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Sheba Tejani and David Kucera

ABSTRACT

This article examines gendered employment implications of structural transformation and technological upgrading in manufacturing. It focuses on 14 countries that relied heavily on exports of labour-intensive and assembly industries that have long provided strategic entry points onto global markets. The study uses accounting decomposition methods to identify the drivers of changes in female shares of manufacturing employment as well as econometric analysis to assess the gendered impacts of technological upgrading. This study is the first to apply either of these methods at a detailed industry level as well as the first to estimate long-run relationships between women's representation in manufacturing employment and technological upgrading. The main findings are that within-industry effects on female shares of employment are generally more important than employment reallocation effects and that there is more often a negative than positive relationship between technological upgrading and female shares of employment at the country and industry levels. These negative effects of technological upgrading are found in four of the five strategic export-oriented industries — food, beverages and tobacco products; textiles; apparel, leather products and footwear; and motor vehicles. The article discusses the policy implications of these findings and of the defeminization of manufacturing employment more generally.

INTRODUCTION

Since the publication in 1999 of a United Nations report on 'the role of women in economic development' in the context of globalization, a growing number of studies have examined the gender implications of export-oriented industrialization (UN, 1999). These studies endeavour to account for the commonly occurring phase of feminization of manufacturing employment

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in the early stages of export-oriented industrialization followed by a phase of defeminization, defined in terms of rising and falling female shares of manufacturing employment. In particular, a number of studies have examined the relationship between defeminization and technological upgrading, with the latter taking the form of technological upgrading within manufacturing industries and compositional shifts away from labour-intensive manufacturing industries — most notably female-intensive textiles and garments — towards higher value-added industries. A general finding of these studies is that technological upgrading is associated with the defeminization of manufacturing employment.

There have been three main types of studies in this regard. These are country-industry case studies (e.g. Barrientos et al., 2004; Joekes, 1999); econometric studies (e.g. Greenstein and Anderson, 2017; Seguino and Braunstein, 2018; Tejani and Milberg, 2016); and studies using accounting decomposition methods to identify the drivers of changing female shares of manufacturing employment (e.g. Kucera and Tejani, 2014; Saraçoğlu et al., 2018). In particular, accounting decomposition methods (of which there are several variations) enable one to identify the relative importance of compositional shifts in employment among industries with different female shares of employment versus changes in female shares of employment within industries, referred to as employment reallocation and within-industry effects respectively. Our study combines the second and third of these approaches, using both econometric and decomposition methods.

A notable limitation of these econometric and decomposition studies is their broad levels of aggregation. That is, the econometric studies look only at the manufacturing sector as a whole, and the decomposition studies focus on three broad groups of manufacturing industries, classified by the labour intensity of production in Kucera and Tejani (2014) and the technology intensity of production in Saraçoğlu et al. (2018). Both Tejani and Milberg (2016) and Greenstein and Anderson (2017) suggest that their analyses of the relationship between female shares of manufacturing employment and technological upgrading should be explored more fully using industry-level manufacturing data. Correspondingly, one of the main contributions of our study is to apply these two methods for 14 manufacturing industries, at as detailed a level as the data allows while maintaining consistency across countries and over time. This matters not just in having a finer sense of the industry-level drivers of results for the manufacturing sector as a whole. In particular, the relative importance of employment reallocation versus within-industry effects resulting from decomposition methods is not absolute for a given country and period but rather depends fundamentally on the level of aggregation of data to which the method is applied. Using their three broad industry groups, both Kucera and Tejani (2014) and Saraçoğlu et al. (2018) find that within-industry effects are generally more important than reallocation effects in driving both the feminization and defeminization of manufacturing employment. Yet the more aggregated are data, the more compositional shifts among industries can be masked within broader industry groups and thus accounted for as within-industry (or within sub-sector) effects. This has policy implications for improving women's representation in manufacturing employment in the face of technological upgrading, a point to which we return below.

These decomposition methods were initially used to identify the relative importance of employment reallocation versus within-industry effects as drivers of aggregate productivity growth. The relative importance of these effects is a central concern of the structural transformation school of development economics, particularly as embodied in Kaldor's 'growth laws' (Kaldor, 1967, 1968). Although structural transformation is initiated by compositional shifts towards manufacturing, Kaldor argued that the associated reallocation effects on aggregate productivity growth are less important than the resultant within-industry effects (Kaldor, 1968: 386). A number of studies applying decomposition methods affirm Kaldor's views of the greater importance of within-industry compared to employment reallocation effects in driving aggregate labour productivity growth (Kucera and Jiang, 2018; Ocampo et al., 2009; Roncolato and Kucera, 2014; Timmer and de Vries, 2009). These studies all decompose aggregate labour productivity growth, and Ocampo et al. (2009: 42) provide a compelling reason for doing so: '[h]istorically, labor productivity increases have been the major contributing factor to growth in real GDP per capita'. While these studies focus on the economy as a whole, structural transformation is also concerned with compositional shifts within manufacturing towards higher value-added industries.

There is a renewed interest in economic policy discussions on structural transformation and industrial policy, the latter serving as means to the former (e.g. Stiglitz et al., 2013; UNCTAD, 2016). One of the reasons for this is concern about the negative implications of deindustrialization and particularly 'premature' deindustrialization in developing and emerging economies, in which the share of industrial output and employment starts declining at much lower levels than in earlier economic development trajectories. Tregenna (2009) analyses how the implications of deindustrialization depend on whether these are assessed in terms of output or employment shares. With respect to employment, Tregenna argues that deindustrialization has a negative impact on aggregate demand because industrial jobs tend to be relatively high paying, particularly compared to the informal jobs in agriculture and services so prevalent in developing countries.

It is these same concerns about premature deindustrialization and its impact on employment that leads to concerns about the defeminization of manufacturing employment. Increasing or at least maintaining women's share of manufacturing employment is important because these are comparatively good jobs, especially in developing countries.[1] This holds all the more strongly in the face of technological upgrading in manufacturing, so that women can benefit from the better jobs created through employment reallocation as well as within industries. Following the same line of argument in their study on gender segregation and structural transformation in developing countries, Seguino and Braunstein (2018) use industrial jobs as a proxy for good jobs, based on the authors' assessment of industry's relatively high labour productivity and relatively low share of 'vulnerable' employment, defined as contributing family workers and own-account workers.

Though focusing on the US, a study by the McKinsey Global Institute (2017) makes a point that holds more generally about manufacturing jobs providing opportunities for less educated workers. In contrast, India's services-led growth path has been associated with weak job prospects for less educated workers in ICT-intensive sectors as well as weak employment growth more generally, leading a number of authors to argue for the continued importance of manufacturing jobs in India (e.g. Eichengreen and Gupta, 2011; Ramaswamy and Agrawal, 2012). Even in developing countries for which the share of industrial employment is increasing — as are most of the countries in the sample we consider — concerns about the defeminization of manufacturing employment remain.

We alluded to the policy implications underlying the relative importance of employment reallocation versus within-industry effects in driving changes in female shares of employment for the manufacturing sector as a whole. Compositional shifts in employment among industries only result in employment reallocation effects in the presence of gender segregation among industries. That is, if female shares of employment were identical across all industries, compositional shifts in employment would have no effect on the female share of employment for the manufacturing sector as a whole. If defeminization were predominately driven by reallocation effects, a key policy objective would be to break down existing patterns of gender segregation among industries.

The patterns of gender segregation among industries on which reallocation effects are premised result in large part from firms' past hiring decisions. Seguino and Braunstein (2018) provide four hypotheses to explain such hiring decisions. These include gender stereotypes about men and women's qualifications; concerns about the negative effect on productivity of hiring women in jobs dominated by men; using gender segregation among occupations as a divide and conquer strategy to weaken workers' bargaining power; and gains to firms through paying men efficiency wages. Seguino and Braunstein (ibid.) view the resultant patterns of gender segregation through

1. For a debate on this point with respect to women garment workers in Bangladesh, particularly in the wake of the Rana Plaza factory collapse in 2013, see Ashwin et al. (2020), Berik (2017) and Kabeer (2004).

the lens of 'job hoarding' in which men get privileged access to good jobs, a problem that is exacerbated when there is a scarcity of such jobs.

While gender segregation among industries is a necessary precondition for employment reallocation effects, within-industry effects can occur even in the complete absence of gender segregation. Within-industry effects are directly driven by firms' contemporaneous decisions about which workers to retain and which to hire anew. Where defeminization is predominately driven by within-industry effects, the policy objective would thus be for firms to retain currently employed women workers. Within-industry effects result from changes in women's employment *relative* to total (men and women's) employment. Yet we will see that in several important cases, women's employment also declined in *absolute* terms in key industries such as textiles and apparel, and footwear. In this context, it is important to understand employers' preference for men rather than women workers particularly in the context of technological upgrading. Summarizing three hypotheses put forth in studies addressing this question, Kucera and Tejani (2014: 570) write the following:

> These studies invoke the lesser importance of low-wage women's labor in more capital-intensive production; gender norms designating men as breadwinners and women as secondary workers, with men more likely to be hired for higher paying jobs; and the different skills requirements of new industrial jobs combined with the purportedly different skills of men and women workers and whether these differences are real or perceived.

Note that these are distinct from the four hypotheses put forth by Seguino and Braunstein (2018). That is, these three hypotheses endeavour to explain why, in the context of defeminization driven by technological upgrading, firms either do not retain women workers they previously hired or maintain the same proportions of men and women workers, rather than why firms in male-intensive industries tend not to hire women workers in the first place. In sum, whether defeminization is driven predominantly by employment reallocation or within-industry effects respectively puts the policy focus on breaking down gender segregation resulting from firms' past hiring decisions versus addressing firms' contemporaneous retention of women workers.

In this article, we focus on a group of countries that relied heavily on exports in labour-intensive and assembly industries that have been historically important for export-oriented industrialization. For these countries, we first carry out a decomposition analysis to identify industry-level drivers of the growth of the female share of employment and distinguish between the relative importance of within- and between-industry effects. We also decompose labour productivity growth for the manufacturing sector as a whole by country to get a summary sense of whether structural transformation is driven by within or reallocation effects. Next, we attempt to explain what factors account for shifts in the female share of manufacturing employment in the long run, using regression analysis, with a particular focus on the importance of technological upgrading (measured by labour productivity growth). We conduct the analysis on a country-by-country basis but also at the industry level by pooling data across countries, which allows us to return to the labour-intensive and export-oriented industries that motivated our analysis and identify the factors that determine the female share of employment within them in the long run. Main findings are that within-industry effects on female shares of employment are generally more important than employment reallocation effects and that technological upgrading has a largely negative effect on female shares of employment at the country and industry levels. For four of the five export-oriented industries that account for the largest shifts in the female share of employment in the decomposition analysis — food, beverages and tobacco products; textiles; apparel, leather products and footwear; and motor vehicles — we find that the negative impact of labour productivity growth emerges as an important cause. We have elaborated on the policy implications of within-industry versus reallocation effects, but the negative relationship between technological upgrading and female shares of employment also has important policy implications, in that it threatens to undo the gains made by women entering into manufacturing employment.

DECOMPOSING THE GROWTH OF FEMALE EMPLOYMENT SHARES AND LABOUR PRODUCTIVITY

Industries and Countries

Our decomposition analysis is based on manufacturing employment and value-added data from the United Nations Industrial Development Organization's (UNIDO) Industrial Statistics Database (UNIDO, 2017). In order to maintain consistency in the number of industries across countries and over time, we combined the 22 two-digit International Standard Industrial Classification (ISIC) industries into 14 industries, with the combined industries grouped in boxes as shown in Table 1. These are all adjacent industries in ISIC, and for the most part it was not necessary to group dissimilar industries.[2] Further information on this data, including the exact years used for each country and data cleaning procedures, is provided in the Data Appendix).

