The Service Sector and Female Market Work: Europe vs US*

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[PRELIMINARY and INCOMPLETE]

ABSTRACT

Aggregate market hours differ dramatically across OECD countries. However, disaggregated by sex differences in market hours do not necessarily match aggregate market hour differences. Continental Europe has seen a smaller rise in formal female employment compared with the United States or Scandinavia. Additionally, Continental Europe has a substantially smaller service sector. These facts coincide with job requirements shifting from physical strength to intellectual abilities. This paper gives empirical evidence on why women predominately work in the service sector. Given the empirical evidence, a model where technical change favoring women, by increasing the service sector, drives female employment is developed. The key is households can produce a substitute for market services and women are, on average, less productive in sectors requiring more brawn, giving them a comparative advantage with respect to staying home and working in the service sector. Therefore, an economy that does not facilitate the movement of women into the labor market, by imposing high taxes, causes service production to remain at home. This reduces the demand for market services, which feeds back into low total hours worked by women (and the total economy). Subsidies to female employment can circumvent the high tax effect, but will lead to welfare loses.

JEL classification: E21, E24, J20.
Keywords: technological progress, sectoral labor allocation, cross-country differences, female labor supply, labor demand/supply, taxation.

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1 Introduction

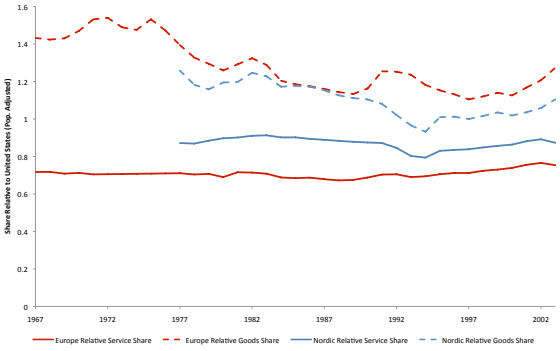
A vast literature exists analyzing cross-country differences of hours worked in OECD countries since 1960. The most common forces attributed to cross-country hours worked discrepancies are taxation differences (Prescott, 2004), productivity differences (Rogerson, 2008), and the substitution of market to home production (Ragan, 2006; Rogerson, 2008). All prior research models the household as a single representative agent. However, McDaniel (2010) finds, analyzing time-use survey data across developed countries, that changes in market work and home production vary to a great extend when disaggregated by sex. One of the greatest phenomena of the 20th century has been the rise in female labor force participation. However, this phenomena has not been uniform, with Continental Europe experiencing a smaller rise in formal female employment compared with the United States or the Nordic countries.[1] The goal of this paper is to quantify the importance of changes in female employment and cross-country differences in aggregate hours worked, by introducing a household unit, consistent of either a single agent or a married couple, rather than focusing on the representative agent. Moreover, to explain the large cross-country female employment differences and its correlation with the service sector size empirical evidence giving weight to a demand side (technology) story is provided. As with prior research, the model will quantify the importance of taxation and productivity in explaining aggregate hours worked.

Income taxation has decreased in the United States since the 1960s leading to more market work and less hours in home production. Continental Europe has seen an increase in tax rates, shifting hours from the market to the home. Lastly, Scandinavia has high taxes, but subsidizes market services such as childcare, elderly care etc. Moreover, some of the subsidies in Scandinavia are specifically target at mothers, with generous maternity leaves, and comprehensive childcare.

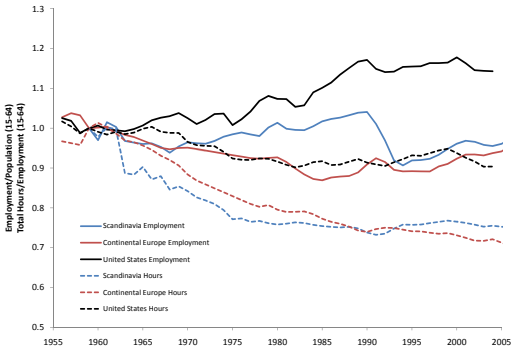
In productivity differences, Continental Europe has a substantially smaller service sector. The correlation between relative female employment change and aggregate service employment is around 0.82 from the 1980s onward for a large set of OECD countries (Rogerson, 2005). In addition, Rogerson (2008) finds that when comparing aggregate employment between the United States and Europe, most of this discrepancy is accounted for by differences in service sector employment. While there are small employment differentials in industry (slightly positive), Europe has an employment differential in services of -9.4 percent in 1950s and -15.5 percent in 2000 compared to the United States. Rendall (2010) provides empirical results for the United Sates showing that job requirements have shifted away from physical attributes toward intellectual attributes since WWII, benefiting women through greater job opportunities, higher wages and increasing returns to education. Moreover, women in the United States have always worked in occupations with relatively low physical requirements compared to men. While some of the demand shift favoring women is related to job requirements changing intra-occupation, a large portion of the decrease in physical requirements is due to a shift toward services, and away from heavy manufacturing, agriculture and mining.

[1] Given data availability, this study defines Continental Europe as France, Germany and Italy, and Scandinavia is defined as Denmark, Finland, Norway and Sweden.

Figure 1: Employment Across Countries



(a) Relative Employment in Continental Europe and Scandinavia



(b) Hours and Employment Evolution

This study develops a general equilibrium model based on the following three facts of labor supply and sectoral labor allocation across Europe and the United States.

1. Women's labor force participation rose from about 40 to 72 percent from 1960 to 2005. Continental Europe and Scandinavia have seen a similar trend over time. However, Continental Europe's female employment has consistently stayed at 80 percent of the United States, while Scandinavia and the United States have been mostly on par, with Scandinavia having slightly higher employment levels in the late 1960s, early 1970s.

2. Service sector employment in the two regions remained constant compared to the United States (see figure 1).

3. Differences in total employment have come from a falling goods sector's (industry and agricultural sector) employment share relative to the United States (see Rogerson, 2008).

