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# The Service Sector and Female Market Work

Michelle Rendall

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Michelle Rendall†
The University of Zurich

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ABSTRACT

This paper develops a multi-sector model to: (i) quantify the feedback from women entering the labor force on the service sector size, and (ii) compute differences in hours worked by gender from taxes, structural change and female employment. Increases in female employment, due to rising wages and structural change, account for a sizable portion of services. Counterfactual results suggest that: (1) working women account for 32 percent of the rise in service employment; (2) using standard micro estimates of Frisch elasticities with two-person households, tax rates account for the majority of Europe-US differences in hours worked, and (3) subsidies to employment circumvent the tax effect on hours, but lead to welfare losses of 5 to 8 percent. The second result validates the relationship between tax levels and hours worked first proposed by Prescott (2004) without using large Frisch elasticities.

JEL classification: E21, E24, J20.
Keywords: technological progress, sectoral labor allocation, female labor supply, labor demand, taxation.

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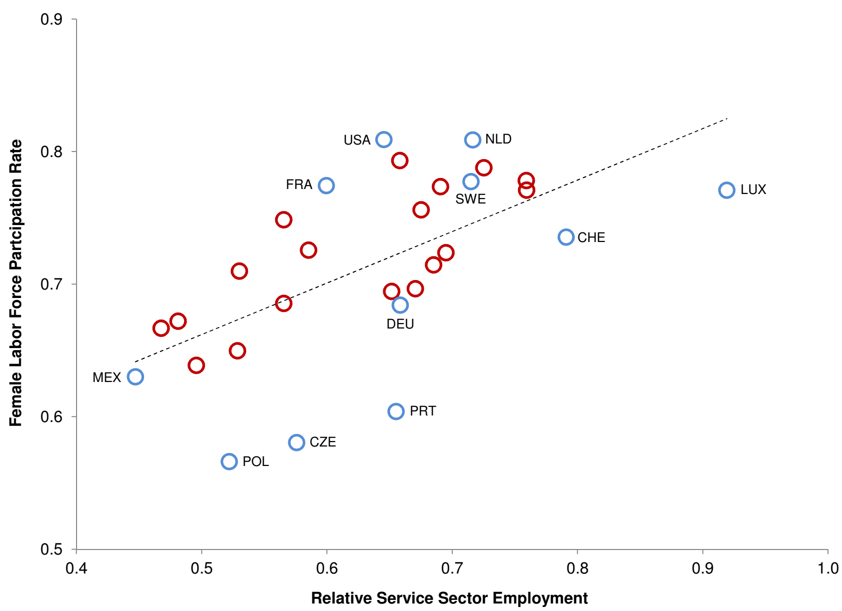
†University of Zurich, Department of Economics, Schönberggasse 1 CH-8001 Zurich.
Email: michelle.rendall@econ.uzh.ch. All errors are mine.

# 1 Introduction

Countries that have large service sectors also tend to have more female employment and a lower gender wage gap. For example, the correlation between aggregate service employment and relative female employment trends is around 0.82 from the 1980s onwards for a large set of OECD countries (Rogerson, 2005). Within those countries, labor force participation and relative service sector employment in 2010 is correlated at 0.62 (see figure 1). The causality likely goes both ways. That is, a larger service sector provides women with better employment opportunities, both in terms of wages and job openings, and a larger female labor force demands more market produced services (e.g., childcare, elderly care, prepared meals) resulting in a larger service sector. The first effect is a *labor demand* channel and the second effect is known as a *labor supply* channel.




Source: OECD Employment Data

Figure 1: Female and Service Sector Employment

The literature on aggregate hours worked suggests that, not only taxes (Prescott, 2004), but a combination of taxes and structural changes are important factors in explaining cross-country differences in hours worked. Rogerson (2008) shows that countries with little service employment also tend to be countries with less hours worked. Subsequent research points to a lack of the *marketization of services*, a term coined by Freeman and Schettkat (2005) as a cause. Specifically, Ragan (2013) and Olovsson (2009) show that higher European tax rates motivate individuals to shift hours from the market to the home (or leisure), in contrast to the low tax rates found in the US. In Scandinavia this tax effect is partially offset by subsidies for market-services (e.g. childcare, elderly care). This literature models the household as a single representative agent. However, McDaniel (2010) finds that market work and home production vary to a large extent when disaggregated by sex. Olivetti and Petrongolo (2011) further show that countries with smaller service sectors have less female employment and larger gender wage gaps. These results highlight the importance of explicitly modeling women and assessing the impact of women on structural change.

In this paper, a standard multi-sector model is used to quantify how the rise in female employment contributed contributed to the rise of the service sector in the US. There are two possible effects any model attempting to explaining female employment and service sector growth should concurrently capture, an income and substitution effect. As women enter the laborforce, they earn an income, which they can spend on goods and services - the income effect. As women spend more time working in the labor market, they must substitute some of their home production for market-purchased services - the substitution effect. A general equilibrium model with married and single households of men and women is developed. Similar to Ngai and Pissarides (2008), households allocate time between the home and labor market, and choose consumption over three types of goods: market produced services, market produced goods and home-produced services. The model has two key assumptions. First, following Greenwood and Guner (2009), households can produce a substitute for market produced services (e.g., childcare, elderly care, meals) using goods and labor time. Second, men and women differ only in terms of productivity. Men are assumed to have equal productivity across all sectors, while women's average productivity in each sector is taken from wage data. That is, women have higher productivity in the service sector. Therefore, women generally prefer working in the service economy, where occupations require neither great physical strength nor have adverse working environments. Since the differences in gender wages cannot be fully explained by productivity differences, women additionally face labor market "discrimination." As such, the two key assumptions disproportionately reinforce the income and substitution effects.

To provide quantitative results, the model must generate the appropriate rise in US female employment over time. Most of the literature accounting for the rise in female labor force participation has focused on supply driven stories. These supply-side stories include, improvements in home technology (see, for example, Greenwood and Guner, 2009, and references therein), rising female wages (Jones, Manuelli and McGrattan, 2003), returns to experience (Olivetti, 2006), childcare provision (Attanasio, Low and Sanchez-Marcos, 2008), and the effects of cultural, social, and intergenerational learning on labor supply (Fernández, 2013; Fogli and Veldkamp, 2011). In the model here, female employment is driven by taxes, sectoral labor reallocation and productivity differences. With this set-up, I can untangle the contribution of each element (taxes, structural transformation, and productivity differences) with respect to the fall (rise) in hours worked, the size of the service sector, and gender employment differences. Two counterfactuals are computed to quantifying the importance of women in increasing the size of the US service sector. The first counterfactual assumes women's home production output remains at the 1965 level and captures the substitution effect from home- to market-services. The second counterfactual captures the income effect by holding women's labor income at the 1965 level.

