Structural Change and the Rise and Fall of Marital Unions*

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Abstract

One of the important facts on marriage that has not been emphasized in the literature is the hump-shaped pattern of the prevalence of marriage in the U.S. over the last 100 years. In this paper, we study the rise and the fall of marital unions and their relations to the structure of the economy. As an empirical contribution of this paper, we establish two facts; i) the hump-shaped pattern of marriage is observed in the most of the OECD countries, and ii) the the ratio of manufacturing share to service share in GDP has a strong correlation with the prevalence of marriage. Motivated by those empirical observations, we build a model of the structural change with endogenous marital decisions where individuals' incentives to marry are affected by the structure of the economy. Key assumptions in our model are; 1) men have a comparative advantage in the manufacturing sector, 2) services produced in the market are substitutes for home-produced goods, and 3) marriage requires fixed costs. We calibrate our model to U.S. data and compare its predictions to the changes in marriage over the last century and the basic facts on the structural changes.

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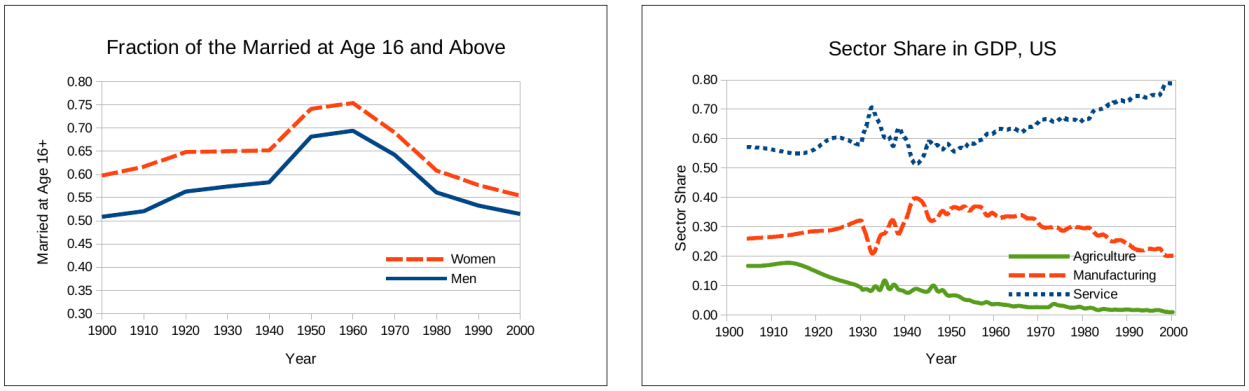

Figure 1: Fraction of the Married and Sector Shares in GDP,
United States, 1900 - 2000

1 Introduction

The formation of household has changed dramatically over the last century. It is well documented in the literature that there has been a significant decline in the fraction of the married in total population during the second half of the twentieth century.[1] Nonetheless, there is another notable fact on marriage that has received little attention in the literature: the pattern of the fraction of married over the last 100 years is hump-shaped (See Figure 1). What are the economic factors that can explain the observed hump-shaped pattern of the prevalence of marriage over the last century? This paper puts forth the idea that the rise and then the fall of marital unions over the last century is connected to the structural transformations of the economy over the same period. We show empirically and quantitatively that labor flows between manufacturing and services as well as those between market and home-produced services are key in explaining the hump-shaped pattern of the prevalence of marriage over the last 100 years.

As an empirical contribution, we establish two facts by using data from 14 OECD countries. First, we document that a hump-shaped pattern of marriage is observed in most of the countries in our sample. The pattern is robust for both men and women even after controlling for the changing age-structure of the population. Second, we show that the ratio of the manufacturing to services share in GDP has a strong correlation with the fraction of the married. The rise of marriage coincides with the rise of the manufacturing sector, while the timing of its decline coincides with the level of income at which the services sector accelerates its growth. These observations suggest the idea that marriage decisions are tied to the structure of the economy, and their changes are driven by the structural change.

Motivated by these two empirical facts, we present a parsimonious model of structural change with endogenous marital decisions that builds on previous work in the literature (Ngai and Pissarides, 2008; Ngai and Petrongolo, 2013). In our model, we make three assumptions through which individuals' incentives to marry are affected by the strfucture of the economy. First, we assume that

[1] See, among others, Stevenson and Wolfers (2007) and Greenwood and Guner (2008) for empirical evidence.

men have a comparative advantage in the manufacturing sector (Galor and Weil, 1996; Rendall, 2010; Ngai and Petrongolo, 2013). With this assumption, an increase in the share of manufacturing relative to services widens the gender wage premium, and the gain from marriage through an increase in specialization in home (females) and market (males). Second, we assume that services produced in the market are substitutes for home-produced goods. With this assumption, when market services become cheaper relative to the home good, the incentives to marry for couples diminish because there are less gains for specialization. Third, we assume that marriage requires fixed costs. Thus, as the economy expands, more individuals become able to get married.

Given our assumptions, the rise and the fall of marriages are explained in the following way: During the 1900 to 1950, manufacturing grows relative to the rest of the economy. A by-product of this fact is the increase of labor demand in this sector. As men have a comparative advantage over women in the manufacturing sector (brawn intensive sector), the market value of a man's labor increases compared to that of women with the raise of manufacturing. At the same time, the growth of the economy makes the fixed costs of marriage relatively cheaper, in turn making marriage affordable for more individuals. Thus, the incentive to marry raises with the increase in manufacturing. During the 1950 to 2000, the services sector in the market starts expanding (due to differential TFP growth in manufacturing and services). As a result, the demand for labor in services starts increasing. As women have a comparative advantage in services, the market value of their labor starts increasing compared to that of men. At the same time, faster productivity growth in the market services sector relative to home services (Bridgman, 2013) increases the price of home services relative to market ones. As the market service is a substitute for home-produced good, the expansion of the service sector reduces the value of marriage. Both effects reduce the (overall) value of the marriage.

Literature

The process of structural transformation that occurs as income grows is well documented in the literature and it has been proved that such process has relevant implications for the macroeconomy. Herrendorf, Rogerson, and Valentinyi (forthcoming) provide a detailed survey of applications of structural change. Here we relate mostly to the strand of the literature linking structural transformation to the allocation of hours worked (Rogerson, 2008; Prescott, 2004; Rendall, 2010). To generate structural change between manufacturing and services we exploit the interaction between differential TFP growth in manufacturing and services and an elasticity of substitution between the two goods smaller than one, as in Ngai and Pissarides (2007). Also, we argue that to understand the allocation of market hours it is necessary to model a home sector as in Ngai and Pissarides (2008) and Buera and Kaboski (2012). Possibly, the most related paper is Ngai and Petrongolo (2013), which considers the time allocation between market and home of men and female who are exogenously paired into household. In contrast, in our setting we allow for endogenous marriage, so that in equilibrium only a fraction of individuals marry, being the rest (women and men) single.

Our work is also build on the literature that studies the link between the economic environment

and family structure. Regalia, Ríos-Rull, and Short (2010) is a pioneering work which provides a quantitative theory to explains the increase in the number of single households. Greenwood and Guner (2008) and Greenwood, Guner, Kocharkov, and Santos (2012) account for the changes in family structure by the progress in home production technology. Salcedo, Schoellman, and Tertilt (2012) attribute the decline in the size of families to the decrease in the price of public goods. All works are close to our paper in the spirit. Here, we provide a theory and empirical evidence that the structure of the economy is an important determinant to the composition of families. Our paper is the first work which connects the family macro literature to the structural change literature.