The paper summarizes empirical evidence from the United States for the labor requirements, and their evolution, over time across sectors and gender. Given the empirical evidence, a general equilibrium model is developed to understand the evolution of female employment and their rise in the service sector. On the demand side, production is modeled as aggregate constant elasticity of substitution (CES) functions for each sector, industry and services, where brain and brawn are the demand inputs as in Guvenen and Kuruscu (2009). 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 goods/services. The model has two key assumptions, similar to Rogerson (2008), households can produce a substitute for market produced services (e.g., childcare, elderly care, meals) using home production technology and labor time.

Second, given United States estimates, it is assumed that the service sector requires less brawn than the industrial sector, and that men and women have the same brain levels, but women have less brawn. Therefore, women generally prefer working in the service economy where occupations do not require much physical strength or have adverse working environments. A rise in the service sector is synonymous with a shift in labor factors away from brawn, as similarly suggested by Galor and Weil (1996), which leads to an improvement in women's labor market outcomes, i.e., higher wages.

From the features of sectoral production, home substitution and women's comparative advantage, a rich set of dynamics capable of generating both a convergence in female and male labor market outcomes, and a rise in the service sector are presented. That is, an economy that does not initially facilitate the movement of women into the labor market, by, for example, imposing high taxes without the social benefits tied to working women in Scandinavia (e.g., subsidized full-day child care, elderly care) causes the production of services to remain in the home. As a result, women do not enter the workforce and the growth of the service sector outside the home is considerably slowed. However, in the Nordic system, women enter the labor market through a tax-subsidy distortion, leading to welfare losses compared to the United States.

The model is calibrated to match the evolution of female employment in the United States from 1950 to 2000. First, we quantify how much of the rise in female employment can account for the rise in the service sector and how important are differences in labor demand inputs, brain and brawn across sectors. Using the calibrated economy of the United States, we can analyze what would have happened if taxes where at the level of Continental Europe. I.e., how much would female employment have grown? How large would the service sector be? Furthermore, in the context of the model, we study the differences between the United States (low taxes) and the Nordic system (high taxes and subsidized market services) with respect to social welfare loses, by setting a subsidy to services which is tied to women's labor force participation that matches female employment levels in the United States.

While the model abstracts from other factors explaining the rise in female employment (e.g., improvements in home technology (see Greenwood and Guner, 2009)) and growth (e.g., capital-skill complementarity, education), the exercise is useful for various reasons. This research expands on the literature accounting for the differences in aggregate labor between Europe and the United States over the last 40-50 years. Prescott (2004) and Rogerson (2006) show that taxes can account for a large fraction of differences in changes of hours worked between the two regions. Here adding a mostly ignored fact in the study of labor market differences between Europe and the United States, i.e., female employment, a more accurate picture of the importance of taxes is presented. Second, it furthers the discussion on why some countries have not developed a large service sector. Rogerson (2008) shows that taxes and technology can account for the difference in both hours worked and in sectoral labor allocations, with a substantially lower service sector in Continental Europe. Rogerson (2007) also explains the large service sector in Scandinavia. Albeit high tax rates substantial subsidies to services, such as childcare, elderly care, etc, can lead to a large service sector with low total hours worked. Lastly, this study highlights the differences that have pushed women

into the labor market, contrasting the United States and Scandinavia and their taxation policies' associated welfare loses. Most of the literature that seeks to account for the rise in female labor force participation has focused on supply driven stories, i.e. improvements in home technology, such as the invention and marketization of household appliances (see, for example, Greenwood et al., 2002, and references therein), or the improvements in baby formulas (see Albanesi and Olivetti, 2006), rising female wages (see Jones et al., 2003) and returns to experience (see Olivetti, 2006), or the effects of cultural, social, and intergenerational learning on labor supply (see Fernández, 2007; Fogli and Veldkamp, 2007). Here, the rise in female labor force participation is instead the result of a change in the demand of labor requirements, in the spirit of Galor and Weil (1996) or Rendall (2010).

As labor demand changes are one of the key motivation for this study, Section 2 provides further evidence for the changing labor market, focusing on the evolution of physical and intellectual job requirements in the United States and women's self-selection into low-strength jobs. The general equilibrium model is outlined in Section 3, and Section 4 provides analytical results of productivity growth in industry on labor demand, labor supply, wages, and sectoral labor shares. Section 5 discusses the estimation and calibration procedure, and Section 6 presents labor market trends across regions resulting from differences in taxation and work subsidies. Lastly, Section 7 concludes.

2 Labor Market Requirements

To explore the relationship between the rise in the service sector, female labor force participation and changes in labor demand, this study focuses on the relative demand and supply of two types of labor inputs: intellect and physical abilities. We start from the premise that women have, on average, less brawn than men. Accepting that women and men have similar levels of brain, men have a comparative advantage in brawn-intensive occupations. However, technological change shifts labor demand toward low-brawn occupations, diminishing men's comparative advantage in the labor market.

In a related paper (see for details Rendall, 2010), job characteristics by United States 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 reduced with principle component analysis to summarize aggregate labor market requirements. The 1977 and 1991 DOT were developed by the United States 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 worked aptitudes; (4) temperaments or adaptability requirements; (5) physical strength requirements; and (6) environmental conditions. For example, general educational development measures the formal and informal educational attainment required to preform a job effectively by rating reasoning, language and mathematical development. Each reported level is primarily based on curricula taught in the United States, where the highest mathematical level is advanced calculus, and the lowest level only requires basic operations, such as adding and subtracting two-digit numbers. Specific vocational preparation is measured

in the number of years a typical employee requires to learn the job tasks essential to perform at an average level. Eleven aptitudes required of a worker (e.g., general intelligence, motor coordination, numerical ability) are rated on a five point scale, with the first point/level equivalent to the top ten percent of the population and the fifth level compromising the bottom ten percent of the population. Ten temperaments required of a worker are reported in the DOT, where the temperament type is reported without any numerical rating. An example of a temperament is the ability to influence people in their opinions or judgments. Physical requirements include a measure of strength required on the job, rated on a five point scale from sedentary to very heavy, and the presence or absence of tasks such as climbing, reaching, or kneeling. Lastly, environmental conditions measure occupational exposure (presence or absence) to environmental conditions, such as extreme heat, cold and noise.