For countries with data that were sufficiently complete across industries and over time from 1990 on, we arrived at a set of 14 mainly developing countries that differed widely in terms of overall export orientation but that

2. The exception is for ISIC industries 29–33, which groups electronics with non-electrical machinery and various other products. Note also that ISIC 23 for Coke, refined petroleum products and nuclear fuel was dropped from the analysis because of problematic data discontinuities, which are discussed further in the Data Appendix.

Table 1. Manufacturing Industry Groups

ISIC (Revision 3)	
15	Food products and beverages
16	Tobacco products
17	Textiles
18	Wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear
20	Wood and cork products, except furniture; articles of straw and plaiting materials
21	Paper and paper products
22	Publishing, printing and reproduction of recorded media
24	Chemicals and chemical products
25	Rubber and plastic products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29	Machinery and equipment NEC
30	Office, accounting and computing machinery
31	Electrical machinery and apparatus NEC
32	Radio, television and communication equipment and apparatus
33	Medical, precision and optical instruments, watches and clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
36	Furniture; manufacturing NEC

Note: NEC: Not elsewhere classified.

all relied heavily on export-oriented industrialization. These are the textiles, apparel and footwear; food, beverages and tobacco products; electronics; and motor vehicles industries. As we will see in our discussion of industry-level decomposition results, all but motor vehicles also tend to have relatively high shares of female employment. In particular, we selected countries that were either leading exporters in these industries or for which exports in these industries made up a large share of their merchandise exports, based on data from the World Trade Organization's *International Trade Statistics* (WTO, 2014).[3] We focus on these countries given our interest in the gender dynamics of export-oriented industrialization. These countries were also very dynamic, with their share of world exports roughly doubling over the period studied (World Bank, 2020).[4]

The 14 countries are listed in Table 2, which depicts 10 indicators providing a broader country context for our empirical results, expressed in terms of annual averages for 2012–14 as well as the difference from annual

3. In *International Trade Statistics* (WTO, 2014), these industries are referred to as: office and telecom equipment, electronic data processing (EDP) equipment, telecommunications equipment, integrated circuits and electronic components (these last three contained within the first, though we looked at the corresponding tables for each of these industries individually); automotive products; and textiles and clothing.
4. Leaving aside Taiwan (China), the 13 countries' share of world exports of goods and services increased from 6.1 to 11.2 per cent from 1990 to 2014.

Table 2. Country Context for Structural Transformation and Female Employment in Manufacturing (2012–14 annual average and difference from 1990–92 annual average)

	Exports of goods and services as a % of GDP		Manufacturing exports as a % of GDP*		Labour force participation rate, female 15+		Employment to population ratio, female 15+		Employment in industry, total as a % of total employment		Employment in agriculture, female as a % of female employment		Employment in industry, female as a % of female employment		Employment in services, female as a % of female employment		Vulnerable employment, female as a % of female employment**		Female-to-male years of educational attainment 15+***	
	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2012-14	Diff.	2010	Diff.
Bangladesh	19.6	12.8	18.9	13.4	31.4	7.6	29.1	5.8	19.0	5.9	64.7	−25.5	14.4	6.6	20.9	18.8	78.6	−4.4	0.82	0.30
Egypt	15.9	−9.5	9.8	1.2	23.2	1.8	17.6	0.4	24.5	3.0	41.2	−11.5	5.2	−5.1	53.6	16.7	44.5	−1.9	0.50	0.08
India	24.3	16.2	17.0	9.0	23.2	−7.3	22.3	−7.5	24.4	9.0	59.5	−16.6	18.7	7.1	21.7	9.5	82.4	−8.8	0.85	0.24
Indonesia	24.1	−4.6	20.4	−2.9	51.1	4.6	48.9	2.8	21.1	6.8	34.2	−21.5	15.6	2.8	50.2	18.7	58.9	−13.9	0.88	0.30
Jordan	43.4	−12.3	24.1	−0.7	14.2	3.5	11.2	3.5	25.1	2.8	1.2	−2.4	16.0	1.7	82.8	0.8	1.7	−0.3	0.93	0.16
Malaysia	76.2	0.1	70.8	2.2	48.4	3.1	46.8	3.5	28.3	−3.4	8.3	−11.9	20.0	−12.2	71.7	24.2	22.7	−5.3	0.94	0.08
Mexico	31.8	15.0	30.3	7.7	44.2	10.1	42.1	9.0	24.4	1.1	3.9	−6.0	16.3	−2.5	79.9	8.5	31.4	−5.7	0.61	0.14
Morocco	34.1	11.1	21.2	9.4	24.4	0.9	22.0	1.3	21.5	1.3	59.9	0.5	12.0	−7.7	28.1	7.2	64.2	−8.7	1.06	0.09
Philippines	29.2	0.5	20.8	2.3	49.1	1.6	47.2	1.2	15.6	−0.4	20.4	−10.9	10.1	−3.7	69.5	14.6	42.9	−5.3	0.88	0.12
South Korea	53.5	28.8	44.8	22.4	50.6	3.6	49.0	3.1	24.6	−11.2	6.0	−11.6	13.8	−15.1	80.2	26.7	24.3	−16.1	0.95	0.05
Sri Lanka	20.4	−9.8	13.7	−10.0	34.4	−7.3	32.1	1.3	26.2	2.9	33.0	−12.7	26.0	−1.5	41.0	14.2	44.4	11.2	0.76	0.19
Taiwan (China)	78.0	33.6	NA	NA	50.4	5.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	0.14
Turkey	23.2	9.4	16.8	7.8	29.7	−3.8	26.6	−4.2	26.8	5.9	35.1	−39.3	15.8	6.0	49.0	33.3	41.4	−24.2	0.89	0.11
Vietnam	83.4	49.5	77.1	42.7	72.7	0.0	71.9	0.4	21.3	8.9	48.8	−20.4	17.1	6.3	34.1	14.1	68.8	−18.4	0.89	0.11
Average	39.8	10.1	29.7	8.0	39.1	1.7	35.9	1.6	23.3	2.5	32.0	−14.6	15.5	−1.3	52.5	15.9	46.6	−7.8	0.85	0.15

Notes: Grey shading indicates countries for which female shares of manufacturing employment declined overall.

*Based on available years of data for 1990–92 and 2012–14 or nearest available year (1993 for India and Indonesia, 2003 for Mexico, 1998 for Vietnam and 2011 for Bangladesh).

**Vulnerable employment is defined as contributing family workers and own-account workers as a percentage of total employment.

***Based on data for 1990 and 2010.

NA = data not available.

Sources: Educational attainment data are from Barro and Lee Educational Attainment Dataset; https://barrolee.github.io/BarroLeeDataSet/

Manufacturing export data are from UN Comtrade; https://comtrade.un.org/

Aside from Taiwan, other data are from World Bank (2020).

For Taiwan, other data are from Statistical Bureau of Taiwan; https://eng.stat.gov.tw/mp.asp?mp=5 averages for 1990–92, with average values (unweighted) shown at the bottom of the table. Grey shading (for Table 2 and subsequent tables) indicates the six countries that experienced falling female shares of manufacturing employment overall. Table 2 shows that exports of goods and services as a percentage of GDP were very high in Malaysia, Taiwan (China) and Vietnam (above 75 per cent) and quite low in Bangladesh and Egypt (below 20 per cent), with similar cross-country variation for manufacturing exports as a percentage of GDP. The table also shows that only three of the 13 countries for which we have data experienced deindustrialization in terms of falling shares of employment in industry: Malaysia, the Philippines and South Korea (though this was negligible in the Philippines). Table 2 also shows female labour force participation and employment rates, the distribution of female employment among agriculture, industry, services and vulnerable employment, and ratios of female-to-male years of educational attainment, to which we return below.

Decomposition Method

The female share of manufacturing employment is defined as female manufacturing employment divided by total (female and male) manufacturing employment, or F/L, and industry-level female shares within manufacturing are correspondingly defined as F^i/L^i. This can be also expressed as:

$$F/L = \sum F^i / \sum L^i \tag{1}$$

Following Ocampo et al. (2009: 54), the growth of female shares in manufacturing employment for any given year can be expressed relative to the share in the prior year as follows:

$$\Psi = \left(1 + \hat{L}\right)^{-1} \sum \left[\theta_0{}^i \left(\hat{F}^i - \hat{L}^i\right) + \left(\theta_0{}^i - \varepsilon_0{}^i\right) \hat{L}^i\right] \tag{2}$$

where:

$$\hat{L}^i = \left(L_1{}^i - L_0{}^i\right) / L_0{}^i$$

$$\hat{F}^i = \left(F_1{}^i - F_0{}^i\right) / F_0{}^i$$

$$\theta_0{}^i = F_0{}^i / F_0$$

$$\varepsilon_0{}^i = L_0{}^i / L_0$$

Note that we decompose the *growth rates* of female employment shares rather than the difference in these shares and do so based on annual data to the extent possible rather than period endpoints, with further elaboration in the Technical Appendix.

The *within-industry effect* on the growth of female employment shares is represented by the left-hand bracketed term in Eq. 2, that is:

$$\Psi_W = \sum \left[\theta_0{}^i \left(\hat{F}^i - \hat{L}^i\right)\right] \tag{3}$$

For any given industry, the within-industry effect is the difference between industry-level female employment growth and total employment growth weighted by the distribution of female employment in the industry relative to female employment in the manufacturing sector as a whole). Positive (negative) within-industry effects result when industry-level female employment grows faster (slower) than industry-level total employment. It is important to note that positive within-industry effects can occur when men lose jobs at higher rates than women, such as during a recession. Such a scenario does not represent real improvements for either women or men workers, and so within-industry effects must be interpreted in a broader country context.

The *reallocation effect* on the growth of female employment shares is represented by the right-hand bracketed term in Eq. 2, that is:

$$\Psi_r = \sum \left[\left(\theta_0{}^i - \varepsilon_0{}^i\right) \hat{L}^i\right] \tag{4}$$

For any given industry, the reallocation effect is the difference between the distribution of female employment in the industry (relative to female employment for the manufacturing sector as a whole) and the distribution of total employment in the industry (relative to total employment for the manufacturing sector as a whole), multiplied by industry-level employment growth. In this context, the expression ($\theta_0{}^i$ - $\varepsilon_0{}^i$) provides a measure of gender segregation, with smaller absolute values indicating less gender segregation.

Positive (negative) reallocation effects result when industry-level employment grows in industries for which the difference between the distribution of female employment and the distribution of total employment is positive (negative), that is, in industries with above (below) average female shares of manufacturing employment.[5] Yet positive reallocation effects also result when industry-level employment contracts in industries with below average female shares of manufacturing employment. Such a scenario does not represent real improvements for either women or men workers and, as with within-industry effects, reallocation effects must be interpreted in a broader country context.

5. Note that while Saraçoğlu et al. (2018) also use UNIDO's Industrial Statistics Database to decompose changes in female shares of manufacturing employment, their method differs in several key respects. Saraçoğlu et al. (ibid.: 5–6) decompose these changes as the difference between period endpoints (rather than growth over annual data) for three industry groups by technology levels. More fundamentally, their reallocation effect is positive whenever the employment share of total manufacturing employment for an industry increases, whether the industry has above or below average female shares of manufacturing employment, which we find counterintuitive.

As noted, we decompose the growth of both female employment shares as well as labour productivity for each of the 14 countries. Substituting value added for female employment in the above formulas (that is, 'X' for 'F') converts them into decompositions of labour productivity growth, with analogous interpretations of within-industry and reallocation effects.

