Female Employment and Structural Transformation∗

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Preliminary and Incomplete. Please Do Not Circulate.

Abstract

Two prominent secular trends characterize changing labor markets in industrialized countries over the past decades. First, employment shifted from manufacturing to services. Second, the share females in aggregate employment increased strongly. This paper documents a novel fact connecting these two trends: female employment shares within manufacturing and within services have remained virtually constant over time and across developed economies. Constant sectoral gender shares implies that an exogenous increase in female labor supply can by itself induce structural change. We provide empirical evidence for the presence of this effect in the data. We then propose a quantitative theory of structural change with nonhomothetic preferences, differential sectoral productivity growth, gender complementarity in sectoral production, and rising female employment, and calibrate it to the U.S. economy. Quantitatively, we find that the rise in female employment accounts for about two-thirds of the structural transformation in the U.S. during the past five decades.

Keywords: Structural Change, Female Employment, Labor Markets

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1 Introduction

In this paper we present evidence and develop a theory that connects two of the most prominent developments in industrialized countries over recent decades – the structural transformation, i.e., a decline of manufacturing employment accompanied by an increase of employment in service industries, and a contemporaneous large increase in female employment. While the previous literature suggested that structural change can induce an increase in female employment, our empirical evidence and quantitative theory highlight the opposite direction of causality: the decline of manufacturing and the rise of service employment were largely caused by the increased labor force participation of women.

To reach this conclusion, we proceed in four steps, with each of them representing a contribution to the existing literature.

1. Nature of Structural Transformation. It is typical in the literature to group industries into “goods producing” and “service producing” and study the reallocation of economic activity from the former to the latter group. Looking directly at the industries as defined by the standard industrial classification system, we find that structural change was highly concentrated in just two of them. Specifically, we find a very large decline in manufacturing employment share, where manufacturing is a separate category in the 2-digit industrial classification. At the same time, there was a large increase of the employment share in the service industry, which includes personal services, business and repair services, entertainment and recreation services, and professional and related services. The employment in all other industries, e.g., construction, transportation, wholesale and retail trade, finance, insurance, and real estate, mining, etc, has remained virtually constant as share of the economy over the last 50 years. We document below that this pattern is apparent not only in the US data, but also in the sample of other highly developed economies. This suggests that for the purpose of analyzing structural change it is helpful to consider three industrial sectors - manufacturing, services, and “Other” - the sector that includes the rest of the economy.

2. Constant Gender Shares in Manufacturing and Services over Time. This partitioning of industries reveals a surprising pattern. While manufacturing employment has declined significantly over the years, the gender shares of manufacturing employment had remained fixed for the last 50 years, with women representing 30% of manufacturing employment. Interestingly, a similar pattern describes the services sector that saw a dramatic increase in employment over the years. Women represent 62% of employment in services with this share remaining unchanged for the last five decades. The fraction of women as the share of employment in the Other sec-

\[\text{This is the type of structural change relevant to the highly developed countries that we study in this paper. Earlier in their development a decline of agriculture was also a prominent feature of structural change.}\]
tor changes over time, with its trend tracking the economy-wide share of female employment. Remarkably, we observe a similar pattern in a broad sample of developed economies, not only qualitatively but also quantitatively, with female share of employment fixed over time at 30% in manufacturing, 62% in Services, and co-moving with economy-wide female employment share in the Other sector.

3. Female Labor Force Participation – a Driving Force of Structural Change? The constancy of female shares in manufacturing and services over time and across developed countries hints at an intriguing possibility. To accommodate an exogenous increase in the number of female labor force participants while keeping female employment shares in manufacturing and services constant, the employment in female-intensive service sector must expand while it must contract in the male-intensive manufacturing. This is just an application of the classic Rybczynski theorem in a two sector economy. The presence of the Other sector may in theory affect this logic, but we show below that this is not the case due to strong restrictions from the data: employment share of Other sector is fixed and its female employment share is parallel to the aggregate economy.

We proceed to test this conjecture empirically. In the first step, we consider a panel of US states and regress the share of manufacturing (or services) in state’s employment on share of female employment in the state. To identify exogenous variation in female labor supply, we instrument the share of female employment in the state by features of state-year level Earned Income Tax Credit (EITC) programs or income tax system. The identifying assumption is that changes in EITC programs or income tax systems affect the labor supply, especially of female workers, but do not directly impact the industrial structure. Alternatively, we also use variation in divorce rates across states as an instrument for female labor supply. For all instrument specifications, we find that an exogenous (to the industrial structure) increase in female employment share leads to a decline of manufacturing employment share and the growth of employment share of services. Estimating similar instrumental variable regressions in a panel of developed economies corroborates the results for the United States.

The implications become even more stark when we implement the same regressions but with the level of manufacturing (or services) employment as a dependent variable and the level of female employment as an independent one controlling in addition for overall employment growth using male employment. We find that an exogenous increase in aggregate female employment

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2 To see this, consider an economy with two sectors, manufacturing $m$ and services $s$. The market clearing requires that $(N - N_s)f_m + N_s f_s = L_f$, where $N$ is total employment, $1 - N_s = N_m$ and $N_s$ are the employment of the manufacturing and service sectors, $f_m$ and $f_s$ are the female employment shares in these two sectors, and $L_f$ is the overall female employment. Dividing both sides by total employment, we have $(1 - n_s)f_m + n_s f_s = \ell_f$, where $1 - n_s = n_m$ and $n_s$ are the manufacturing and service employment shares, and $\ell_f$ is the overall female employment share. Thus, $\frac{df_m}{df_f} = \frac{1}{1 - f_m} > 0$ and $\frac{dn_m}{df_f} = \frac{d1 - n_s}{df_f} = \frac{-1}{f_s - f_m} < 0$ because $f_s = 0.62 > 0.30 = f_m$. 

lowers manufacturing employment not only as the share of the economy, but in absolute terms. This dramatically restricts the set of theories that can be used to interpret the relationship between female employment and structural transformation.\(^3\)

4. Quantitative Theory Evaluation. To quantify the role of increased female employment in determining the extent of the structural change and to verify whether the proposed mechanism is consistent with other prominent features of the data (such as the dynamics of sectoral prices and value added, gender wage premium, etc) we consider a competitive multi-sector model with male and female workers.

Based on our empirical findings, we model male and female workers as perfect complements in manufacturing and services production functions. Consistent with the observed evolution in the gender ratios in the rest of the economy, we allow for more elastic substitution between male and female labor in the Other sector and infer the elasticity of substitution from the data. The model allows for two standard forces of structural change, i.e., the income effect (non-homothetic preferences) and differential sectoral productivity growth. On top of that, the model introduces a novel, third force that leads to structural change, arising from the rise of female labor participation.

