firms (employment <100) in both countries have low female participation compared to larger firms (employment>500); in Costa Rica, female intensity was 21% lower, while in the Dominican Republic, this was 13% lower (see Table 6). Smaller firms are also more likely to export components than final medical devices, with a greater focus on technical production than assembly activities.

5.2. Effect of Upgrading in the Medical Device Industry on Female Intensity

Economic upgrading in the medical devices GVC allows actors to capture more value from their participation (Humphrey & Schmitz, 2002). Numerous upgrading trajectories have been identified in the GVC literature to track how countries improve their participation in an industry. In the case of medical devices, two specific upgrading trajectories stand out that can be empirically tested using the available data: economic upgrading based on total exports and product upgrading based on shifting export composition. In each of these upgrading scenarios, the impact on female employment is analyzed. Overall, we find that upgrading in the medical devices GVC is associated with stable or increasing female intensity. This finding is consistent across the two upgrading indicators analyzed in this section.

Economic upgrading by export growth

In this scenario, export growth is analyzed as a simple measure of economic upgrading (Bernhardt & Pollak, 2016). This variable provides insights into participation of a country in the GVC: *Is the medical devices sector growing, stagnating or declining, and how are firms performing, in general? Also, how does this performance measure vis-à-vis other countries in terms of global market share?* Table 5 shows that Costa Rica and the Dominican Republic followed similar growth patterns during the periods analyzed

(2004-2011 for Costa Rica, and 2006-2016 in Dominican Republic). Using UN Comtrade data to allow for cross-country comparison, it can be seen that both countries increased their sector exports by similar amounts, as well as increasing their share of world market exports. Between 2004/6 and 2011/6, exports grew by 120% and 131%, while they gained 0.11% and 0.09% global market share respectively. At an aggregate level, both countries upgraded.

Table 5. Economic Upgrading: Sectoral Export Growth and Female Intensity

	Costa Rica		Growth Rate 2004-2011 (%) (2006-2016)	Dominican Republic		Growth Rate 2006-2016 (%)
	2004 (2006)	2011 (2016)		2006	2016	
National Sector Exports (US$) [a]	514M (634M)	1,128M (2.509M)	120% (296%)	573M	1.325*	131%
Share of Global Market	0.56% (0.55%)	0.67% (1.23%)	19% (126%)	0.49%	0.58%	17%
Total Employment	3,755	10,272	174%	9,124	20,695	127%
Average Female Intensity [b]	50% (53%)	53% (53%)		65%	67%	

Source: a UN Comtrade (2018), Based on HS-2002 product categories defined in Table A-2; all exporters; downloaded 27/08/2018. b CNFZE (2017); PROCOMER (2012).
Note: National sector exports include exports of all firms in the country, including but not limited to those in the firm-level dataset.

What impact has this expansion of industry exports had on employment, in general, and female intensity in particular? This sectoral growth drove an important increase in employment, with job creation increasing at a faster rate than exports in Costa Rica and a comparable rate in the Dominican Republic. Female jobs accounted for more than half of the new jobs created by the sector's expansion during this period (55% and 68%) and at an aggregate level, this led to a small increase in female intensity of 2-3.6%.

Table 6. Economic Upgrading and Female Intensity at the Firm-Level

		Determinant	No. Firms	Exports		Ave. Length	Female Intensity (2011/6)	Change Female Intensity (Entry-2011/6)	Female Job Creation	% All New Female Jobs	% All New Jobs	% MD Growth
				Average (US$M)	Std Dev (US$M)				CRI: 2004-2011 DRI: 2006-2016			
Costa Rica	All firms		19	64.6	105.2	5.6	48%	5%	2,570	Female/new jobs: 55%		100%
	Labor Force Size	<100	7	3.49	5.29	5	34%	12%	119	3%	5%	1%
		100<x<500	5	11.80	5.87	5.8	57%	2%	-560	13%	14%	8%
		500<x	7	163.46	110.78	6	55%	-2%	3,011	83%	81%	100%
	Export Size	Top Five	5	212.12	110.4	6.6	50%	19%	2,096	58%	59%	133%
		Bottom Five	5	0.92	0.74	3.6	33%	26%	65	2%	3%	0.38%
	Entry Year	Early Investors	7	117.83	134.13	8.0	51%	3%	2,001	78%	54%	97%
		Late Entrants	12	33.57	73.70	4.2	46%	5%	569	22%	46%	n.a.
Dominican Republic	All firms		25	57.0	70.0	8.6	61%	2%	7,860	Female/new jobs: 68%		85%
	Labor Force Size	<100	6	2.90	2.60	5.7	53%	2%	177	2%	3%	3%
		100<x<500	8	16.37	21.06	8.4	61%	1%	1,007	10%	15%	15%
		500<x	11	116.08	67.39	10.4	66%	3%	6,676	89%	82%	62%
	Export Size	Top Five	5	172.3	50.9	10.2	68%	1%	1,743	57%	58%	69%
		Bottom Five	5	1.34	0.88	7.8	47%	-5%	-123	-4%	-2%	-1.1%
	Entry Year	Early Investors	12	86.01	82.75	11.9	71%	0%	4,945	63%	56%	55%
		Late Entrants	13	30.24	43.8	5.5	53%	4%	2,915	37%	44%	n.a.

Source: Own calculation based on CNFZE (2017); PROCOMER (2012).

Within-firm analysis (detailed in Table 6) supports aggregate results, with an average increase in female intensity of 5% and 2% respectively across all firms in the countries. The analysis also shows upgrading was primarily driven by large (employment and exports), early investors, which also contributed the most to export growth. Similar trends were seen in both countries. Employment expansion amongst large employers (x>500)[25] accounted for over 80% of new jobs, as well as 80% of new female jobs in both countries. Mean female intensity in these firms was over 55% across the period; in Costa Rica this decreased slightly (-2%), while in the Dominican Republic, female intensity increased (3%). Large employers notably accounted for over 70% of medical devices export growth in both countries. Firms that were already established in the country at the beginning of the period (Early investors) also accounted for the largest share of total and female employment growth. Early investors drove industry export growth in Costa Rica (97%), while in the Dominican Republic, investment by new large firms during the period led to new firms accounting for 44% of job creation and 45% of export growth.

Product Upgrading

Next, we unpack the potential upgrading trajectories in effect for each country and how these may impact gendered outcomes*; that is, is export growth the result of more of the same or of the incorporation of higher valued products and what opportunities are there for men and women*? Using disaggregate trade statistics, we examine the changes, if any, of products shipped from each country to determine if product upgrading has occurred, that is, a shift into higher value products. This is generally measured using export unit value (Bernhardt & Pollak, 2016; Kaplinksy et al., 2009; Ponte & Gibbon, 2005), but in the medical devices sector, high degrees of heterogeneity of products included under respective trade classifications can result in misleading unit values. Thus, following Bamber & Gereffi (2013), we adopt a classification of products based on regulatory barriers and complexity that contribute to differentiated product margins; products are categorized into six groups from low value to high value. Product upgrading, in this case, thus refers to shifting into products with higher regulatory requirements and, therefore, higher value (Bamber & Gereffi, 2013).