2 Cross-Country Evidence

This section presents empirical evidence on the link between structural change and the hump-shaped pattern of the prevalence of marriage.

2.1 Hump-Shaped Pattern of Marriage in 14 Countries

Our population data is from 14 high-income countries in 10-year intervals over the period 1900-2000.[2] Specifically, the population data by sex, five year age-group, and marital status (single, married, divorced, and widowed) is collected for; Australia, Belgium, Canada, Denmark, France, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, UK and the U.S. Time series of the fraction of the married for men and women at age 15 and above is constructed from the data. In general, we observe that the prevalence of marriage among the old is higher than the young. Therefore, changes in the age structure of population, which have occurred over the twentieth century,[3] might affect the fraction of the married in total population. To control for changes in the age structure, we construct new time series by assuming the age structure of the population in each year is the same as the one in the base year, 2000, while keeping the fraction of the married in each age group unchanged from the original data.[4] Figure 5 displays the fraction of the married in total population at age 15 and above for the raw data (blue/solid line) and the age-adjusted data (red/dashed line) for each of the 14 countries in the sample.[5]

Figure 5 shows that the fraction of the married rose in the early and mid-twentieth century and peaked in 1970 and 1980 for the majority of countries in our sample and it has been decreasing over the ensuing quarter of the century. Also, the pattern is robust for the most of the countries even after controlling for the age-structure of the population. For the U.S., the hump-shaped pattern

[2] For a detailed description of the data sources for each country, see the Appendix B.

[3] The age structure of population has changed due to many reasons. For instance, the majority of countries in our sample experienced war(s) at the beginning and/or in the middle of the last century. Moreover, baby boom occurred across many of OECD countries in the mid-twentieth century and life expectancy has improved dramatically during the second half of the twentieth century.

[4] Using a different base year does not change the hump-shaped pattern observed in data. See Appendix C for a detailed discussion on how the adjustment for the shift in the age distribution is done for each country.

[5] Figure 4 and 5 in Appendix A show the time series data for the fraction of the married in total population at age 15 and above for men and women for 14 countries. Again the hump-shaped pattern is observed for both series of men and women for the majority of countries in our sample.

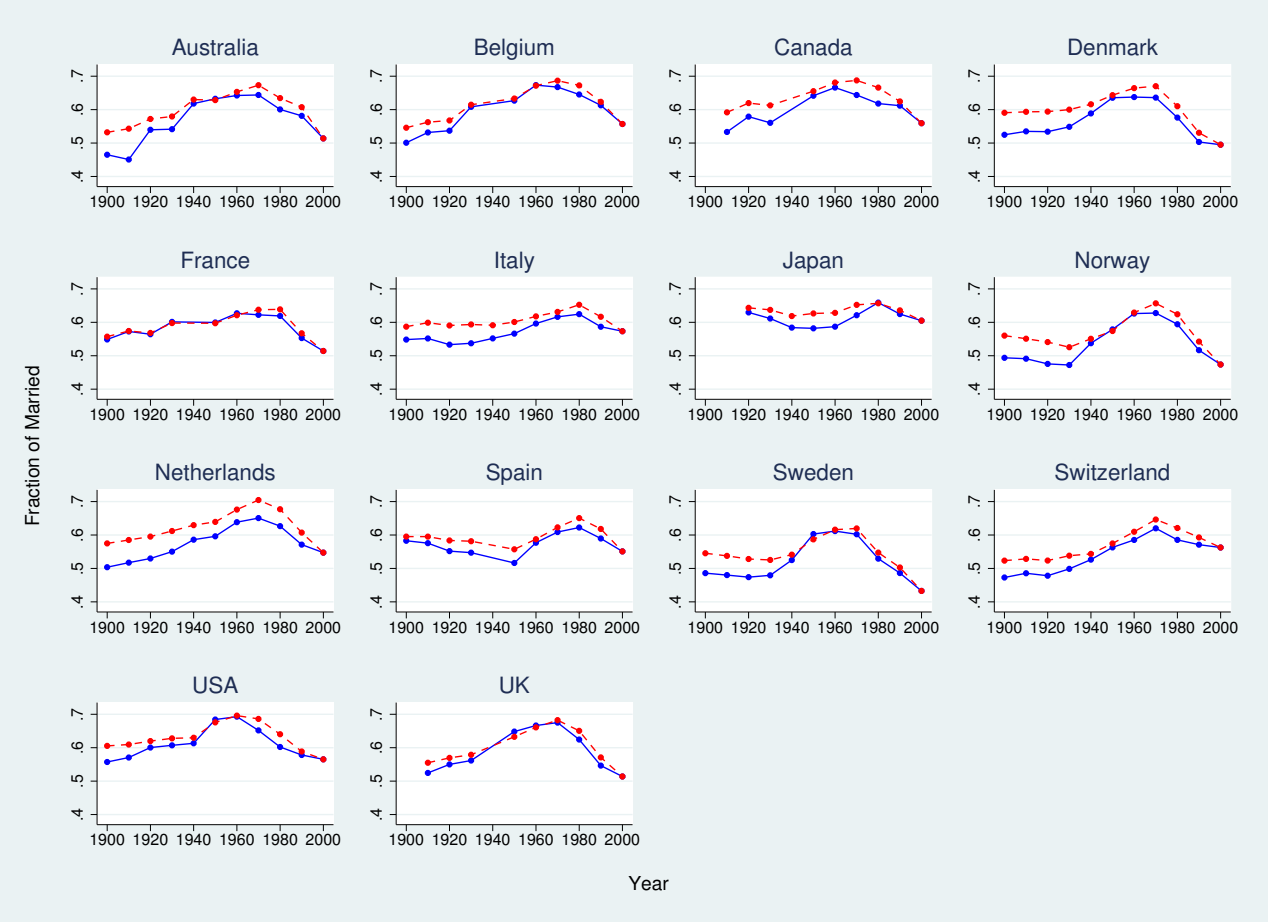

Figure 2: Fraction of Married in Total Population Age 15 and Above for Various Countries, the Raw Data (Blue/Solid Line) and the Age-Adjusted Data (Red/Dashed Line)

for marital unions peaks in 1960 which is consistent with two previous papers which document the pattern (Schoen, Urton, Woodrow, and Bai, 1985; Greenwood and Guner, 2008). The rise and fall in marital unions in some countries, like France, Italy, Japan, Spain and Switzerland, is less pronounced than the other countries in the sample.

2.2 Structural Transformation and Marital Unions

To study the impact of technological progress and structural transformation on marital unions, we follow the approach by Buera and Kaboski (2012) who construct historical time series data for value added shares of manufacturing and services as well as real GDP per capita (1993 base year) over the twentieth century for aforementioned countries in our sample. Specifically, we run separate regressions for each of the data series (the value added share of manufacturing and, service sector, and the fraction of married in total population of 15 and above) on a cubic function of log of GDP per capita with country dummy variables. Then, we subtract out the estimated country-fixed effects from the raw data and create new series. The filtered data series for the share of manufacturing and services, and the fraction of the married are plotted against the real GDP per capita in Figure 3. In all three panels, the solid lines represent the fitted curves.

