Child care costs and stagnating female labor force participation in the US*

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Abstract

The female labor force participation rate in the United States leveled off around 1990 and began to decrease in the late 1990s. This paper shows that structural changes in the child care market play a substantial role in influencing the evolution of female labor force participation. I first provide new estimates of long-term trends in prices and hours of child care using the Survey of Income and Program Participation. Hourly expenditures on child care rose by 32% and hours of daycare used declined by 27%. Then, I build a life-cycle model of married couples that features a menu of child care options to capture important features of reality. The calibrated model predicts that the rise in child care costs leads to a 5% decline in total employment of females, holding all else constant. Finally, this paper provides two hypotheses and their supporting evidence about the causes of rising child care costs: (i) restrictive licensing to home-based child care providers, and (ii) the negative effect of expanded child care subsidies to lower income households on the incentives for those individuals to operate the home-based daycare.

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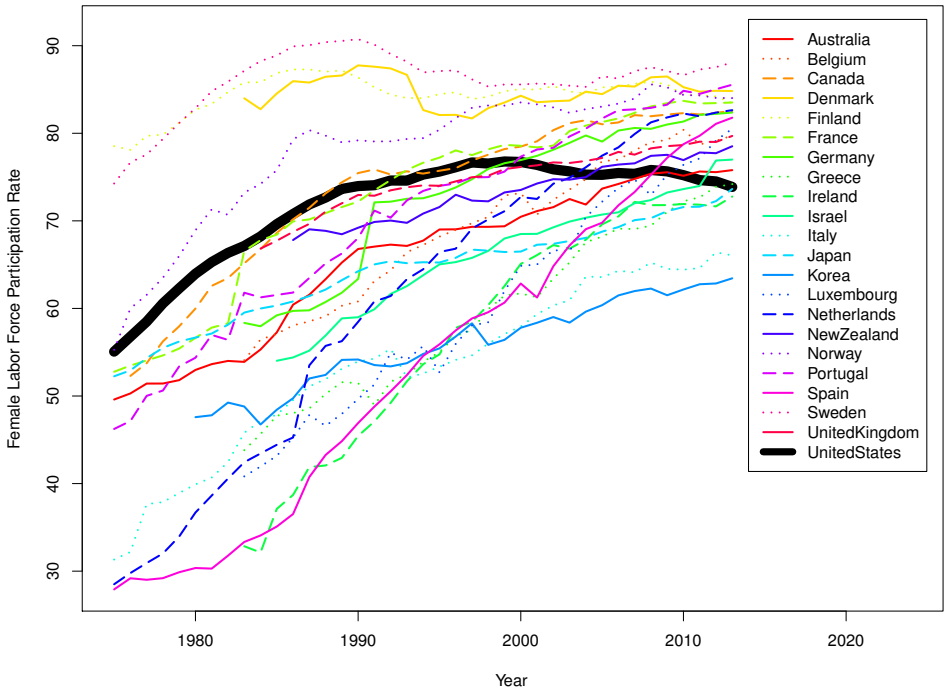
1 Introduction

Figure 1 plots the female labor force participation rates for OECD countries since 1975. Whereas the United States had one of the highest female labor force participation rates until 1990, it now is among the lowest (Blau and Kahn (2013)). A distinctive feature of the US time series is that this rate stagnated in the 1990s and declined after 2000, in contrast to the steady increase in other countries. As United Nations selected gender equality and empowerment of women as one of 17 Sustainable Development Goals, female labor force participation itself is an important policy goal. Also, women's participation in the labor market is an important driving force of economic growth (Hsieh et al. (2013)). The declining trend of female labor force participation rates is a large political, social and economic burden on the United States.

In this paper, I propose a possible explanation for the changing trend of female labor supply in the United States. In particular, I focus on the effects of child care costs on women's labor supply decisions. My analysis consists of three parts. First, I report evidence on rising costs and shrinking hours of child care. Next, I develop a calibrated life-cycle model of family labor supply to evaluated the quantitative consequences of the rising child care costs on female labor supply.



Data: OCED.stat, http://stats.oecd.org

Figure 1: Female labor force participation rates of OECD countries

Finally, I propose possible explanations for the rise in child care costs.

Although public interest in child care costs is intense, evidence in them is somewhat limited. The first contribution of this paper is to create consistent measures of costs and hours of child care using data from the Survey of Income and Program Participation (SIPP) from 1985 to 2011. In particular, I provide the first estimates of the secular trend of *hourly* prices of child care. I address the discontinuity in survey designs of various years of SIPP and build consistent measures. The mean real hourly expenditure on child care was stable until the mid-1990s. However, it jumped up after that: the rate in 2010 is 32% higher than that in 1990. The rising costs caused a substitution from market child care provided by daycare centers, nannies, family daycare homes, etc., toward non-market care, mainly provided by grandparents of children: hours of market child care declined by 27%, while hours of non-market care by family and relative rose by 23% from 1990 to 2010. The evidence also suggests a structural break in the home-based child care sector, i.e., child care provided by individuals in private residences such as family daycare homes, nannies, and babysitters. Although home-based child care exceeded the care by daycare centers in the 1980s, the hours provided by home-based care dropped to half in the 1990s and 2000s.

To evaluate the consequences of the rising child care costs, I build a life-cycle model of married couples. The model incorporates standard features in macroeconomic analysis of life-cycle behavior: saving, labor supply operative intensive and extensive margins, and human capital accumulation. The model also embeds a child care arrangement choice between market care and non-market care by relative/family to capture the substitution observed in the United States. The model is calibrated to match the 1990 data, and then the observed rising child costs are introduced to evaluate the extent to which it can explain the changing trend. The model predicts a 5% decline in total employment of women, and a 13% decline in employment of working mothers with children age under 5. The model also predicts long-run effects of child care costs on older women because of lost human capital accumulation. The model does a good job of accounting for the observed child care arrangement substitution from market toward non-market.

The remaining question is the fundamental cause of the rising child care costs. At first pass, this increase is puzzling since, in 1990s and 2000s, the subsidies to child care enrollments were dramatically expanded by growing expenditures on Head Start, the start of the Child Care Development Fund (CCDF), and state-level expansions of universal pre-K programs. In standard economic models, these subsidies would serve to decrease the costs paid by households and increase the hours of child care. However the US child care market moved in the opposite direction in terms of both price and quantity. The observed sharp decline in home-based child care supply suggests that the home-based care sector might get negative supply shocks. This paper examines two possible factors caused by child care policies: (i) expansion of licensing in the home-based sector and (ii) the

discouraging effect of child care subsidies on home-based care workers.

Although almost all daycare centers are required to obtain licenses for operation, only 42% of home-based providers held licenses in 1990. The fraction increased to 54% in 2000 due to state and federal efforts on regulating child care market along with the expansion of subsidies. The aggregate time series does not provide much opportunity to assess the extent to which changes in licensing might have affected supply. To get additional variation, I turn to state level data since there is substantial variation across states in the extent of licensing. I use a Difference-in-Difference-in-Difference (DDD) approach to control for the country-level trend by year difference, the secular state-level difference in licensing, and the state-level change in child care demand by taking the difference between home-based and center-based providers. The estimation finds a statistically significant effect of the expansion of licensing on child care costs, but it explains only 8% of total increase in costs.

While the first hypothesis considers an aspect of child care programs distinct from the subsidies, the second one considers the effects of subsidies themselves. Wages of home-based care workers are very low: more than half of workers' wages were below the minimum wage in 1990. Even compared with workers in daycare centers, the average wage was 30% lower in 1990. However, this wage gap was at least partially offset by the fact that if a child care worker had her own children, home-based child care jobs allowed her to care for her own kids in the same place and save on child care expenses. The traditional business model of home-based child care was taking care of one's own children together with one's neighbors' kids in one's private residence. More than half of home-based child care providers had children under 12 in 1990. The expansion of subsidies decreased the incentive for working mothers to choose home-based child care as an occupation. The benefit of saving on the child care costs for their own children disappeared because many of these home-based workers became eligible for subsidies, and as a result, they sent their kids to daycare centers and changed their jobs to higher wage ones. I find some evidence consistent with this hypothesis: a sharp decline in the supply of working mothers in the home-based sector, and a vanishing wage gap between home-based and center-based care workers.

Literature Review

Stagnating female labor supply in the United States was emphasized by Blau and Kahn (2013). Using cross-country panel regressions, they find that the delayed expansion of family-friendly policies compared to other advanced countries can explain some part of the stagnation. My paper complements Blau and Kahn (2013) and provides an additional cause, rising child care costs. Declining female labor supply is also included as one part of the overall decline of labor supply in

the United States analyzed by Moffitt et al. (2012), Acemoglu et al. (2016), Barnichon and Figura (2015). Although my paper examines the effects of rising child care costs only on female labor supply, it is also a significant factor on total labor supply.

The long-run trend of child care costs in the United States is estimated by Laughlin (2013) with *total family expenditure on all children* in several years and Herbst (2015) with costs *per mother's hours of work* in only 1990 and 2010. Although they somewhat control for quantity, a more natural definition of child care price is expenditure divided by its hours. My paper is the first attempt to provide long-term measures of *hourly* costs of child care. The database created in this paper also allows detailed studies of child care costs disaggregatec by type of care and family income. This paper also shows hours of market child care per week and its dramatic decline, which are missed in the previous studies. The new findings on hours also complement the literature of long-term trend of time-use, e.g., Aguiar and Hurst (2007).

The model considered in this paper follows the macroeconomic literature on female labor supply with life-cycle models such as Attanasio et al. (2008), Bick (2015), Fernández and Wong (2014), and Guner et al. (2011, 2012, 2013) . My model is rich enough to include essential aspects of life-cycle decisions such as saving, human capital accumulation, and both intensive and extensive margin of labor supply. In addition, this model has advantages in detailed modeling of child care arrangement choice and its comparison with data. This paper also contributes to the large literature of family in macroeconomics recently summarized by Greenwood et al. (2015) and Doepke and Tertilt (2016).

The empirical analysis on rising child care costs is related to applied microeconomic analysis of child care policies such as Chipty and Witte (1997), Blau and Mocan (2002), Blau (2007), Hotz and Xiao (2011), Bastos and Cristia (2012) and Rodgers (2016). Following the literature, this paper also suggests the importance of considering incentives facing child care providers.

The remainder of the paper is organized as follows. Section 2 explains the methodology of child care costs estimation and summarizes long-run facts. Next, I propose a life-cycle model of married couples and its calibration to evaluated the consequences of the rising child care costs on female labor supply. Then, two hypotheses on rising child care costs and their empirical supports are provided in Section 4. Finally, Section 5 concludes.

2 Facts of female labor supply and child care market in the US

This section describes long-term trends of female labor supply and child care allocation in the United States.

2.1 Data source and measurement method

To document the trends in female labor supply and the child care market, I use the March Supplement of the Current Population Survey (CPS) obtained by the IPUMS CPS, 1975-2014, and the Child Care Supplement of the Survey of Income and Program Participation (SIPP), 1985-2011. From the CPS, I estimate the labor force participation and hours of work of women, and also the labor supply of child care workers in the market. SIPP provides the evidence on the demand side of child care market, i.e., the hours of child care used by parents. The sample size of SIPP varies by year: each sample contains about 1000 to 3000 working mothers with children age less than 5.

To describe the long-term trends of the child care market in the United States, I follow two existing studies, Laughlin (2013) and Herbst (2015), and extend their approaches to obtain more detailed data. Laughlin (2013) estimates the *total child care expenditures on all children* in a family, and Herbst (2015) studies the costs *per hour of work of the mother*. Both papers use the Child Care Supplement of SIPP. Although they somewhat control for quantity, a more natural definition of child care price is hourly costs of child care, i.e., child care expenditure divided by its hours.

To identify child care hours and expenditures in SIPP, I define market child care as individual care by non-relative, family day care, day care center, and nursery or preschool. In my estimation of child care expenditure, I exclude monetary payment for care by family/relative, because it may include a significant amount of non-monetary rewards. To keep consistency by year, I construct household level data with limited variables on the primary and secondary child care arrangements of first, second and third youngest children aged 5 or under of employed designated parent (mainly mothers)[1]. I also construct hours of non-market child care as the sum of hours of care by child's other parent/stepparent, brother/sister, grandparent, other relative of child. Hours of non-market care also includes hours of care for self and parent working at home.

The estimation is challenging because the child care hours reported in Child Care Modules of SIPP are inconsistent over time. The structures of the Child Care Modules can be classified into three types.

- Survey A: The first Child Care Module was collected in wave 5 of SIPP1984, which was surveyed in 1985. This survey contains the sample of only working mothers and studies hours and expenditure only on total costs of all children in a family. It studies only primary child care arrangement. Hours of child care is defined as hours while the designated parent (mainly mother) is working.