Table 7. Product Upgrading

	Exports (US$M)			Growth	Share of Exports	
	2004	2006	2016	(2006-16)	2006	2016
Costa Rica	513	634	2,509	296%		
Consumables	0.21	0.22	0.031	-86%	0.035%	0.001%
Disposables	441	454	1,142	151%	72%	46%
Surgical Instruments	38	135	726	439%	21%	29%
Other	0.359	2	9	469%	0.25%	0.36%
Therapeutics	32	42	506	1120%	7%	20%
Capital Equipment	1	1	126	9744%	0.20%	5%
Dominican Rep.		573	1,325	131%		
Consumables		12	7	-42%	2%	0.5%
Disposables		39	216	453%	7%	16%
Surgical Instruments		521	1,015	95%	91%	77%
Other		0.029	65	224,038%	0%	5%
Therapeutics		0.168	16	9,423%	0%	1.2%
Capital Equipment		1	6	500%	0%	0.5%

Source: UN Comtrade, 2018. Based on HS-2002 product categories defined in Table A-2; all exporters; downloaded 27/08/2018.

Table 7 illustrates that upgrading was a result of both more of the same, as well as a diversification into

[25] Firm size was determined by employment at the end of the period.

new products. Both countries experienced absolute growth within original product categories with the exception of low value consumables, which shrank. At the same time, the export profiles of both countries became more diversified, with higher value product segments accounting for an increasingly larger share of exports, and original product share declining. Absent in 2006, higher value product segments in the Dominican Republic accounted for 6.5% of exports by 2016. Analysis of FDA data showed significant product upgrading within these categories as well.[26,27] Firms generally started assembling one product and now produce multiple product families in their operations. This changing composition of medical device exports shows that both Costa Rica and the Dominican Republic were moving toward product categories of higher technological content (*product upgrading*).

How has this product upgrading affected female intensity? In the case of Costa Rica, it is possible to use firm-level data to analyze how female participation evolves as product upgrading takes place for three categories.[28] The results are detailed in Table 8. At an aggregate level, there is an increase in female intensity as product sophistication increases, as well as in each product category (2004/2011: disposables 49/51% compared to instruments 51/52% and therapeutics (2006/2011) 57/59%). The trend persists using firm-specific analysis, in 2011 these categories accounted for 48%, 38% and 52% respectively. For surgical instruments, the mean is considerably lower than the aggregate as a combination of very large, female intense firms with very small, male intense firms (Std dev = 24%). Product upgrading across categories was mostly driven by the entry of new firms into the country focused on these more sophisticated products (Bamber & Gereffi, 2013).[29] Firms are typically concentrated in individual product categories; only 4/19 firms had less than 95% of their output in their primary product category in 2011. This is likely the result of plants being run by specific divisions of multinational firms, rather than as company-wide operations.

Table 8. Product Upgrading and Female Intensity

	No. of Firms	Average Exports 2011 (US$M)	Share All Medical Devices Exports 2011	Average Years in Country	Total Female Employees 2011	Average Female Intensity		Mean Firm Female Intensity 2011 (Stdev)
						2004	2011	
Disposables	7	80.1	50%	6	2,460	49%	51%	48% (19%)
Surgical	6	40.4	22%	6	1,704	51%	52%	38% (24%)
Therapeutics	3	99.8	27%	3	714	57%*	59%	52% (20%)

Note: * based on 2006. There were no Therapeutics exporters in the country in 2004.
Source: Authors calculations based on Procomer, 2012.

Functional Upgrading and Female Intensity Changes

Functional upgrading is the undertaking of new, higher value activities. This assesses whether new value-adding activities are undertaken, including components production and services such as research and development and procurement (upstream) and sterilization, logistics, and post-sales services (downstream). While data was not available to empirically test whether this upgrading has occurred, or its

[26] The number of products registered with the FDA for manufacture grew close to 20% between 2017 and 2018 alone to 726 (FDA, 2018).
[27] The U.S. Food and Drug Administration (FDA) classifies medical devices according to their potential risk to the user (Unclassified, Class I to Class III). Class I devices are considered low risk, and do not require pre-market notifications prior to sale. Class III devices are considered to high risk and are subject to high levels of pre- and post-market scrutiny.
[28] In the Dominican Republic, while the number and type of products has expanded significantly since 2006, many exporters do not differentiate between products codes for the wide variety of medical devices. This makes it difficult to analyze the impact on female intensity by product code.
[29] Analyzing process upgrading using the available data is not possible given the small number of firms within each category.

impact on female intensity, based on extensive interviews of the clusters in both countries, we find that between 2006-2016, Costa Rica has achieved greater functional upgrading than the Dominican Republic. Costa Rica has increased its presence in a range of services, including sustaining engineering (2010/11), sterilization (2011), procurement (2016), and complaints management (2017) (Bamber & Frederick, 2018; Zolezzi, 2018). The Dominican Republic functionally upgraded in terms of sustaining engineering (2012), and sterilization (2017) (Bamber & Frederick, 2018; CNZFE, 2018). Services oriented jobs in EPZs in Costa Rica are characterized by higher levels of female participation than manufacturing at 61% (2015) (PROCOMER, 2016).

5.3. Upgrading, Wages and the Gender Distribution of Role

Finally, we analyze the impact of upgrading on industry wages and the distribution of female employment. The EOI literature suggests that as countries upgrade, wages rise which results in men being favored over women and a less feminized workforce. We use both aggregate statistics and firm-level data for early investors to unpack what impact, if any, occurred. At an aggregate level, wages increased 78% in Costa Rica (2005/11) and 27% for production roles and 30% for technical roles in Dominican Republic (2006/16) (calculated in current US$). Mean wage increases by early investors in DRI was even more pronounced at 94% and 47% respectively. These sectoral wages were higher than in most other EPZ sectors. In Costa Rica in 2011, only services offered higher compensation than medical devices (PROCOMER, 2016). The result is similar in the Dominican Republic (Field Research, 2017).[30]

Table 9. Wage Change and Gender Distribution of Roles

	Sector-Wide (Aggregate)				Early Investors (Firm-Specific)			
	Average Wage Change	**Average Employment Growth**	**Average Female Intensity**		**Mean Wage Change (Stdev)**	**Mean Employment Growth (Stdev)**	**Mean Female Intensity (Stdev)**	
	(2005-2011)		**2005**	**2011**				
Costa Rica	78%	136%	52%	53%				
	(2006-2016)		**2006**	**2016**			**2006**	**2016**
Dominican Rep.		127%	65%	67%				
Production	30%	115%	70%	72%	94% (37%)	118% (200%)	76% (16%)	76% (15%)
Technical	27%	197%	27%	42%	47% (25%)	137% (143%)	36% (24%)	45% (23%)
Professional	NA	172%	51%	51%	NA	204% (271%)	59% (17%)	54% (8%)

Source: Own calculations based on aggregate and firm-level data for medical devices sector CNFZE (2017); PROCOMER (2012)

This wage increase, however, did not result in a decline in female participation. Aggregate results in both countries indicate that female intensity increased during this period. Available data in the Dominican Republic shows that sectoral female intensity in all three job categories increased; with technical positions increasing the most by 15% over the decade, reaching 42% by 2016. While female intensity in technical positions is the lowest, female technical positions were, in fact, the fastest overall growth category of employment (243%, compared to men 170%), despite the significant wage increase at both a sectoral (27%) and firm level (47%) over the period. Within-firm effects for early investors showed a similar large average increase for technical positions (9%). Qualitative analysis reveals that this increase in female technical roles was concentrated in quality oversight (e.g. laboratory technicians, quality technicians, etc.) and supervisory roles. These roles are key for increased adoption of new systems and technologies to drive productivity, ensure operations align with global quality requirements (i.e. process upgrading) and roll out new products

[30] Real wages have stagnated during this period in the Dominican Republic (World Bank, 2016).