It can be seen from the top and middle panels in Figure 3 that the value added share of manufacturing peaks around the same level of log of GDP per capita at which the rate of increase in the value added share of services starts to increase rapidly. The hump-shaped pattern in manufacturing and the late acceleration of services highlight that growth of manufacturing relative to services is higher at the lower level of development and then it declines at the higher level of development.[6] Interestingly, this pattern of structural transformation coincides with the hump-shaped pattern in the fraction of married in total population.

Next, we investigate further whether there is a positive correlation between the ratio of manufacturing to services value-added and the prevalence of marriage. To do so, we calculate the correlation between the filtered series of the fraction of married and the ratio of manufacturing to services. Figure 4 plots the relation of those two series and fitted line. The correlation of the two series exhibits a positive value, 0.39.

[6] This fact is well documented in the structural transformation literature; see Herrendorf, Rogerson, and Valentinyi (forthcoming) and references therein.

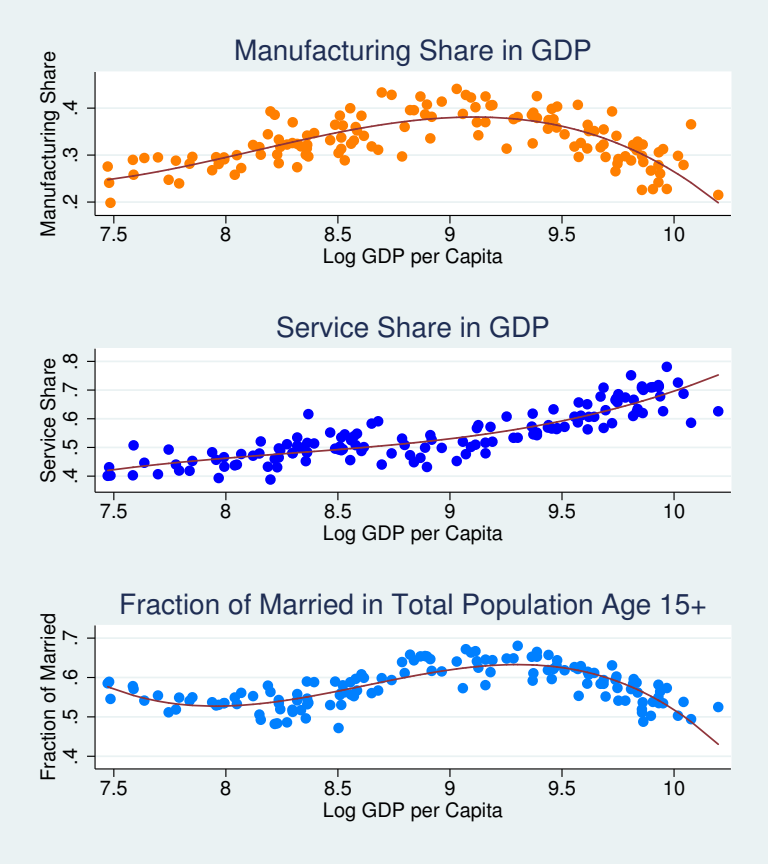

Figure 3: Manufacturing and Service Shares, and Fraction of Married by Log Income per Capita (Fixed-effects are controlled for each series.)

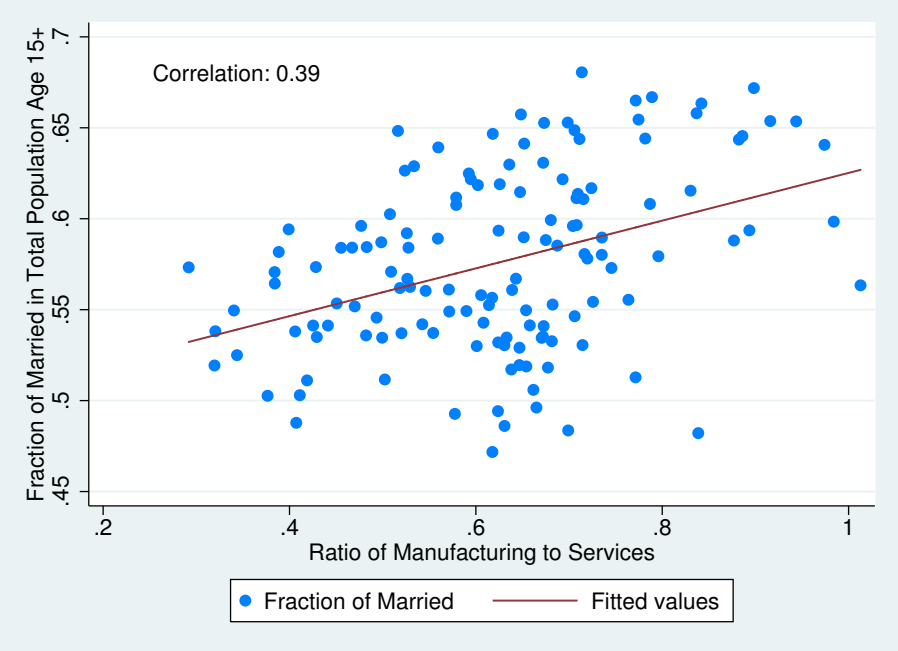

Figure 4: Fraction of Married in Total Population at Age 15 and Above v.s. Ratio of Manufacturing to Services

Our cross-country empirical evidence establishes two facts. First, the hump-shaped pattern in the prevalence of marriage is observed in most of the countries in our sample even after controlling for changes in the age structure of population. Second, the prevalence of marriage exhibits a positive correlation with the ratio of manufacturing to services over the last century.[7] Motivated by these empirical facts, the next section presents a model that includes three sectors (home production, goods and services) and endogenous marital decisions.

3 The Model

This section presents a model of structural change with endogenous marital decisions. Each period a new generation is born and the one existing in the previous period dies. Thus, the model is static in the sense that individuals decide whether they get married or not, and allocate their time in market and home within a period. We assume a frictionless marriage market, and thus strictly positive associative mating (PAM) occurs in the equilibrium of the marriage market.

3.1 Households

Individuals live for one period. There is a unit mass of men (m) and a unit mass of women (f). Individuals in each gender are identical except for their suitability for marriage defined by the parameters $\theta_m \sim F(\theta)$ and $\theta_f \sim F(\theta)$. $F(\cdot)$ is the distribution for θ, which has strictly positive support, and is assumed to be the same for men and women. Individuals have all the same preferences except from the term $\sqrt{\theta_i \theta_j} - \delta$ which adds to the utility of married individuals. Here θ_i and θ_j are the suitability for marriage of the wife i and the husband j and δ is a fixed utility cost of marriage.

3.1.1 Marriage Market

We consider a frictionless marriage market where individuals can choose a partner freely without paying any search costs. Marriage holds between a men and a women when both individuals agree on the Pareto weights α_{ij} and $(1-\alpha_{ij})$ which determine the allocations within married household's problem described in Section 3.1.2. Each individual can only get married with one person by assumption.