Factor analysis or principal component analysis, similarly to Ingram and Neumann (2006), reduces the dimensionality of DOT job characteristics. That is, using principal component analysis, a linear relationship between normally distributed broad skill categories and the DOT characteristics is estimated from the associated correlation matrix. Using maximum likelihood estimation methods, three factors, brain, brawn and motor coordination, are determined sufficient in capturing the information contained in the 1977 and 1991 DOT characteristics. This study focuses on the first two factors, brain and brawn, as the coordination factor remains steady over time and has little cross-gender difference. Each factor includes the job characteristics outlined in Table 1.[2] For additional detail on the estimation procedure and the resulting factor loadings see Rendall (2010).

Table 1: *Factor Composition*

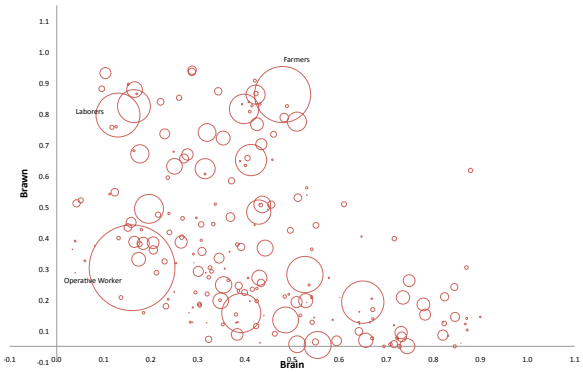
Brain	**Brawn**	**Motor Skills**
Reasoning Development	Climbing/Balancing	Motor Coordination
Mathematical Development	Stooping/Kneeling/	Finger Dexterity
Language Development	Crouching/Crawling	Manual Dexterity
Specific Vocational Preparation	Strength Requirement	Seeing
General Intelligence	Indoor or Outdoor Work	Spatial Aptitude
Verbal Aptitude	Environmental Exposure	Form Perception
Numerical Aptitude		Reaching/Handling/
Clerical Aptitude		Fingering/Feeling
Talking and Hearing		

The aggregate factors are merged with the 1960 United States Census data and the 1968 to 2005 Current Population Survey (CPS) data to compute trends over time.[3] Figure 2,

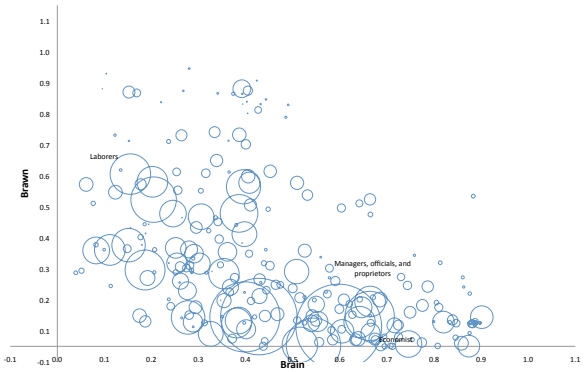
[2]See also Schoellman (2009) for a similar use of principal component analysis on DOT data.

[3]Census and CPS data is obtained from the IPUMS-USA (Ruggles et al., 2010) and the IPUMS-CPS project (King et al., 2010). The IPUMS projects provide a consistent 1950 United States Census classification of occupations and industries over the years, which is used in merging 1977 DOT and 1991 DOT brain and brawn factors.

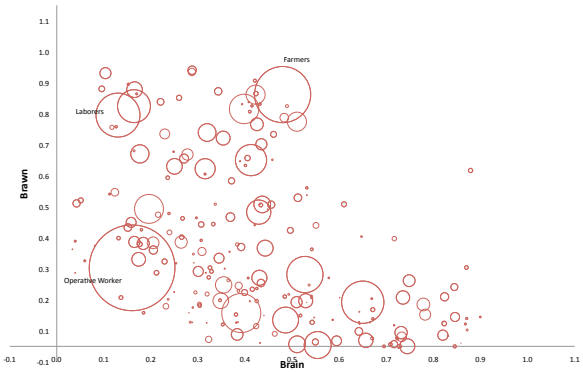
Figure 2: Occupation Factor Requirements by Sector