While this is not the only paper combining female employment, structural transformation and/or taxes, it is the first to combine all three elements within a single model. Buera, Kaboski and Zhao (2013) is most similar in spirit to my paper. Omitting taxes, women's higher productivity in services, and departing from the standard multi-sector model, the authors build on the framework of Buera and Kaboski (2012) to study the role of skill, scale and women in the rise of services. The authors find only a very small feedback effect of women on services. However, they suggest that the model's inability to match the rise in married women's hours may be the driving force. This missing link, in turn, is likely due to omitting women's sectoral productivity differences. Ngai and Petrongolo (2013) focus on the long run trends in the US and changes in structural transformation, but omit tax issues. Their aim is determining how much of the closing gender wage and employment gaps can be explained by structural change. Thus, the authors model an endogenous wage gap to determine the quantitative contribution of structural change on female employment and wages. In contrast, this paper models the closing wage gap exogenously, whether it is due to compositional effects (i.e., human capital) or a fall in discrimination. Matching the actual gender wage gap is important in generating the rise in female employment from 1965 to 2010, a necessary condition to estimate the feedback of women's employment on service employment. Also omitting taxes, Akbulut (2011) focuses on explaining the rise in female employment through structural change. In contrast, omitting the structural transformation aspect, Bick and Fuchs-Schündeln (2012) use differences in taxation to explain differences in female employment over a large cross-section of countries. I, in combining both tax and structural transformation effects over time, make some simplifications on the tax structure. Specifically, the results from section 6 use an average tax measure, where Bick and Fuchs-Schündeln (2012) model different tax issues (e.g., average versus marginal) in detail.

The model is calibrated to match the rise in aggregate US hours from 1965 to 2010. While matching five-sixths of the rise in total hours and nearly all the rise in female hours, the baseline calibration accounts for over half of the rise in relative service hours in the US. Similar to the literature on female employment, the closing gender wage gap, structural change and difference in sectoral productivity explain the majority of the rise in female hours and relative service hours. The shrinking wage gap explains roughly one-half of the change in female hours. Adding changes in market productivity (or a rise of female-friendly service jobs), due to sectoral reallocation, explains another 15 percent. The remainder is explained by structural change. The fall in male hours is driven mostly by the increase in the share of single households.

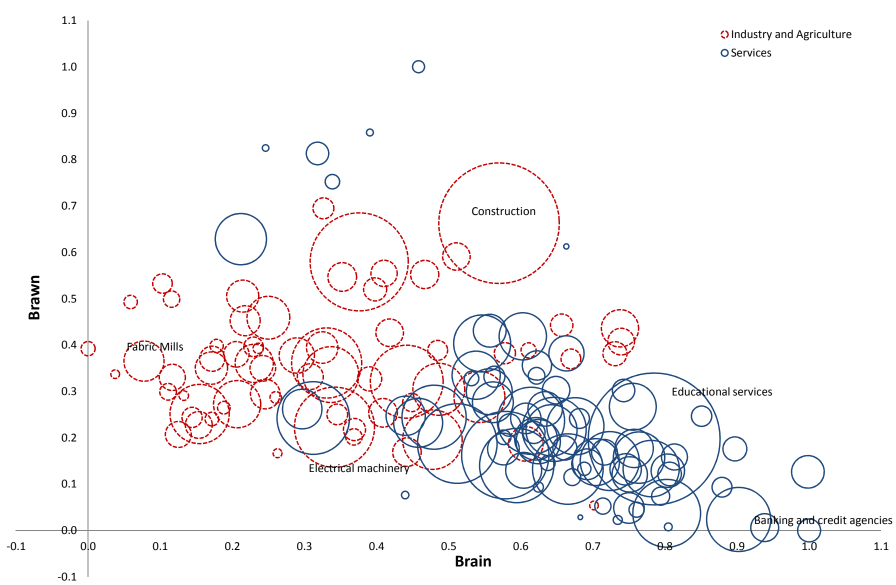
The income and substitution effect of female employment on the service sector can account for roughly one-third of the rise in relative service sector employment in the benchmark or for 17 percent in the US data. The counterfactual also accounts for over half of the rise in relative service consumption in the benchmark. This is mainly generated through a substitution of home production to market-services, as hours worked at home decrease.

Although an extensive cross-country analysis is beyond the scope of this paper, some cross-country comparisons are presented through counterfactuals highlighting the model's mechanism and robustness. First, using the calibrated US economy, the effect of higher taxes can be analyzed. How much would female employment have grown in the US with German style taxes? This counterfactual indicates that a hypothetical US economy with German taxes can account for all the cross-country differences in hours worked. Second, social welfare losses between a high tax system with subsidized market services (e.g., Scandinavia) and a low tax system (e.g., the US) are assessed, yielding average welfare losses for the US of roughly 5 to 8 percent in terms of market goods and service consumption.

As women's productivity across sectors and changes in labor demand are key motivations for this study, Section 2 provides a brief summary of the changing labor market. The general equilibrium model is outlined in Section 3. Section 4 provides analytical results of productivity growth and wage changes on labor supply, consumption, and sectoral labor shares. Section 5 discusses the calibration procedure. Section 6 provides the results for the US calibration and all counterfactuals. Section 7 concludes.

# 2 Empirical Trends

In a related paper (Rendall, 2010), job characteristics by the US census occupation and industry classifications from the 1977 Fourth Edition Dictionary of Occupational Title (DOT) and the 1991 Revised Fourth Edition Dictionaries of Occupational are used to compute aggregate labor market requirements. The 1977 and 1991 DOT were developed by the US Department of Labor, who evaluated approximately 40 job requirements for more than 12,000 occupations, documenting: (1) general educational development; (2) specific vocational training; (3) required working aptitudes; (4) temperaments or adaptability requirements; (5) physical strength requirements; and (6) environmental conditions.




Source: 1977 DOT and 1970 CPS

Figure 2: Occupation Factor Requirements by Sector

Using principal component analysis, Rendall (2010) estimates three labor demand factors (brain, brawn, and motor coordination) from the information contained in the 1977 and 1991 DOT characteristics.[1] Using those 1977 DOT brain and brawn estimates, figure 2 plots all combinations of occupation-sector pairs in the 1970 CPS. The size of each circle is proportional to the labor force within a given occupation in 1970. A sharp sectoral pattern across brain and brawn requirements is visible. Similarly, Goldin (1990) observes that, as far back as the 1920s/1930s, women made work choices based on the level of brawn required, which usually meant women preferred service sector jobs.

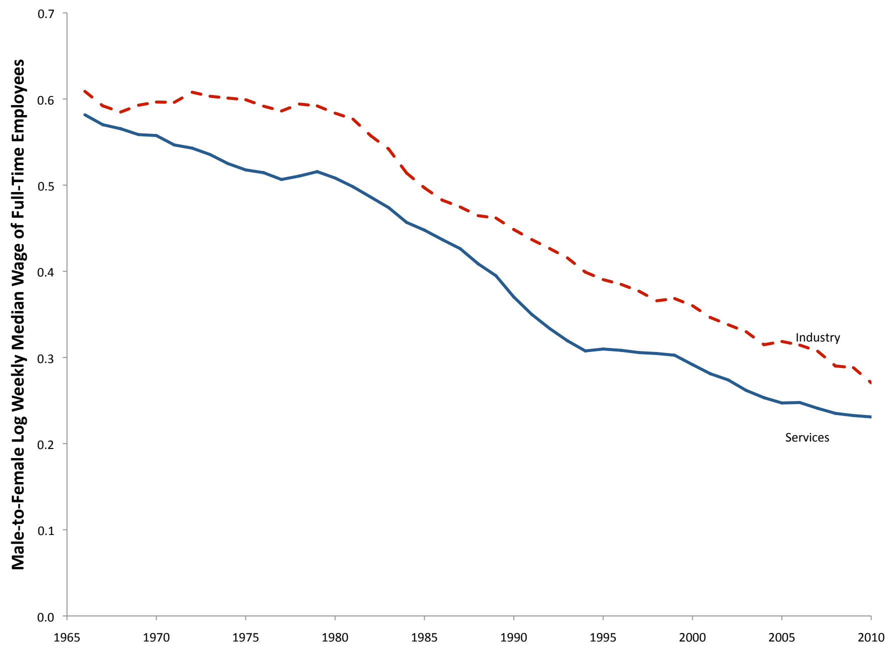
> Clerical work was cleaner and less strenuous than manufacturing work ... It is understandable why young women preferred office work and why the growth of the clerical sector would lead to the continued employment of women after marriage and childbearing. ... If the considerable difference in the earnings of males and females in manufacturing was largely due to rewards to strength, then the replacement of brain for brawn work should have evened starting salaries. ... Although the difference in starting salaries implied by the earnings functions between unmarried male and female clerical workers was negligible, it was 47% in manufacturing. *Extract from Goldin, Understanding the Gender Gap (1992) pp. 108-109*

This evidence strongly supports the hypothesis of productivity differences across sector employment rather than labor market discrimination alone.