DECOMPOSITION ANALYSIS RESULTS

Female Shares of Manufacturing Employment

Results of the decomposition analysis for the 14 countries and 14 manufacturing industries are presented in Table 3. Under the country heading are decomposition results presented in three columns for within-industry effects, reallocation effects and the sum of these two effects. The sums of cross-industry effects for the decomposition of the growth of female shares of manufacturing employment are presented at the bottom of panels A1, A2 and A3 in Table 3. The sums of cross-industry effects for the decomposition of labour productivity growth are presented in panels B1, B2 and B3 in Table 3. To facilitate comparison across countries and the presentation of generally small numbers, we follow Pieper (2000) and normalize decomposition results by dividing each value by the absolute value of the period average growth for each country. We do this for female share growth as well as labour productivity growth respectively.[6] The exception is the final rows of all panels, which present the non-normalized sums of industry-level effects as average per cent changes.

For the three countries with continuous annual data — India, South Korea and Taiwan (China) — the sum of the within-industry and reallocation effects in the penultimate row of panels A1, A2 and A3 represents the average annual change of female employment shares in manufacturing (leaving aside the small interaction effects). Yet the other 11 countries do not have continuous annual data and some of them have large gaps in years of data. This is particularly acute in the case of Bangladesh and Mexico, where there were large increases in female shares in the former and large decreases in female shares in the latter. This limitation in mind, if the sum of within-industry and reallocation effects is positive, this means that the female share of manufacturing employment increased overall, and vice versa if the sum

6. Note that when period averages of changes in female shares of manufacturing employment are small, some industry percentages can be considerably greater than 100, most notably in the cases of Indonesia and Vietnam. These large values nonetheless bear the same proportionate relationship to other industry values within a country whether or not expressed as percentages and can be interpreted accordingly. Note also that the cross-industry sums of within-industry and reallocation effects generally hover around, though are not exactly equal to, 100 per cent, with the difference resulting from interactions referred to in the discussion of Eq. 2.

Table 3. Decomposition Results

Panel A1: Female shares of manufacturing employment	Bangladesh Within	Bangladesh Realloc.	Bangladesh Sum of within & realloc.	Egypt Within	Egypt Realloc.	Egypt Sum of within & realloc.	India Within	India Realloc.	India Sum of within & realloc.	Indonesia* Within	Indonesia* Realloc.	Indonesia* Sum of within & realloc.	Jordan Within	Jordan Realloc.	Jordan Sum of within & realloc.
Food and beverages; Tobacco products	2.14	−2.16	−0.02	***10.12***	−0.53	9.59	***27.66***	***9.44***	37.10	***−1091.72***	155.53	−936.18	3.58	***−9.15***	−5.58
Textiles	***32.68***	***−14.57***	18.11	***11.60***	−1.26	10.34	***34.82***	1.28	36.10	72.86	−20.63	52.23	−2.56	2.18	−0.38
Wearing apparel, fur; Leather, leather products and footwear	***−14.12***	***156.34***	142.22	4.35	***41.07***	45.42	−1.66	***58.15***	56.49	***724.29***	***404.14***	1128.43	***70.45***	***61.05***	131.50
Wood products (excl. furniture)	−0.39	0.00	−0.39	0.27	0.53	0.80	0.74	−0.25	0.49	−61.65	107.13	45.49	0.22	−2.42	−2.20
Paper and paper products	0.16	−0.15	0.01	0.04	−0.45	−0.41	1.85	−1.40	0.45	56.44	−19.42	37.02	−0.18	1.21	1.03
Printing and publishing	0.13	−1.42	−1.29	0.73	0.07	0.80	1.08	−0.04	1.05	0.01	−13.95	−13.94	2.51	−1.03	1.49
Chemicals and chemical products	0.65	−1.71	−1.06	***12.20***	−1.01	11.19	−4.27	−2.00	−6.27	4.83	−10.36	−5.53	3.13	***7.80***	10.93
Rubber and plastics products	0.48	−0.82	−0.34	−0.97	−0.11	−1.08	1.87	−4.59	−2.72	22.71	−101.71	−79.00	3.37	−1.03	2.33
Non-metallic mineral products	1.71	−9.09	−7.38	−0.22	0.42	0.20	−0.20	−7.65	−7.85	−65.33	−56.07	−121.39	1.92	−6.02	−4.11
Basic metals	0.14	−2.72	−2.58	0.08	1.78	1.86	0.27	−8.05	−7.79	9.63	−43.81	−34.17	0.40	−2.21	−1.81
Fabricated metal products	0.21	−0.46	−0.26	1.07	2.60	3.67	1.04	−9.19	−8.15	−1.41	−149.52	−150.93	−0.26	−7.27	−7.52
Electrical and non-electrical machinery and equipment NEC	0.02	−1.28	−1.26	−5.17	2.33	−2.84	1.92	−6.94	−5.01	−0.65	39.13	38.48	0.84	−2.49	−1.64
Motor vehicles, trailers, semi-trailers; Other transport equipment	0.16	−0.59	−0.44	2.21	3.69	5.89	2.38	−5.96	−3.58	119.30	***−208.45***	−89.15	0.00	−0.92	−0.92
Furniture; manufacturing NEC	−0.20	−0.65	−0.86	1.04	−1.50	−0.45	−1.00	0.76	−0.24	44.07	−26.77	17.30	3.51	−6.13	−2.61
Cross-industry sum	23.76	120.71	144.46	37.35	47.64	84.98	66.50	23.56	90.05	−166.62	55.25	−111.37	86.94	33.56	120.50
Cross-industry non-normalized sum	5.84	29.66	35.50	0.74	0.95	1.69	1.51	0.53	2.04	−0.07	0.02	−0.05	4.69	1.81	6.50
Panel B1: Labour productivity															
Cross-industry sum	−59.96	242.79	182.84	88.89	8.52	97.41	89.52	9.95	99.48	86.95	10.34	97.30	63.68	12.54	76.22
Cross-industry non-normalized sum	−2.57	10.40	7.83	12.47	1.20	13.67	2.29	0.25	2.54	7.31	0.87	8.18	1.58	0.31	1.89

(*Continued*)

Table 3. (Continued)

Panel A2: Female shares of manufacturing employment	Malaysia Within	Malaysia Realloc.	Malaysia Sum of within & realloc.	Mexico Within	Mexico Realloc.	Mexico Sum of within & realloc.	Morocco Within	Morocco Realloc.	Morocco Sum of within & realloc.	Philippines Within	Philippines Realloc.	Philippines Sum of within & realloc.	South Korea Within	South Korea Realloc.	South Korea Sum of within & realloc.
Food and beverages; Tobacco products	−2.26	−5.25	−7.52	***−36.81***	1.05	−35.76	***60.05***	−5.55	54.50	38.12	−10.58	27.54	1.31	0.04	1.35
Textiles	−3.77	0.12	−3.64	−9.65	−3.62	−13.27	***9.36***	−3.85	5.50	15.23	−9.49	5.74	***−11.32***	***−11.32***	−22.63
Wearing apparel, fur; Leather, leather products and footwear	−8.16	2.10	−6.06	−8.95	***−15.92***	−24.87	***10.72***	***22.38***	33.11	***−68.24***	***−56.24***	−124.48	−0.77	***−29.57***	−30.34
Wood products (excl. furniture)	−0.08	−4.63	−4.71	−0.41	2.15	1.73	0.01	−0.14	−0.13	6.57	13.81	20.38	−0.71	0.58	−0.13
Paper and paper products	−0.79	−2.30	−3.09	−0.98	0.34	−0.64	−0.27	1.01	0.74	8.71	−2.34	6.37	−0.55	0.20	−0.35
Printing and publishing	−1.91	−0.66	−2.57	NA	NA	NA	0.65	−0.60	0.05	3.06	−0.46	2.60	1.65	−2.12	−0.47
Chemicals and chemical products	0.53	−3.99	−3.46	1.86	0.25	2.10	3.82	−0.69	3.14	10.84	−2.40	8.44	−2.19	0.14	−2.05
Rubber and plastics products	***−14.04***	−0.30	−14.35	−1.25	0.07	−1.18	0.60	−0.81	−0.21	−9.58	−1.61	−11.18	0.40	−0.61	−0.21
Non-metallic mineral products	−1.52	−4.59	−6.11	−4.10	1.67	−2.43	1.42	1.01	2.43	10.43	−5.95	4.48	−1.61	1.72	0.11
Basic metals	0.24	−6.02	−5.78	−1.17	−2.64	−3.81	0.29	−2.58	−2.29	8.84	−1.77	7.07	0.12	−1.00	−0.88
Fabricated metal products	−3.51	−6.86	−10.36	−3.65	−1.54	−5.19	0.72	−2.06	−1.34	10.59	−12.66	−2.07	−1.63	−3.74	−5.38
Electrical and non-electrical machinery and equipment NEC	***−40.59***	***23.53***	−17.06	−8.87	−3.46	−12.33	6.20	0.91	7.12	32.77	***100.67***	133.44	***−23.73***	2.19	−21.53
Motor vehicles, trailers, semi-trailers; Other transport equipment	0.78	***−9.66***	−8.89	***13.67***	***−13.20***	0.46	1.86	−3.78	−1.91	***54.03***	−40.22	13.81	3.83	***−12.03***	−8.20
Furniture; manufacturing NEC	−7.29	−3.70	−11.00	2.41	−0.04	2.37	0.62	−1.10	−0.48	−6.93	6.65	−0.28	−7.63	4.87	−2.75
Cross-industry sum	−82.38	−22.21	−104.59	−57.92	−34.89	−92.81	96.05	4.16	100.21	114.43	−22.58	91.86	−42.82	−50.65	−93.47
Cross-industry non-normalized sum	−1.65	−0.45	−2.10	−5.82	−3.51	−9.33	2.71	0.12	2.82	0.50	−0.10	0.40	−0.77	−0.91	−1.68
Panel B2: Labour productivity															
Cross-industry sum	−155.45	33.66	−121.79	59.65	33.27	92.93	−77.26	198.98	121.72	80.98	12.75	93.73	−69.57	122.93	53.35
Cross-industry non-normalized sum	−3.98	0.86	−3.12	17.01	9.49	26.50	−0.27	0.69	0.42	7.15	1.13	8.28	−0.71	1.25	0.54

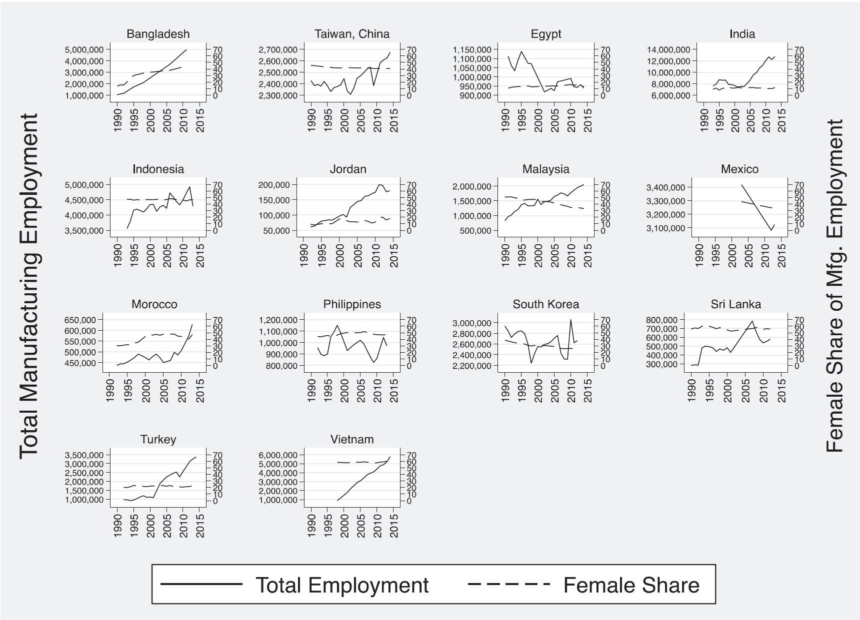
(*Continued*)

Table 3. (Continued)