3.1.2 Married Households

Each household is composed by a male (m) and a female individual (f). Denote the generic household as composed of a woman i and a man j. The utility function of the woman in a married household is

$$U(c_M^i, c_S^i) + \sqrt{\theta_i \theta_j} - \delta = \left[\omega (c_M^i)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega)(c_S^i)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} + \sqrt{\theta_i \theta_j} - \delta, \tag{1}$$

[7] Figure 7,and 8 in Appendix A confirm that our results are robust for changes in age-structure.

where, c_M^i is manufacturing consumption and c_S^i is consumption of services and ε is the elasticity of substitution between manufactured goods and services. We assume $\varepsilon < 1$ which implies goods and services are substitutes. Preferences of man j are also denoted by (1), (2) once superscript i is replaced by j. Manufacturing is purchased in the market, while services is an aggregation of purchased market services (c_{ms}^i) and home produced (c_{hs}^i) services:

$$c_S^i = \left[\psi(c_{ms}^i)^{\frac{\sigma-1}{\sigma}} + (1-\psi)(c_{hs}^i)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

Here σ denotes the elasticity of substitution between market and home-produced services. We assume $\sigma > 1$ which implies that home and market services are substitutes. Total home production of a household composed of a woman i and a man j is obtained through the following linear technology:

$$\bar{y}_{hs}^{ij} = A_{hs}\bar{L}_{hs}^{ij}, \tag{3}$$

where

$$\bar{L}_{hs}^{ij} = \left[\xi_{hs}(\bar{L}_{hs,f}^i)^{\frac{\eta-1}{\eta}} + (1-\xi_{hs})(\bar{L}_{hs,m}^j)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{4}$$

$\bar{L}_{hs,f}^i$ is female labor and $\bar{L}_{hs,m}^j$ male labor in home production. Here, η represents the elasticity of substitution between female and male labor inputs in the production of home services in a married household.

We assume that the household composed of a woman i and a man j agrees on some Pareto weights $0 < \alpha_{ij} < 1$ to solve

$$\max_{c_M^i, c_S^i, c_M^j, c_S^j} \alpha_{ij}\left[U(c_M^i, c_S^i) + \sqrt{\theta_i\theta_j} - \delta\right] + (1-\alpha_{ij})\left[U(c_M^j, c_S^j) + \sqrt{\theta_j\theta_i} - \delta\right], \tag{5}$$

subject to

$$p_M(c_M^i + c_M^j) + p_s(c_S^i + c_S^j) = w_m(L_m - \bar{L}_{hs,f}^{MA}) + w_f(L_f - \bar{L}_{hs,m}^{MA}), \tag{6}$$

$$L_f = \bar{L}_{hs,f}^i + \bar{L}_{ms,f}^i + \bar{L}_{M,f}^i,$$

$$L_m = \bar{L}_{hs,m}^j + \bar{L}_{ms,m}^j + \bar{L}_{M,m}^j,$$

$$c_{hs}^i + c_{hs}^i = \bar{y}_{hs}^{ij},$$

and (1), (2), (3) and (4). Here w_m and w_f are male and female wage rate, L_m and L_f is total labor time of man and woman, and $\bar{L}_{hs,m}^j$, $\bar{L}_{ms,m}^j$, $\bar{L}_{M,m}^j$, $\bar{L}_{hs,f}^i$, $\bar{L}_{ms,f}^i$, and $\bar{L}_{M,f}^i$ are labor allocations of the two genders in the three sectors.

We can prove that the problem in (5) can be re-written into a problem of a representative household such as

$$\max_{c_M^{MA}, c_S^{MA}} U(c_M^{MA}, c_S^{MA}), \tag{7}$$

subject to

$$c_S^{MA} = \left[\psi(c_{ms}^{MA})^{\frac{\sigma-1}{\sigma}} + (1-\psi)(c_{hs}^{MA})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{8}$$

$$p_M c_M^{MA} + p_s c_{ms}^{MA} = w_m(L_m - \bar{L}_{hs,f}^{MA}) + w_f(L_f - \bar{L}_{hs,m}^{MA}),$$

$$L_f = \bar{L}_{hs,f}^{MA} + \bar{L}_{ms,f}^{MA} + \bar{L}_{M,f}^{MA},$$

$$L_m = \bar{L}_{hs,m}^{MA} + \bar{L}_{ms,m}^{MA} + \bar{L}_{M,m}^{MA},$$

$$c_{hs}^{MA} = \bar{y}_{hs}^{MA}, \tag{9}$$

(3) and (4). Here, c_M^{MA} and c_S^{MA} respectively denote household's total consumption of manufactured goods and services. As before, the latter consists of market-produced services, c_{ms}^{MA}, and home-produced services, c_{hs}^{MA}, in the married household. Once such problem has been solved, individual consumption levels of the household are found as:

$$c_M^i = \alpha_{ij} c_M^{MA},\ c_M^j = (1-\alpha_{ij}) c_M^{MA},$$

$$c_{ms}^i = \alpha_{ij} c_{ms}^{MA},\ c_{ms}^j = (1-\alpha_{ij}) c_{ms}^{MA},$$

$$c_{hs}^i = \alpha_{ij} c_{hs}^{MA},\ c_{hs}^j = (1-\alpha_{ij}) c_{hs}^{MA}.$$

3.1.3 Single Women

The utility function of a single woman (SW) is

$$U(c_M^{SW}, c_S^{SW}) = \left[\omega(c_M^{SW})^{\frac{\varepsilon-1}{\varepsilon}} + (1-\omega)(c_S^{SW})^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{10}$$

where, c_M^{SW} is manufacturing consumption and c_S^{SW} is consumption of services. As for married, manufacturing is purchased in the market, while services is an aggregation of purchased market services (c_{ms}^{SW}) and home produced (c_{hs}^{SW}) services:

$$c_S^{SW} = \left[\psi(c_{ms}^{SW})^{\frac{\sigma-1}{\sigma}} + (1-\psi)(c_{hs}^{SW})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}. \tag{11}$$

Home production is

$$\bar{y}_{hs}^{SW} = A_{hs} \bar{L}_{hs}^{SW}, \tag{12}$$

where

$$\bar{L}_{hs}^{SW} = \xi_{hs}^{\frac{\eta}{\eta-1}} \bar{L}_{hs,f}^{SW}, \tag{13}$$

where $\bar{L}_{hs,f}^{SW}$ is labor input of the single woman in home production.

Thus, a SW solves

$$\max_{c_M^{SW}, c_S^{SW}} U(c_M^{SW}, c_S^{SW}), \tag{14}$$

subject to

$$p_M c_M^{SW} + p_s c_S^{SW} = w_f(L_f - \bar{L}_{hs,f}^{SW}), \tag{15}$$

$$L_f = \bar{L}_{hs,f}^{SW} + \bar{L}_{ms,f}^{SW} + \bar{L}_{M,f}^{SW},$$

$$c_{hs}^{SW} = \bar{y}_{hs}^{SW},$$

and (10), (11), (12) and (13). $\bar{L}_{ms,f}^{SW}$ and $\bar{L}_{M,f}^{SW}$ are labor allocations of SW in the two market sectors.