Decomposing gender wage gaps across sectors provides further evidence of women's higher productivity in the service sector. Figure 3 graphs the natural logarithm of male-to-female US weekly median wages by sector of individuals working at least 1,400 hours per year. The wage gap in services is consistently smaller. The difference between the service and industrial gap averages around 6.2 percentage points.[2] The gender gap similarly closes for both sectors, which may explain why structural change alone cannot completely explain the closing wage gap (see Ngai

[1] For details on the data and estimation see Rendall (2010).

[2] The wage gap in agriculture shows large fluctuations across time given the small number of observations, especially for women. Since the female labor share in agriculture is close to zero, the results are omitted here.




Source: 1966 to 2010 CPS

Figure 3: Gender Wage Gap by Sector

and Petrongolo, 2013). The above gaps ignore any selection bias and the productivity difference across sectors could be even larger, as suggested by Goldin (1990).

# 3 General Equilibrium Model

The economy consists of five types of households, (1) married couples where the woman finds a service sector job, (2) married couples where the women only finds a job in manufacturing, (3) single women that can work in services, (4) single women that only find manufacturing work, and (5) single men. The rise in labor force participation has been considerably greater for married women, thus the analytical model focuses on two-person households only. Adding single households does not produce qualitatively different dynamics. The simulation results add single households to match the quantitative targets. There are also two competitive production sectors, goods and services, and a government. Labor reallocation is driven, as in Rogerson (2008), by both non-homothetic preferences and differential sectoral productivity growth.

## 3.1 Household Preferences

Household members are indexed with the superscripts $i \in \{f,m\}$ for their gender. The only difference between the sexes is market productivity, including wage discrimination. There is no bargaining in the household. Households solve a unitary utility $u(C,L)$, by allocating both agents' time to: (1) the market, $h_t^f, h_t^m$; (2) home production, $n_t^f, n_t^m$; and (3) leisure, $\ell_t^f, \ell_t^m$. Household income is used to purchase: (1) goods for consumption, $c_{g,t}$, (2) goods for input into home production, $k_{g,t}$, and (3) services in the market, $c_{s,t}$. The household also consumes a home-produced service-substitute. Home-services, $c_{n,t}$, are produced with time and goods as inputs. Since there is no intertemporal decision, the model is a time-sequence of static maximization problems:

$$\max_{\{c_{g,t},k_{g,t},c_{s,t},h_t^m,h_t^f,n_t\}} \frac{C_t^{1-\phi}}{1-\phi} + \psi \frac{\ell_t^{1-\sigma}}{1-\sigma} \tag{1}$$

s.t.

$$p_{g,t}(c_{g,t}+k_{g,t}) + p_{s,t}c_{s,t} = (1-\tau)(\omega_t^m h_t^m + \omega_t^f h_t^f) + T_t, \tag{2}$$

$$1 = h_t^m + n_t^m + \ell_t^m, \tag{3}$$

$$1 = h_t^f + n_t^f + \ell_t^f, \tag{4}$$

$$n_t = n_t^m + n_t^f, \text{ and} \tag{5}$$

$$\ell_t = \min\{\ell_t^m, \ell_t^f\}. \tag{6}$$

Consumption, $C$, is the composite consumption of services and goods (suppressing time subscripts),

$$C = \left(a_g c_g^{\varepsilon} + (1-a_g) F(\hat{c}_s, c_n)^{\varepsilon}\right)^{\frac{1}{\varepsilon}}, \tag{7}$$

where $F(\hat{c}_s, c_n)$ is composite service consumption,

$$F(\hat{c}_s, c_n) = \left(a_s \left(c_s + \chi h^f\right)^{\rho} + (1-a_s) c_n^{\rho}\right)^{\frac{1}{\rho}}. \tag{8}$$

Market-services are composed of two parts, $\hat{c}_s = c_s + \chi h^f$, privately purchased services and services rebated by the government for female hours worked.[3] Home production is a Cobb-Douglas production function of goods and time,

$$c_n = A_n^{1-\alpha} k_g^{\alpha} n^{1-\alpha}. \tag{9}$$

The leisure of spouses are assumed to be perfect compliments (equation (6)), meaning husbands and wives prefer spending the same time in leisure (not necessarily together). The Frisch elasticity of labor is governed by $\sigma$, which is $\eta_t^i = \frac{1}{\sigma} \frac{\ell_t^i}{h_t^i}$ for individual of gender $i$. The single household problem is identical, expect for leisure, where leisure is enjoyed by the single agent alone.

## 3.2 Production

The competitive sectors use labor and machines to produce final goods and services $\{Y_g, Y_s\}$. By assumption, women are less productive in the goods sector (services require less brawn). Moreover, women also face "general discrimination," $\tau_{d,t}$. The parameter $\tau_{d,t}$ could partly capture negative selection, investment in human capital, and/or discrimination. Women's productivity levels are

[3]The government provides government services automatically to households of working women. Therefore, households do not make a choice on the amount of $\chi h^f$ directly. Alternatively, a specification where services are subsidized could be used. A price subsidy has slightly different implications, as household earnings would matter for the purchased amount of government-provided services - government services would enter the budget constraint.

$\{(1-\tau_{d,t}-\tau_g),(1-\tau_{d,t})\}$ in the goods and service sector, respectively, where $\tau_{d,t},\tau_g>0$. Given the constant difference between the gender wage gap in services and industry (see figure 3), the productivity gap $\tau_g$ has no time variation. The final sectoral output is Cobb-Douglas in machines, $x_j$ and aggregate labor, $L_j$,

$$Y_{j,t}=A_{j,t}^{1-\alpha}x_{j,t}^{\alpha}L_{j,t}^{1-\alpha} \text{ for } j=g,s. \tag{10}$$

Total factor productivity for each sector $j$ is given by $A_{j,t}$, and grows at rate $\gamma_j$, i.e., $A_{j,t+1}=(1+\gamma_j)A_{j,t}$. Final goods producers hire efficiency units of labor at wage rate $w_{j,t}$ and purchase machines to maximize profits,

$$\max_{x_{j,t},L_{j,t}} p_{j,t}Y_{j,t}-p_{j,t}^{x}x_{j,t}-w_{j,t}L_{j,t}, \tag{11}$$

Machines are supplied by monopolists. Monoplists maximize profits,

$$\max_{x_{j,t}} p_{j,t}^{x}x_{j,t}-p_{g,t}x_{j,t}, \tag{12}$$

where each unit of machine requires one unit of the final goods production $Y_{g,t}$.