Panel A3: Female shares of manufacturing employment	Sri Lanka** Within	Sri Lanka** Realloc.	Sri Lanka** Sum of within & realloc.	Taiwan (China) Within	Taiwan (China) Realloc.	Taiwan (China) Sum of within & realloc.	Turkey Within	Turkey Realloc.	Turkey Sum of within & realloc.	Vietnam Within	Vietnam Realloc.	Vietnam Sum of within & realloc.
Food and beverages; Tobacco products	***30.83***	***−68.94***	−38.11	4.45	0.91	5.35	27.03	0.02	27.05	23.27	−68.86	−45.58
Textiles	−23.94	13.57	−10.37	−17.39	−9.14	−26.52	−11.44	45.35	33.91	−19.72	22.39	2.67
Wearing apparel, fur; Leather, leather products and footwear	***−50.19***	***103.12***	52.92	−6.62	***−22.03***	−28.65	−17.17	***238.84***	221.66	8.67	***825.54***	834.20
Wood products (excl. furniture)	10.88	−7.80	3.09	−0.79	0.74	−0.04	0.82	−9.16	−8.34	−4.36	−43.37	−47.74
Paper and paper products	−0.09	0.59	0.50	1.71	0.81	2.52	6.79	−4.91	1.89	−6.82	−33.00	−39.82
Printing and publishing	1.06	−12.71	−11.66	0.71	−0.85	−0.14	4.36	−3.74	0.62	4.12	−18.77	−14.65
Chemicals and chemical products	6.36	−7.29	−0.93	−2.93	−1.34	−4.26	26.75	−0.30	26.45	−8.02	−44.65	−52.67
Rubber and plastics products	−15.28	−27.95	−43.23	***−20.43***	−2.05	−22.48	8.80	−27.86	−19.06	5.07	−55.59	−50.52
Non-metallic mineral products	7.71	15.77	23.48	−4.40	3.32	−1.09	12.16	−37.17	−25.01	−28.16	−148.26	−176.42
Basic metals	0.21	4.59	4.80	−0.33	−4.67	−5.00	6.41	−11.86	−5.45	−8.51	−33.10	−41.61
Fabricated metal products	−0.99	−3.45	−4.44	3.56	−7.79	−4.23	5.18	−51.61	−46.43	−8.35	***−152.88***	−161.23
Electrical and non-electrical machinery and equipment NEC	15.65	−9.29	6.36	***−41.43***	***31.15***	−10.28	14.81	***−39.54***	−24.73	***114.54***	−57.53	57.01
Motor vehicles, trailers, semi-trailers; Other transport equipment	3.22	0.26	3.48	4.79	−2.80	1.99	16.38	***−38.14***	−21.75	39.12	***−141.90***	−102.78
Furniture; manufacturing NEC	−19.83	8.77	−11.06	−3.04	−3.02	−6.06	8.72	***−39.20***	−30.49	−28.66	−44.56	−73.22
Cross-industry sum	−34.40	9.23	−25.17	−82.13	−16.76	−98.89	109.60	20.71	130.31	82.19	5.46	87.64
Cross-industry non-normalized sum	−0.15	0.04	−0.11	−0.37	−0.08	−0.45	0.73	0.14	0.87	0.23	0.02	0.24
Panel B3: Labour productivity												
Cross-industry sum	58.44	21.03	79.47	94.90	6.30	101.20	98.20	−1.23	96.97	107.30	−5.34	101.96
Cross-industry non-normalized sum	2.27	0.82	3.09	4.67	0.31	4.98	29.48	−0.37	29.12	44.61	−2.22	42.38

Notes: Grey shading indicates countries for which female shares of manufacturing employment declined overall.
Bolded and italicized values indicate the top four largest within-industry and reallocation absolute effect values for a country.
*Excludes changes between 1996 and 1998 because of data discontinuities.
**Excludes changes between 2001 and 2007 because of data discontinuities.
NEC: Not elsewhere classified.
NA: Data not available.

Figure 1. Total Manufacturing Employment and Female Shares of Manufacturing Employment



Source: Author's illustration using UNIDO (2017).

is negative. For six of the 14 countries, there was an overall decrease in the female share of manufacturing employment: Indonesia, Malaysia, Mexico, South Korea, Sri Lanka and Taiwan (China). For the other eight countries, there was an overall increase in the female share of manufacturing employment.

A visual sense of these changes can be had to some extent from Figure 1, showing female shares of manufacturing employment alongside the absolute numbers of total (male and female) manufacturing employment, though overall changes in female shares are often too small to show decided trends. In general, we do not observe any evident relationship between changes in female shares of manufacturing employment and changes in total manufacturing employment in our sample of countries. Yet the figure does show that the feminization of manufacturing employment in Bangladesh and Morocco occurred alongside increases in total manufacturing employment whereas feminization in Egypt was accompanied by falling total manufacturing employment. The defeminization of manufacturing employment in Malaysia and Taiwan occurred alongside increases in total manufacturing employment whereas defeminization in South Korea was not accompanied by clear trends in total manufacturing employment. Nor is there any evident relationship between changes in female shares of manufacturing employment and deindustrialization in terms of falling shares of employment in industry.

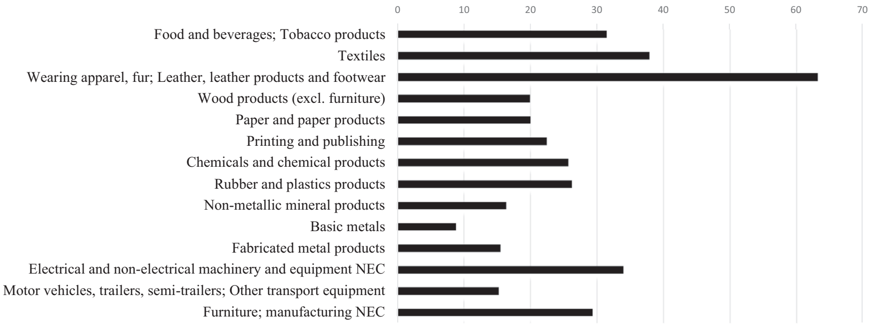
The bottom rows of Table 3 show that within-industry effects were greater (in absolute value) than reallocation effects for 11 of the 14 countries, with Bangladesh, Egypt and South Korea the exceptions — though we note our concerns about the quality of the data for Bangladesh and Egypt in the Data Appendix. Though reallocation effects are emphasized in the literature on how female shares of manufacturing employment rise and fall in the process of industrialization (see, for example, Caraway, 2006), it is actually changes *within* manufacturing industries that matter more in accounting for the feminization and defeminization of manufacturing employment. This holds not only for our sample of countries, but for the larger sample of countries in Kucera and Tejani (2014), who we have noted apply decomposition analysis to three manufacturing industry groups. Yet the more disaggregated the data one works with, the generally more important are reallocation effects relative to within-industry effects, and in this sense our results on the greater importance of within-industry effects are particularly noteworthy.

Though reallocation effects were smaller (in absolute value) than within-industry effects in 11 of 14 countries, this is not to say they were unimportant. Indeed, reallocation effects were at least one-third as large as within-industry effects in India, Indonesia, Jordan and Mexico and at least one-fourth as large in Malaysia and Sri Lanka. The countries for which the cross-industry sum of reallocation effects is negative suggests a potentially challenging context for women's representation in manufacturing employment, in that this represents a compositional shift away from female-intensive and towards male-intensive industries. There were five such countries: Malaysia, Mexico, the Philippines, South Korea and Taiwan (China). Of these five, only in the Philippines was the increase in women's manufacturing employment *within* industries sufficient to more than offset the negative reallocation effect. Indonesia and Sri Lanka represent a mirror image of the Philippines, in that the female share of employment in the manufacturing sector as a whole decreased in spite of compositional shifts in employment being favourable towards women's representation in manufacturing employment.

In defining within-industry and employment reallocation effects, we noted the potential ambiguity in the interpretation of these effects and the importance of country context. For all six defeminizing countries, it is worth noting that men's total employment in manufacturing increased in absolute terms. By definition, women's employment increased by less than men's for these six countries, but women's total employment in manufacturing also decreased in absolute terms in three of these six countries: Mexico, South Korea and Taiwan.[7] For seven of the eight feminizing countries, men's

7. The number of women workers in the manufacturing sector as a whole declined by period average rates of -12.0, -1.8 and -0.02 per cent in Mexico, South Korea and Taiwan respectively.

Figure 2. Female Share of Employment by Industry (%, cross-country avg.)



total employment in manufacturing rose in absolute terms, with Egypt being the exception.[8] In seven of these eight countries, in other words, the growing representation of women in manufacturing employment cannot be interpreted as having occurred at the expense of men workers in any absolute sense.

Industry-level Drivers

We turn next to discussing which industries were the key drivers of changes in female shares of employment in the manufacturing sector as a whole. For this it is instructive to look at Figure 2, showing average female shares of employment across countries by manufacturing industry, using all available years of data. Female shares are highest in apparel, leather products and footwear, at 63 per cent, followed by textiles at 38 per cent and electrical and non-electrical machinery and equipment — including electronics — at 34 per cent. Female shares are also high in food, beverages and tobacco products, at 31 per cent. The motor vehicles industry had below average female shares, at 15 per cent. Table A2 in the Data Appendix provides industry-level female shares of employment and total (male and female) employment growth, which are particularly helpful in interpreting employment reallocation effects.

These four industries are the most important drivers of changes in female employment shares for the manufacturing sector as a whole. This is revealed by looking in Table 3 at the four largest absolute values across industries within each country for within-industry and reallocation effects. (Though the threshold of four is somewhat arbitrary, the same basic story emerges with slightly lower or higher thresholds.) It is useful to first look at

8. In Egypt, the number of men workers in the manufacturing sector as a whole declined by an average rate of -1.1 per cent while the number of women workers increased by an average rate of 0.7 per cent.

within-industry and reallocation effects rather than the sum of these effects. The reason is that even though the sum of the two effects might be small for an industry, underlying this might be large but offsetting within-industry and reallocation effects, one having a having a negative and the other a positive value.

The largest absolute values for within-industry and reallocation effects are the italicized and bolded values in Table 3. Summing across countries, the industries that ranked most frequently among the top four by absolute values are apparel, leather products and footwear (among the top four industries within a country 19 times), food, beverages and tobacco products (nine times), electrical and non-electrical machinery and equipment (eight times), motor vehicles (eight times), and textiles (seven times). No other industries come close in this regard.

Turning to the sum of within-industry and reallocation effects, we see that the industries that have been most important in this sense in contributing to changes in female shares of manufacturing employment are apparel, leather products and footwear; food, beverages and tobacco products; and textiles, in that order.[9] Yet we also observe cases where within-industry and reallocation effects for a given industry within a country are of opposite sign and thus offset each other. Particularly noteworthy in this regard is the pattern of offsetting positive within-industry and negative reallocation effects for motor vehicles. That is, in 11 of the 14 countries, there are negative reallocation effects and positive within-industry effects for motor vehicles, with Jordan, Egypt and Sri Lanka the exceptions. Since motor vehicles has a relatively low share of female employment in all of our countries (Data Appendix Table A2), this means that for these 11 countries, an overall increase in total employment in the industry occurred alongside a rising share of female employment within the industry. In seven of these 11 countries, the sum of within-industry and reallocation effects is negative, meaning that motor vehicles ultimately hurt women's representation in manufacturing employment.[10]

We have noted that within-industry effects result from relative rather than absolute changes in women's employment and have also noted the importance of the textiles and particularly the apparel, leather products and footwear industries in driving changes in female shares of employment for the manufacturing sector as a whole. Of the six defeminizing countries, there were negative within-industry effects for these two industries in Malaysia, Mexico, South Korea and Taiwan. Yet these industries experienced not just relative but also absolute declines in women's employment in these economies, and we have also noted that the last three of these also experienced absolute declines in women's employment alongside absolute

9. Based on the industries with the two largest absolute values across industries within each country for the sum of within-industry and reallocation effects.
10. Mexico, Philippines, Sri Lanka and Taiwan (China) are the exceptions.

increases in men's manufacturing employment for the manufacturing as a whole.[11] In these cases, then, defeminization played out not just in a relative but also an absolute sense.