[1]For example, suppose a mother has four children aged 1, 3, 4 and 5, and each child is cared by a day care center for 30 hours, a baby sitter for 10 hours, and her friend for 5 hours. In this case, only hours and payment of children aged 1, 3 and 4 of the day care center and the baby sitter are included in my sample. Then, the hourly expenditure of child care of this household is measured as the sum of child care expenditures of children aged 1, 3 and 4, divided by total hours 135 calculated by $(30 + 10 + 5) \times 3$.

- Survey B: The second category is wave 3 of SIPP1988 to wave 6 of SIPP1993. It covers data from 1988 to 1994. These surveys also study the sample of working mothers, while they examine the expenditures on both primary and secondary child care arrangements on three youngest kids in each household. The definition of hours of child care is still hours while the designated parent is working.

- Survey C: The final category is wave 4 of SIPP1996 to wave 8 of SIPP2008. The data is collected from 1997 to 2011. These surveys contain the sample of all mothers including both working and non-working mothers. They report the expenditures on all child care arrangements of five youngest kids in each household. The hours of child care are changed to total hours including before/after work hours[2].

As noted by Herbst (2015), these surveys also have significant inconsistency about the child care arrangements of school-age kids. In this paper, I focus on child care costs of children aged under 5 to overcome the problem. In the data, the child care costs for school-age children are small[3].

To make consistent measures of hours and hourly costs of child care, I use a simple extrapolation method to connect these three different types of surveys. First I use Survey C as the baseline dataset because it contains a rich set of variables. I estimate the hours and hourly costs of child care of all working mothers. The hourly expenditures are defined as total child care expenditures divided by hours of market child care of all three youngest children under 5 in each household. I use total hours of child care including before/after mother's work. To compute time-series measures, I calculate the mean of each variable for all working mothers each year.

Next, using Survey B, I estimate mean hours and costs from 1988 to 1994. It has large biases in estimating hourly expenditure of child care because the expenditures are asked as total costs of child care, while hours are limited to those at which mothers are at work. To modify the inconsistency, I adjust the variables derived from Survey B so that it's linear trend matches Survey C. That is, I obtain linear trends of variables from 1988 to 1994 for Survey B and from 1997 to 2011 for Survey C. Then, the mean values obtain in the former are adjusted so that the extrapolated trend in 1995.5 for Survey B matches with that of Survey C. This methodology assumes no structural break between 1994 to 1997.

[2]The while working hours are also surveyed since the wave 4 of SIPP2001. But this variable seems to have significant survey errors as noted by Herbst (2015). It contains unbelievably many samples who answered 0 for while working child care hours but many hours for total hours.

[3]In the SIPP, only 19% of working mothers use paid child care for children older than or equal to 5 in 2005. After educational activities such as sports clubs or ballet lessons are excluded, the child care expenditures of school age children account for only 0.7% of family income among all families with working mothers. In Appendix B, I plot hourly costs of child care of children age 5 to 15. The trend is similar to those of children under 5, i.e., almost flat until the mid-1990s and jumped up after that.

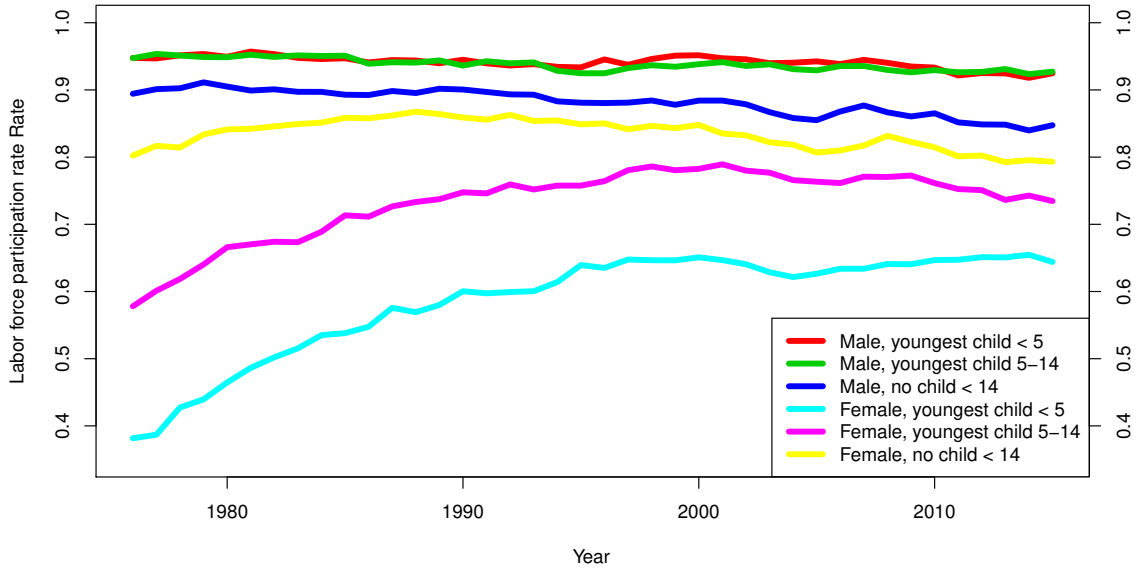


Figure 2: Labor force participation rates by sex and child status, age 25-44

Finally, I also estimate variables by Survey A and adjust them. Survey A records only total hours and expenditures of all children in a family, i.e., it lacks variables for each child. To make a consistent measure, I first compute the mean of variables using a sub-sample of working mothers who have only one child aged under 5 both in 1985 of Survey A. Next I also calculate the value using the same sub-sample in 1988, the first year of Survey B. Then, the values in 1985 are adjusted as

$$\text{final value in 1985} = \frac{\text{mean value of sub-sample in 1985} \times \text{mean value of full-sample in 1988}}{\text{mean value of sub-sample in 1988}} \quad (1)$$

This estimation implicitly assumes that the changes in variables between 1985 and 1988 are the same between the full-sample and the sub-sample.

2.2 Trends of female labor supply and child care market

Figure 2 provides the labor force participation rates by sex and child status of people age 25 to 44. The trend of the labor market participation rates of women whose youngest child's age is under 5 dramatically changed around 2000. The rate increased by 27% from 1976 to 2000, but it has stayed almost constant after that. The trend of women with children aged 5 to 14 also share the similar trend: it increased by 20% from 1976 to 2000 but has been almost unchanged after that. As emphasized by Blau and Kahn (2013), this change in trend pushed the U.S. behind other

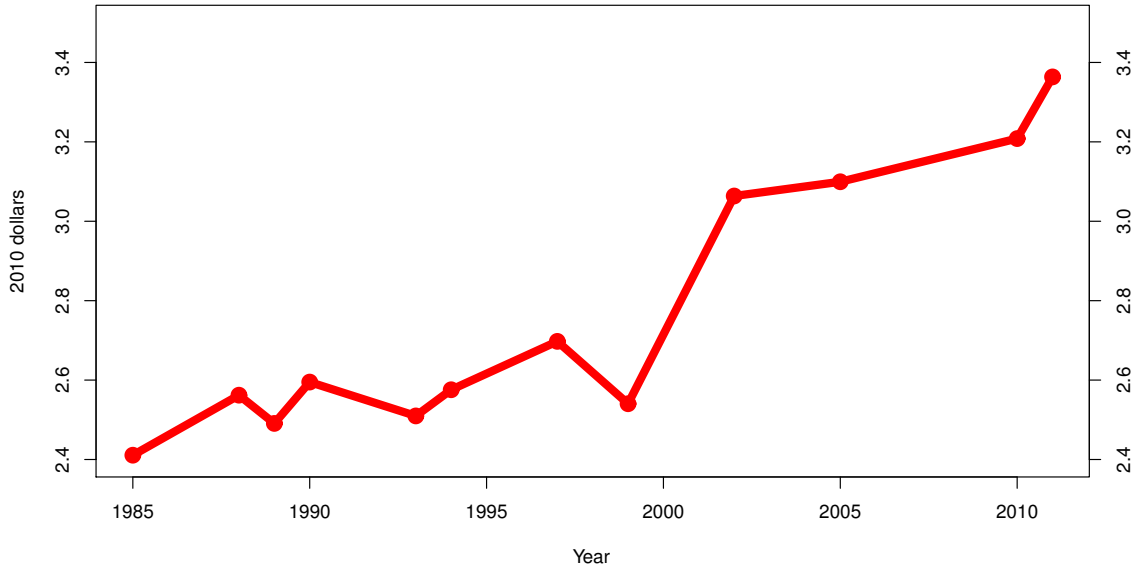


Figure 3: Mean real hourly expenditure on child care

advanced countries which have continued steady growth in female employment. The rates of men of all child status and women without young children have been almost stable for 40 years. They also experienced small declines in the most recent 20 years, referred to as the reversal of employment-population ratio (Moffitt et al. (2012)) or employment sag (Acemoglu et al. (2016)). While the U.S. economy faces some downward pressures on overall employment (e.g., import competition in the manufacturing sector to China as reported in Acemoglu et al. (2016)), they are insufficient to cease the steep upward trend of the increase in female labor force participation rate until 2000.

Price and hours of child care in aggregate

Figure 3 shows the mean hourly child care expenditure of children age under 5. The price level is adjusted by the consumer price index to 2010 dollars. The hourly price was stable until 1994, and increased after that. The kink in child care price around 2000 is consistent with the change in labor force participation trend of mothers.

Hours of child care responded to the increase in price. Figure 4 plots the mean weekly hours of child care in samples of both working and non-working mothers. As the price moved up, households substituted the child care from market to non-market. The U.S. trend is contrary to the tendency of an increasing share of market child care in most of the developed countries (OECD, family database).

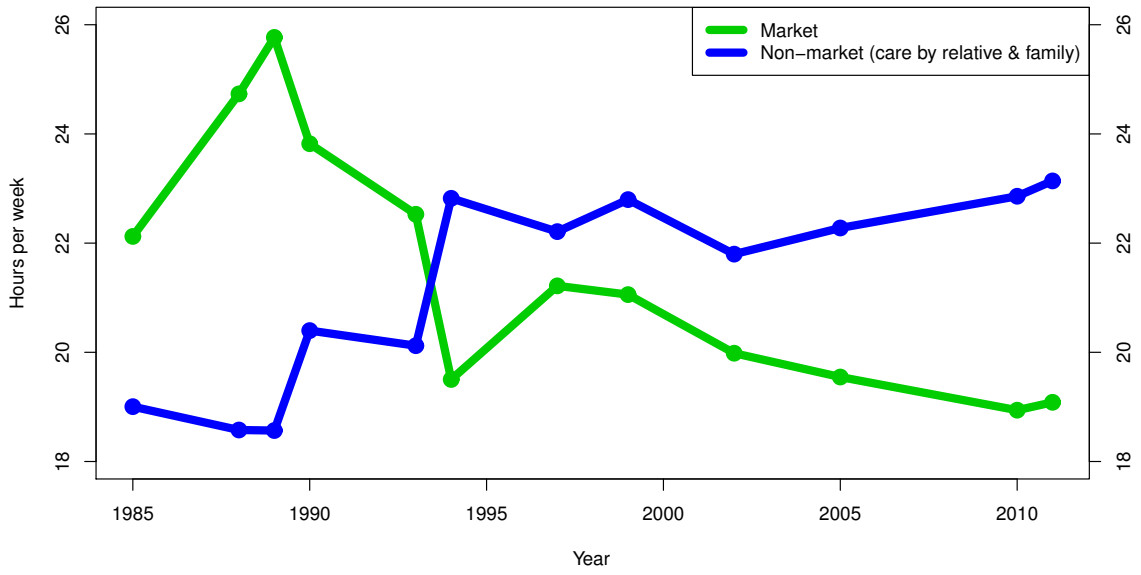


Figure 4: Hours of child care

Price and Hours of child care by category

To explore the trends in more depth, I divide the market child care into two categories. One is *center-based care* defined as a child care arrangement in a dedicated place provided by an organization such as day care center, nursery school, and preschool. The other one is *home-based care* defined as a child care arrangement in a private residence provided by an individual such as family day care, baby sitter and nanny[4].

[4]In SIPP, these are defined as cares by non-relatives.