3.1.4 Single Men

Preferences of a single man (SM) are as in (10) and (11). Home production of the SM is

$$\bar{y}_{hs}^{SM} = A_{hs} \bar{L}_{hs}^{SM}, \tag{16}$$

where

$$\bar{L}_{hs}^{SM} = (1 - \xi_{hs})^{\frac{\eta}{\eta - 1}} \bar{L}_{hs,m}^{SM}. \tag{17}$$

Thus, a SM solves

$$\max_{c_M^{SM}, c_S^{SM}} U(c_M^{SM}, c_S^{SM}), \tag{18}$$

subject to

$$p_M c_M^{SM} + p_s c_S^{SM} = w_m(L_m - \bar{L}_{hs,m}^{SM}), \tag{19}$$

$$L_m = \bar{L}_{hs,m}^{SM} + \bar{L}_{ms,m}^{SM} + \bar{L}_{M,m}^{SM},$$

$$c_{hs}^{SM} = \bar{y}_{hs}^{SM}.$$

and (10), (11), (16) and (17). $\bar{L}_{ms,f}^{SM}$ and $\bar{L}_{M,f}^{SM}$ are labor allocations of SM in the two market sectors.

3.2 Market Firms

There is a representative firm in each of the two market sectors. Thus, in each of the two sectors technology is

$$y_q = A_q L_q, \qquad q = M, ms \tag{20}$$

where

$$L_q = \left[\xi_q L_{q,f}^{\frac{\eta - 1}{\eta}} + (1 - \xi_q) L_{q,m}^{\frac{\eta - 1}{\eta}} \right]^{\frac{\eta}{\eta - 1}}. \tag{21}$$

We assume that $\xi_M < \xi_{ms} < \xi_{hs}$, which implies that women have a comparative advantage in producing services.

Firms in the market maximize profits by solving

$$\max_{L_{q,m},L_{q,f}} p_q A_q \left[\xi_q L_{q,f}^{\frac{\eta-1}{\eta}} + (1-\xi_q) L_{q,m}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} - w_m L_{q,m} - w_f L_{q,f}. \tag{22}$$

It can be shown that home production can be treated as a competitive firm in the market.

Note that home services are produced as in perfectly competitive market sectors. So we can derive implicit prices of home production for the three types of household:

$$p_{hs}^{MA} = \frac{w_f}{A_{hs}\left[\xi_{hs}(\bar{L}_{hs,f}^{MA})^{\frac{\eta-1}{\eta}} + (1-\xi_{hs})(\bar{L}_{hs,m}^{MA})^{\frac{\eta-1}{\eta}}\right]^{\frac{1}{\eta-1}} \xi_{hs}(\bar{L}_{hs,f}^{MA})^{-\frac{1}{\eta}}} \tag{23}$$

for married

$$p_{hs}^{SW} = \frac{w_f}{A_{hs}\xi_{hs}^{\frac{\eta}{\eta-1}}}, \tag{24}$$

for single woman, and

$$p_{hs}^{SM} = \frac{w_m}{A_{hs}(1-\xi_{hs})^{\frac{\eta}{\eta-1}}}, \tag{25}$$

for single man.

3.3 Stable Matching Equilibrium

The equilibrium in the marriage market we consider here is a stable matching equilibrium where no one wants to deviate from their current partner. In this setup, strictly positive associative mating (PAM) occurs an equilibrium. That is, if (i,j) and (i',j') are married pairs in the equilibrium and if $\theta^i > \theta^{i'}$, then $\theta^j > \theta^{j'}$ holds. Given the assumptions that $F(\theta)$ is the same for women and men and that individuals in each gender are identical except from θ, only partners with same θ^i end up getting married in an equilibrium. It can be proven that there exists a unique value of $\hat{\theta} \in [0,1]$ such that all individuals with $\theta > \hat{\theta}$ choose to be married and all individuals with $\theta < \hat{\theta}$ choose to be single. Furthermore, we show that, given consumptions for each marital status $\left\{c_M^{SW}, c_S^{SW}, c_M^{SM}, c_S^{SM}, c_M^{MA}, c_S^{MA}\right\}$, such a threshold value $\hat{\theta}$ is determined by

$$\hat{\theta} = \frac{U(c_M^{SW}, c_S^{SW}) + U(c_M^{SM}, c_S^{SM}) - U(c_M^{MA}, c_S^{MA}) + 2\delta}{2} \tag{26}$$

Note that the fraction of singles in the economy is denoted by $F(\hat{\theta})$ for both women and men. The fraction of married in the economy declines if the utility of married decreases or/and the utility of single man or women increases. Moreover, there is a negative association between the fixed utility cost of marriage and the fraction of the married.

3.4 Equilibrium

An equilibrium for this economic is a set of prices $\left\{p_M, p_{ms}, p_{hs}^{MA}, p_{hs}^{SW}, p_{hs}^{SM}, w_f, w_m\right\}$, allocations for the households $\left\{c_M^{SW}, c_{ms}^{SW}, c_{hs}^{SW}, c_M^{SM}, c_{ms}^{SM}, c_{hs}^{SM}, c_M^{MA}, c_{ms}^{MA}, c_{hs}^{MA},\ \bar{L}_{hs,f}^{MA}, \bar{L}_{hs,m}^{MA}, \bar{L}_{hs,f}^{SW}, \bar{L}_{hs,m}^{SM}\right\}$, allocations for market firms $\{L_{M,f}, L_{M,m}, L_{ms,f}, L_{ms,m}\}$, and a marriage threshold $\left\{\hat{\theta}\right\}$, such that:

1. Given prices, $c_M^{SW}, c_{ms}^{SW}, c_{hs}^{SW}$ and $\bar{L}_{hs,f}^{SW}$ solve the problem of the single woman, $c_M^{SM}, c_{ms}^{SM}, c_{hs}^{SM}$ and $\bar{L}_{hs,m}^{SM}$ solve the problem of the single man and $c_M^{MA}, c_{ms}^{MA}, c_{hs}^{MA}, \bar{L}_{hs,f}^{MA}$, and $\bar{L}_{hs,m}^{MA}$ solve the problem of the married;

2. Given prices, $L_{M,f}$ and $L_{M,m}$ solve the problem of the manufacturing firm and $L_{ms,f}$ and $L_{ms,m}$ solve the problem of the market services firm;

3. The marriage threshold $\hat{\theta}$ is such that all individuals with $\theta > \hat{\theta}$ get married and all individuals with $\theta < \hat{\theta}$ are single, and determined by (26);