(i.e. product upgrading).[31] Thus, while overall sectoral wage increase was driven by a slight tightening of the labor market as more employees were hired into production and by an increase in skills requirement, neither of these resulted in a decline in female employment.

In summary, three key findings should be highlighted: (1) Female employees account for the majority of employment in the medical devices sector in both countries, with a higher intensity than the overall manufacturing sector; (2) Female intensity holds steady as the countries expanded their exports and upgraded into new higher value product categories. Large, early investors played an important role in female job creation and export expansion; and (3) An increase in wages as a result of this upgrading does not result in within-industry defeminization.

6. Gender Dimensions and Feminization in the Medical Devices Global Value Chain

This section examines the gender distribution outcomes observed in the context of five key issues identified in the literature as contributing to feminization/defeminization of export-oriented industries: (1) Precarious work, (2) Access to Education (i.e. productive resources), (3) Gender wage gap, (4) Supportive policies, and (5) Gender norms. Collectively, these five issues are important for policymakers to promote practices that encourage female empowerment while enhancing firm competitiveness. We examine how these factors may be contributing to feminization in the medical devices sector.

Precarious Work

Female precarious work has been highlighted as a major driver of high female intensity in other sectors. Women are said to be concentrated in cyclical or temporary production jobs due to their roles as secondary breadwinners in the family unit. In the two cases analyzed, however, temporary work in the industry is generally low due to stable demand; high regulatory barriers contribute to reduced competition avoiding major fluctuations in production output. Regulatory requirements also result in significant on-the-job training needs, and thus firms prefer to offer permanent contracts to retain staff over the long term. In the case of Costa Rica and the Dominican Republic, the share of temporary labor accounted for less than 1% of total employment during the periods analyzed (CNFZE, 2017; PROCOMER, 2012).

Stakeholder interviewees suggested that the stability of employment in the industry helps to recruit women, particularly single mothers who have a lower potential to withstand employment fluctuations. In both countries, women account for a growing share of primary breadwinners, up to 40% of households.[32] Stable employment with permanent contracts, which include access to social security benefits covering dependents in both countries makes the medical devices industry an attractive sector for these women. While no data is available regarding gender-segregated attrition, anecdotal evidence from interviewees suggests that this is lower for women than men, making female employees more desirable recruits for firms. Alternative job opportunities for women in both Costa Rica and Dominican Republic in the areas where EPZs are located are primarily sectors characterized by high levels of precarious work (e.g. apparel, electronics, and agri-processing). Only one industry in Costa Rica offers a compelling alterative: the global services cluster, co-located with medical devices companies, which pays higher salaries with similar conditions (Fernandez-Stark et al., 2013). This sector competes directly with the medical devices industries for male and female

[31] The number of sites in the Dominican Republic with ISO certification 13845 for medical devices increased more than fourfold (ISO, 2017). The impacts of potential functional upgrading into more technical component manufacturing is not captured in this effect; assembly firms indicated that they do not manufacture components at this stage.

[32] The latest available statistics for the Dominican Republic note that female headed 40% of households in 2015, compared to 36% in Costa Rica in 2013 (Leiton, 2014; World Bank, 2017a). Both countries have experienced an important increase in this figure over the past decade.

employees alike and the strong growth of the cluster likely contributes to the lower levels of female intensity in Costa Rica compared to the Dominican Republic.

<u>Gender Wage Gap</u>
Central to the gender wage gap hypothesis is that low-value, labor-intensive segments of value chains, such as assembly activities, may be highly feminized because of comparatively lower female wages. While gender wage gaps persist in both countries at the national and sectoral level, it is relatively low and has declined in recent years (Enamorado et al., 2009). Costa Rica reports that the national gender wage gap declined from 5.6% in 2011 to just 1.8% in 2016 (OECD, 2018).[33] The difference is slightly larger in the Dominican Republic, although this reaches 6% in 2016 (Instituto Nacional de Estadisticas, 2016a).[34] Under the hypothesis highlighted in the literature, relative lack of a gender wage gap should lead us to expect a similar share of men and women in the industry that declines over time. First, neither country have exhibited declining female shares. Second, this tendency cannot explain the larger female intensity in the Dominican Republic (67%). Of course, national gender wage gaps may mask geographic, public/private sector, industry-specific and degree-specific wage differences. In the Dominican Republic, for example, women with a technical degree earn 66% of the salaries of their male peers (INTEC, 2016). Further research mapping wages gaps in key geographical areas for EPZ areas in which medical devices companies are found would be necessary to uncover if this a driving factor.

<u>Access to Education and Training</u>
Human capital requirements for the industry are relatively high compared to other sectors; therefore, access to education and training is a key determinant for female participation in the industry. At a minimum, production workers require high school education, technical workers should have a one to a two-year technical degree and professional staff, a Bachelor's degree in a relevant field (O*Net OnLine, 2018). Additional specialized training programs and degrees focused on medical devices specifically can increase employability and advancement potential in the industry.

Overall, both countries demonstrate high female participation in all levels of general education (Table 10). Policies supporting equal access to education have been present in both countries for a considerable time; Costa Rica's programs to foster gender parity in education were launched in the 1990s (Guzman Stein & Letendre Morales, 2003).[35] The rate of women completing high school, technical and tertiary education programs is similar to that of men in both countries, except for technical education in the Dominican Republic where lower rates (42%) potentially contribute to lower female intensity in technical jobs in the industry. At a more granular level, however, detailed statistics in Costa Rica show there is still a shortage of female graduates of technical programs for the industrial sector (<18%), with the exception of quality control (50%) (ECCTI, 2018). Comparatively high shares of females in tertiary education (57%) correspond to gender equity in professional levels in the medical devices sector.

Table 10. Access to Education and Training, Select Courses, Share of Women, 2016

<table>
<tr><th>Education</th><th>Costa Rica</th><th>Dominican Republic</th></tr>
<tr><td>Share of the population, % Women [a]</td><td>50%</td><td>50%</td></tr>
<tr><td>High School Enrollment, % Women [a]</td><td>50%</td><td>52%</td></tr>
<tr><td>Technical Education, % Women</td><td>49%[b]</td><td>42%[c]</td></tr>
<tr><td>Tertiary Education, % Women</td><td>55%[b]</td><td rowspan="2">57%[c]</td></tr>
<tr><td>Post Graduate (Doctoral), % Women</td><td>51%[b]</td></tr>
<tr><td colspan="3">Industry Specific Training Programs</td></tr>
</table>

---

[33] This makes it one of the lowest amongst OECD members.
[34] Average hourly income, employed persons, by occupational sector and gender 2008-2016.
[35] *Ley General de Educación Número 66-97* promotes equal access to education in the Dominican Republic.