### 3.2.1 Wages and Labor Supply

Since women prefer to work in services, the simulation assumes that only a fraction of women find employment in the service sector, $\hat{\lambda}_t=\lambda\frac{H_{s,t}}{H_t}$, where $H_{j,t}=H_{j,t}^{m}+H_{j,t}^{f}$ are total hours worked in sector $j$.[4] This probability is a function of the service sector size, $\frac{H_{s,t}}{H_t}$, at time $t$. Holding a service job is more likely when the service sector is larger. This probability can be thought of as a labor market friction, i.e., women live in areas of the country where the primary earner works and few service employment opportunities exist. This friction is necessary in the absence of other

[4]Note that efficiency units of aggregate labor supplies, accounting for women's lower productivity, are, $L_{s,t}=H_{s,t}^{m}+(1-\tau_{d,t})H_{s,t}^{f}$ and $L_{g,t}=H_{g,t}^{m}+\left(1-\tau_{g-\tau_{d,t}}\right)H_{g,t}^{f}$.

heterogeneity. Since men are equally productive in both sectors, the friction has no effect on men's wages or labor supply.

Let $z = \{g, s\}$ denote the superscript for household type. That is, a household where a woman has found a service job is denoted by $z = s$, and $z = g$ otherwise. In terms of household types, there are $\hat{\lambda}_t$ married households where women work in services and $1 - \hat{\lambda}_t$ households where women work in manufacturing. Given free labor mobility, wage rates across sectors must equalize, $w_t = w_{g,t} = w_{s,t}$. Assuming men have a productivity of one in all sectors, the average male wage equals the wage rate, $\overline{\omega}_t^m = w_t$, and the wage gap equals,

$$\frac{\overline{\omega}_t^f}{\overline{\omega}_t^m} = \frac{\hat{\lambda}_t \left(1 - \tau_{d,t}\right) h_t^{f,s} + \left(1 - \hat{\lambda}_t\right) \left(1 - \tau_{g - \tau_{d,t}}\right) h_t^{f,g}}{\hat{\lambda}_t h_t^{f,s} + \left(1 - \hat{\lambda}_t\right) h_t^{f,g}}. \tag{13}$$

## 3.3 Government

The government, who solves a balanced budget, taxes individuals' labor income at rate $\tau$. Tax revenues are rebated to households as a lump-sum transfer, $T$. The government also rebates market-services indexed to women's labor supply as in Ragan (2013) by $\chi$. The government budget constraint is,

$$\tau(w_t H_{s,t}^m + w_t H_{g,t}^m + \omega_t^{f,s} H_{s,t}^f + \omega_t^{f,g} H_{g,t}^f) = T_t + p_{s,t} \chi (H_{s,t}^f + H_{g,t}^f), \tag{14}$$

where $\omega_t^{f,s} = w_t(1 - \tau_{d,t})$ and $\omega_t^{f,g} = w_t(1 - \tau_{d,t} - \tau_g)$ are female wages for the service and goods sector and $H_{j,t}^i$ are the aggregate hours supplied to each sector $j$ by gender $i$ .

## 3.4 Equilibrium

An equilibrium, given female productivity values, $\{\tau_{d,t}, \tau_g\}$, market prices $\{w_t, p_{g,t}, p_{s,t}, p_{g,t}^x, p_{s,t}^x\}$, and government prices $\{\tau, \chi\}$, consists of households' allocation $\{c_{g,t}^z, k_{g,t}^z, c_{s,t}^z, h_t^{m,z}, h_t^{f,z}, n_t^z\}$, firm output $\{Y_{g,t}, Y_{s,t}\}$, monopolist output $\{x_{g,t}, x_{s,t}\}$ and government allocation $T_t$ such that for all $t$:

1. $\{c^z_{g,t}, k^z_{g,t}, c^z_{s,t}, h^{m,z}_t, h^{f,z}_t, n^z_t\}$ solves the married household problem;
2. $\{x_{g,t}, x_{s,t}\}$ solves the monopolist problem;
3. $\{T_t\}$ solves the government problem;
4. Markets clear, with
   a. The labor market, $L^s_{j,t} = L^d_{j,t}$ for $j = g, s$;
   b. The goods market, $c_{g,t} + k_{g,t} + x_{g,t} + x_{s,t} = Y_{g,t}$; and
   c. The service market, $c_{s,t} + \chi \left( H^f_{s,t} + H^f_{g,t} \right) = Y_{s,t}$.

Total household consumption equals $c_{j,t} = \hat{\lambda}_t c^1_{j,t} + (1 - \hat{\lambda}_t) c^0_{j,t}$, summing two married household types.

# 4 Analytical Results

The household makes four choices on: (1) home production, (2) service consumption, (3) goods consumption, and (4) leisure. Since men have a comparative advantage in the labor market, household members specialize, with the male entering the labor market first. As such, the following section analyzes the case of $n^m = 0$, i.e., women spend at least a fraction of their time in the labor market, $h^f > 0$. The case with $n^m > 0$ is similar, except the implicit home production price is different in the two cases. All consumption choices can be solved in terms of time allocated to home production, $n$. A detailed discussion of the leisure allocation is omitted here since the result is standard - higher taxes lead to more leisure. In addition, if the curvature on consumption is smaller than on leisure, $0 < \phi < \sigma$, wealthier households allocate more time to leisure. The precise derivation for leisure allocations and all other first order conditions can be found in Appendix A. Time subscripts are omitted for all derivations.

**Home-Produced Services** Households produce services at home by allocating goods and time at the ratio,

$$\frac{k_g}{n} = \underbrace{\frac{\alpha}{1-\alpha}\frac{p_n}{p_g}}_{\Omega_n}. \tag{15}$$

Goods in home production are a function of home hours, $k_g = \Omega_n n$. The price, $p_n$, is an implicit home production price for time usage, $p_n = \omega^{f,z}(1-\tau) + \chi p_s$.[5] As the price of time in home production increases through higher wages or government rebates to work, the more costly it becomes to work at home (or the more goods relative to time are used in home production). The comparative statics can be summarized as follows:

- $\frac{\partial k_g/n}{\partial \tau} < 0$, higher taxes encourage housework;
- $\frac{\partial k_g/n}{\partial \omega^{f,z}} > 0$, higher wages discourage housework;
- $\frac{\partial k_g/n}{\partial \chi} > 0$, governments subsidies, e.g., childcare for working mothers, discourage housework; and
- $\frac{\partial k_g/n}{\partial p_g} < 0$, a fall in goods prices, due to technological progress, discourages housework.

**Composite Service Consumption** Using the home production allocation, market-service consumption can also be written in terms of home hours, $\hat{c}_s = \Omega_s n$, where

$$\frac{\hat{c}_s}{n} = \underbrace{\left(\frac{a_s}{(1-a_s)\,\alpha}\frac{p_g}{p_s}\Omega_n^{1-\alpha\rho}A_n^{\rho(\alpha-1)}\right)^{\frac{1}{1-\rho}}}_{\Omega_s}, \tag{16}$$

with $\hat{c}_s = c_s + \chi h^f$. As in Ngai and Pissarides (2008), services are "marketized" if $\frac{\hat{c}_s}{n}$ rises. The comparative statics for the marketization of services, if market- and home-services are gross substitutes ($0 < \rho < 1$) are:

[5] If $n^m > 0$ and $h^f = 0$, men face the home price of $p_n = w(1-\tau)$.

- $\frac{\partial \hat{c}_s/n}{\partial p_g} > 0$, more expensive inputs into home production have a direct positive effect on market work; but
- $\frac{\partial \hat{c}_s/n}{\partial \Omega_n} > 0$, relatively more goods in home-production indirectly also leads to female market work if $\alpha\rho < 1$.