Labour Productivity Growth

We have noted that the sums of cross-industry effects for the decomposition of labour productivity growth are presented in panels B1, B2 and B3 in Table 3. As with the decomposition of the growth of female shares of manufacturing employment, within-industry effects are greater (in absolute value) than employment reallocation effects for 11 of the 14 countries.[12] This is consistent with Kaldor's expectation of the greater importance of within-industry than reallocation effects in driving productivity growth for the economy as a whole.

In our decomposition of female shares of manufacturing employment, we suggested that preference for male workers in the face of technological upgrading could be one of the reasons for defeminization within industries as well as for the manufacturing sector as a whole. If employers display a preference for male workers as they upgrade technologically, women will lose out on the resulting gains and remain sequestered in relatively labour intensive and low value-added jobs. We are interested in systematically exploring how technological upgrading as measured by labour productivity growth affects growth in female shares of manufacturing employment. For this, one might be tempted to look at the relationship between within-industry effects for the decomposition of the growth of female share of employment and labour productivity. However, the purpose of constructing industry-level decomposition effects is so that they sum to overall growth, and as such contain industry-level weights that confound the relationship between the growth of female shares of employment and labour productivity at the industry level. For example, the weight term $\theta_0^i = F_0^i/F_0$ has no bearing on the industry-level relationship between labour productivity and female shares of employment and including it in the analysis could create misleading results. As such, the regressions addressed in the next section of the article use direct

11. The number of women workers in the textiles and apparel and footwear industries declined respectively by period average rates of -3.2 and -0.7 per cent in Malaysia, -42.2 and -30.4 per cent in Mexico, -6.8 and -6.3 per cent in South Korea and -3.9 and -3.6 per cent in Taiwan. The number of men workers in these two industries also declined in Mexico, South Korea and Taiwan, though at lower rates than for women workers, and increased in Malaysia.
12. There are two countries for which there is a switch between the within-industry versus reallocation effect being larger, comparing results for the decomposition of the growth of female shares of employment and labour productivity: Egypt and Morocco. Note also that our data indicates that Malaysia experienced declining labour productivity, but this contradicts findings from other studies (e.g. World Bank, 2018) and so results should be viewed with caution.

industry-level measures of the growth of female shares of employment and labour productivity.

REGRESSION RESULTS

Econometric Methodology: ARDL Approach and Pooled Mean Group Estimation

In this section we attempt to identify the key factors that explain shifts in the female share of manufacturing employment with a particular focus on the role of technological upgrading measured as labour productivity growth. Establishing the relationship between technological upgrading and defeminization can point to the direction that policy must take in order to ensure an equitable gender distribution of jobs in manufacturing, as outlined in the introduction. With the female share of manufacturing employment as our dependent variable, we first conduct regressions by country. In order to identify the main industry-level drivers of the country results, we also pool countries and estimate cross-country industry-level elasticities of labour productivity with respect to the female share of employment. Our study is distinctive because we estimate long-run parameters for these relationships by country and individual manufacturing industries, which to our knowledge has not been previously attempted in the literature.

We are able to estimate the long-run relationship between our variables of interest since we have a sufficiently large time span (T) as well as evidence of non-stationarity in our panel dataset. We thus use an autoregressive distributed lag (ARDL) approach with a pooled mean group estimator (PMG) proposed by Pesaran et al. (1999). The PMG estimator produces consistent and efficient long-run estimates in the presence of integrated as well as stationary variables and obviates the need to determine the potentially inconclusive order of integration of the variables in panel data. Unlike the mean group (MG) estimator, it assumes slope homogeneity across industries, which is tested using a standard Hausman test. For more discussion on the PMG and MG estimators and the number of years and panels in relation to them, please refer to the Technical Appendix.

Our general specification in Equation 5 designates the female share of manufacturing employment as the dependent variable and labour productivity, average real wages and salaries,[13] and export share as independent variables. The construction of the variables and data sources are described in Table A3 of the Data Appendix and each of the independent variables is discussed below. Mexico and Bangladesh are dropped because of insufficient data. The model is estimated for each of the remaining 12 countries

13. Since UNIDO (2017) does not provide wage data disaggregated by gender, average wages and salaries had to be used.

using the identical panel dataset (for the years 1990–2014) as the decomposition. All variables are in logs and their coefficients can be interpreted as elasticities.

$$f_{it} = \sum_{j=1}^{p} \lambda_{ij} \cdot \left(f_{i,t-j}\right) + \sum_{j=0}^{q} \delta_{ij}{}' \cdot \left(\chi_{i,t-j}\right) + \mu_i + \varepsilon_{it} \tag{5}$$

where f_{it} is the female share of manufacturing employment; and χ_{it} is a vector of explanatory variables including: labour productivity (ξ_{it}); average real wages and salaries (ω_{it}); and export shares (x_{it}). δ_{ij} are the coefficient vectors of the control variables; λ_{ij} are scalars and coefficients of the lagged dependent variables; μ_i represents the panel specific fixed effect and ε_{it} is the error term. Subscript i denotes industry and t denotes time.

Because a PMG estimator makes large parametric demands on the data, and degrees of freedom are limited, we opt for a parsimonious specification that focuses on the key variables that influence female shares employment as identified in the theoretical and empirical literature. Apart from problems in estimation, multicollinearity with other supply and demand related factors[14] that may impact the dependent variable led to very high variance inflation factors (VIFs) and implausibly large and unstable coefficient estimates, which is another reason they were excluded.

Our main variable of interest is manufacturing labour productivity as technological upgrading is expected to translate into rising value added per worker. Increases in labour productivity also result from the process of structural transformation and are most often driven by within-industry effects related to learning by doing, economies of scale and market expansion as described in the introduction. We would expect labour productivity to have a negative relation with the female share of employment for reasons discussed earlier, including stereotypes about gender-appropriate work, breadwinner norms, job hoarding and lack of on-the-job training.

Real wages and salaries are intended to control for the portion of wages not accounted for by labour productivity, in other words, bargaining power. When both labour productivity and real wages are included as independent variables, we can assume that labour productivity already captures the portion of the wage related to productivity increases. Since women have limited bargaining power and tend to be crowded into low value-added industries, the sign on this coefficient is expected to be negative.[15]

14. The variables that were tested include: GDP per capita; labour force participation ratios (f/m) or alternatively the employment to population ratio (f); average schooling years (f/m); the male unemployment rate to capture the added-worker effect; the age dependency ratio to account for caring burdens; and the services share of employment.
15. Other studies have found evidence of this relationship as well: Ozler (2000) finds that relative wages are negatively associated with the female share of employment in Turkey; Tejani and Milberg (2016) find the same, though using the gender education gap as a proxy for the gender wage gap, for a group of countries in Latin America and Southeast Asia. Seguino

The export share variable captures the average impact of the export competitiveness of manufacturing industries on the dependent variable. In that sense our study goes beyond the discussion on whether trade openness itself drives feminization, or the hiring of women as a source of cheap labour due to greater competition (Standing, 1989; Wood, 1991). Rather, we measure changes in the composition of exports driven by competitiveness, as studies have shown that primary export-oriented industrialization (EOI), where price competition is intense and production is labour intensive, is related to feminization and that secondary EOI is consistent with defeminization (Tejani and Milberg, 2016). Thus the coefficient can be expected to be either positive or negative depending on a country's stage of industrialization, the composition of its exports as well as prevailing gender norms.

Testing these variables for non-stationarity using the Augmented Dickey-Fuller test reveals that we have mix of stationary I(0) and non-stationary I(1) series across countries, which confirms that an ARDL approach with a PMG estimator is appropriate. Theoretically, we would expect a long-run relation to exist between labour productivity, real wages and export share though, in the short run, adjustments will depend on dynamics of the labour market, export volatility and wage fluctuations in each country. Our general specification is thus reparameterized in error correction form in Equation 6. Lag order is selected using consistent Bayesian Information Criterion on a country-by-country basis. Since there are a limited number of observations, we constrain the maximum number of lags to be 1. Because the variables have been log transformed, Equation 6 represents a regression of the growth of the female share of employment on the growth of labour productivity and other control variables.

$$\Delta f_{it} = \phi_i \left(f_{i,t-1} - \beta_i{}' \chi_{it} \right) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta f_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}{}' \Delta \chi_{i,t-j} + \mu_i + \varepsilon_{it} \tag{6}$$

where $\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij})$, $\beta_i = \sum_{j=0}^{q} \delta_{ij} / (1 - \sum_k \lambda_{ik})$.

The parameter ϕ_{i} captures the speed of adjustment of the error correction process and is negative and statistically significant when there is reversion to a long-run equilibrium. The long-run β_{i} coefficients are of primary concern for our purposes while δ_{i} are the short run coefficients of the model.

The validity of the PMG estimator rests on the assumption that there is a long-run relationship between the variables, the regressors are strictly exogenous and residuals are serially uncorrelated (Loayza and Rancière, 2006). When serial correlation is present, it is eliminated by augmenting

(1997) has shown that the feminization of industrial employment in South Korea puts downward pressure on relative wages due to women's lower bargaining power, which is in turn driven by their weaker fall-back position.

lags on the regressors thus also ensuring exogeneity. In order to ensure cross-sectional independence, we time-demean all the variables to control for omitted factors that are common across panels (Pesaran et al., 1999: 622).[16]

Country-level Results

Table 4 presents the long-run parameters and results of our estimation exercise.[17] Jordan and Taiwan display serial correlation, which is eliminated by augmenting lags on the regressors. A Hausman test confirms that the restriction of slope homogeneity across industries is not rejected for all countries, indicating that our PMG estimates are consistent. Since our coefficients are elasticities, and measure the impact of a 1 per cent change in the independent variable on the dependent variable, we organize our discussion around their economic significance. Using summary statistics presented in the Data Appendix Table A4, we calculate the impact of a one standard deviation change in each independent variable on the dependent variable. In addition, we also rely on Table 2 and Table 3 to contextualize the results.

Before discussing the results in more detail, it would be useful to point to some general trends and patterns that emerge across the sample. First, the error correction term is negative and highly significant across the sample indicating that the variables converge to a long-run equilibrium in every country. The speed of adjustment is highest in Jordan and slowest in the Philippines. Second, we find that labour productivity growth is statistically significant in explaining shifts in the female share of employment in 10 out of 12 countries when controlling for other factors. Of these, eight display negative coefficients indicating that technological change is negatively related to the female share of employment in two-thirds of the countries in our sample. In five of these countries, technological upgrading led to defeminization but, critically in three, technological downgrading contributed to a feminization of labour. Third, the results for real wages and salaries variable are mixed, with only five statistically significant coefficients of which three display a positive sign and two a negative sign. Thus in a few countries we see that women are being integrated into industries with relatively higher bargaining power, which could be related to greater skill acquisition and the significant closing of the gender gap in education.[18] Fourth, and in contrast to labour productivity growth, the coefficient on export share growth is largely positive with seven countries displaying a positive and statistically

16. An alternative is to use cross-sectional means as additional regressors (Pesaran et al., 1999) but we do not have sufficient degrees of freedom to use this method.
17. For reasons of space, short-run estimates are not presented but are available upon request from the authors.
18. This has also been documented by other studies such as Seguino (2006).