Medical Devices Operator Course – Production [d, e]	n.a.	62% (2017)
Quality Inspector [g]	50%	--
Engineering Specializations [d, e]	48% (Materials)[f] 41% (Industrial)	63% (2017)
Masters in Medical Devices Engineering (TEC) [f]	37%	--

Source: [a] World Bank (2018); [b] Instituto Nacional de Estadisticas (Costa Rica) (2016); [c] Instituto Nacional de Estadisticas (2016b); [d] ECCTI (2018); [e] Rodriguez (2018); [f] Cubero (2018).

Specialized programs, developed in concert with the industry, have more mixed gender statistics. The new programs, launched over the past three to five years, could have an impact on the gendered division of labor in the future. Female participation in both operator and professional courses in the Dominican Republic reflect the high level of women in the industry, at 62% and 63% respectively. In Costa Rica, gender equity in operator levels begins to decline in post-graduate studies; the Masters in Medical Devices Engineering Program offered by Tecnológico de Costa Rica (TEC) – the most advanced industry-specific program in the country - has seen female participation fall from 37% to just 14% over the past three years (Cubero, 2018).

Support for Reproductive Responsibilities

The presence or lack of gender-sensitive policies is often considered to have an impact on female participation in an industry and potential for advancement. In both countries, there are several initiatives in place at the national, industrial park and firm-level that help to reduce reproductive burdens on women and thus to maintain them in the workforce. These efforts have helped to improve their participation in the workforce, in general, and in this sector in particular in both countries. Specifically, both countries have established laws to support maternity leave and post-natal breastfeeding allowances (Table 11). Overall attrition rates in the Dominican Republic, that has high levels of female participation in the production segment of the chain, are low (~1-2%). While attrition is higher in Costa Rica, this is attributed to a tight labor market rather than the exit of women from the workforce.

Table 11. Select Gender Policies, Costa Rica and Dominican Republic

Policy	**Costa Rica**	**Dominican Republic**
Maternity Leave [a]	Required by law (Labor Code Art. 94-100; 1996); 100% pay for 120 days divided pre & post-natal	Required by law; 100% pay for 98 days (pre & post-natal); extended from 84 to 98 days in 2017 to align with ILO norms.
Breastfeeding Facilities/Times [b]	Required by law (1993) 1 hour/day up to 1 year old (*Politica Publica de Lactancia Materna*) Employers with +30 female employees must provide a feeding room (regulation in process)	Required by law up to 1 year old
Childcare facilities (park or elsewhere)	Not required by law	Not required by law

Source: [a] WEF (2017); [b] León and Thomas (2017); MEPyD (2012)

Gender Norms and Relations

Specific GVCs may have the potential to change gender employment patterns in the countries in which they operate. However, where gender norms of the host countries coincide with those of lead firms in the industry, these are likely to be reinforced in local operations (Bamber & Staritz, 2016). The majority of medical devices firms located in Costa Rica and the Dominican Republic, and particularly early investors, are of US or European origin; by 2011, in Costa Rica, US firms accounted for over 60%, while the share was even higher in the Dominican Republic where even the plants of European firms such as B. Braun (Germany) are managed by US company divisions (Bamber & Frederick, 2018). Legal requirements (i.e.

Equal Employment Opportunity Act), combined with a strong commitment of leadership to diversity and inclusion goals and a substantial focus on gender equity amongst its client base,[36] have helped to contribute to greater gender parity in the industry. Female participation is higher than in most other manufacturing sectors (Liftstream and MassBio, 2017), some 10% higher than overall manufacturing (see Table 1). However, female representation in mid-level management (29%) and senior leadership (24%) roles are still limited, and the female intensity decreases with each level (Liftstream and MassBio, 2017).

In Costa Rica and the Dominican Republic, these firms have shifted manufacturing employment trends to match their own global operations. In both countries, the sector employs considerably higher share of women than manufacturing in general (see Table 2). Less equitable practices in senior leadership and management, on the other hand, have reinforced local norms. There are very few women in senior leadership roles; in the Dominican Republic, there are only three female general managers in the sector. This reflects similar results in the economy at large. Only 15% of firms in Costa Rica and 11% of firms in the Dominican Republic have women in senior leadership positions, and this share falls as firm size increases (ILO, 2017).

7. Conclusions and Policy Implications

As technology-, knowledge- and capital-intensive industries, like medical devices, adopt globalized production platforms, there are numerous opportunities for developing countries to upgrade in GVCs. While employment scale in these sectors is far below that of predecessors, such as apparel, the quality of the work is considerably improved. The two cases examined in this study illustrate that with the appropriate set of policies in place, these industries can contribute to more equitable employment outcomes for both men and women in trade. Key takeaways for policymakers include:

These industries offer good quality jobs for women and female inclusion in the workplace can enhance trade competitiveness. Globally, women tend to account for more than half of medical devices employment; on average, the female intensity is 10% higher than overall manufacturing (Table 1). The country cases illustrate that employment tends to be characterized by relatively high wages and permanent contracts. These characteristics make the industry attractive for the rising share of female breadwinners in many developing countries, in Costa Rica, the Dominican Republic and beyond. These women are increasingly looking for the same degree of stability in their jobs as men, particularly those with permanent contracts with benefits that extend to their dependents. As a result, women will be just as likely (if not more) to seek out stable job opportunities as men, and their low attrition rates can enhance overall competitiveness. This changing dynamic not only boosts available human capital for trade and upgrading, but also puts pressure on governments to attract GVC investments with higher quality work.

The type of FDI attraction is important for gender goals; GVC investors in these industries may differ in their gender policies and practices. Gender parity differs by segment, size, and product focus. Large scale MNC assemblers accounted for the largest share of export growth and female job creation, smaller investors and component manufacturers tended to have a comparatively lower female intensity. Specific products categories within these industries vary in their female intensity with more sophisticated therapeutics offering more opportunities for women than disposables; upgrading between product categories, however, generally requires new investors. Individual plants are typically run by specific MNC divisions and thus are unlikely to diversify into the export of products from other divisions.

[36] All major lead firms have either an established policy towards increasing female participation in the industry, or include female employment under the umbrella policy towards increased diversity and inclusion. The healthcare sector is one of the best performing sectors overall in the US in terms of gender equity. Of the top 100 Forbes list for best place for women to work, 25 are healthcare providers.

Overall, investors are likely to import their gender approaches; where these coincide with host country practices, gender norms will be reinforced rather than altered. For example, while the medical devices sector is strong in gender equity in production, there is minimal participation of women in senior leadership at the global level, and in both cases of offshoring. This deterrent to long-term professional development can undermine long-term attraction and retention goals in the industry. Investment agencies seeking to enhance gender equity in GVC trade should include gender analysis of investors' practices in other locations.