The second effect, where more home inputs leads to more hours worked, follows from the imperfect substitutability of market-services and home-services. Therefore, all comparative statics on $\Omega_n$ have the same indirect effect on the marketization of services.

**Direct Goods Consumption** Using the market consumption allocation, goods consumption can also be written in terms of home hours, $c_g = \Omega_g \hat{c}_s = \Omega_g \Omega_s n$, where

$$\frac{c_g}{\hat{c}_s} = \underbrace{\left( \frac{a_g}{(1-a_g)a_s} \frac{p_s}{p_g} \left( \frac{\hat{c}_s}{F(\hat{c}_s, c_n)} \right)^{\varepsilon - \rho} \right)^{\frac{1}{1-\varepsilon}}}_{\Omega_g}. \tag{17}$$

If services and goods are gross compliments ($\varepsilon < 0$) and service types are substitutes, the comparative statics with respect to the key parameters are:

- $\frac{\partial c_g/\hat{c}_s}{\partial p_g} < 0$, structural change leads to a rise in relative market goods consumption; but
- $\frac{\partial c_g/\hat{c}_s}{\hat{c}_s/F(\hat{c}_s,c_n)} < 0$, more service marketization leads to a fall in relative market goods consumption as $\frac{\varepsilon-\rho}{1-\varepsilon} < 0$.

**Firm Allocation** Monopolists' profit maximization results in machine supply being a linear function of labor and TFP in the goods sector,

$$x_j = \alpha^{\frac{2}{1-\alpha}} A_g L_j. \tag{18}$$

Using equation (18) simplifies the production of goods and services to,

$$Y_g = \alpha^{\frac{2\alpha}{1-\alpha}} A_g L_g \tag{19}$$

and

$$Y_s = \alpha^{\frac{2\alpha}{1-\alpha}} A_g^{\alpha} A_s^{1-\alpha} L_s. \tag{20}$$

The final production functions are linear in labor. However, a rise in goods productivity ($A_g$) matters for both outputs, but more so for goods production. Normalizing the price of goods to one ($p_g = 1$) gives the price of services as a function of productivity, $p_s = \left(\frac{A_g}{A_s}\right)^{1-\alpha}$, and the monopolist prices $p_j^x = \frac{1}{\alpha}$. The wage rate is a function of productivity in the goods sector, $w_t = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} A_g$. Technical change follows from increases in total factor productivity, $A_j$. A rise in $\frac{A_g}{A_s}$ leads to structural change or a fall in relative goods-to-service prices, and a rise in wages.

**Sectoral Labor Shares** Using market clearing and household allocations ($Y_g = c_g + k_g + x_g + x_s$ and $Y_s = \hat{c}_s$) efficiency-unit labor shares in the economy are,

$$\frac{L_g}{L_s} = \frac{1}{1-\alpha^2}\left(\left(\frac{A_s}{A_g}\right)^{1-\alpha} \frac{\hat{\lambda}\left(c_g^s + k_g^s\right) + \left(1-\hat{\lambda}\right)\left(c_g^g + k_g^g\right)}{\hat{\lambda}\hat{c}_s^s + \left(1-\hat{\lambda}\right)\hat{c}_s^g} + 1\right). \tag{21}$$

The labor share of services rise with a faster relative productivity growth in the goods sector. This is the direct effect of structural change on labor shares. The last term is related to machine demand, but is neutral on relative labor shares. Lastly, there is the indirect effect of better job opportunities, $\hat{\lambda}$, and marketization. I.e., better job opportunities increase the service labor share. Since women working in manufacturing face lower wages, those types of households have less service marketization, $\hat{c}_s^z$. In general, the total effect of marketization on the relative labor share is ambiguous, since marketization increases both market-service and goods purchases. However, marketization has a direct effect on market-service consumption and only indirect effects on goods consumption, the marketization effect usually dominates in services, i.e., , $\frac{\hat{c}_s^g}{c_g^g+k_g^g} < \frac{\hat{c}_s^s}{c_g^s+k_g^s}$.

To summarize, there are two main parts, (1) women's labor choices and (2) structural change. First, a rise in women's wages or implicit market value - through more productive opportunities in the labor market, $\hat{\lambda}$, a fall in discrimination, $\tau_d$, or increases in government subsidies, $\chi$ - leads to a rise in total market purchased services. The effect can be decomposed into three parts: (1) wealthier households consume more market-services, (2) households that work less at home compensate for lost home production by purchasing more market-services, and (3) if the government subsidizes market work, more working women lead to more government demand for market-services. Second, a rise in goods sector productivity leads to relative price changes and more work opportunities for women, which then cycles back to (or reinforces) the three effects above.

Higher taxes dampen female market work and, therefore, market-service consumption. Consequently, higher taxation leads to a smaller service sector, as fewer women participate in the formal labor market and fewer services are marketized. A smaller service sector leads to worse job opportunities for women and, therefore, feeds back into less marketization of services and a smaller service sector. The government can affect the relative sector demands by subsidizing consumption of market-services.

# 5 Calibration

The analytical model from section 3 is extended to the five types of households, including singles, to match the hours data: married couples (in service occupations or not), single men, and single women (in service occupations or not). The model is calibrated to various 1965 US hour targets. Since the model has no intertemporal decisions, eliminating any relevant transitions, the results compare the 1965 and 2010 US economies.

Tax rates are taken from the updated time-series, originally described in McDaniel (2007).

Table 1: *Tax Rates*

| Year | **United States** | **Germany** |
|---|---|---|
| 1960 | 21.4 | 33.0 |
| 2010 | 24.7 | 46.9 |
| $\Delta_{2010-1965}$ | 3.3 | 13.9 |

Counterfactuals in section 6.3 show the impact of higher tax rates on working hours. In order to provide a meaningful comparison with existing literature, the exercises use a German tax rate (around the average for Continental Europe). Therefore, table 1 provides German and US tax rates in 1965 and 2010. Both Europe (here Germany) and the US have seen rising tax rates over time. However, the increase has been much larger for Europe. Average tax rates are computed using both income and consumption tax rates, i.e.,

$$\tau = 1 - \frac{1-\tau_h}{1+\tau_c}, \tag{22}$$

where $\tau_h$ is the sum of average tax on household income and the average payroll tax (paid by both employer and employee), and $\tau_c$ is the average tax on consumption expenditures.

Table 2 lists all parameters used in the simulation. The capital labor share is set to one-third. The parameter governing the elasticity of home- and market-services, $\rho$, and the elasticity between goods and services, $\varepsilon$, are taken from previous studies. Various studies have estimated $\rho$ on microeconomic and macroeconomic data. The resulting elasticities vary from 1.6 to 2.0 by Rupert, Rogerson and Wright (1995), depending on whether households are married, single females or single males, to 2.3 by Chang and Schorfheide (2003). Aguiar and Hurst (2007) find an elasticity of 1.8, which yields a $\rho$ of 0.45 (used in this calibration). Consistent with the literature, the elasticity of goods to services is set to $-0.1$, implying an $\varepsilon$ of $-9.0$. For example, Ngai and Pissarides (2008) argue that price elasticities for the entire service sector are between $-0.3$ and $-0.06$, and Herrendorf, Rogerson and Valentinyi (2013), using value added production functions, find it to be

Table 2: *Parameters*

| Type | Parameters | Value | Source |
|---|---|---|---|
| Prior Values | $\alpha$ | 0.33 | Kaldor (1957) |
| | $\rho$ | 0.45 | Aguiar and Hurst (2007) |
| | $\varepsilon$ | -9.0 | Ngai and Pissarides (2008) |
| | $a_g$ | 0.07 | Rogerson (2008) |
| Estimated | $\gamma_g$ | 2.04 | 10-sector database |
| | $\gamma_s$ | 1.24 | 10-sector database |
| | $\tau_g$ | 0.06 | CPS 1965-2010 |
| | $\tau_{d,t}$ | see figure 3 | CPS 1965-2010 |
| Calibrated | $\psi$ | 0.38 | married men's hours 1965 |
| | $\psi_s$ | 0.58 | single men's hours 1965 |
| | $a_s$ | 0.70 | married women's hours 1965 |
| | $\phi$ | 1.05 | single women's hours 1965 |
| | $\sigma$ | 3.48 | male Frisch elasticity 1965 |
| | $A_{g,1965}$ | 3.16 | service hours share 1965 |
| | $\lambda$ | 1.12 | female service sector share 1965 |

as low as $-0.002$. Given the range of the elasticity, $\varepsilon = -9.0$ is in the middle of this range.