4. Markets clear

$$L_{hs,f}^{MA} = (1 - F(\hat{\theta}))\bar{L}_{hs,f}^{MA},$$

$$L_{hs,f}^{MA} = (1 - F(\hat{\theta}))\bar{L}_{hs,m}^{MA},$$

$$L_{hs,f}^{SW} = F(\hat{\theta})\bar{L}_{hs,f}^{SW},$$

$$L_{hs,m}^{SM} = F(\hat{\theta})\bar{L}_{hs,m}^{SM},$$

$$L_{M,f} + L_{ms,f} + L_{hs,f}^{MA} + L_{hs,f}^{SW} = F(\hat{\theta})L_f + (1 - F(\hat{\theta}))L_f = L_f,$$

$$L_{M,m} + L_{ms,m} + L_{hs,m}^{MA} + L_{hs,m}^{SM} = F(\hat{\theta})L_m + (1 - F(\hat{\theta}))L_m = L_m,$$

$$y_M = (1 - F(\hat{\theta}))c_M^{MA} + F(\hat{\theta})c_M^{SM} + F(\hat{\theta})c_M^{SW},$$

$$y_{ms} = (1 - F(\hat{\theta}))c_{ms}^{MA} + F(\hat{\theta})c_{ms}^{SM} + F(\hat{\theta})c_{ms}^{SW},$$

$$y_{hs}^{MA} = (1 - F(\hat{\theta}))\bar{y}_{hs}^{MA} = (1 - F(\hat{\theta}))c_{hs}^{MA},$$

$$y_{hs}^{SW} = F(\hat{\theta})\bar{y}_{hs}^{SW} = F(\hat{\theta})c_{hs}^{SW},$$

$$y_{hs}^{SM} = F(\hat{\theta})\bar{y}_{hs}^{SM} = F(\hat{\theta})c_{hs}^{SM}.$$

4 Quantitative Analysis

In this section, we plan to calibrate our model to the U.S. data to see whether our model is quantitatively able to explain the observed changes in marriages in addition to the basic facts in the structural change literature. At this moment, we only show our preliminary result for a benchmark equilibrium case given ad-hoc values of parameters. Except for the utility cost of marriage, δ, the parameter values are taken from Ngai and Petrongolo (2013). We set the utility cost of marriage, δ, so that the fraction of the married is equal to 0.5 in the equilibrium. Labor endowments for men and women (L_m and L_f) are set to 1 by assumption. For now, we set the productivity in all the sectors equal to 1. All the parameter values are summarized in Table 1.

Table 1: Parameter Values for the Model

Parameter			
Name		Value	Source
ϵ	Elasticity of substitution between c_M and c_S	0.002	Ngai and Petrongolo (2013)
σ	Elasticity of substitution between c_{hs} and c_{ms}	2.3	Ngai and Petrongolo (2013)
ω	Share parameter for the aggregator of c_M and c_S	0.5	Ngai and Petrongolo (2013)
ψ	Share parameter for the aggregator of c_{hs} and c_{ms}	0.5	Ngai and Petrongolo (2013)
η	Elasticity of substitution between L_m and L_f	3	Ngai and Petrongolo (2013)
δ	Utility cost of marriage	0.86	-
A_M	Productivity of manufacturing	1	-
A_{ms}	Productivity of market services	1	-
A_{hs}	Productivity of home services	1	-
L_m	Total endowment of male labor	1	-
L_f	Total endowment of female labor	1	-

In Table 2, we show the equilibrium prices and allocations for the given set of parameters.

Table 2: Equilibrium Prices and Allocations

Variables		
Name		Value
$\frac{w_f}{w_m}$	Women's relative wage to men	0.72
$\frac{L_{M,f}}{L_{M,m}}$	Total female labor to male labor in manufacturing	0.32
$\frac{L_{ms,f}}{L_{ms,m}}$	Total female labor to male labor in market services	1.33
$L_{hs,f}^{MA}$	Hours in home services for married women	0.26
$L_{hs,f}^{SW}$	Hours in home services for single women	0.15
$L_{hs,m}^{MA}$	Hours in home services for married men	0.10
$L_{hs,m}^{SM}$	Hours in home services for single men	0.12
c_M^{SW}	Manufacturing good consumption for single women	0.13
c_{ms}^{SW}	Market services consumption for single women	0.16
c_{hs}^{SW}	Home services consumption for single women	0.10
c_M^{SM}	Manufacturing good consumption for single men	0.17
c_{ms}^{SM}	Market services consumption for single men	0.27
c_{hs}^{SM}	Home services consumption for single men	0.08
c_M^{MA}	Manufacturing good consumption for married households	0.34
c_{ms}^{MA}	Market services consumption for married households	0.33
c_{hs}^{MA}	Home services consumption for married households	0.35
-	Service share in GDP	0.55
$1 - F(\hat{\theta})$	Fraction of the married	0.50

5 Conclusion

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Appendix

A. Additional Figures and Tables

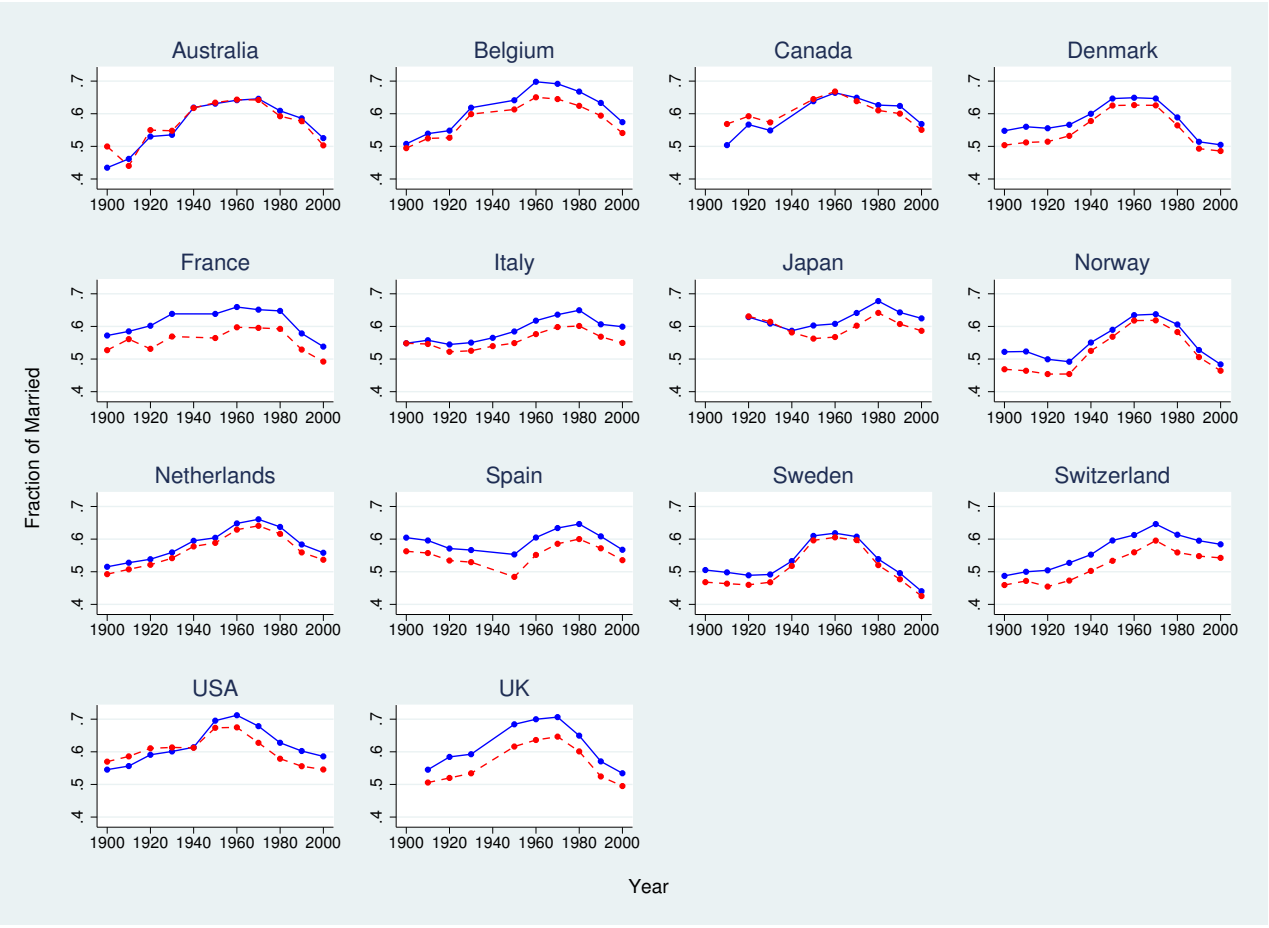

Figure 5: Fraction of Married in Total Population at Age 15 and Above, Men (Blue/Solid Line) and Women (Red/Dashed Line)