Entry into and upgrading within this GVC and ensuring female employment gains requires specific policies. Participation in more knowledge and technology intensive sectors requires a series of key investment policies, from incentives to infrastructure. However, the most important factor is generally the availability of human capital with the relevant qualifications. This can be achieved by fostering increased cooperation between the sector and educational institutes as occurred in both countries. Ensuring gender equity in access to those specific qualifications is then the critical step to support gender goals. At the production and professional levels, equal access to and participation in high school education and industry-specific courses and engineering degrees provided the basis for high levels of female participation in both country case studies. In countries where females have low technical participation, drawing attention to niche job profiles can provide a strong entry point. The increase in female participation in technical training programs – particularly in quality control, had a strong impact on female technical hiring in both countries. Quality oversight is critical to competitiveness in medical devices and other highly regulated industries.

Supportive family/maternity policies that help to reduce the burden of reproductive responsibilities foster female participation in EPZs. In highly regulated sectors, where competitiveness depends on a well-qualified workforce with strong knowledge of industry requirements, retention is critical. Both countries have government and firm-level policies, such as maternity leave, and breastfeeding facilities. These policies that support women's efforts balance their work-life roles ensure ongoing female participation and retention. These policies have been widely adopted in many developed countries and firms.

This exploratory study has made important advances in using a firm-level data approach to mapping gender distribution in the medical devices GVC. Nonetheless, it has its limitations. Specifically, it only analyzes two countries in the industry and uses primarily descriptive statistics due to the number of firms present. Future research can expand this analysis to a broader range of countries entering and upgrading in the industry to help further refine the reasons behind the unexpectedly high female participation in the sector. Indeed, further sector-specific research using a gendered GVC framework into similar high tech or knowledge intensive industries would help to strengthen these findings and identify additional opportunities where trade can help close the gender gap. These sectors differ from early offshoring industries in terms of cyclicality in demand and supply, governance approaches by lead firms, and investment patterns.

Bibliography

Ahmed, Ghada. (2013). Global Value Chains, Economic Upgrading and Gender in the Call Center Industry. In C. Staritz & J. G. Reis (Eds.), *Global Value Chains, Economic Upgrading and Gender: Case Studies of the Horticulture, Tourism, and Call Center Industries*. Washington, D.C.: World Bank.

Alvarado, Laura. (2018). Medical Device Exports From Costa Rica Surpass Agriculture Sector For First Time in History. *The Costa Rica Star*. January 31 from https://news.co.cr/medical-devices-main-product-costa-rica-exports-surpassing-agriculture-sector-first-time-history/70267/.

Bamber, Penny and Karina Fernandez-Stark. (2013). Global Value Chains, Economic Upgrading and

Gender: The Horticulture Industry. In C. Staritz & J. G. Reis (Eds.), *Global Value Chains, Economic Upgrading and Gender: Case Studies of the Horticulture, Tourism, and Call Center Industries* (pp. 11-42). Washington, D.C.: World Bank.
Bamber, Penny and Stacey Frederick. (2018). Central America in Manufacturing Global Value Chains. Durham, N.C.: Duke Global Value Chains Center.
---. (Forthcoming). The Medical Device Global Value Chain. Durham, NC: Duke Global Value Chain Center, Duke University.
Bamber, Penny and Gary Gereffi. (2013). Costa Rica in the Medical Devices Global Value Chain: Opportunities for Upgrading. Durham, N.C.: Duke Global Value Chains Center. Commissioned by the Costa Rican Ministry of Foreign Trade.
Bamber, Penny and Cornelia Staritz. (2016). The Gender Dimensions of Global Value Chains. Geneva: International Centre for Trade and Sustainable Development.
Barrientos, Stephanie. (2001). "Gender, Flexibility and Global Value Chains". *IDS Bulletin, 32*(3): 83-93.
---. (2014a). Gender and Global Value Chains: Challenges of Economic and Social Upgrading in Agri-Food: European University Institute. Robert Schuman Centre for Advanced Studies.
---. (2014b). "Gendered Global Production Networks: Analysis of Cocoa–Chocolate Sourcing". *Regional Studies, 48*(5): 791-803.
Barrientos, Stephanie, Richard M. Auty and John Toye. (1996). Flexible Work and Female Labour: The Global Integration of Chilean Fruit Production. In *Challenging the orthodoxies* (pp. 125-141): New York:St. Martin's Press; London:Macmillan Press.
Barrientos, Stephanie, Gary Gereffi and Arianna Rossi. (2011). "Economic and Social Upgrading in Global Production Networks: A New Paradigm for a Changing World". *International Labour Review, 150*(3-4): 319-340.
Barrientos, Stephanie and Naila Kabeer. (2004). "Enhancing Female Employment in Global Production: Policy Implications". *Global Social Policy, 4*(2): 153-169.
BCDR. (2017). Encuesta Nacional de la Fuerza Laboral, 2017. Santo Domingo, Dominican Republic: Banco Central de la República Dominicana (BCDR).
BD. (2018). Annual Report 2017. Franklin Lakes: Becton Dickinson.
Berik, Günseli. (2000). "Mature Export-Led Growth and Gender Wage Inequality in Taiwan". *Feminist Economics, 6*(3): 1-26.
Bernhardt, Thomas and Ruth Pollak. (2016). "Economic and Social Upgrading Dynamics in Global Manufacturing Value Chains: A Comparative Analysis". *Environment and Planning A, 48*(7): 1220-1243.
BLS. (2018). Occupational Employment Statistics (OES) Survey. Washington, D.C.: Bureau of Labor Statistics (BLS), United States Department of Labor.
BMI Research. (2018). Global Medical Devices Report: BMI Research, Fitch Group.
Boston Scientific. (2018). Annual Report 2017. Boston: Boston Scientific.
Brocca, Michele, Kevin D'Souza, Ted Sisko, and Samantha Baron. (2017). Medtech Manufacturing's Inflection Point: BCG.
Bussolo, Maurizio and Rafael E. De Hoyos. (2009). *Gender Aspects of the Trade and Poverty Nexus: A Macro-Micro Approach*: Washington, D.C.: World Bank; Houndmills, U.K. and New York: Palgrave Macmillan.
Cabrera, Elizabeth. (2009). "Fixing the leaky pipeline: Five ways to retain female talent". *People & Strategy, 32*: 40-45.
Caraway, Teri. (2007). Assembling Women: The Feminization of Global Manufacturing. Ithaca: Cornell University Press.
CFRA. (2018). Health Care Equipment and Supplies: S&P Global.
Christian, Michelle, Barbara Evers and Stephanie Barrientos. (2013). "Women in Value Chains: Making a Difference". *Capturing the Gains Revised Summit Briefing 6.3*.
CNFZE. (2017). Census de Zona Francas, 2006-2016. Santo Domingo, Dominican Republic: Consejo Nacional de Zonas Francas de Exportación (CNFZE).

CNZFE. (2018). First Medical Device Sterilization Company Comes to Dominican Republic. Santo Domingo: Consejo Nacional Zonaas Francas de Exportacion.

Cubero, Jorge Mauricio. (2018). *Coordinator Master of Medical Devices Engineering (TEC)* Personal communication with P. Bamber. November 14.

Deere, Carmen Diana. (2005). The Feminization of Agriculture? Economic Restructuring in Rural Latin America. Geneva: United Nationals Research Institute for Social Development. .

Dolan, Catherine and Kristina Sorby. (2003). Gender and Employment in High-value Agriculture Industries. Washington, DC: World Bank, pp. 1-90.