The consumption share on goods, $a_g = 0.07$, is taken from Rogerson (2008), and the productivity in the goods sector, $A_{g,1965}$, is calibrated to match the relative service sector hours worked in 1965. In all other sectors productivity is set to one in 1965, $\{A_{s,1965} = A_{n,1965} = 1\}$, since the remaining consumption share parameters can be adjusted to account for relative productivity differences. Productivity growth rates, $\gamma_j$, where the next period's productivity is $A_{j,t+1} = (1+\gamma_j)A_{j,t}$, are computed using value added statistics by sector from the 10-sector database.

The adjustment parameter, $\lambda$, that women find service sector employment, is set to match the female hours' share in services in 1965. The probability of finding a job varies with time as a function of the service sector size, $\hat{\lambda}_t = \lambda \frac{H_{s,t}}{H_{g,t}+H_{s,t}}$. Women who can only find a goods sector job can always choose to work zero hours. Women's sectoral productivities are taken from section 2. The productivity difference across sectors, $\tau_g = 0.062$, equals the average difference from 1966 to 2010. The remainder of the wage gap in figure 3 is attributed to discrimination $\tau_{d,t}$.

The curvature on leisure, $\sigma$, is set to match a Frisch elasticity of 0.5 for men in 1965. The remaining preference parameters, $\{\psi, \psi_s, a_s, \phi\}$, the weight on leisure for married and single households, the relative taste for market-services, and the curvature on consumption are matched to four gender/marital specific hours targets in 1965. Both married and single men's hours should be informative for the weight on leisure for married and single households, respectively. Married women's hours should be informative on the share parameter of market- versus home-produced services ($a_s$). Lastly, the curvature on consumption can be calibrated to match average hours worked (or single women's hours). All targets are computed using a five-year moving average from CPS data, from 1962 to 2010.

Agents are *ex-ante* homogeneous (by gender). Therefore, simply a fraction of men and women are randomly married. More precisely, using CPS estimates of the fraction of married women aged 25 to 64, 85.7 percent of women (and men) are married in 1965 in the model. The comparable number in 2010 is 63.3 percent.

The model perfectly matches all targets for the US working population aged 25 to 64 (see table 3 for detail).

# 6 Results

The benchmark model does well in matching trends over time. Table 3 reports hours trends.[6] Hours are reported in weekly working hours, and the service-market hour shares are in percentage points.

The model generates four-fifths of the rise in aggregate hours worked, with the remainder missed because the model produces a fall in single men's hours (compared to a small rise in the data). Similarly, the model misses just under one-third of the rise in single women's hours. The results match the trend direction and magnitude for both married men and women. Both married

[6] Hours refer to actual hours, not efficiency-units.

Table 3: *US Time Trend*

| | $h_s/h$ | $h$ | $h^m$ | $h^f$ | $h^m_{sing}$ | $h^m_{marr}$ | $h^f_{sing}$ | $h^f_{marr}$ |
|---|---|---|---|---|---|---|---|---|
| 1965 Data | 58.4* | 24.1 | 36.5 | 11.6 | 28.0* | 38.0* | 20.5* | 10.1* |
| 1965 Model | 58.4* | 24.1 | 36.5 | 11.6 | 28.0* | 38.0* | 20.5* | 10.1* |
| 2010 Data | 76.7 | 29.8 | 34.1 | 25.5 | 29.5 | 36.8 | 27.2 | 24.4 |
| 2010 Model | 68.3 | 28.8 | 33.2 | 24.5 | 27.1 | 36.7 | 25.1 | 24.1 |
| Explained (%) | 54 | 84 | 137 | 93 | -59 | 105 | 68 | 98 |

* calibrated moments

hours are almost matched perfectly. In addition to matching the hour trends, the model generates over half of the rise in relative service employment.

Even with the extreme assumptions of perfect substitutability between male and female time in home production and perfect compliments in leisure made in section 3, the model does well in matching leisure changes in the data. Aguiar and Hurst (2007) report an increase in leisure from 1965 to 2003 of 6.2 hours for men and 4.9 for women. The model generates 41 percent of the increase for men and 51 percent for women. From 1965 to 2010 leisure time increased by 2.6 hours for males and 2.5 hours for females per week within the model.

The Frisch elasticity for men in 1965 is matched perfectly at 0.5, and the resulting elasticity for women is 1.65. In 2010, the elasticities are 0.58 for men and 0.77 for women. Micro estimates for male Frisch elasticities range from 0 to 0.5 for men and 0.5 to 2.2 for women (for a survey on Frisch elasticities see Reichling and Whalen, 2012) bounding the resulting model elasticities within standard estimates. Consistent with Blau and Kahn (2007), who report a fall in married women's elasticity of 50 to 56 percent from 1980 to 2000, the model generates a fall of 57 percent for married women from 1965 to 2010 (1.77 to 0.75).

## 6.1 Decomposition of Trends

What accounts for the time trends in the model? The female labor force participation literature has found changes in the closing gender gap, returns to experience, service employment, and improvements in home technology matter to varying degrees. The results here are aligned with a substantial part of this literature.

Table 4 provides the results of various experiments. Each column reports how much of the rise in the benchmark model is explained (in percentage points) if certain changes from 1965 to 2010 were excluded. For example, the benchmark generates a 9.9 percentage point increase in service employment, which decreases to 2.6 percentage points or 26 percent of the benchmark (see column (1)) when excluding structural change, $\gamma_j = 0$.

Table 4: *Driving Forces*

| | **Structural** (1) | **Gap** (2) | **Labor Market** (3) | **Economy** (4) | **Marriage** (5) | **Taxes** (6) |
|---|---|---|---|---|---|---|
| $h^f$ (%) | 76 | 46 | 32 | -6 | 96 | 107 |
| $h^m$ (%) | 98 | 80 | 76 | 73 | 41 | 86 |
| $h^s$ (%) | 26 | 90 | 82 | -10 | 99 | 103 |

Column (1) shows the importance of exogenous structural change. The experiment reports hour trends by setting $\gamma_g = \gamma_s = 0$. The results of table 4 suggest that structural change can explain a large share of the rise in relative service hours and about one-quarter of the rise in female hours. The result for female hours is similar to Akbulut (2011), who abstracts from women's market productivity using a simplified version of home production, also producing a one-quarter rise in female market hours.