The calibrated quantitative model with non-homothetic preference, differential sectoral productivity growth, and rise in female labor force participation is successful in accounting for all empirical patterns regarding the structural change, including the paths for sectoral prices, value-added, employment, and gender composition. In addition, the model endogenously delivers a substantial decline in the gender-wage gap over time consistent with the data. Thus, the model provides a laboratory to decompose the importance of each the three forces to the structural change. We find that the rising female employment accounts for about two-third of the structural transformation, measured as the employment reallocation from the manufacturing sector to the service sector.

1.1 Related literature

We contribute to a literature that explores the relationship between structural change and female labor force participation. Ngai and Petrongolo (2017) emphasize that structural change and the rise in female labor force participation tend to be studied in separate literatures, \(^3\)Suppose women have a comparative advantage in services. An exogenous increase in female labor force participation would then increase the size of the service sector and reduce the size of the manufacturing sector as share of the economy. But it is unlikely to reduce the absolute size of the manufacturing sector: an increase in female employment will tend to to make female labor cheaper increasing female to male ratio of employment in both sectors and expanding employment in both sectors. This will not happen only if male and female workers must be hired in essentially fixed proportions in the two sectors, i.e., if gender ratios are fixed over time.
although the two phenomena might be related. Specifically, they argue that structural change has increased demand for female market work because women have a comparative advantage in service production. Rising demand for service workers induced an increase in female labor force participation. A similar demand side mechanism was studied by Olivetti (2014) and Olivetti and Petrongolo (2014, 2016). We do not dispute the relevance of this mechanism, but identify the importance of causality running in the opposite direction, i.e., that structural change is itself a consequence of rising female labor force participation.

There is a large literature that studies secular increases in female labor supply over time, including, among others, Goldin (2006), Greenwood, Seshadri and Yorukoglu (2005), Albanesi and Olivetti (2016), Galor and Weil (1996), Attanasio, Low and Sánchez-Marcos (2008), and Fernández (2013). Greenwood and Seshadri (2005) review the literature on economic transformation, including the movement of women out of the household into the labor market. We do not contribute to this literature per se but use its insights to rationalize some of the forces inducing the increase in female labor force participation that our theory predicts to be a necessary condition for structural change.

With respect to the structural transformation literature, Herrendorf, Rogerson and Valentinyi (2014) provide a systematic discussion on the theory and facts of structural transformation. Our primary contribution to this literature is to identify female labor force participation as a novel and quantitatively very important driver of the structural change in developed economies. Our work also differs from the tradition in this literature as we abstain from an ex-ante allocation of industries into sectors (e.g., goods and service producing) and instead group industries with respect to their change in employment shares over time. Doing so reveals the striking patterns for the gender employment composition that give rise to the argument of the paper.

Finally, the mechanism that explains the narrowing of the gender wage gap is similar in our paper and in Ngai and Petrongolo (2017), although it is quantitatively much stronger in our model. The mechanism is an application of the Stolper-Samuelson theorem which predicts that the rise in the relative price of a services increases the return to the factor used intensively in service production, which is female labor.

The rest of the paper proceeds as follows. Section 2 describes the data sources and presents the empirical analysis. Section 3 presents the model, calibrates it to the U.S. economy, and presents the counterfactual simulations. Section 4 concludes.
2 Empirical Analysis

Our empirical analysis first provides results on structural change for three countries for which we have access to rich high frequency data – the United States, Germany, and France. For each of these countries, we rely on labor force microdata to document the shift in employment composition across industries and gender ratios within industries over time. We find that these three countries share strikingly similar pattern with respect to the structural change and the gender composition across industries. We then broaden our analysis to countries that are among the 25 countries with the highest GDP per capita in 1970 and which have their periodic population Census data in IPUMS International data set (Minnesota Population Center, 2020). Once again, we document essentially the same patterns: structural change in employment is limited to just two narrowly defined manufacturing and service industries, which have essentially fixed gender shares across time and across countries.

2.1 The Nature of Structural Transformation and Sectoral Gender Shares

2.1.1 United States

For the United States, we rely on data from the March supplement of the Current Population Survey (CPS) obtained from IPUMS (Flood et al., 2021). The CPS data is the source for labor market reporting in the United States and offers a large representative sample of the U.S. population with rich demographic and labor market information. We rely on CPS microdata from 1976 until today. We abstain from any sample selection when constructing employment shares and use the harmonized IPUMS industry codes based on the 1990 Census Bureau industrial classification system.

Panel (a) in Figure 1 shows the changes in employment shares for ten disaggregated industries between 1976 and today. Whereas most industries saw hardly any change over time, two industries stand out: the employment share of manufacturing declined sharply while the employment share of services grew at least as dramatically. Based on this observation, we group industries into three aggregated industry groups manufacturing, services, and other – the latter sector combining all remaining industries that show little to no change in employment over time.

The panels (b)-(d) of Figure 1 plot, for each of these three industries, the female employment share and the industry’s share in overall employment. We also plot each of these panels the female share of the aggregate employment. Looking first at the aggregate female employment

\[ 4 \text{Services contains business and repair services, personal services, entertainment and recreation services, and professional and related services.} \]
Figure 1: Industry employment shares and female employment shares in the U.S.

(a) Change of employment shares

Notes: Panel (a) plots the change of employment shares for each industry. Panel (b) shows the share of females in total employment of the manufacturing sector (blue line), the employment share of the manufacturing sector (red line), and the female share in employment in the entire labor market (dashed black line). Panels (c) and (d) plot the same variables for the services and the other sector.

share, we observe a large increase from 40 percent in the mid 1970s to 47 percent in the early 2000s. Second, we also see the secular trend of structural change with a shift from manufacturing to services. The service industry accounts for only 30 percent of the total employment in the late 1970s, but for almost 45 percent in 2010. At the same time, manufacturing declines from almost 25 percent of the total employment to only 10 percent. The employment share of other industry remained roughly constant.

The striking new fact that emerges in Figure 1 is the virtually constant gender shares within the manufacturing and service industry during this period. The female employment share in the service sector is around 62 percent. The female employment share in manufacturing is around 30 percent. Hence, we find that despite a massive increase in female employment, the within-sector gender employment share is almost unchanged over half a century. For the other sector, we find that the female share roughly tracks the macroeconomic female share over time at a slightly lower level.
2.1.2 Germany

For Germany, we use data from the German Microcensus from 1973 to 2018. The German Microcensus is a 1 percent household survey of the German population and we rely on a scientific use file with a 70 percent subsample provided by the Research Data Center of the German Statistical Office. Participation in the survey is mandatory for sampled households and reporting on the German labor market to international institutions is based on Microcensus data which follows the internationally comparable ILO classification for labor market states. For consistency over time, we restrict the sample to employed workers in West Germany but abstain otherwise from any sample selection. We group in each survey, the reported industries to most closely align with the industry grouping for services, manufacturing, and the other sector in the U.S. data.