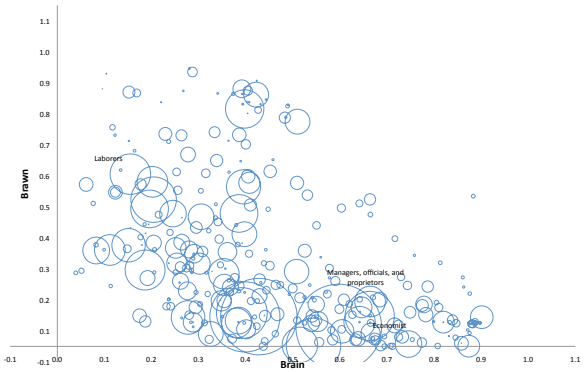
(a) Industry 1960



(b) Services 1960



(c) Industry 2005

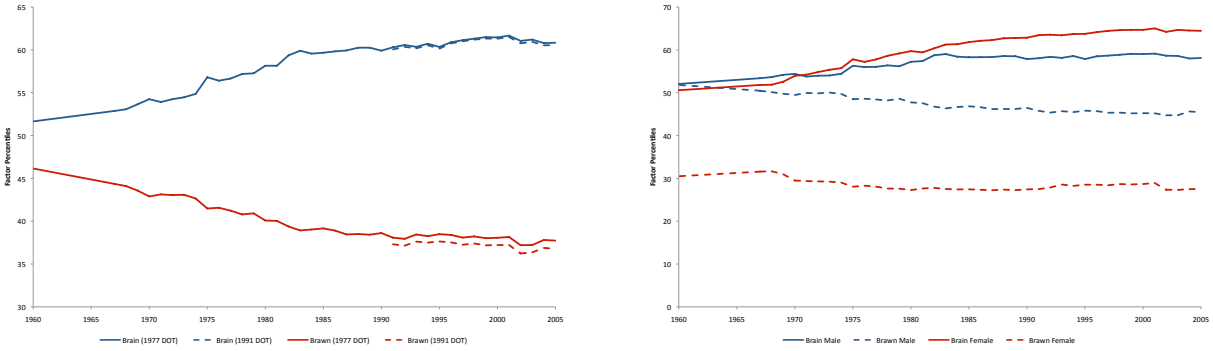


(d) Services 2005

which plots all 1977 occupational brain and brawn combinations by sector in 1960 and all 1991 combinations in 2005, clearly depicts the difference in brain and brawn requirements across sectors, but the similarities over time within sectors. Figure 3 depicts brain and brawn averages in the economy and by gender over time. To compute aggregate factor demand changes in the United States over time, occupation-industry factor estimates are aggregated using United States Census and CPS civilian labor force weights.[4] Since factors following principal component analysis have no natural scale, factors from the principal component analysis are normalized, following Autor et al. (2003), to percentiles of the 1950 US factor distributions. This scaling is done for both the 1977 and 1991 DOT factors to allow for consistent comparisons overtime. That is, factors are assigned a percentile rank for the United States using 1950 Census population weights of individuals aged 15 to 65. All factors have, therefore, mean 50 in 1950 for the United States. Note that using a single

[4]For the 1991 DOT only a merge on occupations , not industries is possible

Figure 3: Average Factor Requirements



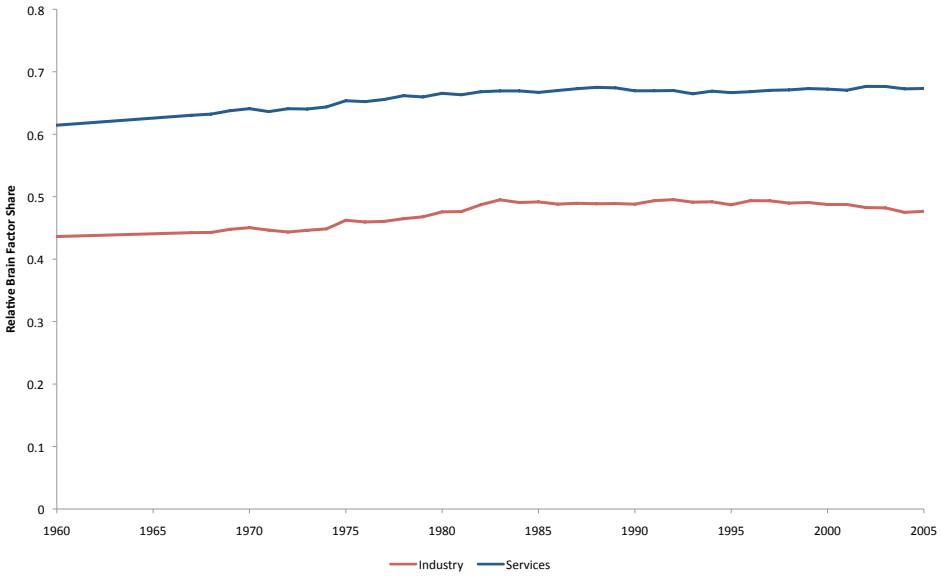
(a) Average Factors

(b) Factors by Gender

DOT survey to determine job requirements implies that the specific job factor requirements did not change over the last five decades. The second approach is to exploit the changes between the 1977 and 1991 DOT for occupations present in both datasets. That is, while the first approach only accounts for changes in the occupation/industry distribution over time, labeled the "extensive" margin by Autor et al. (2003), the second approach additionally allows for changes in job requirements within occupation, or the "intensive" margin. The first graph depicts both the extensive margins and intensive margin (dashed line from 1991 onward). Most of the change in brain and brawn has occurred on the extensive margin. The graph on the right, shows the selection of women into occupations with low brawn requirements. Figure 4 depicts relative brain factor shares by sector, i.e., $\frac{Brain}{Brain+Brawn}$. While both sectors have gained in occupations with brain requirements, the relative brain share has been virtually constant across sectors. Additionally, the service sector has always had a low level of brawn requirement. Given the steady share, we assume each brain share constant within sectors throughout the study. Given women's lower innate brawn levels, this bias toward low brawn occupations can be either due to employee self-selection or employer "discrimination." Goldin (1990) observes that as far back as the 1920s/1930s women made work choices based on the level of brawn required.

> 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)

Figure 4: *Relative Brain Factor Share by Sector*



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This evidence gives strong support to the hypothesis of productivity differences across sector employment rather than overall labor market discrimination.

Given the above facts, a general equilibrium model, concentrating on the service sector and female employment is presented in the following section.

3 General Equilibrium Model

The simulated economy consists of a representative married household, composed of a man and a woman[5]; two competitive production sectors, industry and services; and a government.

3.1 Technology and Preferences

Government

The government, who solves a balanced budget, taxes individuals labor income at rate, τ (yielding the underlying cross-country differences over time). Tax revenues are rebated to

[5]The rise in labor force participation was considerably greater for married women, the analytical model focuses on only married households. Adding single households does not provided further dynamics to the model, not affecting any of the qualitative results. The simulation results will add single household to match the quantitative targets.

households as a lump-sum transfer, T, price subsidizes on market services, v, and/or rebates for service goods indexed to women's labor supply as in Ragan (2006), ϕ.

$$\tau(w_t^m h_t^m + w_t^f h_t^f) = T_t + v p_{st} c_{st} + \phi h_t^f, \tag{1}$$

where w_t^m, w_t^f are male and female wage detailed below and h_t^m, h_t^f are the respective labor supplies.