Column (2) removes the closing gender wage gap, $\tau_{d,t} = \tau_{d,1965}$ for all $t$. The closing gender wage gap plays a central role in generating part of the rise in female hours (similar to Jones, Manuelli and McGrattan, 2003). This experiment generates less than half of the rise in female hours. On the flip-side of column (1), the closing gender gap accounts for 10 percent of the rise in service employment. The impact on male hours is larger than in column (1) due to the large effect on female hours and complementarity in leisure.

There are two parts to women's employment opportunities, the general closing of the wage gap and the increasing availability of service sector jobs.[7] Column (3) reports the results when assuming that women in 2010 only have access to industry sector jobs, $\lambda = 0$ or $\tau_s = \tau_g = 0.06$, and the 1965 gender gap prevailed, $\tau_{d,t} = \tau_{d,1965}$. The experiment considers both better opportunities and increases in market wages. The explained female employment drops by an additional 15 percentage points, now explaining just one-third of the rise in female hours. Ngai and Petrongolo (2013) find that gender-biased demand shifts can explain 36 percent of the rise in female market hours. Although the models are not directly comparable, the effects are similar. The effect of productivity differences across service and industry are somewhat smaller, with a 15 percent difference between column (2) and (3). The smaller impact may be explained by the lack of heterogeneity in skills, thus ignoring the reversal of selection bias in women's labor supply across sector and over time. Therefore, some of the drop in column (2) might more correctly be attributed to column (3), if the model allowed for heterogeneity and selection.

Column (4) reports the results for column (1) through (3) together. The experiment now explains none of the rise in female hours and relative sector hours, but still produces a large fall in male hours. Column (5) indicates that the fall in male hours (age 25 to 64) is driven largely by the increase in the share of single households. If marriage rates from the 1965 were applied in 2010, men's hours fall by 41 percent less. In contrast, marital changes have little impact on female hours (and sectoral hours), since married women's hours are similar to single women's hours in 2010.

Lastly, column (6) summarizes the result from the increased taxes between 1965 and 2010. The

[7] Part of the general closing gender wage gap could be due to changing female selection into the labor market with a rise in female-friendly job opportunities.

higher tax rate in 2010 suppresses both female employment and service employment. In contrast, higher taxes increase the hours for men. This outcome is, again, related to the interaction between female and male hours at home.

The effects on female hours and service employment from columns (1), (2), (3) and (6) suggest that female work and market services are closely interlinked, something explored further in the next section.

## 6.2 Women and the Rise of Services

One aim of this study is to understand the importance of rising female labor hours in explaining the size of the service sector. Since the benchmark model does well in matching most labor market changes from 1965 to 2010, and the decomposition of the driving forces is consistent with the wider literature on female work, the model is ideally suited to study the feedback between women and the rise of the service sector.

To assess the contribution of women's labor choices on the service sector, the 2010 economy is solved with different assumptions. Men's labor market choices are unchanged from the benchmark, while three separate scenarios are computed for women. In column (1) of table 5, women's market and home hours are fixed to the 1965 values. This exercise captures the total effect of women having entered the labor market since 2010. In column (2), women's market hours are fixed to 1965 hours, but home hours are left at the 2010 value. This counterfactual captures the importance of increased disposable income due to working wives (the first effect mentioned in section 4) - the income effect. Column (3) does the opposite, setting market hours to 2010 and home hours to 1965 levels, capturing the importance of substituting home-produced services for market-services (the second effect from section 4) - the substitution effect. As $\chi = 0$ for the calibration, the third effect of increased government service demand does not exist here. In each counterfactual, given the constraints on women' hours, the total labor supplied is suboptimal. Nonetheless, a new general equilibrium is solved for in each column, where households re-optimize by choosing $k_g$, $c_g$ and

$c_s$. The suboptimal labor supply also affects women through a lower $\hat{\lambda}$, i.e., a smaller service sector leads to potentially less job opportunities. Each column reports the contribution to the rise in relative service consumption and hours in percentage points for the benchmark economy.

Table 5: *Women and the Rise in Services*

| | **All** (1) | **Income** (2) | **Substitution** (3) |
|---|---|---|---|
| $\Delta h^s$ (%) | 32 | 4 | 26 |
| $\Delta c_s$ (%) | 53 | 10 | 41 |

The counterfactuals reported in table 5 show the sizable impact of women's entry into the labor market on market-service consumption and relative service sector employment (in hours). Changes in women's labor allocation account for slightly under one-third of the change in relative hours from the benchmark and over half of consumption. Given that the benchmark explains 54 percent of the total rise in relative hours worked in the US, column (1) explains 17 percent ($54 \times 32$) of the rise in the data. Most of this effect comes from the substitution of home- to market-services (column (3)). While the effects shown in column (2) are small, columns (1) and (3) closely match. The remainder of the difference between column (2) plus (3) and column (1) is explained by the interaction of the income and substitution effect.

## 6.3 Higher Taxes

Prescott (2004) first suggested that higher taxes could explain differences in hours worked between the US and Europe. His original analysis, using a representative single agent model, relied on larger Frisch elasticities to explain cross-country differences. Including secondary worker decisions, the modified model presented here does well in matching trends in hours for the US over time with Frisch elasticities falling within micro estimates. Using the benchmark, this counterfactual tests the implication of German taxes on hours worked in the US. The model predicts that higher taxes result in fewer hours worked, fewer women in the labor market and a smaller service sector. The US benchmark with German taxes would generate even lower hours worked compared to actual German data in 2010. Table 6 summarizes the results on hours of work, the relative service sector would have been 25 percent smaller in 2010 than in the benchmark.

Table 6: *United States with High Taxes*

| | | $h$ | $h^m$ | $h^f$ |
|---|---|---|---|---|
| 2010 Benchmark | (1) | 28.8 | 33.1 | 24.5 |
| 2010 DEU Taxes | (2) | 23.0 | 29.5 | 16.4 |
| 2010 Model Germany rel. US (%) | (3) | 80 | 89 | 67 |
| 2010 Data Germany rel. US (%) | (4) | 87 | 92 | 79 |
| Explained (%) | | 108 | 104 | 115 |

Row (1) restates the benchmark results. Row (2) shows the results for this counterfactual and row (3) shows row (2) over row (1). Hours worked drops for all individuals, particularly for women, with total hours worked 20 percentage points lower than in the benchmark. Row (4) provides the corresponding data value for Germany relative to the US in 2010. The model over-predicts the fall in total hours by 8 percentage points. The largest discrepancy between model and data exists for women, where the model overstates the difference by 15 percentage points. Of course, Germany and the US also have different marriage rates, fertility rates, etc. The goal of this exercise is only to show the impact of taxes in a model with two-person households, and not to fully explore the differences in hours worked between Germany and the US. The results are estimated with a standard Frisch elasticity of labor consistent with micro estimates.[8]

[8] Olovsson (2009) also generates hours differences between the United States and Sweden with a Frisch elasticity of 0.5. However, he does not explicitly model or study women's labor market choices.

## 6.4 Subsidies

Scandinavia and Continental Europe have similar average tax rates, but France and the Nordic countries tend to have much larger service sectors and female employment. In addition, these countries also tend to provide more childcare subsidies, longer maternity leave, after-school programs, etc.[9]

What if the US implemented higher European-style taxes, but incentivized women to enter the labor market by tying service provision to work, $\chi > 0$? That is, the subsidy $\chi$ is calibrated such that the hours of women who receive the subsidy are equal to the corresponding hours from the benchmark. Given the government budget constraint (equation (14)), an increase in $\chi$, without changing tax rates, is financed through a smaller rebate, $T$.