ECCTI. (2018). Talento Humano Técnico en Costa Rica. 2014-2017. Retrieved November 23, 2018, from http://eccti.or.cr/talento-humano-tecnico.html.

Enamorado, Ted, Ana Carolina Izaguirre and Hugo Nopo. (2009). *Gender Wage Gaps in Central American Countries: Evidence from a Non-Parametric Approach*. Washington, D.C. : Inter-American Development Bank.

Farole, Thomas. (2011). Special Economic Zones in Africa: Comparing Performance and Learning from Global Experience. Washington, D.C.: World Bank.

FDA. (2018). Establishment Registration & Devices: Dominican Republic. In U. S. F. a. D. A. (FDA) (Ed.). Washington, D.C.

Fernandez-Stark, Karina and Penny Bamber. (2018). Promoting Skills, Jobs and Competitiveness in Global Value Chains: Policies and Practices for Developing Countries. In A. Sakamoto (Ed.), *Skills and the Future of Work: Strategies for Future Growth in Asia Pacific*. Bangkok: International Labour Organisation.

Fernandez-Stark, Karina, Penny Bamber and Gary Gereffi. (2013). Costa Rica in the Offshore Services Global Value Chain: Opportunities for Upgrading. Durham N.C.: Center on Globalization, Governance and Competitiveness. Commissioned by the Costa Rican Ministry of Foreign Trade.

Ferrant, Gaelle, Luca Maria Pesando and Keiko Nowacka. (2014). Unpaid Care Work: The Missing Link in the Analysis of Gender Gaps in Labour Outcomes. Paris: OECD Development Center.

Field Research. (2012). *Costa Rica: Summer 2012 Series*. Personal communication with P. Bamber, G. Gereffi & S. Frederick. July 2-6.

---. (2017). *Dominican Republic Field Research*. Personal communication with P. Bamber. December

---. (2018). *Singapore Field Research*. Personal communication with P. Bamber. July.

Fontana, Marzia. (2006). *Survey of Research on Gender and Trade: Insights, Gaps and Coverage*. Paper presented at the Gender in Global and Regional Trade Policies: Contrasting Views and New Research

---. (2011). *Integrating Gender Dimensions into Trade Projects*. from http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/TRADE/0,,contentMDK:22882654~menuPK:2644066~pagePK:64020865~piPK:51164185~theSitePK:239071,00.html.

Frederick, Stacey. (2017). *GVC Modules and Applications*. Paper presented at the Seminar on Accounting for Global Value Chains. from https://unstats.un.org/unsd/trade/events/2017/luxembourg/presentations/CH10_Frederick%20GVC%20Modules.pdf.

---. (2019). Global Value Chain Mapping. In G. Gereffi, S. Ponte & G. Raj-Reichert (Eds.), *Global Value Chain Handbook*. Cheltenham, United Kingdom: Edward Elgar Publishing.

Fussell, Elizabeth. (2000). "Making Labor Flexible: The Recomposition of Tijuana's Maquiladora Female Labor Force". *Feminist Economics, 6*(3): 59-79.

Gereffi, Gary and Karina Fernandez-Stark. (2016). Global Value Chain Analysis: A Primer. Second Edition. Durham, North Carolina, USA:: Duke University Center on Globalization, Governance & Competitiveness (Duke CGGC).

Gereffi, Gary, Karina Fernandez-Stark and Phil Psilos. (2011). *Skills for Upgrading: Workforce Development and Global Value Chains in Developing Countries*. Durham: Duke University Center on Globalization Governance & Competitiveness.

Ghosh, J. (2002). "Globalization, Export-Oriented Employment for Women and Social Policy: A Case

Study of India". *Social Scientist 30*(11/12): 17-60.
Guzman Stein, Laura and Anne Letendre Morales. (2003). Género y educacion en Costa Rica. Geneva: UNESCO.
Hamrick, Danny and Penny Bamber. (2019). Pakistan in the Medical Devices Global Value Chain. Durham, NC: Duke Global Value Chains Center.
Humphrey, John and Hubert Schmitz. (2002). "How Does Insertion in Global Value Chains Affect Upgrading in Industrial Clusters". *Regional Studies, 36*(9): 1017-1027.
ILO. (2016). Decent Work in Global Supply Chains. Geneva: International Labour Organization.
---. (2017). Women in Business and Management: Gaining Momentum in Latin America and the Caribbean. Geneva: Bureau for Employers' Activities, International Labour Organisation.
INEC. (2017). Encuesta Nacional de Empresas, 2017. San Jose, Costa Rica: INSTITUTO NACIONAL DE ESTADÍSTICA Y CENSOS Costa Rica (INEC).
INEGI. (2018). Encuesta Anual de la Industria Manufacturera 2013-2016. In INEGI (Ed.). Mexico City: Instituto Nacional de Estadistica y Geografia (Mexico).
Instituto Nacional de Estadisticas. (2016a). Encuesta Nacional de Fuerza de Trabajo: Ingreso promedio por hora de los ocupados por sector de ocupacion y sexo 2008-2016. Cuado 3.40-4. Santo Domingo, Dominican Republic
---. (2016b). Encuesta Nacional de Fuerza de Trabajo: Población Económicamente Activa (PEA) por sexo y año, según nivel educativo, 2008-2016. Santo Domingo
Instituto Nacional de Estadisticas (Costa Rica). (2016). Encuesta Anual de Hogares: Población de 15 anos o más por nivel de instruccion según zona, regi'pon de planificación y sexo. San Jose: INEC-CR.
INTEC. (2016). Brechas de género: entre el dicho y el hecho de la autonomía de las mujeres en la República Dominicana. Santo Domingo, Dominican Republic: Instituto Tecnológico de Santo Domingo (INTEC); Centro de Estudios del Género.
ISO. (2017). ISO Survey 2017. Geneva, Switzerland: International Organization for Standardization (ISO).
Jomo, Kwame Sundaram. (2009). "Export-Oriented Industrialisation, Female Employment and Gender Wage Equity in East Asia". *Economic and Political Weekly, 44*(1): 41-49.
Kaplinksy, Raphael, Jeff Readman and Olga Memedovic. (2009). Upgrading Strategies in Global Furniture Value Chains. Geneva: UNIDO.
Kimelberg, Shelley McDonough and Lauren A. Nicoll. (2012). "Business Location Decisions in the Medical Device Industry: Evidence From Massachusetts". [Article]. *Economic Development Quarterly, 26*(1): 34-49.
Kucera, David and Sheba Tejani. (2014). "Feminizations, Defeminization, and Structural Change in Manufacturing". *World Development, 64*: 569-582.
Leiton, Patricia. (2014). Uno de cada tres hogares en Costa Rica es dirigido por una mujer. *La Nacion*. May 12 from https://www.nacion.com/economia/indicadores/uno-de-cada-tres-hogares-en-costa-rica-es-dirigido-por-una-mujer/ENPCUPDCSNG6TKKWO7LLAVLZMY/story/.
León, Viviano de and Juan Eduardo Thomas. (2017). A partir de hoy la licencia por maternidad se amplía de 12 a 14 semanas. *Listin Diario*. February 9 from https://listindiario.com/la-republica/2017/02/09/453436/a-partir-de-hoy-la-licencia-por-maternidad-se-amplia-de-12-a-14-semanas.
Liftstream and MassBio. (2017). Opening the Path to a Diverse Future: Creating Gender Balance in Massachusetts LIfe Sceines Sector. Cambridge: Massachusetts Biotechnology Council.
Lo, Chris. (2018). Inside Costa Rica’s Super-Sized Medical Device Sector. *Verdict Medical Devices*. August 30 from https://www.medicaldevice-network.com/features/inside-costa-ricas-super-sized-medical-device-sector/.
Lopez-Acevedo, Gladys and Raymond Robertson (Eds.). (2016). *Stitches to Riches? Apparel Employment, Trade, and Economic Development in South Asia*. Washington D.C.: The World Bank.
Maertens, Miet and Johan Swinnen. (2009). *Are African High-Value Horticulture Supply Chains Bearers*