We follow the approach for the U.S. data and look at ten industries and their change in employment over time. Panel (a) in Figure 2 shows the changing employment shares with very similar pattern to the United States. Most industries’ employment shares hardly change over the forty five year sample period but manufacturing shows a strong decline and services an equally strong increase.\(^5\) The only other industry with a notable change in Germany is agriculture with decline of over 7 percent. We once again aggregate industries into the three broad industry groups, \textit{manufacturing}, \textit{services}, and \textit{other}.

In Panels (b) to (d) of Figure 2 we plot industry employment shares, females employment shares within industries, and the aggregate female employment share over time. We observe a strong structural transformation of the German labor market. In 1973, 37 percent of employment was in manufacturing whereas 40 years later only 20 percent of workers are employed in manufacturing. In contrast, the service industry expanded from 15 to 42 percent of employment. The other industries declined by only about 7 percentage points over time due to the decline of agriculture. At the same time, we observe a secular increase of the female employment share in the German labor market from 35 percent in 1973 to almost 50 percent today.

Strikingly, we once again find that despite these large changes the within-industry female employment shares in services and manufacturing remained virtually constant at 60 percent and 28 percent respectively. Remarkably, the female employment shares in the manufacturing and services are not only constant over time but also at almost exactly the same level as in the United States. For the other industry, we observe — in line with the patterns for the United States — that its female employment share roughly tracked the macroeconomic female share over time although at a lower level.

\(^5\)The service industry includes \textit{Services} and \textit{Households and Non-profit Organizations} where services include healthcare, hospitality, and information and communication.
Figure 2: Industry employment shares and female employment shares in Germany
(a) Change of employment shares 1973-2018
(b) Manufacturing
(c) Service
(d) Other

Notes: Panel (a) plots the change of employment shares for each industry. Panel (b) shows the share of females in total employment of the manufacturing sector (blue line), the employment share of the manufacturing sector (red line), and the female share in employment in the entire labor market (dashed black line). Panels (c) and (d) plot the same variables for the service and the other sector.

2.1.3 France

The data on employment by industry and gender for France are obtained from INSEE. The data are available for the period from 1989 to 2019 and are representative for the French labor market. Figure 3(a) shows that, as in the United States and Germany, structural change to be narrowly concentrated in two industries, manufacturing and services, whereas other industries show roughly constant employment shares over time. Thus, we aggregate the industries into the three industry groups, manufacturing, services, and other.

Panels (b) to (d) of Figure 3 show the employment shares of each industry, female employment share in each industry and the aggregate female employment share. The time period is now more than 10 years shorter than for Germany and the United States but we still see a substantial increase in the aggregate employment share of females from less than 45 percent in

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6https://www.insee.fr/en, Table “T102 : Emploi salarié en fin d’année en France (hors Mayotte) selon le secteur d’activité (A17 et A38) et le sexe.”
Notes: Panel (a) plots the change of employment shares for each industry. Panel (b) shows the share of females in total employment of the manufacturing sector (blue line), the employment share of the manufacturing sector (red line), and the female share in employment in the entire labor market (dashed black line). Panels (c) and (d) plot the same variables for the service and the other sector.

1989 to 50 percent in 2019. Over the same time period, the manufacturing employment share contracts by around 10 percentage points and the services’ share expands by the same amount. The other industry’s share remains virtually constant between 1989 and 2019.

The French data also corroborate the key finding that female employment shares within service and manufacturing are virtually constant over time. Moreover, the French female employment shares in manufacturing and services again aligning closely with the shares for the United States and Germany with around 30 percent of female employment in manufacturing and 60 percent in services. The female share in the other industries rises again in lockstep with the macroeconomic female employment share but at a lower level.

2.1.4 Broad Sample of Developed Economies

To further assess the patterns of sectoral gender composition and structural change, we now consider a sample of countries that are among the 25 countries with highest GDP per capita
Figure 4: Industry employment shares and female employment shares across countries

(a) Change of employment shares 1970-2015

(b) Manufacturing

(c) Service

(d) Other

Notes: Panel (a) plots the change of employment shares for each industry, where the dark bars are for the sample of countries that report data for both 1970 and 2015 and the light bars are for the sample of all countries after imputing the missing data. Panel (b) shows the share of females in total employment of the manufacturing sector (blue line), the employment share of the manufacturing sector (red line), and the female share in employment in the entire labor market (dashed black line). Panels (c) and (d) plot the same variables for the service and the other sector.

in 1970. IPUMS provide data for nine of these countries: Austria, Canada, Finland, France, Germany, Italy, Netherlands, United Kingdom, and United States. Countries provide data for different years in IPUMS and some also report only for part of the period from 1970 to 2015. For the industry classification, we rely on the harmonized industry definition in IPUMS international. For the aggregation to manufacturing, service, and other, we follow as closely as possible the aggregation approach for the U.S. data.\textsuperscript{7}

Figure 4 reports our usual statistics now based on cross-country-year averages (we show all country-year observations in panels (b)-(d)). The dark bars in Panel (a), indicate the change in sectoral employment shares for four countries that report data for both 1970 and 2015 that allows us to compute the change directly.\textsuperscript{8} The light bars average across all countries in

\textsuperscript{7}Manufacturing is a unique industry code and we include in services: hotels and restaurants, services (not specified), business services and real estate, education, health and social work, and other services.

\textsuperscript{8}We take for 1970 data from waves taken in 1968, 1970, 1971, or 1975 and average if there is data for one
the sample after imputing the missing data. Specifically, we estimate country-industry-specific
time trends for employment shares in each industry from the full sample and predict using these
linear trends the employment shares in all possible waves. Based on these imputed employment
shares, we proceed as before and compute employment shares for 1970 and 2015 to compute
changes over time.

Looking at structural change in the top left panel of Figure 4, we find that the main employ-
ment changes across industries are concentrated in manufacturing and services. In contrast to
the United States but similar to Germany, we find in this broad cross-section of countries a no-
table decline of agriculture by around 5 percent for the direct and imputed estimate. Looking at
manufacturing in the top right panel, we find again a constant share of females in manufacturing
employment at 29% over time. At the same time, we find a strongly increasing aggregate female
employment share by more than 10pp on average between 1970 and 2015. The manufacturing
employment share declines over the same time period from 30% to 10% across countries. In
the bottom left panel, we observe a constant female share of service employment at 61% across
countries. The growing share of employment in services from 20% to almost 50% indicates
strong structural change. Finally, the female employment share in the other sector tracks the
aggregate female employment share. There is a decline in the employment share of the other
sector that mainly stems from the decline of employment in agriculture.

2.1.5 Discussion

The evidence presented above highlights massive changes in industry composition and female
employment over recent decades in the U.S. and other highly developed countries. All countries
experienced a decline in manufacturing and an increase in services employment whereas the
employment share of other industries remained largely unchanged (except for the decline in
agriculture still taking place in several countries). We also find that despite a massive change
in employment, the female employment shares in manufacturing and services are very similar
across countries and they remained virtually constant over time.