Production

The competitive sectors combine two aggregate inputs, brain and brawn, $\{B, R\}$, supplied by households, in a CES production function to produce final goods/services, $\{Y_i, Y_s\}$. By assumption the production of industrial goods is more efficient in using brawn inputs (requires more brawn) than the service sector. Each production process uses all inputs supplied, brain B_j and brawn R_j, which are the aggregated individual labor supplies of brain and brawn for sector j. The final sectoral output is,

$$Y_{jt} = A_{jt}\left[\alpha_j B_{jt}^{\rho} + (1-\alpha_j) R_{jt}^{\rho}\right]^{\frac{1}{\rho}} \quad \text{for } j = i, s, \tag{2}$$

where α_j is the factor share of brain inputs; $\epsilon_\phi = \frac{1}{1-\phi}$ is the elasticity of substitution between the two inputs; A_{jt} is total factor productivity and B_{jt}, R_{jt} are aggregate factor supplies for each sector j. By assumption on brawn-intensity across sectors, $\alpha_s > \alpha_i$. Therefore, firms maximize by choosing brain and brawn factor demands,

$$\max_{B_{jt}^d, R_{jt}^d} p_{jt} Y_{jt} - w_{jbt} B_{jt}^d - w_{jrt} R_{jt}^d \tag{3}$$

Household Preferences

Household members are indexed with the superscripts $g \in \{f, m\}$ for their gender. The only difference between genders is the lower innate brawn levels of women. Without loss of generality, innate intellectual abilities, $b^m = b^f \equiv 1$, and innate brawn $r^m \equiv 1 > r^f \equiv (1-\tau_r)$, are normalized. There is no bargaining in the households and the households solves a unitary utility $u(C, L)$, by allocating the labor time of both agents to the market, home production, and leisure; purchasing industry goods, c_i, and services, c_s, in the market, and producing home produced service substitutes at home, c_n.

$$\max_{\{c_{it}, c_{st}, h_t^m, h_t^f, n_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t a_c \log(C_t) + (1-a_c)\log(L_t) \tag{4}$$

s.t.

$$\begin{aligned}
p_{it} c_{it} + (1-v) p_{st} c_{st} &= (1-\tau)(w_t^m h_t^m + w_t^f h_t^f) + T_t, && (5)\\
1 &= h_t^m + n_t^m + \ell_t^m, && (6)\\
1 &= h_t^f + n_t^f + \ell_t^f, && (7)\\
n_t &= n_t^m + n_t^f, && (8)
\end{aligned}$$

where C is the consumption composite of services and goods (suppressing time subscripts), i.e.,

$$C = (a_i c_i^{\epsilon} + (1 - a_i) F(\hat{c}_s, c_n)^{\epsilon})^{\frac{1}{\epsilon}}, \tag{9}$$

where $F(\hat{c}_s, c_n)$ is the service composite, i.e.,

$$F(\hat{c}_s, c_n) = \left(a_c \left(c_s + \phi h^f\right)^{\eta} + (1 - a_c) c_n^{\eta}\right)^{\frac{1}{\eta}}, \tag{10}$$

where $\hat{c}_s = c_s + \phi h^f$ are the total market purchased services, both privately and rebated by the government for female hours worked. Home production is linear in labor $c_n = A_n n$. Lastly, leisure is assumed to be Leontief, i.e., husband and wife prefer spending time together when not engaged in work $L = \min\{1 - h^m - n^m, 1 - h^f - n^f\}$, which implies that leisure $\ell^m = \ell^f \equiv \ell$.[6]

Wages

Since individuals supply both brain and brawn in fixed quantities when they work, and sectors use these inputs in different quantities, there are four wage rates, $\{w_{ibt}, w_{irt}, w_{sbt}, w_{srt}\}$. Thus, an individual that works h_{jt}^g fraction of time in sector j will earn a wage $w_{jt}^g = w_{ibt} b^g + w_{irt} r^g$. Note, due to free mobility of labor, individuals will allocate to the sector where they can earn higher wages. Therefore, if a man works in both sectors, his wage is $w_t^m = w_{ibt} + w_{irt} = w_{sbt} + w_{srt}$, given assumptions on brain and brawn above. As a consequence, with the assumption on α_j and r^f, women will work only in the service sector and earn a wage $w_t^f = w_{sbt} + w_{srt}(1 - \tau_r)$. Similarly, if women work in both sectors, their wage is $w_t^f = w_{ibt} + w_{irt}(1 - \tau_r) = w_{sbt} + w_{srt}(1 - \tau_r)$ and male wages are $w_t^m = w_{ibt} + w_{irt}$. Therefore, men and women's wages are,

$$\begin{aligned} w_t^m &= w_{ibt} + w_{irt}, \text{ and} \\ w_t^f &= w_{sbt} + w_{srt}(1 - \tau_r). \end{aligned} \tag{11}$$

In addition, total factor supply by sectors is then, if men work in both sectors,

$$\begin{aligned} B_{it}^s &= h_{it}^m, \\ R_{it}^s &= h_{it}^m, \\ B_{st}^s &= h_t^m - h_{it}^m + h_t^f, \text{ and} \\ R_{st}^s &= h_t^m - h_{it}^m + h_t^f (1 - \tau_r) \end{aligned} \tag{12}$$

or, if women work in both sectors,

$$\begin{aligned} B_{it}^s &= h_t^m + h_{it}^f, \\ R_{it}^s &= h_t^m + h_{it}^f (1 - \tau_r), \\ B_{st}^s &= h_t^f - h_{it}^f, \text{ and} \\ R_{st}^s &= \left(h_t^f - h_{it}^f\right)(1 - \tau_r) \end{aligned} \tag{13}$$

[6]The single household problem is identical, expect for leisure, where leisure is enjoyed by the single agent alone.