Figure 6: Fraction of Married (Age Structure Adjusted) in Total Population at Age 15 and Above, Men (Blue/Solid Line) and Women (Red/Dashed Line)

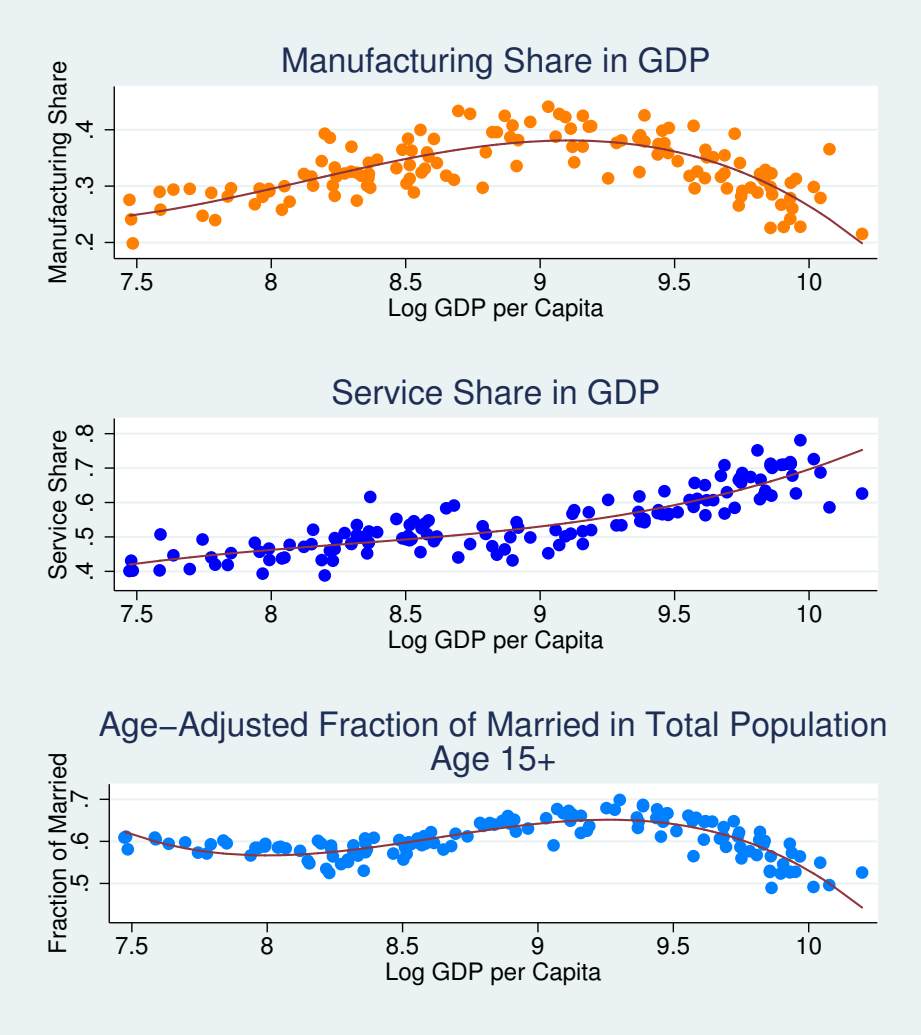

Figure 7: Manufacturing and Service Shares, and Fraction of Married (Age-Adjusted) by Log Income per Capita

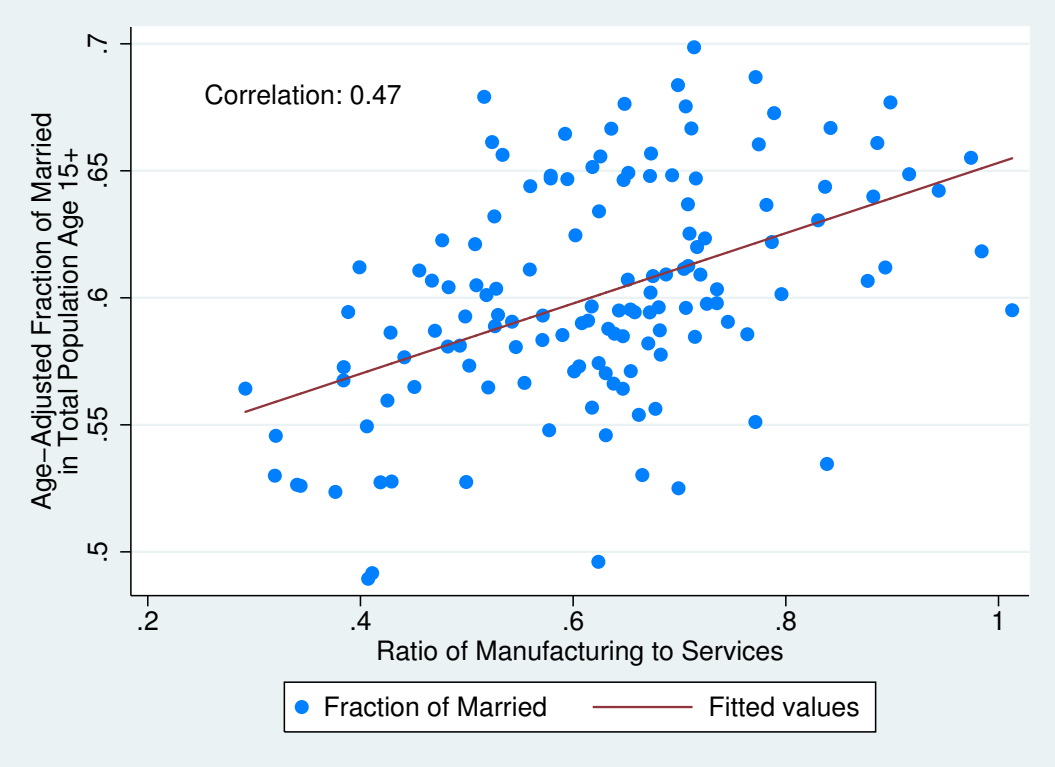

Figure 8: Fraction of Married (Age-Adjusted) in Total Population at Age 15 and Above v.s. Ratio of Manufacturing to Services

B. Data Sources

Data on marital status (single, married, divorced and widowed) by five-year age-groups and sex over the period 1900 to 2000 is collected from the following sources:

Australia

- For 1900, Australian Statistical Yearbook published in 1901 (p.175-179) is used. Census of the Commonwealth of Australia is the source of data for 1910, 1920, 1930, 1940, 1950 and 1960. Censuses published in the following years are use: 1911 (Vol. III - Part IX, p.1078-1081), 1921 (Vol. I, Part VIII, p.494-497), 1933 (Vol. II, Part XVIII, p.1118-1119), 1947 (Vol. I, Part X, p.604-605), 1954 (Vol.VIII, Part I, p.20-21). For 1970, data is extracted from Census of Population and Housing published in 1971 (Bulletin No 3 - Part 9, p.1)
- 1980-2000: UN Database for Marriage and Divorce

Belgium

- Between 1900 and 1970, Annuarie Statistique la Belgique et du Congo Belge (statistical yearbook of Belgium) is used. Data for 1900-1910 is from the yearbook published in 1914 (p. 70-73) and data for 1920 and 1930 are from yearbooks published in1933 (p. 26-27) and 1940 (p. 36-37), respectively. For 1950 we use yearbooks published in 1955 (p.46-47) which reports the data for 1947. For 1960 and 1970, yearbooks published in 1965 (p.69) and 1975 (p.33) are used.
- 1980-2000: UN Database for Marriage and divorce Manufaturing

Canada

- For 1910 and 1921, data is extracted from Census of Canada published in 1921 (Vol. II, Table 29, p.140-141). For 1930, Census of Canada published in 1931 (Table 12, p. 94-95) is used.
- 1950-2000: UN Database for Marriage and Divorce

Denmark

- For 1900, 1910, 1950, 1960, 1970 and 1980 Statistisk Årbog Danmark (statistical yearbook of Denmark) is used. Yearbooks published in the following years are used: 1901 (Table 6, p.10-11), 1914 (Table 7, p.11), 1954 (Table 10, p.12), 1963-64 (Table 11, p.31), 1970 (Table 11, p.42), 1980 (Table 10, p.21) and 1990 (Table 40, p.31).
- For 1920, 1930 and 1940, Folketaellingen I Kongeriget Danmark (Denmark Census) is used. The years of publications respectively are 1921 (Table2, p.22-23), 1930 (Table IIa, p.22-23) and 1940 (Table IIa, p.28-29)

- For 2000 we get the data from Danish Statistical Database STATBANK. It is available at: http://www.dst.dk/en/Statistik/statistikbanken.aspx

France

- Between 1900 and 1950, we collect the data from Annuaire Statistique (statistical yearbook of France). Yearbooks published in the following years are use: 1905 (Table 3, p.7), 1914-15 (Table 3, p.9), 1927 (Table 5, p.8), 1936 (Table 5, p.9), 1954 (Table 1, p.10-12).
- 1960-2000: UN Database for Marriage and Divorce

Italy

- Between 1900 and 1990, we collect the data from Censimento Generale della Popolazione (Italian Census). Data for 1910 and 1920 is from the yearbook published in 1921 (No.55, p.180-181). For other years Italian census published in the following years are used: 1901 (Table 3, p.337), 1931 (Vol.4, Part 2, Table 8, p.66-69), 1936 (Vol.3, Part 1, Appendix Table 5, p.114-118), 1951 (Vol.7, Table 20, p.123), 1961 (Vol.6, Table 2, p.120), 1971 (Vol.5, Table 2, p.232-233), 1981 (Vol.5, Table 12, p.191-192) and 1991 (Vol.1, Table 2.1, p.73-74).
- For 2000 we used Italian Census Data accessed through http://dawinci.istat.it/Database

Japan

- For 1920-2000 we collect the data from Japanese Census, Statistics Bureau, Ministry of Internal Affairs and Communications.
  This is available at: http://www.e-stat.go.jp/SG1/estat/eStatTopPortalE.do

Netherlands

- For 1910, 1920 and 1940 we use De Nederlandse Volkstellingen (Dutch Census). Yearbooks published in the following years are respectively used: 1909 (Table II, p.375-378), 1921 (Table II, p.247-249) and 1947 (Table 1B, p.60-61).
- For 1900 and 1930 we obtained the data for 1899 and 1931 from Statline Database Netherlands. For 1950 to 2000 we also used Statline Database Netherlands. This database is available at: http://statline.cbs.nl/statweb/dome/?TH=3600&LA=nl

Norway

- Between 1900 and 2000, we use Folketellingen I Norge (Statistical yearbook of Norway). Yearbooks published in the following years are use: 1904 (Table 5, p.6-7), 1912 (Table 7, p.82-83), 1926 (Table 8, p.8-9), 1935 (Table 7, p.6-7), 1946 (Table 12, p.14), 1956 (Table 10, p.14), 1963 (Table 10, p.14), 1973 (Table 9, p.10), 1982 (Table 11, p.14), 1992 (Table 19. p.45) and 2000 (Table 63, p.79)

Spain

- Between 1900 and 1930, data is extracted from Census of Spain published in the following years is used: 1900 (Vol.3, p.296-297), 1910 (Vol.3, p. 402-403), 1920 (Vol.3, p.276-277) and 1930 (Vol.2, p.4-5)
- 1950-2000: UN Database for Marriage and Divorce

Sweden

- Between 1900 and 1990, we use Population changes during 250 years: Historical statistics for Sweden. The reference to the book is the following: Sweden, Statistics. (1999): "Befolkningsutvecklingen under 250 år." Historisk statistik för Sverige, p. 30-37.
- For 2000, Data for marital status extracted from the Swedish Statistical Database access via `http://www.scb.se/en_/Finding-statistics/Statistical-Database/`. See Statistical Yearbook of Sweden in 2002 (Table 62, p.63)

Switzerland

- Between 1900 and 1990, we use Historical Statistics of Switzerland (Table B10A, p.118 and Table B11A, p.120). The reference of this book is the following: Siegenthaler, H. (1996) "Historische Statistik der Schweiz", edited by H, Ritzmann-Blickenstorfer.
- For 2000 we use UN Database for Marriage and Divorce

United Kingdom

- For 1910, 1920, 1930 and 1980 we use Census published in 1911 (England and Wales only), 1921 (England and Wales only), 1931 (England and Wales only) and 1981, respectively.
  This is available at: `http://www.statistics.gov.uk/hub/index.html`
- For 1951 (England and Wales only), 1961 (England and Wales only), 1971 (England and Wales only), 1991 and 2000, we use UN Database for Marriage and Divorce.

United States

- Between 1900 and 2000, is extracted from IPUMS Census.
  This is available at: `https://usa.ipums.org/usa/`

C. Adjustment in Population Structure

To do the age adjustment we consider a typical method that is used by demographers. Suppose for country i, data on marital status is collected by J age groups for the entire time period. Let, x_t^i, x_t^{ij}, and m_t^{ij} respectively represent the total population in the country i, total population in the j-th age group and number of married in that age group at time t. The fraction of married in the total population in the country i at time t is obtained from:

$$F_t^i = \sum_{j=1}^{J} \frac{m_t^{ij}}{x_t^{ij}} \frac{x_t^{ij}}{x_t^i}$$

Hence, the age adjusted measure for the baseline year (for example 2000) can be obtained from:

$$F_t^i = \sum_{j=1}^{J} \frac{m_t^{ij}}{x_t^{ij}} \frac{x_{2000}^{ij}}{x_{2000}^i}$$

In other words, we keep the age composition of the population unchanged (age composition in the base year) while the fraction married for each age group gets its own value from data.