We note that in this paper we consider relatively broadly defined industry sectors relevant
for the study of structural change. Our finding of constant gender shares in manufacturing
and services is quite unexpected given the well documented changes in gender composition over
time in more finely defined sectors (see, e.g., Hsieh et al. (2019) and references therein). Given
the focus of our paper, it is not necessary to develop an aggregation theory that yields constant
gender shares at the level of broad sectors, which we take as given. Nevertheless, developing
such a theory seems to be an interesting research question.
It is also important to note that the patterns we uncover are characteristic of highly advanced economies. We did not engage in a systematic study of economies at earlier stages of development but a casual exploration did not reveal systematically constant gender shares in manufacturing and services among those countries.

Finally, while data on sectoral employment by gender is more widely available than the corresponding data on hours of work, the patterns revealed by available data are quite similar. Appendix Figures A-3 and A-4 illustrate this for Germany and U.S., respectively. The patterns of structural change are very similar when measured in terms of employment or hours. Gender shares of hours in manufacturing in services are constant over the last forty years (there was some movement in the US prior to mid 1980s, although not in Germany). Moreover, the levels of gender shares of hours and employment are quite similar.

2.2 Changing Female Employment: A Driving Force of Structural Change?

The descriptive evidence shows the tight correlation between structural change and female employment. The constant manufacturing and services gender shares in combination with rising aggregate female employment suggest that in theory (Rybczynski theorem) rising female employment may itself induce structural change. Before conducting a more structural quantitative theory evaluation of the role of this mechanism, in this section we present some basic empirical evidence suggesting its potential importance. To do so, we consider several instrumental variable regressions exploiting first a cross-state variation within the United States and next the variation among the broad sample of countries that we explored in the descriptive analysis.

2.2.1 State-Level Evidence from the United States

To assess the impact of an exogenous change in female employment on the industrial structure, we consider a U.S. state-year level regression

$$y_{it} = \alpha_0 + \alpha_1 x_{it} + \varepsilon_{it},$$

where $x_{it}$ is the aggregate female employment share in state $i$ at time $t$, and $y_{it}$ is the manufacturing or services employment share in state $i$ at time $t$. To identify an exogenous (to structural change) variation in female employment, we consider a number of instruments for $x_{it}$, including state-year level marriage or divorce rates, variation in Earned Income Tax Credit (EITC) programs, differences in income tax systems. None of these instruments is entirely perfect, but, taken together, the results based on a all of them paint a fairly consistent picture.
Table 1: IV Estimates of the Impact of Female Employment on Industrial Structure

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing Share</th>
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<th>Service Share</th>
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<td>(1) (2) (3) (4)</td>
<td>(5) (6) (7) (8)</td>
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<tr>
<td></td>
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<td>Marriage Divorce E4 E1–E4</td>
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<tr>
<td>Observations</td>
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<td>1734 1734 1734 1734</td>
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<tr>
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<td>704.14 96.30 684.01 171.26</td>
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** p<0.05, *** p<0.01

Notes: This table reports the instrumental variable estimates where the aggregate female employment share is instrumented by the marriage rate, divorce rate, or EITC schedules.

**Marriage and Divorce** Differences in marital status are associated with large differences in female employment. There is large variation in marriage and divorce rates across US states. Extensive sociological research highlights that these differences are largely induced by religion, norms, attitudes, and differences in divorce laws. Our identifying assumption is then that these differences are not induced by the cross-state differences in the industrial structure. We construct the marriage rate and the divorce rate for each state and year among working-age women (between 16 and 65 years old).9

Table 1 reports the instrumental variable estimates where we use either the marriage rate or the divorce rate as instruments for aggregate female employment share. We find that as the aggregate female employment share increases by 1%, the employment share of manufacturing decreases by about 1.9% to 3.2% and the service share increases by about 2.7% to 3.1%.

**Earned Income Tax Credit** It is well established that differences in the EITC programs or income tax systems affect the labor supply, particularly so for female workers. Under the assumption that they do not directly impact the industrial structure, they are a valid instrument for the aggregate female employment.

We summarize an EITC schedule (see Appendix I.2 for details) by four parameters \((E_1, E_2, E_3, E_4)\), such that income interval \([0, E_1]\) is the phase-in part, \([E_1, E_2]\) the flat phase, \([E_2, E_3]\) the phase-out part of the schedule, and \(E_4\) is the amount of maximum benefit. Thus an EITC schedule...
as a function of income can be represented by
\[
\text{EITC}(Y) = \frac{E_4}{E_1} Y \cdot 1_{\{0 \leq Y \leq E_1\}} + E_4 \cdot 1_{\{E_1 \leq Y \leq E_2\}} + \left[ E_4 - \frac{E_4}{E_3 - E_2} (Y - E_2) \right] \cdot 1_{\{E_2 \leq Y \leq E_3\}},
\]
where \( 1 \) denotes an indicator function and \( Y \) denotes family labor income. The set of parameters \((E_1, E_2, E_3, E_4)\) varies across states and over time.

Columns (3)–(4) and (7)–(8) in Table 1 report the results using EITC as instrumental variable. We use two different sets of IVs, one only with \( E_4 \), which both varies the most and affects labor supply the most, and the other with all four parameters \( E_1 \) to \( E_4 \). We find that as the female employment share increases by 1%, the manufacturing share decreases by 2.6% and the service share increases by 3.2%. The point estimates are quite similar to the estimates using divorce and marriage rates as instruments.

Appendix I.1 shows that the results remain quantitatively similar when we use income tax parameters as instruments.

**Discussion.** What would the theory imply? Consider, for simplicity, our motivating framework with only two sectors, manufacturing \( m \) and services \( s \). Given the constant gender shares within these two sectors, the market clearing condition requires that

\[
N_m f_m + N_s f_s = L_f,
\]

where \( N_m \) and \( N_s \) are the employment of the manufacturing and service sectors, \( f_m \) and \( f_s \) are the female employment share in these two sectors, and \( L_f \) is the overall female employment. Dividing both sides by total employment, we have

\[
n_m f_m + n_s f_s = \ell_f,
\]

where \( n_m \) and \( n_s \) are the manufacturing share and service share, and \( \ell_f \) is the overall female employment share. Substituting \( n_m = 1 - n_s \), yields

\[
\frac{dn_s}{d\ell_f} = \frac{1}{f_s - f_m}.
\]

Empirically, we have \( f_m \approx 0.30 \) and \( f_s \approx 0.62 \), which implies that

\[
\frac{dn_s}{d\ell_f} = \frac{1}{0.62 - 0.30} = 3.13.
\]
Hence, this theoretical framework with only reallocation of labor between manufacturing and service, consistent with a constant other sector, implies a causal effect of $\ell_f$ on $\ell_s$ that is 3.13. Our IV estimates in the data are very similar. Extrapolating these estimates illustrates their economic significance: a 8pp increase in female employment will be associated with a 25pp to 26pp increase of the service sector. However, we have to be careful with such an extrapolation of the regression results as they abstract from general equilibrium effects and changes in the other sector that also increased its female employment share. To quantify the contribution of female employment to structural change, we will therefore rely on our model in Section 3 that takes these effects into account.