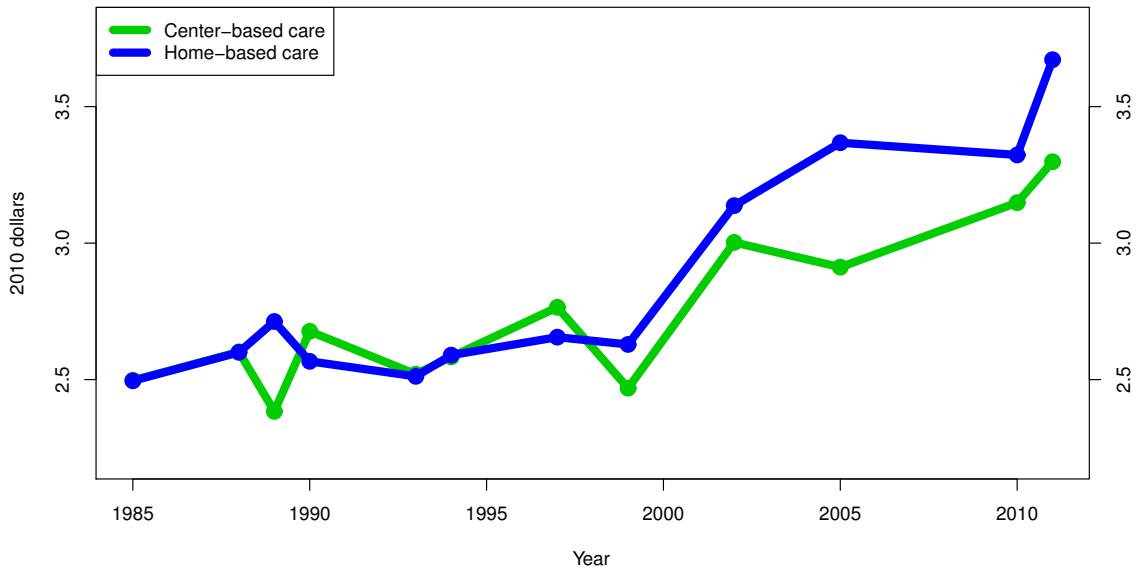


Figure 5: Real hourly costs of child care by category

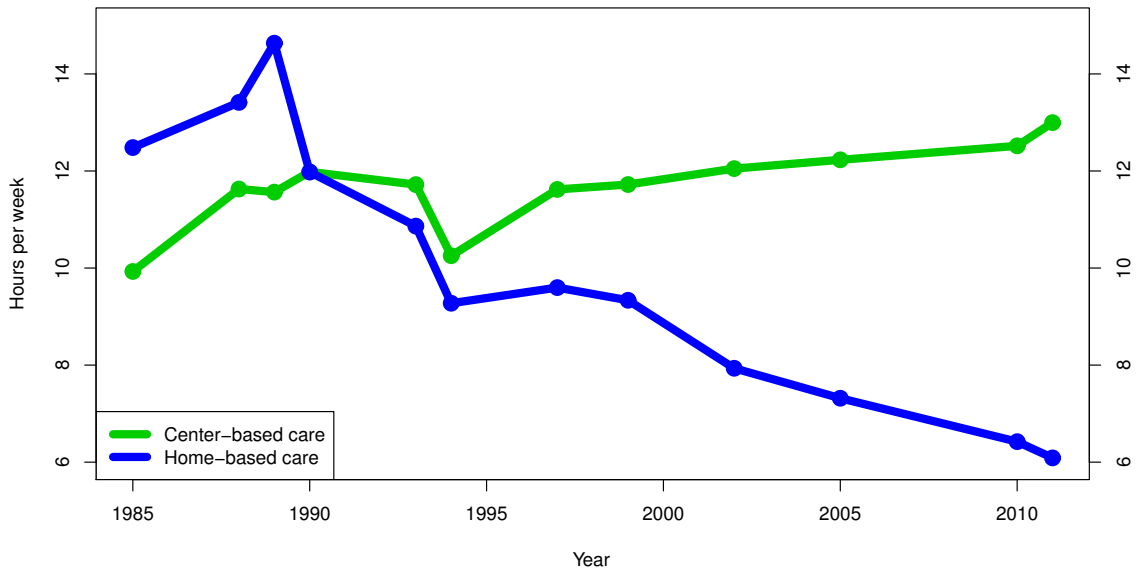


Figure 6: Hours of child care by category

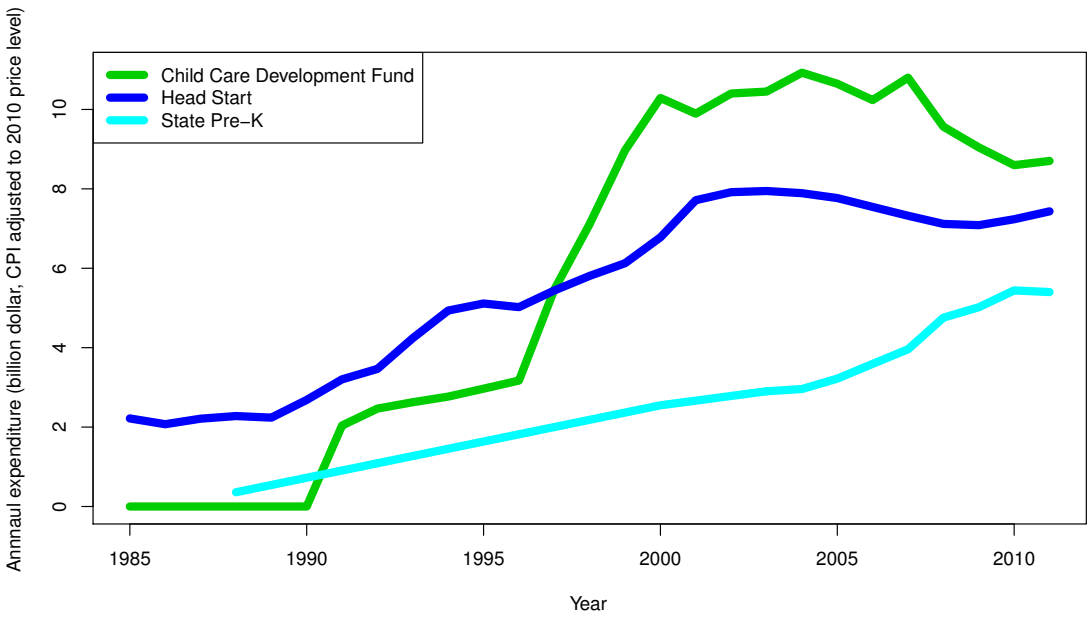


Figure 7: Real annual expenditure of child care subsidy programs

Figure 5 documents the mean real hourly child care expenditure by child care arrangement. Both center-based and home-based child care costs were almost the same and constant until the late 1990s, but jumped up in the 2000s. In particular, the costs of home-based child care rose more. The hours of child care by category is shown in Figure 6. While hours in center-based child care have been almost stable, hours of home-based child care have dropped substantially. These findings suggest a negative supply shock to the home-based child care sector. The driving forces of the home-based child care trends will be explained in Section 4.

Child care subsidy and its effect on household behaviours by family income

While child care costs have risen, the federal and state governments have expanded child care subsidies in particular for low-income families to support mother's labor market participation and improve early education of young children. The country has mainly three programs[5]: (i) The Child

[5]As noted by Besharov and Higney (2003), there are some other programs such as Child and Adult Care Food Program (CACFP), Social Service Block Grants (SSBG) and direct expenditure by Temporary Assistance for Needy Families (TANF). The whole structure is terribly complicated because TANF also transfers funds to other programs. The expenditures of these minor programs are relatively small, and their budgets have been nearly unchanged. In addition to the government spendings, the child care costs are also covered by The Child and Dependent Care Tax Credit (CDCTC). The expenditures on CDCTC has been stable in 20 years. Rodgers (2016) finds that the impacts of CDCTC on households may be limited because a large part of benefits from CDCTC is transferred to supplier side through increases in price and wage.

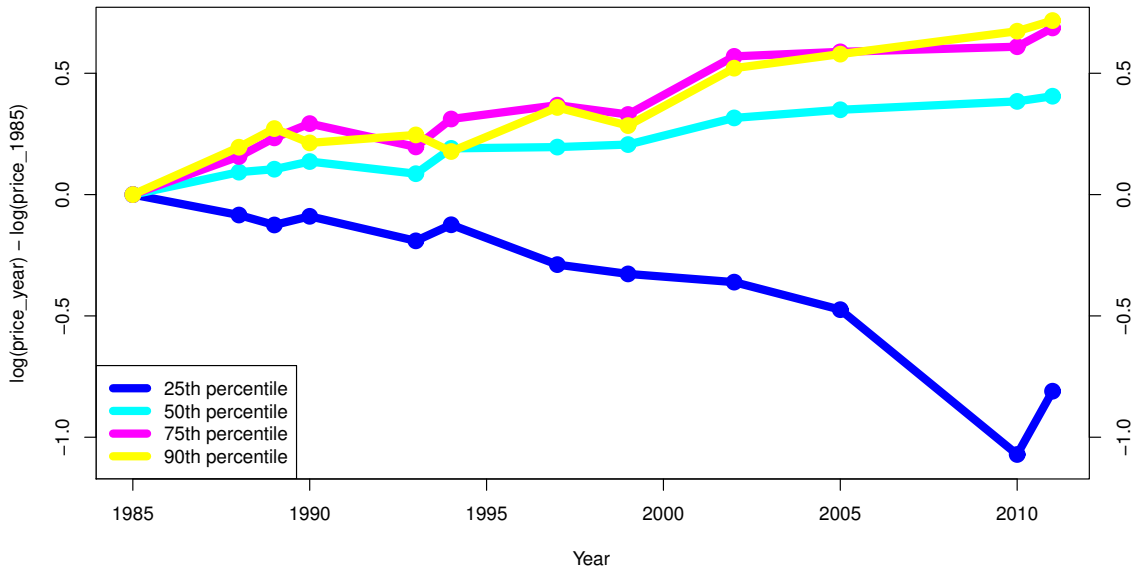


Figure 8: Cumulative log change of real hourly child care costs by percentile

Care Development Fund (CCDF), (ii) Head Start, and (iii) Pre-K schooling by each state[6]. All programs are interpreted as government subsidies to child care for low-income families. CCDF is a federal program to provide funding for low-income working families to support enrollments in child care. The fund provides block grants from the federal government to states, territories, and tribes. The CCDF was started as a part of the 1996 welfare reform law to consolidate multiple child care fundings[7] into a single new funding stream. The funds are mainly provided as vouchers, that cover nearly all costs of child care[8]. Head Start is a federal preschool program for economically disadvantaged children begun in 1965. The fund is provided to the supply side, i.e., the program mainly operates in centers and schools. The service is provided almost for free. From 1995, the Early Head Start was also created to provide education for younger children from birth to 3 years old. State pre-K programs are subsidized educational programs for pre-school age children operated by each state. The budget has been significantly expanded to attain its goal to provide universal pre-K, i.e., free education for all pre-school children, but only 29% are enrolled in 2015. Like CCDF and Head Start, state pre-K programs are means-tested in most of the states.

[6]Data source: Child Care and Development Fund Expenditure Data published by the Office of Child Care and Head Start Program Fact Sheet by the Office of Head Start, The House Ways and Means Committee Green Book 1998, and The State of Preschool Yearbook 2003-2015 published by National Institute for Early Education Research.

[7]Prior to 1996, the CCDF line on Figure 7 plots the total expenditure of the preceding programs including AFDC/JOBS Child Care Program, Transitional Child Care, At-Risk Child Care Program and Child Care and Development Block Grant.

[8]In my estimation by Child Care and Development Fund Administrative Data in 2005, 90.3% of total child care

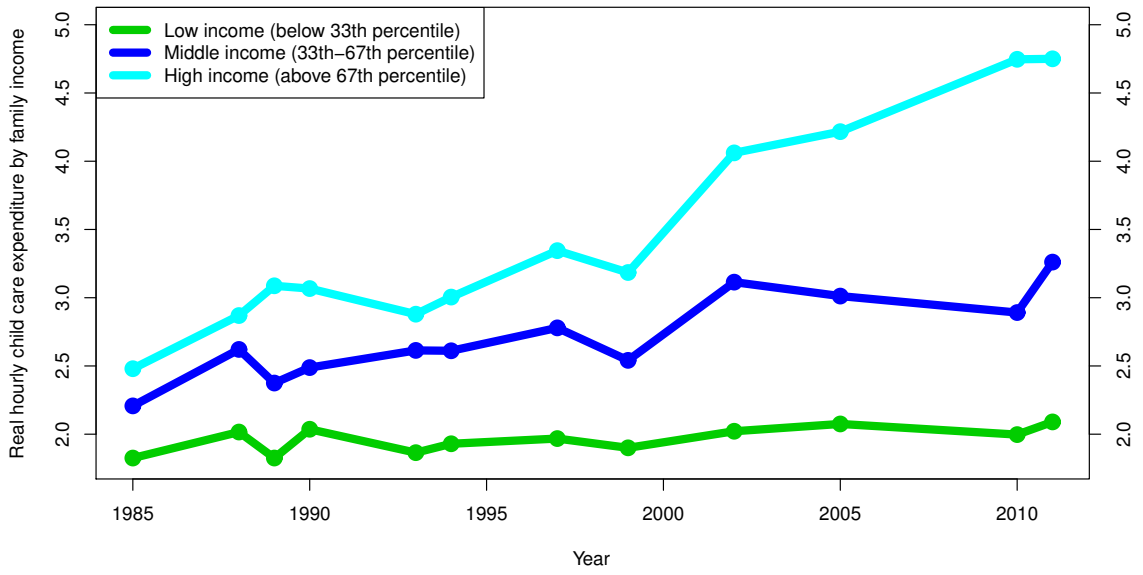


Figure 9: Real hourly child care costs by family income

The subsidy impacted the distribution of child care costs. Figure 8 plots the cumulative log change in the percentiles of real hourly child care expenditures since 1985, i.e., the log child care cost each year subtracted from the log cost in 1985. The 25th percentile cost has dropped dramatically. These should be interpreted as net costs because the measures are estimated as the hourly expenditures by households. The large drop of the lower tail of the distribution reflects the expansion of the child care subsidies. The figure does not plot the 10th percentile because the price hit zero in 1994. The diagram also tells us that the increase in upper tail prices is slightly higher than the median[9].

expenditure is covered by the subsidy.