Table 4. Long-run Effects of Labour Productivity Growth on Female Share by Country

	Labour productivity	Real wages	Export share	Error correction	Constant	Hausman pval	Obs.	Log-likelihood
Egypt	−0.1022**	0.0665	−0.0515*	−0.6560***	0.0081	0.9594	152	91.67
	(0.049)	(0.044)	(0.030)	(0.087)	(0.012)			
India	0.0176	−0.0026	0.2224***	−0.5798***	0.0086	0.3411	280	144.7
	(0.061)	(0.069)	(0.034)	(0.112)	(0.008)			
Indonesia	0.0860***	−0.0070	−0.1506***	−0.3298***	0.0082	0.9801	247	371.1
	(0.025)	(0.033)	(0.037)	(0.104)	(0.007)			
Jordan	−0.1762***	0.3076***	0.3927***	−0.7782***	0.0156	0.9018	194	81.17
	(0.059)	(0.054)	(0.037)	(0.217)	(0.051)			
Malaysia	0.0630*	0.0640	0.0322*	−0.3157***	−0.0089**	0.6219	252	422.1
	(0.036)	(0.052)	(0.019)	(0.103)	(0.004)			
Morocco	−0.3160**	0.0928	0.0298	−0.3100***	0.0156	0.9048	208	221.3
	(0.156)	(0.218)	(0.044)	(0.108)	(0.010)			
Philippines	−0.3269***	0.5046***	0.3251***	−0.1612**	0.0223*	0.4827	154	231.2
	(0.054)	(0.069)	(0.034)	(0.075)	(0.013)			
South Korea	−0.1311***	−0.0042	0.0437**	−0.3289***	0.0011	0.61	308	584
	(0.046)	(0.056)	(0.021)	(0.074)	(0.004)			
Sri Lanka	−0.0960***	−0.0451***	−0.0337***	−0.3650***	0.0296***	0.873	154	191.5
	(0.012)	(0.014)	(0.010)	(0.081)	(0.011)			
Taiwan (China)	−0.1105***	0.0075	0.2269***	−0.2450***	−0.0006	0.7132	322	977.2
	(0.017)	(0.013)	(0.030)	(0.052)	(0.001)			
Turkey	0.0078	0.0536**	0.1549***	−0.4026***	0.0062	0.5394	280	328.5
	(0.005)	(0.026)	(0.025)	(0.111)	(0.004)			
Vietnam	−0.0824***	−0.0477***	0.0656***	−0.4921***	0.0023	0.7786	182	318.6
	(0.014)	(0.017)	(0.009)	(0.134)	(0.007)			

Standard errors in parentheses.
***$p<0.01$, **$p<0.05$, *$p<0.10$.

significant sign and three a negative sign. The pattern across countries suggests that rising export shares — a sign of growing export competitiveness — promote a greater reliance on female labour in more than half the countries in our sample. Yet this positive impact exists once the largely negative impact of labour productivity growth is controlled for, which highlights women's continuing segregation in low productivity export-oriented jobs in manufacturing. We discuss each of the variables in turn.

A one standard deviation rise in labour productivity leads to some of the largest declines in the female share of employment in Philippines (24 per cent), Morocco (23 per cent) and Jordan (14 per cent). For the remaining countries, the impact on female share is not negligible either, with a similar rise in labour productivity leading to a decline of 11 per cent in the female share of employment South Korea and 8 per cent each in Egypt and Sri Lanka. It should be noted that the negative relationship holds for feminizing (Egypt, Jordan, Morocco, the Philippines and Vietnam) as well as defeminizing (Sri Lanka, South Korea and Taiwan) countries. The negative impact of labour productivity is mostly taking place in an environment of expanding total manufacturing employment, except in Egypt, South Korea and, to some extent, Taiwan. In these countries, where deindustrialization is underway, it is possible that the shrinking pool of remunerative and higher productivity jobs in manufacturing are being rationed to men.

Labour productivity growth driven by within-industry effects has been strong in Egypt, the Philippines and Taiwan and relatively moderate in Sri Lanka but in all cases has gone along with a defeminization of labour. South Korea experienced a decline in labour productivity growth within industries, but this was concentrated only in electrical and non-electrical machinery and equipment while other industries experienced strong productivity growth and defeminization. But not all countries show positive labour productivity growth in our sample and technological downgrading emerges as a common theme for some feminizing countries. For instance, Morocco showed strong feminization over the period while experiencing sizable declines in within-industry labour productivity across a range of industries but most significantly in food, beverages and tobacco and apparel, leather products and footwear. In Jordan and Vietnam, the expansion of the relatively lower productivity apparel, leather products and footwear industry dampened total labour productivity growth (through negative reallocation effects) but spurred a feminization of labour. Industry is becoming an important source of employment for women relative to agriculture in both countries and in Vietnam manufacturing is a female dominated sector.

Indonesia and Malaysia are noteworthy for their positive and significant coefficients on labour productivity growth. A one standard deviation rise in labour productivity leads to a 10 per cent rise in the female share of employment in Indonesia. Although Indonesia is defeminizing across a range of industries, this was offset to a significant extent by an increase in the female share of employment in textiles as well as apparel, leather products and footwear, which also experienced technological upgrading during the period. The coefficient for Malaysia is only significant at the 10 per cent level and given the unexpected finding of negative labour productivity growth mentioned previously, the results must be viewed with caution.

The results for real wages are more mixed,[19] with the largest positive coefficients seen in Jordan, and the Philippines, where a one standard deviation increase in bargaining power led to a 26 per cent and 18 per cent rise in the female share of employment respectively. In the Philippines, and to a lesser extent Jordan, this represents gains for women who have entered a range of new industries in manufacturing though in Jordan the absolute number of women in manufacturing remains low. In both countries, key female-intensive industries such as food and beverages (Jordan and Philippines), as well as apparel, leather products and footwear industries (Jordan only) continued to feminize even as wages rose. When interpreted in conjunction with the findings on labour productivity, it suggests that the preference for female labour in relatively low wage industries can persist even when labour productivity increases, likely due to the cost advantage of employing women when industries compete on the basis of unit labour costs.[20]

Sri Lanka and Vietnam display negative coefficients for real wages and are in line with other studies that emphasize women's concentration in relatively low wage jobs with low bargaining power. In both countries, this compounds the already negative impact of labour productivity on the female share of employment and implies that technological upgrading and a rise in bargaining power tend to disadvantage women on average.

Finally, the statistically significant results for the export share variable are mostly positive and roughly the reverse of those for labour productivity. Export competitiveness in the form rising export shares has the most economically significant impact on the female share of employment in the Philippines and Jordan, where a one standard deviation rise leads to a 81 per cent and 51 per cent rise in female share respectively. These countries tend to display some of the largest elasticities for the female share of employment when economic significance is considered, despite the negative effects of labour productivity growth. The Philippines has become a major world exporter of office and telecom equipment evident in a massive shift in the composition of exports towards the electrical and non-electrical

19. In order to test for the potential confounding effects of labour productivity and real wages, we ran the regression by excluding real wages altogether. The results are broadly similar to those reported here in that the coefficient on labour productivity was negative in more cases than it was positive. We also ran a regression by dropping labour productivity (instead of real wages) and confirmed that the coefficient on real wages continued to be positive in six countries.
20. Still it is noteworthy that in both countries, other key female-intensive industries such as textiles show the opposite pattern: the female share of employment fell when wages rose. In the Philippines, feminization in the electrical and non-electrical machinery and equipment took place as the average wage actually declined.

machinery and equipment industry, which feminized over time. Feminization also took place in other export-intensive industries that increased their share of total exports such as food, beverages and tobacco and the relatively male-dominated motor vehicles industry. The story is similar in Jordan where the composition of exports shifted towards the apparel, leather products and footwear and food, beverages and tobacco industries, which also enlisted more women workers over time.

Indonesia, Sri Lanka and Egypt display negative coefficients for export share with a one standard deviation rise in an industry's export share leading to a 13 per cent decline in the female share of employment in Indonesia and a 6 per cent decline each in Sri Lanka and Egypt. Indonesia and Sri Lanka are both defeminizing countries in which manufacturing exports as a percentage of GDP contracted over time, with the decline in Sri Lanka being as high as 10 per cent of GDP (see Table 2). Alongside this contraction, in Indonesia the composition of exports shifted away from female-dominated industries, such as apparel and textiles, and towards male-dominated ones, such as motor vehicles, which adversely affected the gender composition of employment. In Sri Lanka, female-intensive industries such as textiles, apparel, leather products and footwear and electrical and non-electrical machinery and equipment upgraded and defeminized even as their export shares declined or stagnated from 2000 onwards. Egypt is primarily a commodity exporting country in which the shares of the most important manufacturing exports — textiles and apparel, leather products and footwear — have also declined and feminized over time. This suggests that feminization may be a strategy to stem the decline of competitiveness of the industry.

Industry-level Results

In order to identify the industry-level drivers of technological upgrading and defeminization, we also pool data across countries and obtain long-run estimates (based on Equation 6) for our key variables by industry following the identical procedures as described earlier. We find evidence for serial correlation in the wood and cork products industry and augment lags on the regressors to eliminate it. For three industries, the assumption of slope homogeneity across panels (countries in this case) was rejected using the Hausman test and for those industries we present both the PMG and MG estimates. The MG results apply. Table 5 presents the estimates.

In general, our analysis identifies eight industries as being important drivers of defeminization through technological upgrading as well as two that buck the trend. The results confirm our previous country level finding that increases in labour productivity have a largely negative impact on the female share of employment. On the other hand, the positive impact of average wages or bargaining power on the female share of employment appears to be stronger at the industry rather than the country level, with seven

Table 5. Long-run Effects of Labour Productivity Growth on Female Share by Industry

	Model	Labour productivity	Real wages	Export share	Error Correction	Constant	Hausman pval	Obs.	Log-likelihood
Food and beverages; Tobacco products	PMG	−0.1980***	0.1583***	−0.1921***	−0.4498***	0.004	0.9522	194	350.8
		(0.040)	(0.029)	(0.017)	(0.116)	(0.008)			
Textiles	PMG	−0.0521**	0.1404***	0.1603***	−0.3111***	−0.0091	0.121	194	340.5
		(0.026)	(0.046)	(0.033)	(0.094)	(0.009)			
Wearing apparel, fur; Leather, leather products and footwear	PMG	0.0201***	0.0675***	0.2026***	−0.4419***	−0.0047	0.0641	194	441.6
		(0.007)	(0.016)	(0.028)	(0.138)	(0.007)			
Wearing apparel, fur; Leather, leather products and footwear	MG	−0.1582*	0.0629	0.1458**	−1.1591***	0.0052	0.0641	194	
		(0.096)	(0.067)	(0.060)	(0.308)	(0.019)			
Wood products (excl. furniture)	PMG	0.046	−0.1159**	0.1282***	−0.5231***	0.0286	0.8977	186	227.1
		(0.030)	(0.049)	(0.020)	(0.136)	(0.035)			
Paper and paper products	PMG	−0.1901***	0.3458***	0.0712	−0.3874***	0.0127	0.1305	199	262.2
		(0.043)	(0.044)	(0.051)	(0.128)	(0.013)			
Printing and publishing	PMG	0.0667**	−0.2989***	0.2265***	−0.2037**	0.0115*	0.042	192	275.6
		(0.029)	(0.077)	(0.049)	(0.095)	(0.006)			
Printing and publishing	MG	−3.1522	2.7133	0.6376	−0.6530***	0.0222**	0.042	192	
		(3.119)	(2.857)	(0.751)	(0.187)	(0.009)			
Chemicals and chemical products	PMG	0.2561***	0.1206**	0.0536	−0.3266**	0.0007	0	194	320.4
		(0.076)	(0.056)	(0.034)	(0.132)	(0.006)			
Chemicals and chemical products	MG	0.1519	0.1975	−0.1175*	−0.7679***	−0.0071	0	194	
		(0.113)	(0.181)	(0.062)	(0.093)	(0.006)			
Rubber and plastics products	PMG	0.0245***	−0.0522***	−0.0384***	−0.3568***	0.0079	0.9958	194	333.9
		(0.005)	(0.020)	(0.007)	(0.118)	(0.007)			

(*Continued*)