**Size vs. Share** Our simple organizing framework suggests an even more striking implication that with constant gender employment shares in manufacturing and services, an increase in the aggregate female employment will lead to a decline in manufacturing employment not only as a share of the economy, but in the absolute level. To see this, note that

$$N_m f_m + N_s f_s = L_f, \quad N_m (1 - f_m) + N_s (1 - f_s) = L_m.$$  

Rearranging the second equation

$$N_s = \frac{L_m - N_m (1 - f_m)}{1 - f_s}$$

and plugging it into the first equation yields

$$N_m f_m + \frac{L_m - N_m (1 - f_m)}{1 - f_s} f_s = L_f.$$  

After collecting terms, we get that conditional on constant male employment ($dL_m = 0$)

$$\frac{dN_m}{dL_f} = \frac{1 - f_s}{f_m - f_s} < 0$$

because in the data $0.30 \approx f_m < f_s \approx 0.62$.

We contrast this theoretical prediction with the data by examining the impact of aggregate female employment changes on the absolute sector sizes using the following regression specification:

$$y_{it} = \alpha_0 + \alpha_1 x_{it} + \alpha_2 z_{it} + \varepsilon_{it}, \quad (2)$$

where $x_{it}$ is now the level of the aggregate female employment, $y_{it}$ is the manufacturing or services employment level, and $z_{it}$ is male employment level in state $i$ at time $t$. The latter regressor controls for the overall employment growth as required by the simple theoretical
Table 2: IV Estimates of the Impact of Female Employment on Industrial Structure (in Size)

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing Employment</th>
<th>Service Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) (2) (3) (4)</td>
<td>(5) (6) (7) (8)</td>
</tr>
<tr>
<td>Female</td>
<td>-0.948*** -2.499*** -1.376*** -1.278***</td>
<td>1.781*** 1.417*** 2.030*** 1.950***</td>
</tr>
<tr>
<td></td>
<td>(0.130) (0.593) (0.107) (0.102)</td>
<td>(0.107) (0.273) (0.086) (0.082)</td>
</tr>
<tr>
<td>Male</td>
<td>1.020*** 2.321*** 1.380*** 1.297***</td>
<td>-0.770*** -0.464** -0.978*** -0.911***</td>
</tr>
<tr>
<td></td>
<td>(0.109) (0.497) (0.090) (0.086)</td>
<td>(0.090) (0.229) (0.072) (0.069)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Marriage Divorce E4 E1–E4</th>
<th>Marriage Divorce E4 E1–E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations</td>
<td>1734 1734 1734 1734</td>
<td>1734 1734 1734 1734</td>
</tr>
<tr>
<td>Weak Id. F</td>
<td>189.87 21.37 394.69 102.17</td>
<td>189.87 21.37 394.69 102.17</td>
</tr>
</tbody>
</table>

** p<0.05, *** p<0.01

Notes: This table reports the instrumental variable estimates where the female employment is instrumented by the marriage, divorce, or EITC schedules.

derivation above. We instrument aggregate female employment using the same instruments as above. Table 2 reports results for marriage rate, divorce rates, and EITC instruments, while Table A-2 for income tax system instruments.

The results are consistent with the theoretical prediction that with constant gender shares in manufacturing and services, increasing aggregate female employment leads to a decline of the male-intensive sector (manufacturing) and an increase of the female-intensive sector (services). The estimates are also quantitatively consistent with the basic theory. For example, the theory implies that for $f_s = 0.62$ and $f_m = 0.30$ and conditional on constant male employment ($dL_m = 0$),

$$\frac{dN_s}{dL_f} = \frac{1}{f_s - \frac{1-f_s}{1-f_m} f_m} = 2.1,$$

which is very close to the corresponding estimates in the data. As in the case of shares, these estimates have to be interpreted carefully as they abstract from several effects that our structural model below takes into account.

2.2.2 Cross-Country Evidence

Preceding analysis based on U.S. states suggests that an exogenous increase in aggregate female employment is associated with a decline in the share and the level of employment in manufacturing and an increase in the share and the level of employment in services. We now assess whether a similar relationship holds in our sample of 25 advanced economies.
Table 3: Cross-Country IV Estimates of the Impact of Aggregate Female Employment on Industrial Structure

<table>
<thead>
<tr>
<th></th>
<th>Employment Share</th>
<th></th>
<th>Employment Level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manufacturing</td>
<td>Services</td>
<td>Manufacturing</td>
<td>Services</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Divorce IV</td>
<td>-1.54</td>
<td>2.52</td>
<td>-1.07</td>
<td>2.39</td>
</tr>
<tr>
<td></td>
<td>(0.32)</td>
<td>(0.34)</td>
<td>(0.13)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Attitudes IV</td>
<td>-1.44</td>
<td>1.78</td>
<td>-1.62</td>
<td>4.12</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(0.60)</td>
<td>(0.87)</td>
<td>(1.88)</td>
</tr>
<tr>
<td>no. observations</td>
<td>37/32</td>
<td>37/32</td>
<td>37/32</td>
<td>37/32</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parenthesis.

As in the case of U.S. states, we need to construct instruments for changes in female employment. We propose two such instruments. First, we use attitudes toward female employment from the 2002 International Social Survey: Family and Changing Gender Roles (ISSP 2002). The ISSP is a long-running social survey program that asks respondents across countries about a variety of topics. It includes specific modules, such as on the family and changing gender roles, which we use to construct our instrument. Specifically, we use the response to the question, “To what extent do you agree or disagree with being a housewife is just as fulfilling as working for pay?” Respondents can choose from five answers ranging from strongly agree to strongly disagree, or they can answer that they cannot choose. We use the average response to this question for each country as our first instrument.10

Second, as an alternative instrument, we use the share of divorcees as measure of divorce legislation and practice as well as social norms in each country. We use the same sample as in the analysis of employment shares and determine the share of divorcees for each country-year observation using information on marital status in IPUMS.11

Table 3 reports the results for the two IV regressions for the four outcome variables of interest — manufacturing and service employment shares and levels. The results are similar to those based on U.S. states. The manufacturing employment share and level decrease while the services employment share and level increase as females enter the labor market.

10 We treat the answer cannot choose as missing.
11 We count as divorced all individuals who report being separated, divorced, or absent spouse.
3 Quantitative Model

In this section we propose a quantitative model of structural change induced by differential sectoral productivity growth, income effects due to non-homothetic preferences, and rising female employment over time. As for different productivity growth and income effects, we do not model the sources of the rise in female employment but refer to the large literature that provided a plethora of potential explanations (see Olivetti and Petrongolo, 2016, for a survey).