[9]Herbst (2015) emphasizes the difference between mean and median child care costs. Although the variance of child care prices significantly increased, my analysis does not share the finding. In my estimation, the mean costs increased by 29%, while the median costs increased by 32% between 1990 and 2010. It is because Herbst (2015)'s median variable is significantly biased by his measure, expenditure over mother's hours of work, among mothers with school-age children. It is an inappropriate measure of child care *per quantity* because, while their mothers are at work, children are in school most of the time instead of paid child care services. In short, Herbst (2015) calculates, for school-age children,

$$\frac{\text{Expenditure on before/after school service}}{\text{Hours of school} + \text{Hours of before/after school service}},$$

where the numerator and the denominator are inconsistent. Since more than half samples in his main dataset are mothers with school-age children, his median mainly reflects the costs of mothers with school-age children with this improper measure. Consistent with my estimation, Herbst (2015) also reports smaller gap between mean and median costs if the sample is limited to working mothers of children age 0-5. Appendix B plots my re-estimation of Herbst (2015)'s measure of children age 0-5. I find the similar increase in child care costs in late 1990s to middle 2000s both

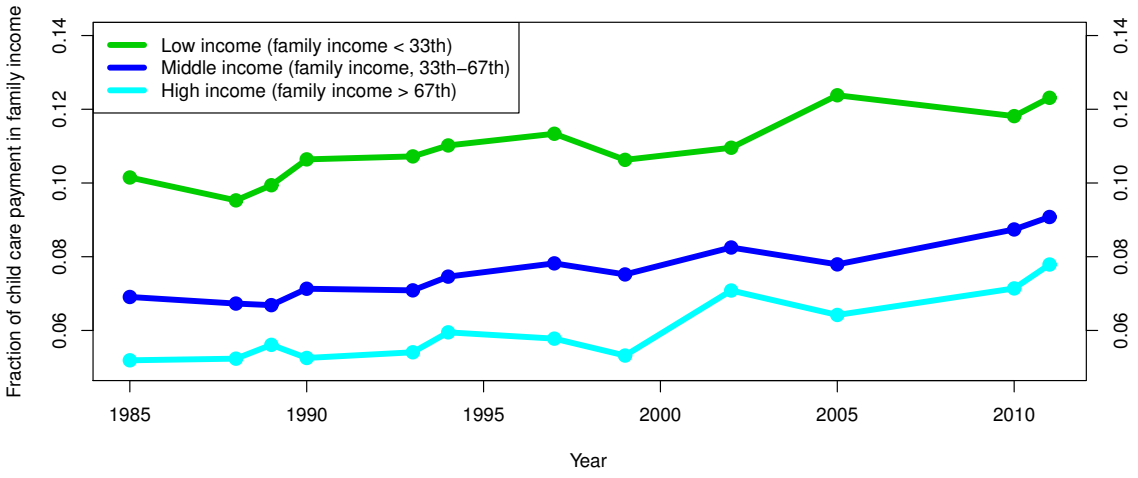


Figure 10: Fraction of child care payment in family income

The factor driving inequality of child care costs is income inequality. Figure 9 plots the the real hourly child care costs since 1985 by family income. The price has been almost unchanged for low-income families, and has increased for middle and high income families. The growth rate of costs for high income families dominates the increase for middle income ones. The rising variance of hourly child care costs by income is consistent with the study of costs per hours of work by Herbst (2015) and of child care arrangements by Laughlin (2015).

Figure 10 records the ratio of child care payment to family income for low, middle and high-income families. The share has increased among all groups. This diagram does not confirm a type of Tiger Mom hypothesis that the preference of care by high-income parents changed toward high quality ones (Ramey and Ramey (2010) and Herbst (2015)). The divergence of price has emerged mainly by rising dispersion of income.

Finally, Figure 11 plots the weekly hours of child care by family income. The left hand side plots weekly hours of market child care, and the right hand side shows non-market care (by relative/family). The rising child care costs led all categories to substitute the child care from market to non-market. In particular, middle-income families had the largest changes in the child care arrangements. Low-income families are eligible to receive subsidies to maintain or lower costs as shown in Figure 9. The rising costs have relatively minor impact on high-income families because the share of child care costs is relatively small as plotted in Figure 10.

in mean and median values. Both measures do not show steep increase in costs because they do not account for the decline in child care hours as shown in Figure 4.

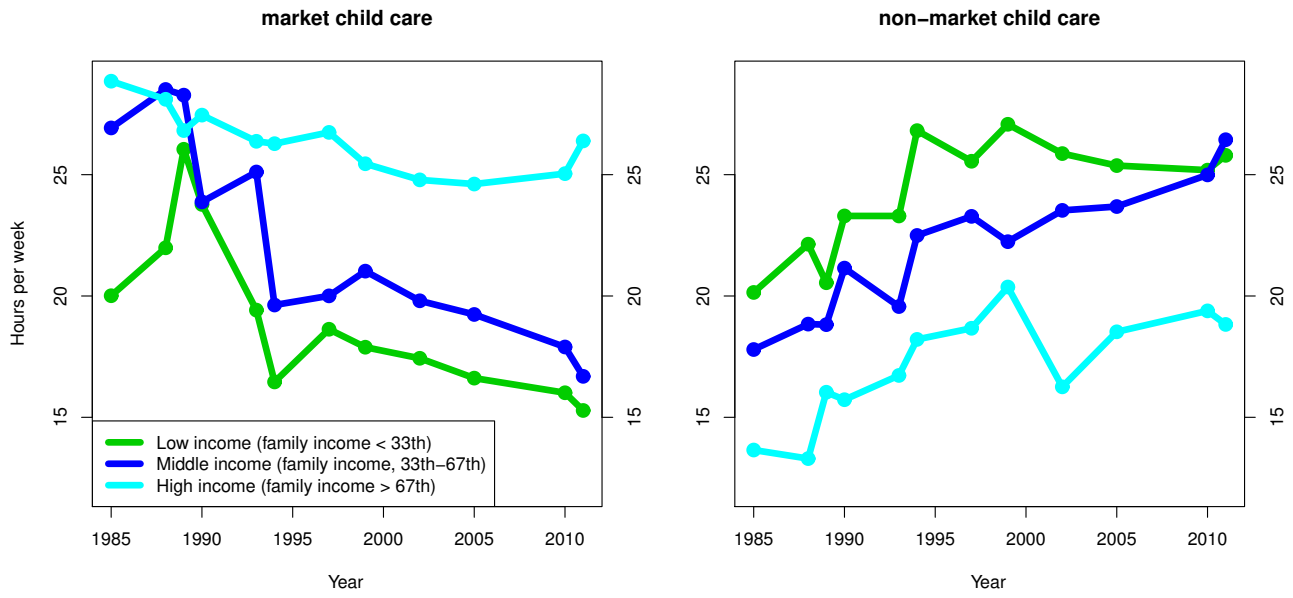


Figure 11: Weekly hours of child care by family income

3 Quantitative evaluation of rising child care costs on household behaviors by a life-cycle model

This section proposes a life-cycle decision model of married couples with children and evaluates how much the rising child care costs have pushed down the increasing trend of the female labor force participation rate in the United States. The model incorporates decisions on saving, work, and child care choice between market (e.g., daycare center) and non-market (e.g., care by grandparents). The model is calibrated to match 1990 data. Then, the rising child care cost estimated in Section 2 is introduced into the model.

3.1 Environment

This section builds a life-cycle of married couples. In the economy, there are many married couples with heterogeneity explained below. It is a partial equilibrium decision model, i.e., couples make decisions given fixed market prices. They have working periods from age 25 to 65, and retired periods from age 65 to 80. The model assumes one period to be 5 years; hence couples have 8 working periods and following 3 retired periods.

Heterogeneity in child bearing and care

Half of the couples bear two children in the first period, age 25-30, and the other half give birth to the children in the second period, age 30-35. This is a common assumption in the literature[10] that approximates the actual fertility rate and age distribution of childbearing in the U.S.

The model also assumes heterogeneity in the options for child care arrangement. A fraction θ of couples have access to non-market child care, but the other 1-θ couples are unable to use it. It represents the reality that some couples live nearby their parents or other relatives, while other couples live far away from them[11]. Heterogeneity in child bearing and care is denoted by $\omega \in \{ya, yu, oa, ou\}$, where y represents child bearing in young age, o is in older age, and a means non-market child care is available, and u represents unavailable. I keep the heterogeneity so that each category has mass $\theta/2$, $(1-\theta)/2$, $\theta/2$, $(1-\theta)/2$, respectively. The distribution of ω is also independent from the human capital distribution described below.

Heterogeneity in human capital

I introduce heterogeneity in human capital to generate wage distributions and capture the diversity in household behavior in data. Husbands and wives' human capitals are accumulated following a stochastic process. This paper uses superscript m for male or husband, and f for female or wife hereafter. For working periods, age 25-65, a husbands' human capital follows

$$\ln h^m_{t+1} = \ln h^m_t + g_t + v^m_{t+1}, \tag{2}$$

where h^m_t is the amount of the husband's human capital at period t, g_t is an age-dependent wage growth rate at period t, and v^m_{t+1} is a permanent income shock. For simplicity, Equation (2) assumes that all husbands work full time in all working periods; hence, there is no human capital depreciation by non-employment.

A wife's human capital follows

$$\ln h^f_{t+1} = \ln h^f_t + \mathcal{I}(n_t > 0) g_t - \mu(n_t)\delta + v^f_{t+1}, \tag{3}$$

[10] See, e.g., Attanasio et al. (2008)

[11] Bick (2015) assumes that non-market child care is available for all couples mainly because the relationships between the availability of care by grandparents and maternal employment are very weak in German Socioeconomic Panel. This paper first followed Bick (2015) and allowed all households to access non-market child care; then the simulation predicted that nearly all low-income couples used non-market care and most of the all high-income couples chose market care. In my 1990 SIPP data, the difference of child care choice by the income groups is small as shown in calibration part. In order to improve the matching of the model with data, I introduce the heterogeneity in non-market child care access. Posadas and Vidal-Fernández (2013) find that availability of grandparental child care is an important determinants of female labor market participation. Besides, in real world, there also variety of reasons to affect the availability of child care by grandparents such as employment statuses or health conditions.

where $n_t \in \{0, 0.2, 0.4\}$ indicates the wife's labor market participation: not in employment, part-time work and full-time work respectively. The indicator function $\mathcal{I}(n_t > 0) \in \{0, 1\}$ represents labor market participation, and $\mu(n_t)$ represents depreciation of human capital:

$$\mu(n_t) = \begin{cases} 0 & \text{if } n_t = 0.4, \\ \bar{\mu} & \text{if } n_t = 0.2, \\ 1 & \text{if } n_t = 0. \end{cases} \tag{4}$$

The above specification reflects no depreciation for full-time employment, partial depreciation $\bar{\mu}\delta$ with $0 < \bar{\mu} < 1$ for a part-time work, and full deprecation δ for non-market participation. In the literature, no partial depreciation of human capital in part-time work is assumed in several papers such as Bick (2015) and Guner et al. (2011). In my calibration, without the partial depreciation, nearly all young women choose part-time jobs, and most of the elder women work full time. This employment division by age contradicts the data. The partial depreciation parameter $\bar{\mu}$ is important for the model to match the model in the fraction of part-time workers by generation. The last term v_{t+1}^f is the permanent stochastic shock for wife's human capital. Equation (2) and Equation (3) assume that the age dependent human capital growth rate g_t is gender neutral, following Bick (2015) and Guner et al. (2011). In the calibration, I will estimate g_t using only male wage growth to avoid selection problems in female labor supply.