Table 5. Continued

	Model	Labour productivity	Real wages	Export share	Error Correction	Constant	Hausman pval	Obs.	Log-likelihood
Non-metallic mineral products	PMG	0.1684** (0.075)	−0.3252*** (0.077)	0.1886*** (0.042)	−0.4222** (0.192)	0.014 (0.020)	0.8501	187	274
Basic metals	PMG	−0.1895*** (0.049)	0.1872*** (0.067)	0.1592*** (0.042)	−0.4461*** (0.093)	0.0213 (0.015)	0.1625	194	226.1
Fabricated metal products	PMG	−0.0691*** (0.015)	0.1771*** (0.046)	0.2184*** (0.050)	−0.5348*** (0.124)	0.0048 (0.014)	0.5453	194	241.8
Electrical and non-electrical machinery and equipment NEC	PMG	0.0660*** (0.025)	0.0953* (0.053)	−0.1850*** (0.057)	−0.3101*** (0.105)	−0.0079 (0.017)	0.0922	199	322.8
Electrical and non-electrical machinery and equipment NEC	MG	−0.1088 (0.315)	0.1286 (0.217)	0.1319 (0.090)	−0.8613** (0.352)	−0.0114 (0.023)	0.0922	199	364.4
Motor vehicles, trailers, semi-trailers; Other transport equipment	PMG	−0.1176** (0.048)	0.2517*** (0.065)	0.1232*** (0.031)	−0.4237*** (0.097)	0.0185 (0.013)	0.3753	194	171.6
Furniture; manufacturing NEC	PMG	−0.0513** (0.022)	0.0664** (0.029)	0.2723*** (0.020)	−0.5777*** (0.160)	−0.0171* (0.010)	0.8606	194	265

Standard errors in parentheses.
***$p<0.01$, **$p<0.05$, *$p<0.10$.
Note: MG results are shaded in grey and presented only in cases where the Hausman *p*-val is lower than 0.10.

industries displaying positive and three displaying negative coefficients. Export share again appears as an important determinant of the female share of employment across countries, with eight out of 11 statistically coefficients displaying a positive sign and three a negative sign.

Four of the five industries that have been strategically important for export-oriented industrialization in developing countries — namely food, beverages and tobacco products; textiles; apparel, leather products and footwear; and motor vehicles — display negative and statistically significant coefficients for labour productivity. These four industries account for some of the largest shifts in the female share of employment in our decomposition analysis, and we can confirm here that technological upgrading is a critical factor driving these shifts. Together, these four industries also accounted for 62 per cent of total female manufacturing employment across the sample in 2013. The largest negative effects of labour productivity on the female share of employment in the group come from food, beverages and tobacco (-19.8 per cent) followed by apparel, leather products and footwear (-15.8 per cent). Other industries like paper and paper products and basic metals too show sizable negative impacts of labour productivity. It is noteworthy that the furniture and manufacturing (NEC) industry, which has a relatively large average female share of employment of about 30 per cent across the sample (see Figure 2), also displays a negative labour productivity coefficient.

In contrast, women are gaining from the positive impact of average real wage or bargaining power on the female share of employment, most notably in the paper and paper products, motor vehicles, basic metals as well as fabricated metal products, which are relatively male-dominated. The closing gender education and skills gap witnessed in many countries may account for these effects though it should be noted that they coexist with the negative impacts of labour productivity growth. Moreover, in many of these industries the absolute number of women employed remains very low. For instance, in 2013 there were approximately 248,000 women employed in motor vehicles across the 12 countries (for which the regression analysis was conducted) as compared to 1.89 million men, or a little over one-tenth. In basic metals, this ratio is even more skewed with about 63,000 women for 1.43 million men, or 1/25th as many women as men. Women's integration into these industries is no doubt a positive development but the policy goal should be to ensure that these gains are not undone as industries upgrade technologically. This is also true for relatively female-intensive industries such as food and beverages and textiles, which also display positive coefficients for real wages.

Across countries, employers also show a marked preference for female labour when an industry's share of exports increases, suggesting that female labour remains an important source of export competitiveness. This is likely due to closing education gaps, the persistence of universal gender wage gaps but perhaps also because the 'trope of productive femininity'

(Salzinger, 2003) mobilized by firms to facilitate the hiring of women for labour-intensive and export-oriented jobs has endured. Yet, this positive impact also holds in industries with differing export intensities once the (largely negative) impact of labour productivity is controlled for: some of the largest positive effects are seen in furniture and manufacturing (NEC) and fabricated metal products where average export shares are 3 per cent and 1 per cent respectively as well as in textiles and apparel, leather products and footwear where average export shares are 5.4 per cent and 16.7 per cent respectively.

CONCLUDING REMARKS

This article examined gendered employment implications of structural transformation and technological upgrading in manufacturing. We focused on 14 countries that rely heavily on exports of labour-intensive and assembly industries that have long provided strategic entry points onto global markets. Six of these countries experienced the defeminization of manufacturing employment in recent years, defined in terms of falling shares of female employment: Indonesia, Malaysia, Mexico, South Korea, Sri Lanka and Taiwan (China). Our study addresses similar questions as prior studies, using accounting decomposition methods to identify the drivers of changes in female shares of manufacturing employment as well as econometric analysis to assess the gendered impacts of technological upgrading in manufacturing. To our knowledge, however, ours is the first study to apply either of these methods at a detailed industry level, for 14 manufacturing industries. This enables us to have a more definitive sense of the relative importance of within-industry versus employment reallocation effects as well as to identify the industry-level drivers of the negative relationship between technological upgrading and women's representation in manufacturing employment observed by prior studies. By conducting our regression analysis using an ARDL model and pooled mean group estimator, we are able to estimate long-run relationships between women's representation in manufacturing employment and technological upgrading as well as other key variables, again a first in the literature to our knowledge.

Our study found that for 11 of these 14 countries, within-industry effects are more important than employment reallocation effects in accounting for changes in female shares of manufacturing employment, yet reallocation effects are nonetheless sizeable in a number of countries. We found negative (statistically significant) relationships between technological upgrading and female shares of manufacturing employment for eight countries, consistent with the prior literature, and positive (statistically significant) relationships for two countries. The decomposition analysis reveals that changes in female shares of employment were driven predominantly by the same industries that have driven export-oriented industrialization, namely, food, beverages and tobacco products; textiles; apparel, leather products and footwear; electrical and non-electrical machinery and equipment; and motor vehicles. For these strategic industries, the industry-level econometric analysis showed a negative (statistically significant) relationship between technological upgrading and female shares of employment for food, beverages and tobacco products; textiles; apparel, leather products and footwear (with the MG estimator); and motor vehicles, and no positive (statistically significant) relationships. At both the country and industry level, then, we observe that technological upgrading is predominantly associated with the defeminization of manufacturing employment. Though beyond the scope of this article, it would be important for future research to understand what accounts for these differences among countries and industries and the extent to which they are amenable to policy intervention.

We observe not just relative but also absolute declines in the number of women workers in Mexico, South Korea and Taiwan as well as in the textiles and apparel, leather products and footwear industries in several countries. With regard to the defeminization of manufacturing employment in the face of technological upgrading, Barrientos et al. (2004: 5) write, 'What explains these trends and what happens to the women workers who lose or fail to find jobs is obviously of considerable policy interest'. Our empirical approach does not enable us to directly address this issue, but we close our discussion by returning to Table 2 to provide broader country context for our findings.

The female employment-to-population ratio declined only in India and Turkey, countries that experienced the feminization of manufacturing employment.[21] This ratio increased in all other countries, both feminizing and defeminizing, meaning that declines in the female share of manufacturing employment in the six defeminizing countries went against the prevailing current. Looking at female employment in the agriculture, industry and service sectors as a share of total female employment, we observe compositional shifts towards services in all 13 countries for which we have data and away from agriculture in all but one country (Morocco). The contrasting patterns of feminization and defeminization of manufacturing employment we have observed thus occurred alongside these similar broad structural shifts in women's employment. Industry provides a more mixed picture, but in general, these patterns are what we expect from processes of structural transformation.

Vulnerable employment, defined as contributing family workers and own-account workers, declined in all countries except for Sri Lanka. With the exception of Sri Lanka, then, the defeminization of manufacturing employment is consistent with an increase in the quality of employment by this measure. Yet this measure sets the bar very low for job quality. While not tracing the work transitions of individual women workers, the data

21. The female labour force participation rate also declined for India and Turkey as well as Sri Lanka.

presented in Table 2 is consistent with the view that women shifting from manufacturing to service sector jobs did not generally find themselves in the lowest tiers of service sector informal employment. Yet this tells us nothing about how job quality and earnings changed for women shifting from *paid* employment in manufacturing to services, especially in light of the prospect of better manufacturing jobs resulting from technological upgrading. We also observe that the ratio of female-to-male years of educational attainment increased in all 14 countries, closing the gender gap in educational attainment, and was 0.85 or greater in 10 of these countries as of 2010. While this is a very imperfect measure of workplace skills in manufacturing, it does not provide evident support for the notion that men are preferred in the face of technological upgrading because of their greater skills.

The manufacturing sector tends to provide relatively good jobs in developing countries as well as ready job opportunities for less educated workers, including those shifting out of agriculture, particularly when compared to ICT-intensive service sector jobs. On these grounds and following from our findings, we argue that a key policy objective should be for firms to retain previously hired women workers in the face of technological upgrading, especially as upgrading enables firms to pay higher wages and improve job quality more generally. Yet patterns of gender segregation matter too, and it is also important to break down gender segregation so that more women are hired in higher productivity and better paid, predominately male, manufacturing industries. Among the policies advocated to break down gender segregation across sectors and occupations are social policies to encourage girls and women to enter into traditionally male jobs and labour market policies to provide unbiased job evaluations and training, including continuing vocational training (Borrowman and Klasen, 2017; EGGE, 2009).

DATA APPENDIX

UNIDO employment data refer to employees and exclude 'home workers … working proprietors, active business partners and unpaid family members' (UNIDO, 2011: 33). In the process of data cleaning, we came across a number of implausible discontinuities in the UNIDO dataset, and we took care to not evaluate changes over such discontinuities. We looked for such discontinuities by evaluating annual growth rates for each industry in each country, focusing on increases of 100 per cent or more and decreases of 50 per cent or more. In some cases, such large changes are plausible as they are based on small absolute numbers. Yet in other cases, there are large changes in a given year across a number of industries, and these changes we did not evaluate. See the notes in Table 2 in this regard. Given the need to maintain the full set of industries over time for the decomposition analysis, we also occasionally resorted to linear interpolations of missing or problematic data for individual industries, predominately for single years of data. Despite this, the data for Bangladesh and Egypt were too rife with discontinuities to adequately address and data for Mexico were only available for the years 2003, 2012 and 2013. As such, results for these three countries must be viewed with particular caution. Regarding price indices to deflate the value-added data, these were not available in the UNIDO dataset for some industries for 11 of the 14 countries, and so national data sources were used to fill in these gaps. This enabled us to convert all value-added data to constant national currency units at the industry level. Detailed documentation on all these procedures are available from the authors upon request.