Decentralized Equilibrium

An equilibrium, given wages $\{w_{ibt}, w_{irt}, w_{sbt}, w_{srt}\}$, market prices $\{p_{it}, p_{st}\}$, and government prices $\{\tau, v, \phi\}$, consists of the time path of households' allocation $\{c_{it}, c_{st}, h_t^m, h_t^f, n_t\}$, firm factor demands $\{B_{it}^d, R_{it}^d, B_{st}^d, R_{st}^d\}$, output $\{Y_{it}, Y_{st}\}$ and government allocation $\{T_t\}$ such that for all t:

1. $\{c_{it}, c_{st}, h_t^m, h_t^f, n_t\}$ solves the Household Problem (4);
2. $\{B_{it}^d, R_{it}^d, B_{st}^d, R_{st}^d\}$ solves the firm problem (3);
3. $\{T_t\}$ solves the government problem (1);
4. Markets clear, with
   a The labor market, $B_{jt}^s = B_{jt}^d$ and $R_{jt}^s = R_{jt}^d$ for $j = i, s$; and
   b The goods market, $c_{jt} = Y_{jt}$ for all $j = i, s$.

3.2 Analytical Results

The firm's problem is straight forward, but will be useful in the discussion of the household's problem. Therefore, we start with the firm's problem.

Firm Optimization

From the firms optimization of (3), one can obtain prices for the two final products as well as factor demands for both sectors. The relative wage rates are,

$$\frac{w_{jbt}}{w_{jrt}} = \frac{\alpha_j}{1-\alpha_j}\left(\frac{B_{jt}}{R_{jt}}\right)^{\rho-1}. \tag{14}$$

Per unit of production factor demands resulting from the relative wage equation and the production function are,

$$\frac{B_{jt}}{Y_{jt}} = \frac{1}{A_{jt}}\left(\frac{\alpha_j}{w_{jbt}}\right)^{\frac{1}{1-\rho}}\left[\alpha_j^{\frac{1}{1-\rho}} w_{jbt}^{\frac{-\rho}{1-\rho}} + (1-\alpha_j)^{\frac{1}{1-\rho}} w_{jrt}^{\frac{-\rho}{1-\rho}}\right]^{\frac{-1}{\rho}} \text{ for } j = i, s, \tag{15}$$

and similarly for R_{jt}. Using the per unit factor demands, one can obtain the price of the final good $j = i, s$, $p_{jt} = w_{jbt}\frac{B_{jt}}{Y_{jt}} + w_{jrt}\frac{R_{jt}}{Y_{jt}}$, or,

$$\Rightarrow p_{jt} = \frac{1}{A_{jt}}\left[\alpha_j^{\frac{1}{1-\rho}} w_{jbt}^{\frac{-\rho}{1-\rho}} + (1-\alpha_j)^{\frac{1}{1-\rho}} w_{jrt}^{\frac{-\rho}{1-\rho}}\right]^{\frac{\rho-1}{\rho}}. \tag{16}$$

Technical change in terms of total factor productivity, i.e. a rise in $\frac{A_{it}}{A_{st}}$, leads to a fall in relative goods to service prices. In terms of per unit factor demands, a rise in A_{it} leads to a fall in the demand of both inputs per unit of output. If brain and brawn inputs in production are gross substitutes, $0 < \rho < 1$, relative brain wages should be higher in the service sector.

Household Optimization

For a household, the problem is in the same vein as Ngai and Pissarides (2008). Specifically, the household problem can be solved in steps. The household solves three intertemporal choices, starting at the service consumption decision, proceeding to the goods consumption decision, and ending with the leisure decision. Since men are born with more brawn, they have a comparative advantage in the labor market. Household members consequently specialize, with the man entering the labor market first. As such, we will only analyze the case of $n^m = 0$, i.e., women spend at least a fraction of their time in the labor market.[7] Time subscripts are omitted for all intertemporal decisions.

Composite Service Consumption

Households choose time allocated to home production, n, in maximizing (10) s.t. (5). The resulting first order condition can be summarized in terms of relative market services to home services,

$$\frac{\hat{c}_s}{c_n} = \left(\frac{a_s}{1-a_s} \left(\frac{p_n}{(1-v)p_s} + \frac{\phi}{A_n} \right) \right)^{\frac{1}{1-\eta}}, \tag{17}$$

where p_n is an implicit home production price $p_n = \frac{w^f(1-\tau)}{A_n}$. As in Ngai and Pissarides (2008), services are "marketized" if $\frac{\hat{c}_s}{c_n}$ rises. The comparative statics for the "marketization" of services, if market and home services are gross substitutes, $0 < \eta < 1$, can be summarized as follows:

- $\frac{\partial \hat{c}_s/c_n}{\partial \tau} < 0$, that is, higher taxes discourage market work;
- $\frac{\partial \hat{c}_s/c_n}{\partial w_{sb}} > \frac{\partial \hat{c}_s/c_n}{\partial w_{sr}}$, higher brain demand will encourage female market work;
- $\frac{\partial \hat{c}_s/c_n}{\partial \phi} > 0$, governments subsidies on, e.g., childcare for working mothers, encourages female market work; and
- $\frac{\partial \hat{c}_s/c_n}{\partial w/((1-v)p_s)} > 0$, a fall in service prices through subsidies or technological progress through higher wages, encourages female market work.

Composite Consumption/Industrial Goods Consumption

Next households maximize (9), the final composite consumption, by choosing c_i. The first order condition can be summarized as relative market service to goods consumption,

$$\frac{\hat{c}_s}{c_i} = \left(\frac{1-a_i}{a_i} \frac{p_i}{(1-v)p_s} a_s \left(\frac{\hat{c}_s}{F(\hat{c}_s, c_n)} \right)^{\frac{\eta-\epsilon}{\eta}} \right)^{\frac{1}{1-\epsilon}}. \tag{18}$$

Again, we can look at the comparative statics with respect to the key parameters. If services and goods are gross compliments, that is $\epsilon < 0$ and with $0 < \eta < 1$:

[7] The case with $n^m > 0$ is very similar, however, the implicit home production price will be different in the two cases.