Finally, the distribution of permanent income shocks follows

$$\begin{bmatrix} \ln v_t^m \\ \ln v_t^f \end{bmatrix} \sim N\left(\begin{bmatrix} -\sigma^2/2 \\ -\sigma^2/2 \end{bmatrix}, \begin{bmatrix} \sigma^2 & \sigma^2\rho \\ \sigma^2\rho & \sigma^2 \end{bmatrix} \right) \tag{5}$$

where ρ is the correlation between husband and wife's human capital. I assume that men and women share the same variance of the innovations following the literature, e.g., Attanasio et al. (2008) to overcome selection problems again. For simplicity, the model does not include transitory shocks for simplicity as assumed in Attanasio et al. (2008). In the literature, even if transitory shocks are assumed, the persistence of the income shocks is very high, e.g., Fernández and Wong (2014), Bick (2015).

Decision variables

The main decision in the model is wife's hours of work. It affects household income, labor disutility and human capital accumulation of wives. In every working period, both husband and wife have 1 unit of time each. Wives choose hours of work n_t for $t \in \{1, 2, \ldots, 8\}$ from a set

$\{0, 0.2, 0.4\}$, where the elements represent non-employment, part-time employment, and full-time employment respectively. All husbands are assumed to be employed full-time, i.e., their hours of work are 0.4 for all working periods. I assume no unemployment.

Another decision is saving. In both working and retired periods, $t \in \{1, 2, \ldots, 11\}$, couples decide the amount of saving and choose the next period asset a_t. Borrowing is also allowed with a natural borrowing limit $\bar{a}(t, \omega)$. In the simulation, it is defined as the discounted present value of future income stream if the worst human capital realization of both husband and wife will continue for all future periods.

The final decision variable is child care choice. The model supposes that couples with children less than age 5 need to use market or non-market child care arrangements while wives are at work. Hours of market child care in period t are denoted by $x_t \in \{0, 0.2, 0.4\}$, and non-market child care is represented by $z_t \in \{0, 0.2, 0.4\}$. A time constraint $n_t = x_t + z_t$ is imposed, i.e., working mothers must use market or non-market in her working hours[12]. Couples with type $\omega \in \{yu, ou\}$ have no access to non-market child care; their constraints are $z_t = 0$ and $n_t = x_t$.

The model omits the child care arrangements and costs for school age children, i.e., before/after school care for age 5 to 14. The child care costs of school age children are believed to be high in the literature. For instance, Guner et al. (2013) calibrate the costs as 7.7% of average household income in 2005[13], which is surprisingly high compared to 10% for pre-school children. However, this number is calculated by *only families who use market child care*. In my estimation with SIPP microdata, only 19% of working mothers use market child care in 2005. It is problematic to assume this large amount of costs for all families with school-age children. Also, the costs may include educational activities such as sports clubs or ballet lessons. In my estimation[14], the child care expenditure of school age children accounts for only 0.7% of family income among *all families including those with zero payment*.

Preferences

The consumption utility is defined as

$$U_c(c;\ t, \omega) = \log\left(\frac{c}{\psi(t, \omega)}\right), \tag{6}$$

[12]This model also allows to use both care, $x_t = z_t = 0.2$, if wife is full-time employed, $n_t = 0.4$

[13]They obtain the number from an aggregated summary of SIPP, *Who's Minding the Kids? Child Care Arrangements: Summer 2006 - Detailed Tables.*
http://www.census.gov/data/tables/2004/demo/2006-tables.html

[14]I follow Herbst (2015) and assume that the costs include only center-based care, home-based care, and school-based activities *inside school*. This sample excludes lessons and clubs.

where $\psi(t,\omega)$ is the square root scale of family size adjustment as recently used by OECD[15].

The utility from wife's leisure is separated from consumption utility.

$$U_n(n;\ t,\omega) = d(t,\omega)\frac{(1-n)^{1-1/\gamma}}{1-1/\gamma}, \tag{7}$$

where $n \in \{0, 0.2, 0.4\}$ represents wife's market participation. It has coefficient $d(t,\omega)$ defined as

$$d(t,\omega) = \begin{cases} \bar{d}^1 & \text{if the couple has children age under 5,} \\ & \text{i.e., } (t,\omega) \in \{(1,ya),(1,yb),(2,oa),(2,ob)\} \\ \bar{d}^2 & \text{if the couple has children age 5 to 15,} \\ & \text{i.e., } (t,\omega) \in \{(2,ya),(2,yb),(3,ya),(3,yb),(3,oa),(3,ob),(4,oa),(4,ob)\} \\ \bar{d}^3 & \text{otherwise.} \end{cases} \tag{8}$$

The leisure depends on child status. In the calibration, this assumption captures the idea that labor force participation causes more disutility of parents because staying with children is precious.

In addition, if couples choose non-market child care (care by family/relative) when their children are age 0-5, they incur linear disutilities

$$d_z z_t \tag{9}$$

for $z_t \in \{0, 0.2, 0.4\}$ hours. The cost of non-market child care is defined as disutility in the model. One interpretation is the non-monetary costs of helping the caregiver reciprocally in future. It can also be understood that the leisure of caregivers is also included in the family preference, hence $d_z z_t$ represents the lost leisure of the caregivers. The linearity assumption is for simplicity in the calibration.

Budget constraint

The budget constraint is represented by

$$c_t + \frac{a_{t+1}}{1+r} = (1-\tau)[0.4wh_t^m + nwh_t^f] - px_t + a_t \tag{10}$$

for working periods. The parameter τ represents a linear labor income tax rate. Husband's income is $0.4wh_t^m$ because he works full-time. Wage per unit of productivity is w. Wife's income is $wh_t^f n$ for $n \in \{0, 0.2, 0.4\}$. I assume no part-time pay penalty. With a valid identification strategy, Aaronson

[15]See Chapter 8 in OECD (2013). Precisely, $\psi_t = 2 = \sqrt{4}$ for couples with children age under 15, i.e., Period 1,2,3 for $\omega \in \{ya, yu\}$, and Period 2,3,4 for $\omega \in \{oa, ou\}$. Couples without children under 15 have $\psi_t = \sqrt{2}$.

and French (2004) find little evidence for wage penalty for women. The cost of market child care is represented by px_t.

3.2 The optimization problems

First, the optimization problem in a retired period, $t = 8, \ldots, 12$, is simply formulated as

$$V_t(a_t) = \max_{a_{t+1}, c_t} U_c(c;\ t, \omega) + \beta V_{t+1}(a_{t+1}), \tag{11}$$

$$\text{s.t. } c_t + \frac{a_{t+1}}{1+r} = a_t, \tag{12}$$

$$a_t \geq -\bar{a}(t, z), \tag{13}$$

$$V_t(a_t) = 0 \text{ for all } a_t \geq 0 \text{ at } t = 12. \tag{14}$$

The couple decides only the amount of consumption and saving given the budget constraint.

Next, the following problem defines the decision in a working period without pre-school age children, i.e., at Period $2, \ldots, 8$ if $\omega \in \{ya, yu\}$, and at Period $1, 3, 4, \ldots, 8$ if $\omega \in \{oa, ou\}$.

$$V_t^{\omega}(h_t^m, h_t^f, a_t) = \max_{a_{t+1}, c_t, n_t} U_c(c;\ t, \omega) + U_n(n;\ t, \omega) + \beta V_{t+1}^{\omega}(h_{t+1}^m, h_{t+1}^f, a_{t+1}) \tag{15}$$

$$\text{s.t. } c_t + \frac{a_{t+1}}{1+r} = (1-\tau)[0.4 w h_t^m + w h_t^f n] + a_t \tag{16}$$

$$a_t \geq -\bar{a}(t, \omega) \tag{17}$$

$$\ln h_{t+1}^m = \ln h_t^m + g_{t+1} + v_{t+1}^m \tag{18}$$

$$\ln h_{t+1}^f = \ln h_t^f + \mathcal{I}(n_t > 0) g_t - \mu(n_t)\delta + v_{t+1}^f \tag{19}$$

The value function depends on time-invariant type $\omega \in \{ya, yu, oa, ou\}$. In addition to consumption and saving, the couple also decides wife's hours of work $n_t \in \{0, 0.2, 0.4\}$, which affects leisure utility, labor income and human capital accumulation.

Finally, the couple needs to also consider child care arrangements if they have pre-school age

children, i.e., at Period 1 if $\omega \in \{ya, yu\}$, and at Period 2 if $\omega \in \{oa, ou\}$.

$$V_t^{\omega}(h_t^m, h_t^f, a_t) = \max_{a_{t+1}, c_t, n_t, x_t, z_t} U_c(c;\ t, \omega) + U_n(n;\ t, \omega) - d_z z_t + \beta V_{t+1}^{\omega}(h_{t+1}^m, h_{t+1}^f, a_{t+1}), \tag{20}$$

$$\text{s.t. } c_t + \frac{a_{t+1}}{1+r} = (1-\tau)[0.4wh_t^m + wh_t^f n] - px_t + a_t, \tag{21}$$

$$a_t \geq -\bar{a}(t, \omega), \tag{22}$$

$$\ln h_{t+1}^m = \ln h_t^m + g_{t+1} + v_{t+1}^m, \tag{23}$$

$$\ln h_{t+1}^f = \ln h_t^f + \mathcal{I}(n_t > 0) g_t - \mu(n_t)\delta + v_{t+1}^f, \tag{24}$$

$$n_t = x_t + z_t, \tag{25}$$

$$z_t \in \{0, 0.2, 0.4\} \text{ for } \omega \in \{ya, oa\}, \text{ and } z_t = 0 \text{ for } \omega \in \{yu, ou\}. \tag{26}$$

The time constraint indicates the children must be cared in market or non-market while mother works. The non-market child care z_t is unavailable for $\omega \in \{yu, ou\}$.

3.3 Calibration

To quantitatively evaluate the effects of the rising child care costs on household behaviors, I calibrate the model to match data. There are two types of parameters: (i) parameters of the human capital accumulations and (ii) the preference parameters. Most of the former parameters are directly calculated from data without solving the model. A few other parameters are also taken from the literature. Then, I choose the preference parameters so that the model's prediction match the real world data. The calibration mainly uses IPUMS 5% sample of census 1990 data. The main reason I use census data is its large sample size. Since the census is cross-section data, I implicitly assume that the 1990 U.S. economy is in a steady state. The analyses with repeated cross-section or panel data remain for future research.

Calibration of human capital parameters

Most of the parameters in the human capital accumulation equations are directly obtained without solving the model. To calibrate human capital parameters, I use mean hourly wages of groups of people classified by sex and age in 1990. For convenience, they are adjusted to 2010 price by the Consumer Price Index. Compared to using annual income, this approach suits this model because of the part-time work choice. Also, the hourly wage allows an easy calculation of the relative price between hourly wage and hourly child care costs estimated in Section 2.

Age-dependent human capital growth rates $g_2, \ldots, g_8$ are obtained by the difference in mean

α_2	α_3	α_4	α_5	α_6	α_7	α_8	$w\bar{h}_1^m$	$w\bar{h}_1^f$	σ	δ	ρ	p
0.233	0.138	0.053	0.032	-0.072	-0.071	-0.058	10.88	9.66	0.561	0.34	0.25	2.59

Table 1: Human capital related parameters

wage of married men in each generation. This paper follows Bick (2015) and Guner et al. (2011), and uses only male wages to avoid the bias by selection effect. Next, the mean wages of the first period, $w\bar{h}_1^m$ and $w\bar{h}_1^f$, are obtained from the wages of all married and employed men and women aged 25-29. Again, selection bias is possible, but the simulation result shows that the mean wage of employed women in Period 1 is almost the same as $w\bar{h}_1^f$, i.e., the bias is small[16]. The variance of the permanent shock σ is determined so that the accumulated male wage variance over the working periods is equal to the observed wage variance of married men age 60-64. The standard deviation of the shock adjusted per year is 0.138, which is almost the same as the number in Attanasio et al. (2008), 0.13.

In addition, two parameters are taken from the literature. One is the human capital depreciation rate δ. It is hard to calibrate with cross-section data. I choose $\delta = 0.34$ for one period, which corresponds to 0.08 for the implied annual depreciation rate, given that Attanasio et al. (2008) derived 0.074, and Fernández and Wong (2014) obtained 0.083. The correlation of husband and wife wages, ρ, is set to 0.25 following Attanasio et al. (2008).

Finally the hourly price of child care in 1990 was already estimated in Section 2. It is 2.59 in CPI adjusted 2010 price.