of Gender Inequality? Paper presented at the FAO-IFAD-ILO Workshop on Gaps, Trends and Current Research in Gender Dimensions of Agricultural and Rural Employment: Differentiated Pathways Out of Poverty.,

Medtronic. (2018). Annual Report 2017. Minneapolis: Medtronic.

MEPyD. (2012). Ley de Estrategia Nacional de Desarrollo 2030. Santo Domingo, Dominican Republic: Ministerio de Economía, Planificación y Desarrollo.

O*Net OnLine. (2018). Home. Washington, D.C.: National Center for O*Net Development; sponsored by U.S. Department of Labor

OECD. (2011). ISIC REV. 3 Technology Intensity Definition. Paris, France: OECD Directorate for Science, Technology and Industry.

---. (2018). OECD Data: Gender Wage Gap. from https://data.oecd.org/earnwage/gender-wage-gap.htm#indicator-chart. .

Pickles, John and Shane Godfrey. (2012). "Economic and Social Upgrading in Global Apparel Production Networks". *Capturing the Gains Briefing Notes*(No 2).

Ponte, Stefano and Peter Gibbon. (2005). "Quality Standards, Conventions and the Governance of Global Value Chains". *Economy and Society, 34*(1): 1-31.

Powell, Catherine and Ann Mei Chang. (2016). Women in Tech as a Driver for Emerging Economies. New York: Council on Foreign Relations.

PROCOMER. (2012). Census de Zona Francas. San Jose, Costa Rica: Promotora de Comercio Exterior de Costa Rica (PROCOMER).

---. (2015). Balance de Zonas Francas: Beneficio Neto del Régimen para Costa Rica 2010-2014. San Jose, Costa Rica: Promotora de Comercio Exterior de Costa Rica (PROCOMER).

---. (2016). Balance de Zonas Francas: Beneficio Neto del Régimen para Costa Rica 2011- 2015. San Jose, Costa Rica: Promotora de Comercio Exterior de Costa Rica (PROCOMER).

Rodriguez, Raquel. (2018). *Adozona: Medical Devices Course Enrollment in Dominican Republic*. Personal communication with P. Bamber. 13 November.

Saraçoğlu, Dürdane Şirin, Emel Memiş, Ebru Voyvoda, and Burça Kızılırmak. (2018). "Changes in Global Trade Patterns and Women's Employment in Manufacturing, 1995–2011". *Feminist Economics, 24*(3): 1-28.

Sarkar, Sandip and Balwant Mehta. (2018). What do Workers Gain from Being in a GVC? ICT in India. In D. Nathan, M. Tewari & S. Sarkar (Eds.), *Labour in Global Value Chains in Asia*. Cambridge: Cambridge University Press.

Seguino, Stephanie. (1997). Export-Led Growth and the Persistance of Gender Inequality in the Newly Industrialized Countries. In J. Rives & M. Yousefi (Eds.), *Economic Dimensions of Gender Inequality: A Global Perspective* (pp. 11-33). London, Wesport, CT: Praeger.

---. (2000). "The Effects of Structural Change and Economic Liberalization on Gender Wage Differentials in South Korea and Taiwan". *Cambridge Journal of Economics, 24*(4): 437-459.

Seguino, Stephanie, Günseli Berik and Yana Van Der Meulen Rodgers. (2010). An Investment that Pays Off: Promoting Gender Equality as a Means to Finance Development. Berlin: Friedrich Ebert Stiftung International. .

Staritz, Cornelia and Jose Guilherme Reis. (2013). *Global Value Chains, Economic Upgrading and Gender: Case Studies of the Horticulture, Tourism, and Call Center Industries*. Washington, D.C.: World Bank.

Tejani, Sheba. (2011). The Gender Dimension of Special Economic Zones. In T. Farole & G. Akinci (Eds.), *Special Economic Zones in Africa: Comparing Performance and Learning from Global Experience* (pp. 247-282). Washington D.C.: World Bank.

Tejani, Sheba and William Milberg. (2016). "Global Defeminization? Industrial Upgrading, Occupational Segregation and Manufacturing Employment in Middle Income Countries". *Feminist Economics, 22*(2): 24-54.

UN Comtrade. (2018). UN Comtrade Database: Medical Devices Exports to World (HS02-9018-9022). Retrieved August 10, 2018, 2018, from http://comtrade.un.org/.

UNCTAD. (2014). Trade, Gender and the Post-2015 Development Agenda Post-2015. Geneva: United Nations Conference on Trade and Development (UNCTAD).
---. (2015). Ensuring Gender-Sensitive Implementation of the Post-2015 Development Framework. Geneva: United Nations Conference on Trade and Development (UNCTAD).
UNIDO. (2018). INDSTAT Industrial Statistics Database (ISIC Rev. 4; 4 digit). Retrieved July 8, 2018, from https://stat.unido.org.
WEF. (2017). The Global Gender Gap Report. Geneva: World Economic Forum.
WHO. (2017). Global Atlas of Medical Devices. Geneva: World Health Organization.
World Bank. (2011). Moving up the Value Chain: A Study of Malaysia's Solar and Medical Device Industries. Washingon DC: The World Bank.
---. (2016). Special Economic Zones in the Dominican Republic: Policy Considerations for a More Competitive and Inclusive Sector. Washington, D.C.: World Bank Group. Trade and Competitivenes Global Practice.
---. (2017a). Hogares encabezados por mujeres (% de hogares con jefa de hogar). Washington, D.C.
---. (2017b). Labor force, female (% of total labor force). Washington, D.C.
---. (2017c). Zonas Francas En República Dominicana: Consideraciones de Política para un sector más competitivo e incluyente Santo Domingo, Dominican Republic: World Bank.
---. (2018). World Development Indicators. *World Development Indicators* Retrieved November 15, 2018, from http://data.worldbank.org.
Zolezzi, Sandro. (2018). *Costa Rican Investment Promotion Agency (CINDE)*. Personal communication with P. Bamber. January 18.

Annex.