- $\frac{\partial \hat{c}_s/c_i}{\hat{c}_s/F(\hat{c}_s,c_n)} >$), more service marketization leads to rise in relative market service consumption as $\frac{\eta-\epsilon}{1-\epsilon} > 0$;
- $\frac{\partial \hat{c}_s/c_i}{\partial \tau} < 0$, higher taxes, lead to lower service marketization and, therefore, relatively less market service consumption (indirect effect through lower marketization, similarly this will be true for a smaller brain demand);
- $\frac{\partial \hat{c}_s/c_i}{\partial \phi} > 0$, again through the indirect effect of marketization, the government can artificially increase the relative service demand; and
- $\frac{\partial \hat{c}_s/c_i}{\partial v} > 0$, with a price subsidy on all service goods, the government can increase the relative services demand even further, through both an indirect effect through marketization and a direct price effect.

To summarize the comparative statics between different government actions, if a price subsidy is equivalent to the work subsidy, and the government only employs one at a time, the relative service share will be largest with the price subsidy and smallest without any subsidy, assuming the same tax rate for all economies, i.e., $\left(\frac{\hat{c}_s}{c_i}\right)_{\{v>0,\phi=0\}} > \left(\frac{\hat{c}_s}{c_i}\right)_{\{v=0,\phi>0\}} > \left(\frac{\hat{c}_s}{c_i}\right)_{\{v=0,\phi=0\}}$.

In conclusion, large taxation will lead to a smaller service sector, as fewer women participate in the formal labor market and less services are marketized. The government can affect the relative sector demands by subsidizing consumption of services. However, a subsidy tied to women working is less powerful.

Leisure

To conclude the intertemporal choices of the household, individuals choose leisure by maximizing (4). The first order condition can be described in terms of relative leisure to consumption,

$$\frac{\ell}{C} = \frac{1-a_c}{a_c a_i} \frac{p_i}{w(1-\tau)(2-\tau^f)+(1-v)p_s\phi} \left(\frac{c_i}{C}\right)^{1-\epsilon} \tag{19}$$

where $\ell = \ell^m = \ell^f$. That is, leisure will be greater with government price and work subsidies given equal tax rates.

Sectoral Labor Share

Using market clearing, the firm and household allocation, the labor supply equations (12), and wages for men and women (11), we can solve for labor shares and wage rates. Specifically, if only men work in the industrial sector, the relative labor allocation is,

$$\frac{L_s}{L_i} = \frac{c_s}{c_i} p_s^{\frac{1}{1-\rho}} \left(\frac{\alpha_s}{w_s b}\right)^{\frac{1}{1-\rho}} \tag{20}$$

and

$$\frac{L_s}{L_i} = \frac{c_s}{c_i} p_i^{\frac{-1}{1-\rho}} \left(\frac{\alpha_i}{w_i b}\right)^{\frac{-1}{1-\rho}} \tag{21}$$

if both men and women work in goods production. From the comparative statics on relative market service to goods, marketization will lead to a rise in service labor shares. Similarly, the wage rates can be solved for a given labor supply of men and women. If men work in both sector, men and women's labor supply to the service sector will equal

$$L_s^m = \frac{c_s p_s^{\frac{1}{1-\rho}}}{\tau_r} \left[\left(\frac{(1-\alpha_s)}{w_s r}\right)^{\frac{1}{1-\rho}} - (1-\tau_r) \left(\frac{\alpha_s}{w_s b}\right)^{\frac{1}{1-\rho}} \right], \text{ and} \tag{22}$$

$$L_s^f = \frac{c_s p_s^{\frac{1}{1-\rho}}}{\tau_r} \left[\tau_r \left(\frac{\alpha_s}{w_s b}\right)^{\frac{1}{1-\rho}} - \left(\frac{(1-\alpha_s)}{w_s r}\right)^{\frac{1}{1-\rho}} \right] \tag{23}$$

and wage rates using $w_{ir} \equiv 1$ as the numeraire,

$$w_{sr} = \frac{1-\alpha_s}{1-\alpha_i} \frac{1}{\left(\frac{L_s^m + L_s^f}{L_s^m + (1-\tau_r) L_s^f}\right)^{\rho-1} + 1}, \text{ and} \tag{24}$$

$$w_{sb} = \frac{\alpha_s}{1-\alpha_s} \left(\frac{L_s^m + L_s^f}{L_s^m + (1-\tau_r) L_s^f}\right)^{\rho-1} w_{sr}, \text{ and} \tag{25}$$

$$w_{ib} = \frac{\alpha_i}{1-\alpha_i}. \tag{26}$$

[Discussion to be added].

In summary, this section has shown that larger government taxation will lead to a smaller service sector and less female labor force participation. Governments can increase female labor force participation, and therefore also the service labor share, by subsidizing female employment or the purchase of services. In addition, subsidizing female employment through a rebate in services has the added effect of increasing service employment, and therefore brain demand, e.g., more childcare facilities do not only provide services for households, but also employment opportunities for women.