Table A1. Years of Data Used for Each Country

Bangladesh	1990–92, 1995, 1998, 2006, 2011
Egypt	1991–95, 1997–98, 2002, 2004–06, 2010–14
India	1993–2013
Indonesia	1993–96, 1998–2013
Jordan	1992–93, 1995–98, 2000–14
Malaysia	1990–97, 1999–2010, 2012, 2014
Mexico	2003, 2012–13
Morocco	1992–98, 2000–05, 2007–10, 2012–13
Philippines	1992–99, 2001, 2003, 2005–06, 2008–10, 2012–13
South Korea	1990–2012
Sri Lanka	1990–2001, 2007–12
Taiwan (China)	1990–2014
Turkey	1992–2001, 2003–14
Vietnam	1998, 2001–14

Table A2. Industry-level Female Shares of Employment and Total (Male and Female) Employment Growth (%, period averages)

Female shares of employment	**Bangladesh**	**Egypt**	**India**	**Indonesia**	**Jordan**	**Malaysia**	**Mexico**	**Morocco**	**Philippines**	**South Korea**	**Sri Lanka**	**Taiwan (China)**	**Turkey**	**Vietnam**
Food and beverages; Tobacco products	10.6	11.7	***19.1***	***50.2***	8.0	34.4	35.6	28.1	33.3	***47.4***	39.4	***46.1***	***22.6***	53.7
Textiles	12.1	***14.6***	10.5	***53.2***	***21.5***	***44.3***	32.9	***43.1***	***51.7***	***46.1***	***57.6***	***49.6***	***29.3***	***63.6***
Wearing apparel, fur; Leather, leather products and footwear	***61.6***	***48.5***	***38.5***	***76.1***	***43.7***	***71.2***	***55.7***	***73.8***	***73.3***	***65.3***	***81.8***	***68.0***	***45.2***	***81.5***
Wood products (excl. furniture)	10.8	3.5	7.1	35.9	0.7	30.2	17.6	7.6	19.8	22.1	30.0	40.5	8.8	44.5
Paper and paper products	5.4	7.3	5.3	22.1	***13.9***	31.0	24.5	14.7	27.1	21.8	20.5	33.2	14.0	38.8
Printing and publishing	1.5	8.7	4.2	31.2	10.3	38.4	NA	18.9	35.1	30.8	15.7	35.8	17.7	43.3
Chemicals and chemical products	5.7	***17.8***	10.0	35.6	***20.1***	28.5	***42.3***	21.0	31.2	22.0	31.0	32.7	***21.8***	39.8
Rubber and plastics products	5.3	9.7	4.7	37.8	7.5	42.6	***39.3***	23.0	34.5	26.6	33.5	***42.9***	13.6	45.6
Non-metallic mineral products	4.0	5.8	4.7	23.5	1.7	21.1	18.5	7.7	20.8	19.2	29.1	31.0	9.4	32.5
Basic metals	0.5	2.3	0.9	8.2	2.2	15.6	11.8	6.4	14.6	9.0	8.8	17.0	5.2	20.8
Fabricated metal products	3.1	6.0	1.7	24.7	1.6	26.0	18.9	8.0	23.5	20.1	13.9	32.3	10.6	26.4
Electrical and non-electrical machinery and equipment NEC	3.5	9.8	4.5	***49.3***	7.3	***60.9***	***43.9***	***41.3***	***65.8***	***31.5***	38.8	***47.8***	15.5	55.4
Motor vehicles, trailers, semi-trailers; Other transport equipment	2.1	4.2	1.6	12.5	4.1	19.3	35.5	16.5	25.8	12.1	17.1	24.7	9.1	28.7
Furniture; manufacturing NEC	10.6	7.7	***12.0***	44.3	4.6	33.2	***40.7***	19.0	41.5	33.0	***51.9***	***48.5***	12.6	51.2
Average	27.4	13.6	10.9	47.1	13.4	43.6	37.7	40.7	47.2	30.5	56.9	42.1	21.8	58.8

(*Continued*)

Table A2. (Continued)

Total employment growth	Bangladesh	Egypt	India	Indonesia	Jordan	Malaysia	Mexico	Morocco	Philippines	South Korea	Sri Lanka	Taiwan (China)	Turkey	Vietnam
Food and beverages; Tobacco products	21.8	−0.5	1.3	2.8	7.0	5.9	8.5	5.2	1.1	−0.6	4.3	0.0	5.1	16.4
Textiles	12.7	−4.2	0.5	−1.2	2.3	−3.2	−27.0	−3.9	−6.3	−5.3	1.4	−3.0	5.2	10.3
Wearing apparel, fur; Leather, leather products and footwear	72.4	6.9	7.7	1.8	13.8	−0.7	−25.8	1.9	−2.7	−6.2	1.5	−3.3	9.6	16.9
Wood products (excl. furniture)	9.0	−0.5	1.5	−2.8	10.8	1.5	−33.9	0.9	−2.8	−2.5	2.7	−4.9	8.9	19.0
Paper and paper products	26.1	−0.2	2.7	1.3	5.8	7.3	−3.9	−0.9	2.3	−0.6	3.8	−0.6	5.8	12.0
Printing and publishing	31.3	5.1	0.9	2.3	4.3	5.2	NA	2.1	0.6	−0.8	4.9	0.9	10.7	11.6
Chemicals and chemical products	19.6	0.1	3.9	1.2	5.7	7.6	−10.3	1.3	0.9	0.8	3.5	0.7	3.1	12.5
Rubber and plastics products	49.8	0.4	5.1	2.9	3.4	2.4	0.3	2.2	0.3	2.3	5.1	−1.8	11.4	18.0
Non-metallic mineral products	83.5	0.6	4.5	1.3	2.7	3.4	−11.4	−0.2	0.3	−2.0	1.1	−1.4	6.8	14.2
Basic metals	77.0	−0.5	2.6	1.8	5.9	9.1	22.9	13.5	−0.6	0.5	−4.0	1.0	3.3	8.7
Fabricated metal products	34.4	−1.5	5.9	4.4	7.1	5.5	6.0	1.6	3.0	3.4	3.1	1.3	11.7	24.5
Electrical and non-electrical machinery and equipment NEC	38.0	3.1	2.3	4.2	8.5	2.2	−17.9	8.4	5.5	1.5	4.7	2.7	7.6	19.1
Motor vehicles, trailers, semi-trailers; Other transport equipment	19.5	−2.1	3.0	4.1	20.3	9.2	69.5	6.1	10.0	2.8	−1.3	0.6	7.4	18.2
Furniture; manufacturing NEC	30.5	4.5	8.9	1.3	6.5	4.6	1.8	7.7	−1.4	3.7	6.0	−1.7	17.6	24.1
Total	32.2	−1.0	2.7	1.3	6.0	2.5	−2.7	2.1	0.5	−0.1	2.0	0.4	7.1	16.1

Notes: Grey shading indicates countries for which female shares of manufacturing employment declined overall.
Bolded and italicized values indicate female shares of employment above the country average.
NA = data not available.

Table A3. Variables in Regression Analysis

Variable	Name	Explanation	Source
f	Female share	Female mfg. employment/Total manufacturing employment	Calculated using UNIDO (2017)
ξ	Labour productivity	Value added (VA)/Employment VA is deflated to the year 2010 using industry level producer price indices obtained from country sources.	Calculated using UNIDO (2017)
x	Export share	Exports/Total manufacturing exports Three-digit level export data classified according to SITC Revision 2 from the UN's Comtrade (2019) database is converted to ISIC Rev. 3 using product concordance tables to maintain consistency with UNIDO data. As data for Taiwan are not available on Comtrade, we use Merchanse Exports/GDP as the export share variable instead.	Calculated using Comtrade (2019); For Taiwan, WTO (2018) and IMF (2018)
ω	Real wages	Real Wages and Salaries Wages and salaries are deflated to the year 2010 using industry level producer price indices from country sources to obtain the product wage.	UNIDO (2017)
y	GDP per capita	GDP per capita In constant local currency units deflated to the year 2010 using GDP deflators	World Bank (2020)

Table A4. Summary Statistics for Long-run Estimations by Country

	Labour productivity		**Average Real Wages**		**Share in Total Exports (%)**	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Egypt	56,796	47,207	18,564	13,275	3.9	4.5
India	5,42,398	4,01,943	1,46,677	1,07,343	6.0	5.2
Indonesia	16,40,00,000	18,30,00,000	2,01,00,000	1,44,00,000	4.2	3.5
Jordan	13,706	11,273	3,092	1,783	5.7	7.4
Malaysia	1,01,046	86,752	27,614	14,730	5.6	12.5
Morocco	2,10,160	1,50,478	81,025	39,934	6.0	8.9
Philippines	5,56,233	4,15,568	1,38,275	71,016	6.0	14.8
South Korea	12,00,00,000	10,20,00,000	2,43,00,000	1,31,00,000	6.6	10.6
Sri Lanka	8,44,787	6,88,765	1,61,769	1,06,613	6.8	12.5
Taiwan (China)	10,07,687	6,26,225	5,97,693	4,05,885	43.6	7.5
Turkey	32,270	27,708	15,067	6,857	6.5	6.5
Vietnam	14,50,00,000	9,09,00,000	3,70,00,000	1,35,00,000	5.7	8.4

TECHNICAL APPENDIX

Decomposition analysis. The data used in the decomposition analysis of female shares of employment and labour productivity for manufacturing are available annually. Note that we decompose annual *growth rates* of these measures, which need to be calculated in discrete time. This is in contrast with Saraçoğlu et al. (2018), for example, who decompose *differences* in female shares of manufacturing employment between period endpoints. In their discussion of decomposition methods, Ocampo et al. (2009) present a simplified algebraic presentation of the decomposition of labour productivity growth considering only two points in time, 0 and 1, which we have noted is equivalent to the decomposition of the growth of female share of employment by substituting value added for female employment in Eq. 2. The growth rate of female shares of employment for any given industry between time 0 and 1 can then be expressed as follows:

$$\Psi^{i} = \left(1 + \hat{L}^{i}\right)^{-1}\left(\hat{F}^{i} - \hat{L}^{i}\right)$$

As Ocampo et al. (2009: 54) point out, terms such as $(1 + \hat{L})^{-1}$ are commonly referred to in the literature as 'interactions' arising from the discrete measurement of time, and they are generally negligible.

The growth of female shares of employment for all manufacturing industries can be expressed in turn as follows:

$$\Psi = \left(1 + \hat{L}\right)^{-1}\sum\left[\theta_0{}^{i}\left(\hat{F}^{i} - \hat{L}^{i}\right) + \left(\theta_0{}^{i} - \varepsilon_0{}^{i}\right)\hat{L}^{i}\right]$$

This expression (Eq. 2) makes explicit the industry-level weights for the distribution of female and total employment among manufacturing industries (given that $\theta_0{}^{i} = F_0{}^{i}/F_0$ and $\varepsilon_0{}^{i} = L_0{}^{i}/L_0$). This provides us with the within-industry and employment reallocation effects on the growth of female employment shares, as represented by the left-hand and right-hand bracketed terms respectively.

In the above expression, reallocation effects are driven by shifts in total (male plus female) employment. Though not used in our current analysis, this can be rewritten so that reallocation effects are driven by shifts in female employment as follows:

$$\Psi = \left(1 + \hat{L}\right)^{-1}\sum\left[\varepsilon_0{}^{i}\left(\hat{F}^{i} - \hat{L}^{i}\right) + \left(\theta_0{}^{i} - \varepsilon_0{}^{i}\right)\hat{F}^{i}\right]$$

Econometric analysis. The PMG estimator is an intermediate estimator in that it constrains long run coefficients to be equal but allows intercepts, short run slopes and error variances to differ across entities, or industries in our case (Pesaran et al., 1999). On the other hand, the less restrictive mean group (MG) estimator allows variation across groups and calculates cross-group coefficients using a simple arithmetic average but is quite sensitive to outliers as a result (Pesaran et al., 1995). The choice of estimator depends on whether the assumption of slope homogeneity across industries is a reasonable one, which is assessed using a standard Hausman test. The PMG estimator is preferable for our purposes because it is a consistent and efficient estimator as compared to the MG, which is consistent but not efficient.

We have 14 industries (N) and a maximum of 25 years (T) of data for each country and although our N is small our T is relatively large for panel data. The PMG estimator is consistent for small N and large T samples as well (Pesaran et al., 1999: 627) while the MG estimator is consistent only for large N and T. For some countries, gaps in the series shrink the number of available years for estimation but Pesaran et al. (ibid.) demonstrate the effective application of the PMG estimator to relatively small T as well. There can be a downward bias in the size of the coefficients when T is small but the PMG remains robust to outliers and choice of lag (ibid.). The models are fit using a maximum likelihood procedure.

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