Calibration of preference parameters

I choose the preference parameters so that the simulated prediction of the model matches moments obtained from census and SIPP 1990 data[17]. Seven parameters are chosen by the same number of moments as shown in Table 2 and Table 3.

[16]Two factors cancel out each other. High wage women have more incentive to participate the market because they care earn more. But, by the wage correlation between husband and wife, they tend to married with high wage husbands. By income effect, it lessens the incentive of work.

[17]The model is numerically solved by a simple discretization method with finite period problem. Since the model has three continuous state variables: husband's human capital, wife's human capital, and asset, its computation is somewhat hard. To overcome the problem, following Aruoba and Fernández-Villaverde (2015), I use loops with monotonicity and the envelope condition instead of vectorizations to avoid unnecessary computations, and choose Julia as main computation language. The calibration uses the global optimization algorithm suggested by Guvenen (2011). I parallelized and run the calibration on a cloud computing service provided by Amazon EC2.

Parameters	Explanation	Value
d_n^1	leisure weight for mothers with children age under 5	0.30
d_n^2	leisure weight for mothers with children age 5 to 14	0.52
d_n^3	leisure weight for mothers without children age less than 15	0.26
γ	Frisch elasticity	0.64
d_y	non-market child care disutility weight	0.30
θ	fraction of couples accessible to non-market child care	0.31
$\bar{\mu}$	Human capital depreciation adjustment for part-time jobs	0.37

Table 2: Preference parameters

Moment	Data	Simulation
Labor force participation rate of women with children age under 5	0.656	0.666
Labor force participation rate of women with children age 5 to 14	0.74	0.715
Labor force participation rate of women without children age under 15	0.71	0.700
Fraction of part-time workers among all women with children under 15	0.206	0.180
Fraction of part-time workers among all women without children under 15	0.139	0.118
Share of non-market child care, income less than median	0.406	0.380
Share of non-market child care, income more than median	0.503	0.529

Table 3: Moments to match

3.4 Simulation results

I use the calibrated model to evaluate how much rising child care costs lower the increasing trend of female labor supply in the United States. A 32% increase in child care costs between 1990 to 2010 estimated in Section 2 is introduced into the calibrated model.

To compare with data, I estimate a deviation from the past trend as follows: I calculate a linear trend by regressing variables on years until 1990. The data is Annual Social and Economic Supplement of the Current Population Survey obtained by IPUMC CPS. Then, I extrapolate the trend to 2010 and take the difference from the data [18]. The data and linear trends are plotted on Figure 12.

[18]Since I have no data about long-term hourly share of the non-market child care before 1985, its deviation from the trend is simply calculated as the difference between the share in 1990 and in 2010, i.e., a constant trend is implicitly assumed. The long-run trend of the share of child care arrangements without considering hours is plotted in Appendix B. As the changing trend of female labor force participation rate in the U.S., the trend of child care arrangement also share a reversal.

Variable	(1) Data	(2) Model
LFPR of women with all child status	−0.159	−0.054
LFPR of women with children age under 5	−0.287	−0.129
LFPR of women with children age 5 to 14	−0.242	−0.046
LFPR of women without children age under 15	−0.095	−0.043
Weekly hours of work of women with all child status	−4.97	−2.38
Fraction of part-time workers among all employed women	−0.031	0.042
Share of non-market child care (by relative/family)	0.210	0.152

LFPR denotes labor force participation rate. Column (1) shows the deviation from trend estimated in data. Column (2) summarizes the response of the calibrated model.

Table 4: Results of the model's responses compared to deviation from the trends in data

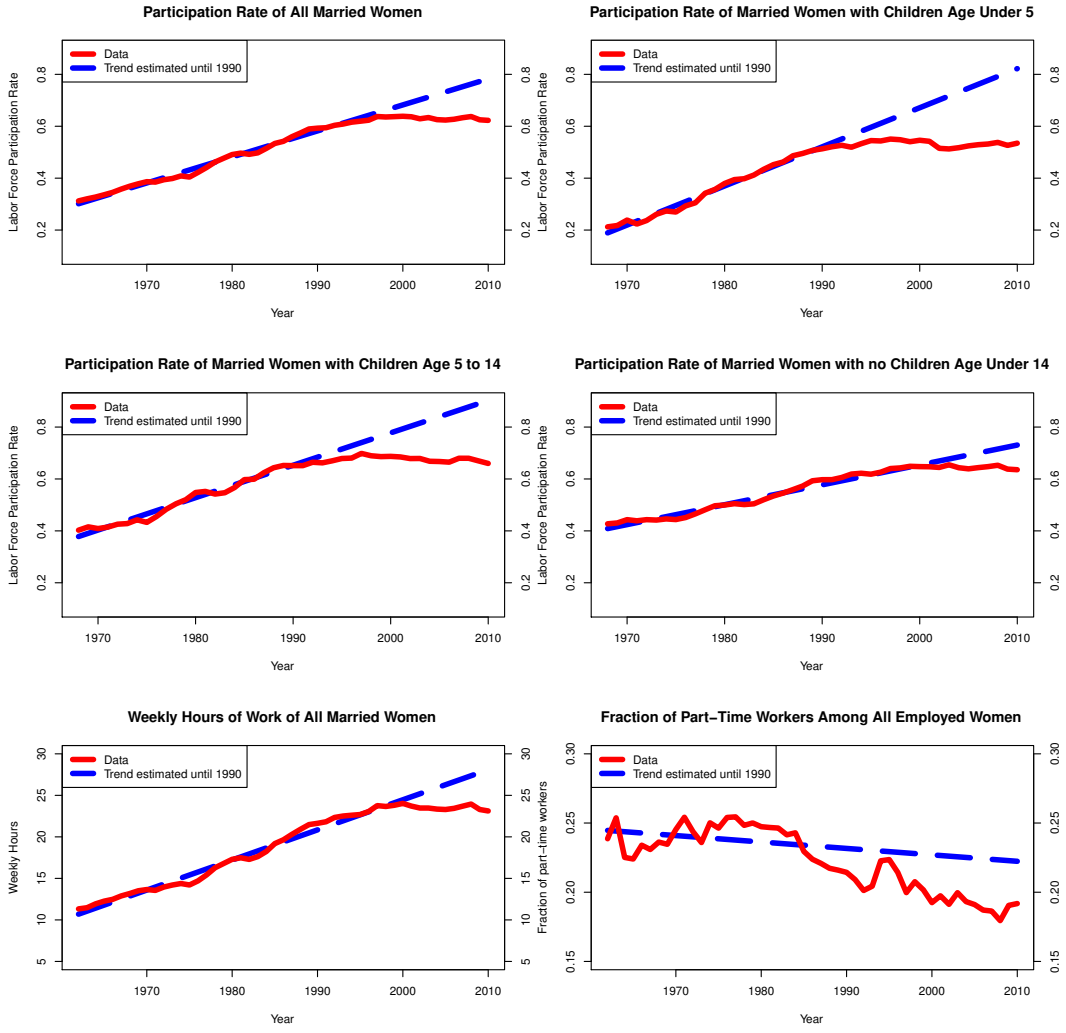


Figure 12: Time series and their linear trend until 1990

The results are summarized in Table 4. It shows the deviations from the trends and model's

prediction about changes in variables by the child care costs shock. Overall, the model explains a significant part of the deviation from the trend. The model predicts a 5.4% decline in the labor force participation rate of all women. It explains about one-third of the deviation from the trend, 15.9%. The model also succeeds to explain the higher decline in the labor force participation rate of women with young children. It also captures about half of the decline in hours of work. The linear trend is an extreme assumption because the participation rate is bounded by 100%. If a concave trend is assumed, the model explains higher fractions of the deviations from the trends.

The model also succeeds to predict the large increase in the share of non-market child care (by relative/family). As the child care costs have increased, couples have substituted child cares from market to non-market. The only thing that the model's prediction is inconsistent in the data is the decrease in the share of part-time workers. There might be some other factors enhancing women to work in full-time jobs more, e.g., improvement in education.

4 Hypotheses on rising child care costs

This section discusses two hypotheses for why the child care costs have rapidly increased in the United States since the mid-1990s. Both hypotheses are about home-based child care providers, since its supply has been dramatically declined. The first one is restricting licenses in the home-based child care sector. I use state level differences in the expansions of licensing to estimate its causal effect on child care workers' wages, which is the dominant factor in total child care costs. Quantitatively, it explains 8.4% of the rising costs.

The second hypothesis is the discouraging effects of the child care subsidies on home-based care providers' incentives. Traditionally, home-based child care workers are also working mothers, i.e., they take care of both their neighbour's children and the worker's own kids at private residence. Although their wages are very low, the jobs allow home-based child care workers to save the daycare costs of their own children. In the 1990s and 2000s, the child care subsidies to poor families expanded dramatically. Since the home-based care providers are mainly low-income workers, after the expansion of subsidies, they are able to receive them, send their kids to daycare centers outside home, and change their jobs to higher wage ones. This decreased the child care supply and increased the prices. I will provide supporting evidence such as a sharp decline in the supply of working mothers in the home-based sector and a vanishing wage gap between home-based and center-based care workers.

Variable	1990	2000	log change
Mean real wage, all female workers	12.67	14.06	0.10
Real Wage, center-based child care workers	7.67	8.19	0.06
Real Wage, workers in family daycare home	5.34	6.85	0.24
Number of center-based providers (in 1992)	86,212	106,246	0.20
Number of all family daycare home (in 1992)	524,381	559,639	0.06
Number of licensed family daycare home	220,867	304,958	0.32

The real wages are calculated by IPUMS census 5% sample in 1990 and 2010. The price level is adjusted to 2000 level by CPI. The numbers of all center-based and family daycare home are obtained from 1992 Economic Census. The number of licensed family daycare home is from Hamilton et al. (2002).

Table 5: Wages and numbers of providers in the child care industry

4.1 Effects of licensing on family daycare providers

In this subsection, I study the effects of the expansion of licensing among family day care homes on child care costs. Family daycare homes are defined as provisions of child care at workers' own residences. Family daycare homes have a significant share in the child care industry: they account for 87% of the home-based child care sector and 35% of all the child care industry in terms of hours of care in SIPP 1990. Many of the family daycare homes are unlicensed: only 42% are licensed, while almost all center-based child care providers are required to receive licenses[19]. It is because many providers caring small numbers of children are exempt from licensing[20].

The child care workers' wages and the number of providers are summarized in Table 5. Compared to the real wage for an average female worker and center-based child care worker[21], the mean wage of home-based child care workers grew rapidly. The total number of family day care homes increased by 6 log points, while that of center-based care rose by 20 log points. Interestingly, the number of *licensed* providers increased by 32 log points. The supply of family daycare homes did not increase so much, but the share of licensed providers among them has increased significantly. These observations imply a possibility that increased requirements of licensing pushed up the costs of home-based child care and dampened its supply.

There are several possible reasons why the licensing expanded among home-based child care providers between 1990 and 2000. First, some states started to require daycare homes to obtain

[19]The fraction, 42%, is calculated as the number of licensed providers divided by the total number of providers who report their income to the IRS as shown in Table 5. Actual number is even lower because many unlicensed providers do not file tax return (Kontos (1992)).

[20]Morgan et al. (2001) summarizes the licensing requirements for family daycare homes in June 2001. 13 state require license to all family daycare home, 35 states require license to care if the number of enrolled children exceed some threshold, and 3 states require no license. Among center-based child care providers, daycare centers affiliated with religious groups are exempt from licensing. In 2016, 16 states allow some exceptions to them, and six states offer nearly complete discretion.
https://www.edcentral.org/religiouscc/

[21]In Census 1990, 97% of the child care workers are female.

licenses in this period. The number of states requiring licensing for all family daycare home[22] increased from 7 to 13, and the number of states requiring licensing to family daycare home caring more than a certain number of children increased from 27 to 35. Next, Child Care Development Fund (CCDF) started from 1996 and made additional incentives for family daycare homes to obtain licenses. In 16 states, family daycare providers are required to be licensed in order to receive child care subsidies. In addition, in most states, at least registration and simple background checks are required to obtain child care subsidies. CCDF also increased the expenditure on child care quality improvement[23], which possibly enhanced license.

The expansions of licensing in family daycare vary by state. Between 1990-2000, the number of licensed family day care increased by more than 200% in 8 states, while slightly decreased in 10 states. The main reason is that states have larege discretions in child care policy. As first summarized by Hotz and Xiao (2011) and extended by Bassok et al. (2012), there are many differences in state-level child care regulation policies including licensing requirements, teacher-student ratio, ongoing training for providers, etc. Besides, CCDF allows states discretion in how to use the fund, in particular, in deciding eligibility requirements of the subsidies[24]. These differences generate substantial state-level heterogeneity in the spread of licensing among family daycare home providers.