4 Simple Calibration

The model is simulated to the United States, tax rates are then adjusted to account for differences between Continental Europe, Scandinavia, and the United States. Tax rates are taken from McDaniel (2007). Although tax rates have been increasing over time in all three regions, this calibration takes an average tax rate over time, with the United States having a 22 percent tax rate, and Europe and the Nordic countries having a 43 percent tax. The parameter governing the elasticity of substitution between home and market services, η, and the elasticity between goods and services, ϵ, are taken from previous studies. Various studies

have estimated η on microeconomic and macroeconomic data. The resulting elasticities vary from 1.60 to 2.00 by Rupert et al. (1995), depending on the whether households are married, single females or single males, to 2.3 by Chang and Schorfheide (2003). Aguiar and Hurst (2006) find an elasticity of 1.80, which implies an η of 0.45 used in this calibration. Ngai and Pissarides (2008) suggest that, given price elasticities of the entire service sector of -0.30 to -0.06, a model with home production the elasticity of 0.30 should be an upper bound, implying a value of $\epsilon = -2.30$, which is used in the calibration below.

To estimate the elasticity in firm production, we use the 1977 and 1991 DOT factor estimates to construct an aggregate data series of brain and brawn supply over time (see Appendix A for details). The elasticity is assumed to be equal across sectors. To determine the substitution parameter, ρ, taking logs of (14), we can estimate a regression similar to Katz and Murphy (1992, pg. 69), where the constructed brain to brawn aggregate are the relative labor supplies. The wage series of brain and brawn prices is constructed by estimating the regression of average residual male wages by occupation over time on brain and brawn factors, capturing occupation specific returns. The residual wages are taken from a Mincer-wage regression of full-time male workers[8] on standard explanatory variables. The resulting estimate of ρ varies between 0.62 for the 1977 DOT and 0.67 for the 1991 DOT, therefore ρ is set to 0.65.

The yearly discount rate is set to $\beta = 0.96$. Productivity in the Industrial sector is set to one in 1950, i.e, $A_{i1950} = 1$. Home productivity A_n is assumed constant over time, abstracting from improvements in home technology, which could partly explain the rise in female employment. It is assumed that the United States has reached its steady state by 2005 (there is evidence of flattening female labor force participation and gender wage difference in the last few years). The remaining parameters $\{\alpha_s, \alpha_i, a_c, a_s, a_i, A_{s1950}, A_{s2005}, A_{i2005}, A_n, \tau_r\}$ are set in order to match the following nine steady state (2005) and 1950 targets:

- Gender wage gap;
- Relative goods to services hours;
- Married female market hours of work;[9]
- Married male market hours of work; plus
- Growth rate in male wages from 1950 to 2005.

4.1 Preliminary Results

The model does well in matching all targets, except it does underestimate the rise in female hours worked by four percentage points. Table $2-3$ shows the United States data

[8] Full-time workers are defined as working at least 39 weeks and 35 hours per week (prior to 1976 only hours worked prior to the survey week are recorded).

[9] assuming individuals have a total time endowment of 15×365 hours

targets with the model results. The two red columns were not targeted. Specifically, while

Table 2: *US Female Targets*

Female	H_f 1950s	H_f 2005	H_f/N_f 1950s	H_f/N_f 2005	Wage Gap 1950s
Data	0.11	0.23	0.33	0.80	0.64
Model	0.11	0.21	0.29	0.88	0.66

Table 3: *US Male and Total Targets*

Male/Total	H_m 1950s	H_m 2005	$H_s/(H_s+H_i)$ 1950s	$H_s/(H_s+H_i)$ 2005
Data	0.36	0.32	0.54	0.74
Model	0.41	0.37	0.54	0.74

female hours relative to total hours worked rose from about six to 23 percentage points, the model generates a rise from six to 19 points. Moreover, on the male employment side the model generates a 5 percentage points larger labor force in the 1950s, but a similar fall over time. To highlight the importance of differing labor inputs across sectors, the model without brain and brawn demand differences generates 52 percent of the observed U.S. female hours growth compared to 79 percent in the base model

The following results show that the mechanism highlighted in this study does well in generating differences in female employment rates and service sector labor shares across different tax regions. To estimate the Continental European Experience, we assume, similar

Table 4: *Continental Europe Changes in Labor Force Particiaption*

Total	Female LFP Growth Rate	Male LFP Growth Rate (-)
Data	2.62	.54
Model	2.21	.66

to Rogerson (2008) that Europe lags the United States in 1950s by 33 years. Table $4-5$ summarize the model results for Continental Europe. The numbers presented in table 4 are relative to the United States, that is, female labor force participation growth was 2.6 times larger in the United States than Europe during this time period. The model generates a similar discrepancy in female and male labor force growth rates than in the data. The numbers in table 5 are similarly relative to the United States. Taxes and productivity differences, account for a 17 percentage point increase in hours, compared to 40 percentage points in the data for the United States relative to Europe, i.e, the model gets roughly half of the difference. The model does generate large sector labor reallocations.

Table 5: *Continental Europe Total Model Results*

Total	H 1950s	H 2005	$H_s/(H_s+H_i)$ 1950s	$H_s/(H_s+H_i)$ 2005
Data	0.84	1.24	1.58	1.11
Model	0.95	1.12	1.37	1.01

For Scandinavia, we do not have a good estimate of what ϕ should be. However, we can calibrate ϕ such that the the relative share of female employment is identical to the data in 2005, i.e., the relative female labor share of the Nordic countries to the United States was about 95 percent in 2005. In this case, $\phi = 3.50$, which equates in 2005 to about 22 percent of the market services consumed are provided by the government through female employment subsidies, which accounts to a social welfare loss in terms of utils of roughly four percent to up to 12 percent in the earlier stages of development.
[More to be added]

5 Conclusion

To summarize, this paper develops a theory that can explain both a rise in services and a rise in female labor supply concurrently. The model is consistent with general trends in labor supply (male and female) and leisure with a male Frisch elasticity of around .52. It accounts well for differences between Continental Europe and the United States in the service sector labor share and female employment over time. A high tax country will have a lower service sector and lower female employment by subduing marketization. A simple computation of the social welfare loss of high taxes and subsidizing female labor force participation in Scandinavia compared to an equivalent outcome in female labor force participation with low taxes and no subsidies shows a non-negligible loss.
[More to be added]

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Appendix A: Factor Estimation

[To be added]