Keeping the preference parameters as before, table 7 provides welfare gains and losses in terms of market consumption equivalence. That is, the table reports how much more market-services and goods, in percentage points, a household requires to remain indifferent between a Scandinavian-style economy and the benchmark. Since government provided services might disproportionately go to households with children, the experiment is reported both if all women would benefit from the scheme, row (1), and if only half of the women (young) would benefit, row (2) and (3). Row (4) provides the average for this second experiment, by household type. Average welfare losses, the last column, account for the rising employment opportunities for women (household composition), as the service sector grows. For the results in row (2)-(4), $\chi$ is calibrated to generate only hours worked for young women equal to the benchmark.

For row (1), $\chi = 0.11$, which translates into the government providing 9.0 percent of all market-services consumed. For rows (2) and (3), $\chi = 0.12$ is equivalent to 5.2 percent of service consumption. Given that taxes are distortionary, both experiments show welfare losses, on average. Single men have the largest welfare losses, ranging from 17 to 20 percent, as they receive none of the benefits and only receive part of a lump-sum rebate. This is followed by married households. In

[9] See Domeij and Klein (2012) and OECD (2007) for details.

Table 7: *Welfare Costs: United States*

| | | $h^{s}_{Marr}$ | $h^{g}_{Marr}$ | $h^{m}_{Sing}$ | $h^{f,s}_{Sing}$ | $h^{f,g}_{Sing}$ | **Average** |
|---|---|---|---|---|---|---|---|
| All (%) | (1) | 12.7 | 13.0 | 20.2 | 0.2 | -0.2 | 7.8 |
| Young (%) | (2) | 9.3 | 9.6 | 16.9 | -3.7 | -4.2 | 5.4 |
| Old (%) | (3) | 17.6 | 17.7 | 16.9 | 13.3 | 12.9 | 11.1 |
| Total (%) | (4) | 13.5 | 13.6 | 16.9 | 4.8 | 4.4 | 8.2 |

these households, if women do not want to work more, they can rely on their husband's income. Ergo, the tax distortions are exacerbated. Single women (young) are the only beneficiaries. These women must work regardless of the job opportunities they face. However, row (4) shows welfare losses, even for single women, over the life-cycle of households (averaging young and old). Of course, the model does not account for returns to experience or habit formation if these young women enter the labor market. Thus, the average losses for single women could potentially turn into gains in a model with work experience.[10]

These results suggest that higher taxes may be beneficial if they allow for policies targeted specifically at young single mothers. However, higher tax rates harm all other households, including dual-parent household, as they incur large welfare losses over the life-cycle. Therefore, effective policies must be small and well targeted.

# 7 Conclusion

This paper uses a standard multi-sector model with two major modifications: (1) households are either two-member households or single, and (2) men and women differ in their productivity across sectors. The model does well in accounting for trends in the labor market over time, which makes

[10]For example, Guner, Kaygusuz and Ventura (2013) find that while poor household see welfare gains from fully subsidized childcare other households loose.

the model suitable to measure the feedback effect of women entering the labor market on the size of the service economy. The resulting estimates are non-negligible, with US women accounting for roughly one-third of the growth in relative service hours and half of the growth in relative service consumption. The majority of the feedback effect comes from women entering the work force and shifting consumption from the home to the market, i.e., requiring childcare services, restaurant meals, etc.

Decomposing the driving forces underpinning the model suggests that women have benefited more from structural change. Consequently, women have seen a decreasing wage gap and improved job opportunities through a larger service sector. Men's labor hours have mostly reacted to a fall in the marriage rate and the slight increase in taxes.

In addition, the model is able to capture cross-country differences in employment due to taxes. This allows for welfare experiments comparing economies with high taxes and government service provisions with economies offering low taxes without service provisions. While there are welfare benefits for some parts of the population (i.e., single mothers), the welfare cost from high taxes outweigh the benefits. This suggests that policies targeting certain groups may be welfare improving for society, but must not significantly raise taxes.

While this study includes some simplifying assumptions (e.g., abstracting from individual heterogeneity in human capital and skills), it fills a significant gap in the current literature between taxation, structural change, and women's work.

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# A Mathematical Appendix: Household Optimality Conditions

Married households optimize by choosing $\{c_g, k_g, c_s, n, \ell\}$ each period. The first order conditions used to derive the analytical results in section 4, derived from maximizing equation (1) subject to the constraints (2) – (6), are provided below. The derivations below use the binding constraints,

$$\begin{aligned} \ell &= \ell^f = \ell^m, \\ n &= 1 - \ell - h^f, \\ h^m &= 1 - \ell \end{aligned}$$

and

$$k_g = \frac{(1-\tau)(\omega^m h^m + \omega^f h^f) + T - p_g c_g + p_s c_s}{p_g}. \tag{A.1}$$

For a given $\ell$, the first order condition with respect to home hours $n$ is,

$$(1-a_s)(1-\alpha)\frac{c_n}{n}c_n^{\rho-1} = (1-a_s)\alpha\frac{\omega^f}{p_g}\frac{c_n}{k_g}c_n^{\rho-1} + a_s\chi(c_s+\chi h^f)^{\rho-1}. \tag{A.2}$$

The first order condition with respect to market-service consumption $c_s$ is,

$$a_s(c_s+\chi h^f)^{\rho-1} = (1-a_s)\alpha\frac{p_s}{p_g}\frac{c_n}{k_g}c_n^{\rho-1}, \tag{A.3}$$

and with respect to goods consumption $c_g$ is,

$$a_g c_g^{\varepsilon-1} = (1-a_g)(1-a_s)\alpha\frac{c_n}{k_g}c_n^{\rho-1}F(\hat{c}_s, c_n)^{\varepsilon-\rho}. \tag{A.4}$$

Combining equations (A.2) and (A.3) yields equation (15), the relative home production goods purchase to hours at home relationship. Equations (15) and (A.3) yield the market service to home hours relationship of equation (16). The relative goods to service consumption of equation (16) follows from equations (17) and (A.4).

Given consumption bundles conditional on leisure, the household maximizes total utility by setting leisure time, $\ell$. Using the results and notation from section 4, and equation ($A$.1), hours worked at home are,

$$n = \frac{(1-\ell)\left((1-\tau)(\omega^m h^m + \omega^f h^f) + \chi p_s\right) + T}{p_g(\Omega_n + \Omega_g\Omega_s) + p_s(\Omega_s + \chi)}. \tag{A.5}$$

Define $\Omega = p_g\left(\Omega_n + \Omega_g\Omega_s\right) + p_s\left(\Omega_s + \chi\right)$, $I = (1-\tau)(\omega^m h^m + \omega^f h^f) + \chi p_s$ and the composite consumption good as functions of results in section 4 relative to home hours,

$$\begin{aligned}\hat{C} &= \frac{C(\Omega_g, \Omega_s, \Omega_n)}{n} \\ &= \left(a_g\left(\Omega_g\Omega_s\right)^{\varepsilon} + (1-a_g)\left(a_s\left(\Omega_s\right)^{\rho} + (1-a_s)\left(a_n\Omega_n^{\theta} + (1-a_n)\right)^{\frac{\rho}{\theta}}\right)^{\frac{\varepsilon}{\rho}}\right)^{\frac{1}{\varepsilon}}.\end{aligned}$$

The leisure allocation solves,

$$\left[(1-\ell)\left(\Omega - I - T\right)\right]^{-\phi}\left(\Omega - I\right)\left(\frac{\hat{C}}{\Omega}\right)^{1-\phi} = \psi\ell^{-\sigma}. \tag{A.6}$$