Table A. 1. Gender Dimension Indicators of a Gendered GVC Framework

Dimension	Indicator
Patterns of segregation	Participation of women by sector, GVC stage, occupation, or job profile Women's share of supervisory, managerial, professional, technical, and clerical work
Vulnerable employment	Women's share of informal/contract/seasonal employment Women's share in permanent jobs with contracts
Access to training	Women's participation rate in TVET and other external training programs Women's participation in "on the job" training programs
Wage gap	Average wages by gender by GVC stage Ratio of women's wages to men's wages for similar work
Working conditions	Average number of working hours for women vs. men Number of occupational health and safety incidences for women vs. men Share of women with access to social security Share of women with access to paid sick leave Share of women with access to maternity leave Provision of on-site child care and nursing facilities Share of female workers with discrimination/sexual harassment claims

Source: Bamber and Staritz, 2016

Table A. 2. Medical Devices Product Categories, Based on Trade Data Classifications

Product Category	Product Examples	HS Code Aggregation	HS96 Codes 6-Digit (HS02-07 changes)
Disposables	Needles, syringes, catheters, tubing, IV sets, bandages	90183, 3006.9	901831: Syringes, with or without needles 901832: Tubular metal needles and needles for sutures 901839: Needles, catheters, cannulae etc. (medical) (changes to Catheters, cannulae & the like in HS02) 9018391010-90: Infusion equipment 9018399010-20: Infusion and transfusion of serum 9018399090: Other needles and catheters, cannulae and the like 3006.91: Appliances identified for ostomy use
Medical & Surgical Instruments	Dental Instruments, Forceps, Medical Scissors, Dialysis Devices, Defibrillators	90184 90185 90189 3006.1	901841: Dental drill engines (expands to dental drill engines, whether/not combined on a single base with other dental equipment in HS02) 901842: Instruments and appliances, used in dentistry 901850: Ophthalmic instruments and appliances (expands to "" nes 90.18 in HS02) 901890: Instruments, appliances for medical, etc. science, nes (expands to Instruments & appliances used in medical/ surgical/veterinary sciences, incl. other electro-medical apparatus & sight-testing instrument, nes in 90.18 3006.1 Suture materials, sterile catgut, etc.
Therapeutic Devices	Artificial body parts, hearing aids, pacemakers, crutches, implants, prosthetics	9021	902111: Artificial joints (changes to 902131: Artificial joints HS02) 902119: Orthopedic/fracture appliances, nes (changes to 902110: Orthopedic/fracture appliances in HS02) 902121: Artificial teeth 902129: Dental fittings, nes 902130: Artificial body parts, aids, and appliances, etc. (changes to 902139: Artificial parts of the body other than teeth, dental fittings & joints in HS02) 902140: Hearing aids, except parts and accessories 902150: Pacemakers 902190: Orthopedic Appliances, nes (expands to appliances which are worn/carried/implanted in the body, to compensate for a defect/disability (excl. of 9021.10-9021.50) in HS02)
Capital Equipment	MRI, Ultrasound	841920 90181	841920: Medical, Surgical or Laboratory Sterilizers 901811: Electro-cardiographs

	machine, X-rays, Patient Monitoring Systems, Blood Pressure Monitor	90182 9022	901812: Ultrasonic scanning apparatus 901813: Magnetic resonance imaging apparatus 901814: Scintigraphic apparatus 901819: Electro-diagnostic apparatus, nes (expands to "" used in medical/ surgical/dental/ veterinary sciences (incl. apparatus for functional exploratory examination/for checking physiological parameters), nes in 90.18) in HS02) 901820: Ultra-violet or infra-red ray apparatus (expands to "" used in medical/surgical/dental/veterinary sciences in HS02) 90221: Apparatus based on the use of X-rays, whether or not for medical, surgical, dental or veterinary uses, including radiography or radiotherapy 90222: Apparatus based on the use of alpha, beta or gamma radiations, whether or not for medical, surgical, dental or veterinary uses, including radiography or radiotherapy apparatus 902230: X-ray tubes 902290: Other, including parts and accessories
Consumable s/Medical Supplies	Bandages and dressings	3005	300510: Dressings, adhesive; and other articles having an adhesive layer, packed for retail sale for medical surgical, dental and veterinary use. 300590: Wadding, gauze, bandages ad similar (excluding adhesive dressings) impregnated or coated with pharmaceutical substances, packaged for retail.
Other Appliances	Breathing devices and other mechano-therapy devices	9019 9020	9019: Mechano-therapy appliances; massage apparatus; psychological aptitude-testing apparatus; ozone therapy, oxygen therapy, aerosol therapy, artificial respiration or other therapeutic respiration apparatus; 9020: Other breathing appliances and gas masks (excluding protective masks having neither mechanical parts nor replaceable filters)

Source: Bamber & Frederick (2018) ; see also Bamber & Gereffi (2013) for another application.

Table A. 3. Medical Devices Entrants Per Year, By Country

Entry Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Costa Rica	7	2	2	0	4	1	2	1	-	-	-	-	-
Dominican Republic	-	-	12	1	1	2	1	2	1	2	0	2	1

Note: Entry year based on first year employment data was reported. Firms present in the first year of analysis for each country (2004 and 2006 respectively) are noted as entrants for that year.

Table A. 4. Descriptive Statistics of Datasets for Firm-Level Analysis

CRI	Longevity	Total Exports (US$,M) 2004	2011	Total Employment 2004	2011	Female Employment 2004	2011	Female Intensity 2004	2011	Entry	Medical Devices Exports (US$,M) 2004	2011
Mean	5.6	74.8	64.6	536	541	266	288	0.47	0.48	0.43	26.8	60.8
Median	6	16.7	14.9	94	199.08	50	110	0.50	0.52	0.50	0	11.6
Std Dev	2.5	110.0	105.2	790	757	391	407	0.18	0.20	0.23	71.5	99.9
Range	7	278.0	381.7	1,977	2,668	991	1,394	0.56	0.65	0.75	280	348.9
Min.	1	1.5	0.15	19	10	2	1	0.10	0.1	0	0	0
Max.	8	280.0	381.8	1,997	2678	993	1,394	0.65	0.75	0.75	280	349.01
Sum	106	747.8	1,227.7	3,755	10,272	1,854	5,472	3.3	9.0	8.3	482.6	1,154.8
Count	19	9	19	7	19	7	19	7	19	19	19	19
		Total Exports (US$,M)		**Total Employment**		**Female Employment**		**Female Intensity**			**Medical Devices Exports (US$,M)**	
DRI	**Longevity**	**2012**	**2016**	**2006**	**2016**	**2006**	**2016**	**2006**	**2016**	**Entry**	**2012**	**2016**
Mean	8.6	59.6	57.0	760	828	494	552	0.72	0.61	0.59	39.8	49.8
Median	10	13.4	16.6	742	355	500	225	0.74	0.68	0.67	1.3	6.4
Std Dev	3.8	68.0	70.0	598	948	374	682	0.15	0.18	0.19	61.9	71.9
Range	11	175.7	244.6	1,559	3,419	1,003	2,550	0.64	0.76	0.81	169.5	243.7
Min.	1	2,884	0.016	47	30	45	2	0.32	0.067	0.1	0	0
Max.	12	175.7	244.6	1,606	3,449	1,048	2,552	0.96	0.83	0.91	169.5	243.7
Sum	215	1,193	1,425	9,124	20,695	5,933	13,793	8.6	15.4	14.9	995.5	1, 246
Count	25	20	25	12	25	12	25	12	25	25	25	25