3.1 Setup

Preferences. Consumers’ preference over the sectoral goods \( m \) (manufacturing), \( s \) (service), and \( o \) (other) exhibit the following nested CES structure:

\[
Y = \left[ \beta y^{\rho - 1} + (1 - \beta) (y_o - \bar{y}_o)^{\rho - 1} \right]^{\frac{1}{\rho - 1}}; \quad y = \left[ \alpha (y_m - \bar{y}_m)^{\varepsilon - 1} + (1 - \alpha) (y_s - \bar{y}_s)^{\varepsilon - 1} \right]^{\frac{1}{\varepsilon - 1}},
\]

where \( y \) is a composite of manufacturing goods and services. Preferences are non-homothetic, as characterized by parameters \( \bar{y}_m, \bar{y}_s, \) and \( \bar{y}_o \). We denote the price of each sectoral good by \( p_m, p_s, \) and \( p_o \), respectively. We define the price index by

\[
P \equiv \left[ \beta p_{m}^{1 - \rho} + (1 - \beta) p_{o}^{1 - \rho} \right]^{\frac{1}{1 - \rho}}; \quad p \equiv \left[ \alpha p_{m}^{1 - \varepsilon} + (1 - \alpha) p_{s}^{1 - \varepsilon} \right]^{\frac{1}{1 - \varepsilon}},
\]

where \( p \) defines the price index of the manufacturing-service composite. Consumers optimization problem implies the following demand system:

\[
p_m = \alpha p \left( \frac{y_m - \bar{y}_m}{y} \right)^{-\frac{1}{\varepsilon}}; \quad p_s = (1 - \alpha) p \left( \frac{y_s - \bar{y}_s}{y} \right)^{-\frac{1}{\varepsilon}},
\]

and

\[
p = \beta P \left( \frac{y}{Y} \right)^{-\frac{1}{\rho}}; \quad p_o = (1 - \beta) P \left( \frac{y_o - \bar{y}_o}{Y} \right)^{-\frac{1}{\rho}}.
\]

We normalize the price index to \( P = 1 \).

Technology. Each sector has a specific production function that takes male and female labor services as inputs. Denote the labor inputs by \( N_\ell \) and \( N_g \) for female and male workers, respectively (\( \ell \) for ladies and \( g \) for gentlemen). We abstract from capital for simplicity.\(^{12}\) The empirical evidence in Section 2 revealed constant gender ratios in the manufacturing and service sectors over time and across countries. We therefore assume that production functions are

\(^{12}\)Introducing a frictionless capital market would result in the same reduced form production functions for labor inputs.
Leontief in these two sectors given by

\[ F_j (N_{\ell,j}, N_{g,j}) = A_j \min \{ N_{\ell,j}, B_j N_{g,j} \}, \]

where \( A_j \) is TFP and \( B_j \) captures the gender input intensity in sector \( j \in \{ m, s \} \). The production function in the other sector takes a similar form, but the gender intensity parameter is a function of the economy-wide female employment share \( B_o (L_\ell/L) \), which is parameterized as a polynomial. Within each sector, there are representations firms. Firms take wages as given and solve the following cost minimization problem

\[
\min_{N_{\ell,j}, N_{g,j}} w_\ell N_{\ell,j} + w_g N_{g,j} \\
\text{s.t. } F_j (N_{\ell,j}, N_{g,j}) \geq y_j,
\]

where \( w_\ell \) and \( w_g \) are the wages of each gender. Note that workers are assumed to be freely mobile across sectors so that wages are equalized across sectors

\[
w_\ell,m = w_\ell,s = w_\ell,o := w_\ell, w_g,m = w_g,s = w_g,o := w_g.
\]

**Equilibrium.** The definition of a competitive equilibrium is standard. It is an allocation of workers across sectors \( \{ N_{\ell,m}, N_{\ell,s}, N_{\ell,o} \} \) and \( \{ N_{g,m}, N_{g,s}, N_{g,o} \} \) such that the representative firms take prices as given and maximize profits. Prices are such that the labor market clears for each gender \( \sum_j N_{\ell,j} = L_\ell \), \( \sum_j N_{g,j} = L_g \) and there is goods market clearing \( y_j = F_j (N_{\ell,j}, N_{g,j}) \) for each sectoral good \( j \in \{ m, s, o \} \). There is free entry so that the zero-profit condition holds in each sector

\[
p_j F_j (N_{\ell,j}, N_{g,j}) - w_\ell N_{\ell,j} - w_g N_{g,j} = 0, \quad \forall j \in \{ m, s, o \}.
\]

### 3.2 Calibration

There are two secular trends in this economy. First, sectoral TFP \( A_m, A_s, \) and \( A_o \) change over time. Second, more female workers \( L_\ell \) enter the labor market. Thus, the model features three sources of structural change: (1) income effect embedded in the non-homothetic preference, arising from overall growth; (2) differential sectoral productivity growth; (3) changing resource constraint due to rising female labor force participation. The first two are standard while the last one is new. Our ultimate objective is to quantify the importance of each source to the observed structural change during the past five decades.

**Parameters to be calibrated.** There are 7 preference parameters to be calibrated: \( \alpha \), the weight parameter for manufacturing in the manufacturing-service composite production; \( \varepsilon \),
the elasticity of substitution between manufacturing and services; $\beta$, the weight parameter for manufacturing-service composite relative to other sector good; $\rho$, the elasticity of substitution between manufacturing-service composite and other sector good; $\bar{\gamma}_m$, $\bar{\gamma}_s$, and $\bar{\gamma}_o$, the non-homotheticity parameters associated with the manufacturing goods, service goods, and other goods, respectively.

The technology parameters to be calibrated are the following. First, $B_m$ and $B_s$, the gender intensities of the production functions that determine gender employment shares in manufacturing and service, respectively. Second, the polynomial $B_o \left( L_{\ell}/L \right)$ for the other sector, which is parameterized as a quadratic form. In addition, we have 3 TFP series to calibrate: $\{A_{m}^{t}, A_{s}^{t}, A_{o}^{t}\}$.

Lastly, the rise in the number of female workers in the labor market, $\{L_{t}^{\ell}\}$.

**Calibration strategy.** The model is calibrated to the US data. The rise in female workers’ labor market participation, $\{L_{t}^{\ell}\}$ is taken directly taken from the data.

The constant employment shares of male and female workers in manufacturing and services in the data pin down $B_m$ and $B_s$. To match the observed gender share in manufacturing and services, 0.30 and 0.62, respectively, we calibrate $B_m$ to 0.4286 ($= 0.30/0.70$) and $B_s$ to 1.6316 ($= 0.62/0.38$). We then estimate $B_o \left( L_{\ell}/L \right)$ by fitting a polynomial of $B_o^{t}$ on $L_{t}^{\ell}/L^{t}$. The TFP path $A_{j}^{t}$ in each sector is inverted directly from sectoral value added and employment data as

$$A_{j}^{t} = \frac{Y_{j}^{t}}{\min \{ N_{t,j}^{\ell}, B_j N_{g,j}^{t} \}} = \frac{Y_{j}^{t}}{N_{t,j}^{\ell}},$$

where $Y_{j}^{t}$ is the value-added of sector $j$ at time $t$ and $N_{t,j}^{\ell}$ is the female employment of sector $j$ at time $t$. The Leontief production function leads to such tractability. Since the model abstracts away from capital, we account for the labor share in the free entry condition of each sector in the calibration.