This paper uses the increase in the number of licensing family daycare providers as a proxy for the spread of licensing in its market. There are many dimensions in the changes in licensing such as requirement by state law or requirement to obtain CCDF subsidy. The changes in a variety of policies prevent me from finding a single policy to derive a statistically significant effect[25] Therefore, an increase in the number of licensed providers can be interpreted as a summary of many dimensions of the changes in child care policies.

I estimated the causal effect of the increase in the number of licensed family child care providers on their wages using state-level differences between 1990 and 2000. I use the difference-in-difference-in-difference (DDD) approach following Gruber (1994). The usual difference-in-difference (DD) framework considers the state-level difference in family child care licensing and in time difference. Since the research interest is only about family daycare home, one more difference can be introduced: the difference between family child care and center-based child care. I consider the following

[22]The 1991 data is obtained from Kisker et al. (1991), and the 2001 data obtained from Morgan et al. (2001)

[23]Under the law, at least four percent of CCDF funds must be used to improve the quality of child care.

[24]They are summarized in Child Care and Development Fund: Report of State Plans and Child Care and Development Fund (CCDF) Policies Database
http://www.acf.hhs.gov/opre/research/project/child-care-and-development-fund-ccdf-policies-database-2008-2013

[25]Hotz and Xiao (2011) note that several measures of child care regulations are correlated. It justifies to use only a few representative variables such as teacher-student ratio and ongoing training requirement in regression equation. This observation is correct for child care centers, but the policies seem uncorrelated for family daycare providers in the database provided by citehotz2011impact and Bassok et al. (2012).

regression equation.

$$\ln(W_{it}) = \beta_0 + \beta_1 X_{ijt} + \beta_2 \tau_t + \beta_3 \delta_j + \beta_4 T_i + \beta_5 \tau_t \delta_j + \beta_6 \delta_j T_i + \beta_7 T_i \tau_t + \beta_8 \tau_t \delta_j T_i. \tag{27}$$

In this equation, subscript i represents individual, subscript j indexes state, and t indicates year. W is the log real hourly wage, X is a vector of observable characteristics, τ is a year fixed effect ($\tau_t = 1$ if $t = 2000$, $\tau_t = 0$ if $t = 1990$), δ_j is the first (continuous) treatment variable of log change in licensed family child care, and T_i is a second (dummy) treatment variable representing $T_i = 1$ if individual i works in family child care, and $T_i = 0$ if individual i is employed in center-based child care.

This specification first controls year effects. There are national trends in the wages of the treatment group, family child care workers. Secondly, the state effect controls the secular wage differences between the states experiencing increases in licensing and not. In addition to these two usual DD controls, the DDD approach controls one additional dimension, wage differences between family child care workers and center-based workers. It controls for the total demand effect for child care, e.g., states with growing demand on child care leading to an increase in child care worker's wage might also pass laws to restrict regulations in the market. The identification assumption is that there is no shock correlating with licensing to affect relative outcomes between family and center-based child care workers.

Equation (27) uses real hourly wage as the measure of child care costs instead of using hourly child care expenditure estimated in Section 2. It is because SIPP has a limited number of the sample of working mothers each year. Compared to SIPP, IPUMS census contains the sample of 5% of total population. The hourly wage is a good approximation of total costs in family daycare providers because the worker compensations are dominant costs. Helburn and Howes (1996) reports 66.9% of the total costs are labor costs. The percentage may be higher because capital costs include food, repair, or home supplies that are possibly shared with private home use of the workers.

I compare only two years, 1990 and 2000 because of the availability of census data. The number of licensed family daycare providers are obtained from Kisker et al. (1991) and Morgan et al. (2001), but the data is originally reported in Family Child Care Licensing Study privately published by The Children's Foundation. This report was discontinued in 2004, and the work was proceeded by The National Association for Regulatory Administration (NARA). However, I find large discontinuities between the publications by the two associations, in particular, in the state-level data of the number of licensed facilities.

The estimation results are summarized in Table 6. In all specifications, the coefficient β_8 is statistically significant at the 5% level or smaller. Column (1) is the baseline case formulated in

	(1)	(2)	(3)	(4)	(5)
W_{it}	Hourly Wage	Hourly Wage	Hourly Wage	Annual Income	Hourly Wage
Sample	CC workers	CC workers	All female workers	Full-time CC workers	CC workers
δ_j	log change licensed FCC	log change licensed FCC per children < 10	log change licensed FCC	log change licensed FCC	log change licensed FCC
Method	DDD	DDD	DDD	DDD	DD
β_8	0.045	0.045	0.033	0.070	0.058
	(0.022)	(0.019)	(0.011)	(0.033)	(0.019)

Table 6: DDD Estimates of the Impact of Increase in Licensed Family Daycare Providers on Worker's Hourly Wage

Equation (27). Column (2) controls the increase in licensed daycare due to the increase in rising population of children. Column (3) classifies all the other female workers into the control group, i.e., the coefficient β_8 reflects the relative change in wage between family daycare workers and all the other female workers. Column (4) uses the annual income of full-time child care workers instead of hourly wage. Finally, Column (5) is the result of DD estimation, which excludes the sample of center-based care workers.

In the baseline case, a 1% increase in the number of licensed family daycare providers increases their wage relative to center-based care workers by 0.045%. Since the log change in the total number of licensed family daycare providers in all states is 0.32, it increases their wage by $0.32 \times 0.045 = 0.0145$. Therefore the increase in licensing explains about $8\% = 0.0145/(0.24 - 0.06)$ of the relative change in the wages between family daycare and center-based workers.

Although the estimations derive statistically significant results, the licensing can explain only a small portion of the increase in the child care costs. The next subsection suggests the existence of a more drastic cause.

4.2 Discouraging effects of child care subsidy on home-based providers

While the subsidy on child care has hugely increased as shown in Figure 7, hourly expenditure has risen and hours of child care has declined, i.e., the net price has increased and the quantity has decreased in the child care market. It is puzzling because, in the standard economic model, a subsidy leads to an increase in quantity and decrease in net price. Both price and quantity moved the opposite way as if, instead of demand, there were negative supply shocks. This intuition leads to a hypothesis that the dramatic increase in subsidies might have unexpected consequences on the supply side of child care market. In particular, Figure 6 suggests supply shocks in the home-based child care sector, which consists of 43% of total child care supply in 1990.

Many home-based child care providers are also working mothers. In 1990 census data, 51.5%

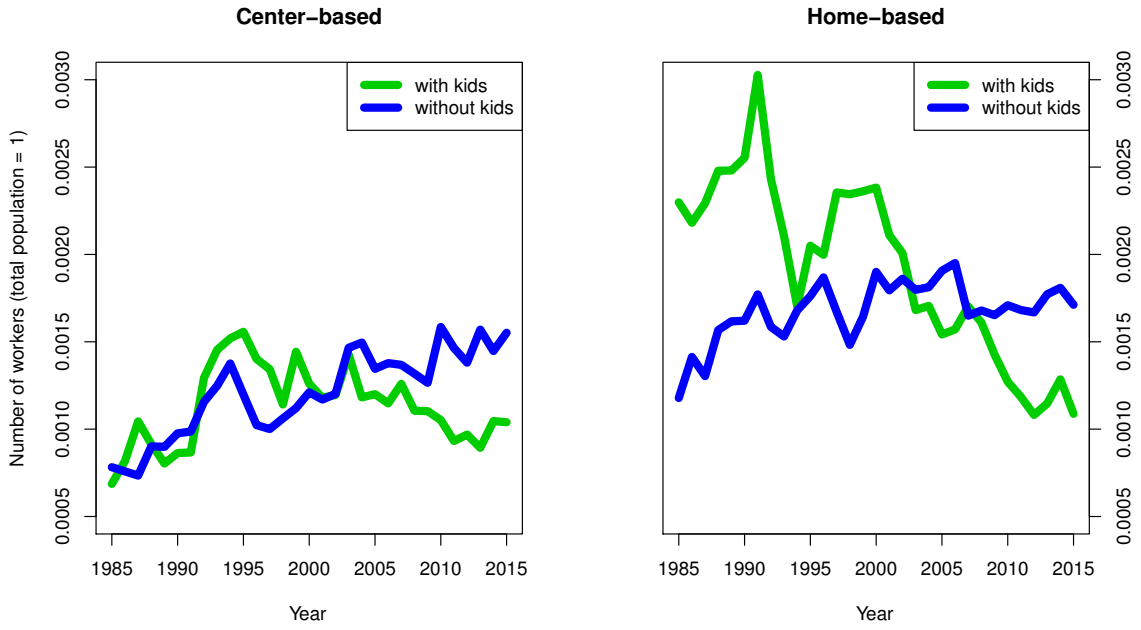


Figure 13: The number of child care workers by category and child status

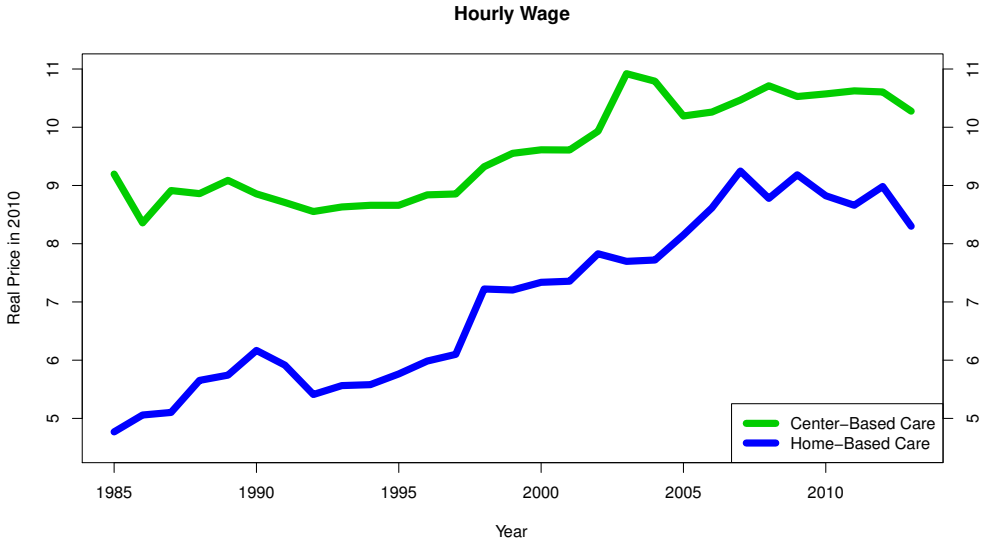
of home-based child care providers have children under 12 living in the same household. The percentage is significantly higher than 34.1% for center-based child care workers and 29.2% for all female workers in all occupations. In the traditional business model, home-based child care workers take care of their neighbors' children together with their own children in private residences. Kontos et al. (1995) report that the biggest reason the workers choose the family daycare job is staying with their own children.

Home-based care worker's wage was significantly lower than center-based child care workers before the subsidies expanded, although these occupations are almost the same[26]. The log difference in mean hourly wages of home-based and center-based child care worker was 0.362 in Census 1990. The hourly wages of more than half of home-based child care workers were below the minimum wages, which did not violate the law since most of them are self-employed.

Due to the low wage, the expansion of the child care subsidies shown in Figure 7 might relocate home-based child care workers to other sectors. In 2010, 25% of working mothers were eligible to use nearly free child care provided by Head start, CCDF, or state pre-K service, while 43% of working mothers in home-based child care were eligible in 2010 in my estimation[27]. Given that

[26]The difference in observable characteristics such as education and race cannot explain the difference in the wages between home-based and center-based child care workers.

[27]By IPUMS census 5% sample, I estimated the income level of lower 25% households. To keep the number of family member, I use only the sample of household with 4 family members. Then, I estimate the fraction of home-based care workers whose family income is below the level. While 43% is still less than half, more working mothers



The price level is adjusted by CPI to 2010 level.

Figure 14: Real hourly wage of child care workers by arrangement

their wage was very low, it created strong incentives to change their jobs. The main reason working mothers chose home-based child care was saving in the child care costs of their own children. It made home-based child care jobs competitive to others, although the wage was significantly lower. But after the child care subsidy was expanded, this advantage diminished because many home-based care workers are eligible to receive subsidy and send their kids to daycare centers. They have less incentive to stay in the low wage occupation. Therefore, the expansion of child care subsidy might make home-based child care occupation less attractive and decrease its supply.

This hypothesis is consistent with two facts. First, Figure 4.2 shows the number of child care workers by arrangement (center vs. home) and child status[28] (having children under age 15 or not). There has been a sharp decline in the labor supply of working mothers in home-based sectors since 2000, while the labor supplies in the other categories have been stable. The expansion of child care subsidies might affect workers in this category.