The remaining preference parameters are calibrated internally. The model is solved as a series of static equilibria with exogenous sequences of sectoral productivity and economy-wide female labor supply. We estimate these 7 parameters by minimizing the distance of the model and data counterpart of the following moments: (1) the time paths of the sector sizes of manufacturing and services; (2) the time paths of the relative price of the service goods to manufacturing goods and the other goods to manufacturing goods.

Table 4 reports the values of internally calibrated parameters. Figure 5 plots the calibrated paths of sectoral productivity over time. The manufacturing sector has experienced the fastest productivity growth, and the service sector the slowest. The productivity growth in the other sector lies in between.
Table 4: Internal Calibration

<table>
<thead>
<tr>
<th>Meaning</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elasticity of substitution between $m$ and $s$</td>
<td>$\varepsilon$</td>
<td>1.10</td>
</tr>
<tr>
<td>Elasticity of substitution between $m/s$ and $o$</td>
<td>$\rho$</td>
<td>1.65</td>
</tr>
<tr>
<td>Weight parameter on $m$ vs. $s$</td>
<td>$\alpha$</td>
<td>0.14</td>
</tr>
<tr>
<td>Weight parameter on $m/s$ vs. $o$</td>
<td>$\beta$</td>
<td>0.51</td>
</tr>
<tr>
<td>Nonhomotheticity parameter for $m$</td>
<td>$\bar{y}_m$</td>
<td>0.47</td>
</tr>
<tr>
<td>Nonhomotheticity parameter for $s$</td>
<td>$\bar{y}_s$</td>
<td>-0.58</td>
</tr>
<tr>
<td>Nonhomotheticity parameter for $o$</td>
<td>$\bar{y}_o$</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Notes: Internally calibrated preference parameters and their calibrated values in the model.

Figure 5: Calibrated Sectoral Productivity Growth

Notes: This figure plots the calibrated sectoral productivity processes.
3.3 Model Fit

**Notation.** Sector $j$’s female share refers to the fraction of its employees who are female:

$$\text{female share}_j = \frac{N_{\ell,j}}{N_{\ell,j} + N_{g,j}}.$$  

Sector $j$’s size refers to its employment share as a fraction of the economy-wide employment:

$$\text{sector size}_j = \frac{N_{\ell,j} + N_{g,j}}{\sum_{j \in \{m,s,o\}} (N_{\ell,j} + N_{g,j})}.$$  

Figure 6 shows the model fit for the key objects of interest for the manufacturing, services, and other sector. The blue dots plot the employment share of female workers in each sector in the data, and the blue lines are the model counterpart. The red dots plot the sector employment share in the data, and the red lines are the model counterpart. The black dashed line in each panel tracks the economy-wide female employment share in the data, which evolves in exactly the same way in the model. As all the lines are almost exactly on top of the corresponding dots, the model is able to replicate the structural shift from manufacturing to services. The constant gender employment shares in manufacturing and services, and the parallel trend relative to the economy-wide gender share in the other sector are matched by construction.

In addition, Figure 7(a) shows that the model reproduces the movements in the relative prices of the sectoral goods. As before, dots are data and lines are model counterparts. Figure 7(b) plots the paths of value-added of each sector in the data and in the model.

Finally, the model is consistent with a significant reduction in the difference between the average wages of male and female workers – the gender gap in wages – as we show in Appendix Figure A-5. While the rise in female labor supply tends to push their relative wages down, this is more than offset by the sharp rise in the price of services relative to the other two sectors. As the production of services is intensive in female labor, the relative wage of female workers increases.

In summary, the model is able to reproduce the key facts describing of sectoral reallocation over the past 50 years, including the time paths of sectoral employment, gender shares, prices, value added, and the gender gap in wages. This allows us to use the model a quantitative laboratory where we shut down each driver of the structural change to evaluate its importance.
Figure 6: Model Fit—Sector Size and Gender Share

Notes: This figure plots the employment size of each sector, gender ratio of each sector, and female share in the economy, both in the data (dots) and in the model (solid lines). From left to right: manufacturing, service, other.

Figure 7: Model Fit—Price and Value Added

Notes: The left panel plots log price ratio of sectoral goods. The right panel plots value added of sectoral goods. Dots are data points and solid lines are model counterparts.
Three forces potentially lead to structural transformation of employment reallocation from manufacturing to service: (1) income effect embedded in the non-homothetic preference due to productivity growth; (2) differential productivity growth across sectors; (3) rise in the number of female workers in the labor market.

All three forces are essential in accounting for the observed patterns of structural change in the data. With the rise in the number of female workers only, one can obtain structural employment reallocation from manufacturing to services, but the relative price of the service to manufacturing good would decline in the model while it increases in the data. In contrast, in the absence of the rise in the number of female workers, one can still get some structural employment reallocation from manufacturing to service, as long as there are differential technological growth and/or an income effect. This has been well-known in the structural change literature. But without the rise of female employment, structural change must happen by reallocating women from the other sector, implying a decreasing female employment in the other sector. This prediction of the theory is counterfactual given the empirical fact that the female employment increases in the other sector. This observation leads to the conclusion that rising female employment is a necessary condition for generating structural change in theory in line with the empirical evidence.

How important is each of the three forces? In particular, how much of the structural transformation of employment reallocation from manufacturing to service can be explained by the rise of female workers in the labor force?

To answer this question, we conduct two counterfactual experiments where we shut down certain forces. Quantifying the importance of each force requires a metric for measuring “structural transformation.” Here we evaluate “structure” in terms of the sectoral employment allocation, measured by the difference in the services employment share and the manufacturing employment share. That is, we quantify structural change by $\Delta Q$ where $Q$ is defined as

$$Q := \text{sector size}_{\text{service}} - \text{sector size}_{\text{manufacturing}}.$$ 

In the data, $Q$ goes from 6.6pp in 1976 to 32.6pp in 2019, i.e., a 26pp of the observed structural change as measured by $\Delta Q_0$. The baseline model accounts for 95% of the structural change in the data (i.e., 24.7 pp).

To evaluate the role of the rise of female workers in the labor force, we shutdown the increase of female employment and compare the counterfactual economy with the baseline. To do so, we consider a counterfactual economy where the economy-wide female employment stays at its level in 1976, i.e., $L_t^f = L_t^0$ for all $t$, while keeping the paths of sectoral productivity
Notes: This figure plots the magnitude of the employment reallocation from manufacturing to service in the counterfactual economies.

growth as estimated. The path of structural transformation in this counterfactual economy is plotted as the red line in the right panel of Figure 8. In this counterfactual economy, there is a $\Delta Q_1 = 8.7$ ppt structural change, which suggests that rise in female accounts for 65% ($= (\Delta Q_0 - \Delta Q_1)/\Delta Q_0$) of the structural change. Figure A-6 plots details of the employment allocation in this counterfactual economy.

As second counterfactual experiment to evaluate the role of rise in female in the labor force, we shutdown the productivity growth across sectors by assuming all three sectors have zero productivity growth (note that this also eliminates most of the income effects). This counterfactual is plotted as the green line in the left panel of Figure 8, with a structural change of 18.7pp. This comparison suggests that rise in female employment accounts for 75.8% of structural change.

4 Conclusions

Labor markets underwent large changes during the last five decades. Industrialized countries observed massive shifts from a male-dominated labor market with a large share of employment in manufacturing to a service-dominated economy with aggregate female employment almost on
par with men. Against this background, we find a strikingly constant gender ratios in the man-
ufacturing and service sectors that underwent the largest shifts in employment. We document 
these facts for the United States and other advanced economies. These empirical findings guide 
our extension of the standard model of structural change to include a complementarity between 
male and female workers in sectoral production. The model implies that rising female labor force 
participation can be the cause rather than the consequence of structural change. A rising ag-
ggregate female employment in the model leads to rising employment share of services as sectoral 
gender balance constraints prevent the manufacturing sector from absorbing women who enter 
the labor market. On the flip side, the model implies that rising aggregate female employment 
is indeed necessary to to support a large employment shift from male-intensive manufacturing 
to female-intensive services. We provide evidence based on instrumental variable regressions 
supporting the presence of this mechanism in the data. Our quantitative theory evaluation 
suggests that the increase in aggregate female employment accounts for about two-thirds of the 
structural transformation that happened in the U.S. during the past five decades.
References


I   Additional Empirical Results

I.1   Using Tax Parameters as Instruments

We follow the recent macroeconomic literature (Heathcote et al., 2017; Borella et al., 2023; Qiu and Russo, 2022) and describe the overall income tax system as:

\[ T(Y) = Y - (1 - \lambda)Y^{1-\tau}, \]

where \( T \) denotes taxes and \( Y \) total income. The parameter \( \lambda \) governs the average tax rate and the parameter \( \tau \) captures the degree of progressivity of the income tax system. We estimate the parameters using the logarithm of post-tax income and the logarithm of pre-tax income in each state and in each year. Figure A-1 illustrates how the tax function looks like.

Table A-1 reports the instrumental variable estimates for industry employment shares, where female employment share is instrumented by the tax parameters. We use two different sets of IVs, one only with \( \lambda \) and the other with both \( \lambda \) and \( \tau \). The resulting point estimates support the previous findings consistent with a causal mechanism. Quantitatively, we find that as the
Table A-1: IV Estimates of the Impact of Female Employment on Industrial Structure

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing Share</th>
<th>Service Share</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Female Share</td>
<td>-1.845***</td>
<td>-2.188***</td>
</tr>
<tr>
<td></td>
<td>(0.198)</td>
<td>(0.199)</td>
</tr>
<tr>
<td>Instrument</td>
<td>λ, λ, τ</td>
<td>λ</td>
</tr>
<tr>
<td>Observations</td>
<td>1734</td>
<td>1734</td>
</tr>
<tr>
<td>Weak Id. F</td>
<td>337.64</td>
<td>182.03</td>
</tr>
</tbody>
</table>

** p<0.05, *** p<0.01

Notes: This table reports the instrumental variable estimates where the female employment share is instrumented by the income tax system parameters.

Female employment share increases by 1%, the manufacturing share decreases by about 1.8% to 2.2% and the service share increases by 2.8% to 3.1%.

Table A-2 reports the corresponding instrumental variable estimates in the size specification.

I.2 The Earned Income Tax Credit

Initially set up in 1975, the Earned Income Tax Credit (EITC) was designed to boost the income of working families. Over the years, it has expanded significantly, particularly in 1986, 1993, and 2009, evolving into one of the most substantial income support programs in the United States.

To qualify for the EITC, individuals must have a dependent child, earn a positive income, and have an adjusted gross income below a specified threshold, which changes over time and with the number of dependent children. The structure of the EITC benefit includes a phase-in period offering a proportional subsidy on earnings, a stable benefit plateau, and a phase-out period where benefits diminish. The federal EITC schedule for families with two children in selected years is depicted in Figure A-2. In our study, we calculate a household’s total EITC benefits by adding together the federal and state EITC credits.
Table A-2: IV Estimates of the Impact of Female Employment on Industrial Structure (in Size)

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing Employment</th>
<th>Service Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Female Employment</td>
<td>-0.608***</td>
<td>-0.924***</td>
</tr>
<tr>
<td></td>
<td>(0.119)</td>
<td>(0.119)</td>
</tr>
<tr>
<td>Male Employment</td>
<td>0.735***</td>
<td>1.000***</td>
</tr>
<tr>
<td></td>
<td>(0.100)</td>
<td>(0.100)</td>
</tr>
<tr>
<td>Instrument</td>
<td>λ</td>
<td>λ, τ</td>
</tr>
<tr>
<td>Observations</td>
<td>1734</td>
<td>1734</td>
</tr>
<tr>
<td>Weak Id. F</td>
<td>199.22</td>
<td>114.44</td>
</tr>
</tbody>
</table>

** p<0.05, *** p<0.01

Notes: This table reports the instrumental variable estimates in absolute size where female employment is instrumented by the income tax system parameters.

Figure A-2: Federal EITC Schedules for Families with Two Children (in 2015 Dollars)

Notes: The figure plots the federal Earned Income Tax Credit as a function of earned income for families with two children in selected years. Amounts are expressed in 2015 US dollars.
Figure A-3: Industry hours shares and female hours shares in Germany

(a) Change of hours shares 1973-2018

(b) Manufacturing

(c) Service

(d) Other

Notes: Panel (a) plots the change of hours shares for each industry. Panel (b) shows the share of female hours in total hours of the manufacturing sector (blue line), the hours share of the manufacturing sector (red line), and the female share in hours worked in the entire labor market (dashed black line). Panels (c) and (d) plot the same variables for the service and the other sector.
Notes: Panel (a) plots the change of hours shares for each industry. Panel (b) shows the share of female hours in total hours of the manufacturing sector (blue line), the hours share of the manufacturing sector (red line), and the female share in hours worked in the entire labor market (dashed black line). Panels (c) and (d) plot the same variables for the service and the other sector.
II Additional Quantitative Results

Notes: This figure plots the gender earnings gap in the model.

Figure A-6: Employment Reallocation in the Counterfactual Economies
(a) Shutting Down Sectoral Productivity Growth
(b) Shutting Down Rise in Female Labor Force

Notes: This figure plots the employment reallocation in the counterfactual economies.