Secondly, Figure 14 shows the mean real hourly wages of child care workers in center-based and

in home-based child care were eligible in 1990s and 2000s, because their relative wage was significantly lower before the child care subsidy expanded.

[28]Total female population each year is normalized to 1. The data source is Annual Social and Economic Supplement of the Current Population Survey obtained by IPUMC CPS. To adjust the difference in hours of work, person weight is multiplied by hours of work. I follow Bassok et al. (2012) and Herbst (2015) to obtain the classification of child care occupations. Mainly, center-based child care workers are defined as child care workers employed by daycare centers or schools, and home-based child care workers are self-employed or employed by individual. They seem to use year independent occupation classification such as OCC1990 in IPUMS CPS. This procedure is problematic because most of the center-based workers are misclassified as teacher-aides from 1992 to 2002. To overcome the discontinuity by survey design, I use a time-dependent variable, OCC in IPUMS CPS, to classify the workers in each survey. The large parts of discontinuities are eliminated.

home-based sectors. As the subsidies have expanded, the home-based workers' wage has significantly risen, and the gap with center-based workers has diminished. The wage gap reflected the child care costs of child care workers' own children; hence the vanishing gap is consistent with the introduction of child care subsidies. In Appendix A, a simple analytical model describes the hypothesis for illustration.

5 Conclusion

In 2014, President Obama signed bipartisan legislation that comprehensively updated the Child Care and Development Block Grant (CCDBG) Act for the first time since 1996. The law proposes a new emphasis on providing high-quality early education and care with setting stricter health and safety requirements.

This paper provides new insights on the female labor supply and the child care market in the United States. The first contribution is creating consistent measures of costs and hours of child care using data from the SIPP from 1985 to 2011. The mean real hourly expenditure on child care increased 32% between 1990 and 2010, while hours of market child care declined by 27% in the same periods. Facts categorized by household income suggest that child care subsidies massively support child care of the low-income families. Besides the data imply the existence of significant negative supply shocks in the home-based child care sector. Next, to evaluate the consequences of the rising child care costs, I build and calibrate a life-cycle model of married couples incorporating saving, labor supply operative intensive and extensive margins, human capital accumulation, and child care arrangement choice between market care and non-market care by relative/family. The model predicts that the rising child care costs cause a 5% decline in total employment of women and a 13% decline in employment of working mothers with children age under 5. The model also does a reasonable job of accounting for the observed child care arrangement substitution from market toward non-market. Finally, I provide two hypotheses on the rising child care costs and their supported evidences possibly caused by the both federal and state child care policy reforms in the 1990s and 2000s: (i) expansion of licensing in the home-based sector supported by a DDD estimation using state-level differences, and (ii) the discouraging effects of child care subsidies on home-based care workers consistent with the facts on their labor supplies and wages.

This paper has several implications about the policy reforms in child care and female employment. First, this paper confirms the importance of child care costs on female labor supply decisions. Compared to the literature on the macroeconomic analysis of female market work, I introduce several additional assumptions possibly dampening the importance of child care costs such as child

care arrangement choice, part-time work options, and no child care costs on school-age children. But, this paper still finds that child care costs are significant determinants of female labor force participation. It is consistent with the findings of microeconometric studies on the elasticity of labor supply with respect to childcare costs[29]. As the new CCDBG Act of 2014 emphasizes, the current policy focuses more on the quality of child care instead of its costs. This paper provides additional evidence to defend the importance of the costs. Secondly, too much focus on regulations to improve child care quality may crowd out casual care operated in the home-based settings. Providing high quality early childhood education is a top priority policy (Heckman (2013)), but simple regulation schemes may also distort the supply of affordable and flexible child care such as family daycare home and babysitter. In addition to the quality improvement policies, the governments may also need to provide supports to keep the home-based child care supply such as tax benefits for licensed home-based providers. Finally, the expansions of the subsidies for consumers are very complex in the child care market compared to other industries. It is because the child care workers are also working mothers who are also eligible to use the subsidies. This paper suggests a possibility that subsidies significantly extended since the 1996 reform may discourage the supply of home-based child care. To evaluate policy consequences, the understandings of incentives of child care workers are necessary.

Although this paper sheds light on the hidden effects of the child care policies, their quantitative evaluations remain for future research. A possible avenue is an extension of this paper's partial equilibrium model to general equilibrium one incorporating the details of the structures and policies in the child care market.

[29]See, e.g., Gathmann and Sass (2012) for a study with a quasi-experimental situation

Appendix A: a simple model of discouraging effects of child care subsidy

This appendix provides a simple model to show the discouraging effects of child care subsidy. The effect is complicated because the subsidies affect both the demand and supply sides in the child care market. The model also provides analytical conditions that the supply side negative shocks dominate the demand side shock so that the price rises and the quantity drops.

Household

- Two types of mothers. I consider Roy model of each type
  - Type A: works in consumption good production or being a homemaker.
  - Type B: works in consumption good production or opens family child care home. Type B woman has no option to leave job[30].
  - Each population is θ and $(1-\theta)$, respectively.
  - Note that I eliminate child care center workers for simplicity.
- Child care cost
  - A worker in both types employed in good production must use child care with endogenous price p.
  - A Type B worker in family child care home does not need to pay the child care cost for her own kid. She can take care of her own kids together with other kids at work.
- Skill distribution
  - Heterogeneous skill in consumption good production. i.i.d random draw from $s \sim F_i(s)$ for $i = A, B$. A skill s is intepreted that one unit of indivisible labor input produces s unit of consumption good. I assume that $F_i(s)$ has density function $f^i(s)$ for all $s > 0$.
  - No heterogeneity in child care skill. One worker can take care of one kid in addition to her own kid.
- Suppose that the consumption good price is normalized to 1.
- I assume that each person has linear utility function, $u(c) = c$.

[30]The number of choice is limited to two so that I can find a simple cutoff rule.

- The wage for efficiency unit of labor is normalized to 1.
- Decision problem of a Type A worker

$$\max_{n\in\{0,1\}} c - dn \;\text{ s.t. } c = sn - p(1-\tau_A)n,$$

where $n \in \{0,1\}$ is the decision on good production work, c is the amount of consumption, d is labor disutility, sn is the labor income. The term $p(1-\tau_A)n$ represents the payment on child care cost, where τ_A is the linear child care subsidy rate.

- The optimal decision of Type A worker is

$$n_A(s) = \begin{cases} 1 & \text{if } s > p(1-\tau_A) + d \\ 0 & \text{otherwise} \end{cases}$$

- Decision problem of Type B worker

$$\max_{n\in\{0,1\}} c - d \;\text{ s.t. } c = sn + p(1-n) - p(1-\tau_B)n,$$

where $n = 1$ implies employment at good production, and $n = 0$ means that the worker opens a family child care home. Then, the net labor income is $s - p(1-\tau_B)$ for consumption good production, and p for family daycare. She does not need to pay child care cost if $n = 0$.

- The optimal decision of Type B worker is

$$n_B(s) = \begin{cases} 1 & \text{if } s > p(1-\tau_B) + p \\ 0 & \text{otherwise} \end{cases}$$

Equilibrium

- By Walras law, I consider only child care market equilibrium

$$\text{demand } = \theta \int n_A(s) dF_A(s) + (1-\theta) \int n_B(s) dF_B(s) = (1-\theta) \int [1 - n_B(s)] dF_B(s) = \text{ supply}$$

- It is written as

$$\theta\Big[1 - F_A\big(p^*(1-\tau_A) + d\big)\Big] + (1-\theta)\Big[1 - F_B\big(p^*(2-\tau_B)\big)\Big] = (1-\theta) F_B\big(p^*(2-\tau_B)\big) \quad (28)$$

Lemma 1. *There exists unique equilibrium*

Proof. In Equation (28), LHS is strictly decreasing, and the RHS is strictly increasing in p. If $p = 0$, $LHS > RHS = 0$, and If $p \to \infty$, $0 = LHS < RHS$. □

Two types of government interventions: I introduce two types of income taxes: an increase in τ_A which is a typical subsidy economists usually consider, and an increase in τ_B which is a hidden effect of subsidies on the supply side of the child care market. I consider increases in each one separately, and the case that both increases in the same rate.

Increase in τ_A

Lemma 2. *If τ_A increases given fixed τ_B, the gross price of child care p increases and its supply $(1-\theta)F_B\big(p^*(2-\tau_B)\big)$ increases*

Proof. The implicit function theorem is applied to (28), then

$$\frac{\partial p^*}{\partial \tau_A} = -\frac{\theta p^* f_A}{-\theta(1-\tau_A)f_A - 2(1-\theta)(2-\tau_B)f_B} > 0$$

By the increase in p^*, the child care supply also increases, □

Lemma 3. *By marginal increase in τ_A, the net price of for Type A, $(1-\tau_A)p^*$ decreases.*

Proof. By Lemma 2,

$$\frac{\partial (1-\tau_A)p^*}{\partial \tau_A} = \left[\frac{\theta(1-\tau_A)f_A}{\theta(1-\tau_A)f_A + 2(1-\theta)(2-\tau_B)f_B} - 1\right] p^* < 0$$

□

The equilibrium price p^* is defined as an implicit function of τ_A, τ_B by (28). Define the average net price as

$$NE(\tau_A, \tau_B) = p^*(1-\tau_A)W_A(\tau_A, \tau_B) + p^*(1-\tau_B)W_B(\tau_A, \tau_B),$$

where $W_A(\tau_A, \tau_B)$ and $W_B(\tau_A, \tau_B)$ are weight,

$$W_A(\tau_A, \tau_B) = \frac{\theta\big[1 - F_A\big(p^*(1-\tau_A) + d\big)\big]}{\theta\big[1 - F_A\big(p^*(1-\tau_A) + d\big)\big] + (1-\theta)\big[1 - F_B\big(p^*(2-\tau_B)\big)\big]}$$

$$W_B(\tau_A, \tau_B) = \frac{(1-\theta)\big[1 - F_B\big(p^*(2-\tau_B)\big)\big]}{\theta\big[1 - F_A\big(p^*(1-\tau_A) + d\big)\big] + (1-\theta)\big[1 - F_B\big(p^*(2-\tau_B)\big)\big]}$$

Lemma 4. *Suppose $\tau_A = \tau_B = \bar{\tau}$ initially, and the government marginally increase τ_A. Besides, $(1-\bar{\tau})f_A\big(1-F_B\big) < 2(2-\bar{\tau})f_B\big(1-F_A\big)$. Then, $NE(\tau_A, \tau_B)$ is decreasing in τ_A.*

Proof.

$$\frac{\partial NE(p^*, \tau_A, \tau_B)}{\partial \tau_A} = \frac{\partial p^*}{\partial \tau_A} \cdot [(1-\bar{\tau})W_A + (1-\bar{\tau})W_B] - p^* W_A + p^*(1-\bar{\tau}) \left[\frac{\partial W_A}{\partial \tau_A} + \frac{\partial W_B}{\partial \tau_A}\right]$$

Becasue $W_A + W_B = 1$ is an identiy, the last term is zero. Then,

$$\frac{\partial NE(p^*, \tau_A, \tau_B)}{\partial \tau_A} = p^* \left[\frac{\theta(1-\bar{\tau})W_A + \theta(1-\bar{\tau})W_B}{\theta(1-\bar{\tau}) + 2(1-\theta)(2-\bar{\tau})\frac{f_B}{f_A}} - W_A\right]$$

The sufficient condition for $\frac{\partial NE(p^*, \tau_A, \tau_B)}{\partial \tau_A} < 0$ is that the inside of the bracket is negative. It is,

$$\frac{(1-\bar{\tau})}{2(2-\bar{\tau})}\theta W_B < \frac{f_B}{f_A}(1-\theta)W_A$$

$$\Leftrightarrow (1-\bar{\tau})f_A\big(1-F_B\big) < 2(2-\bar{\tau})f_B\big(1-F_A\big)$$

□

The sufficient condition is realistically satisfied because $1-F_B$ is small enough in the simulation. It is due to low reservation wage for family child care workers.

Increase in τ_B

Lemma 5. *If τ_B marginaly increases given fixed τ_A, the gross price of child care p^* and the net price for Type A worker $(1-\tau_A)p^*$ increases.*

Proof. The implicit function theorem is applied to (28), then

$$\frac{\partial p^*}{\partial \tau_B} = \frac{2(1-\theta)p^* f_B}{\theta(1-\tau_A)f_A + 2(1-\theta)(2-\tau_B)f_B} > 0$$

□

Lemma 6. *The supply of child care $(1-\theta)F_B\big(p^*(2-\tau_B)\big)$ decreases.*

Proof. The net price for Type B is decreasing in τ_B, because

$$\frac{\partial p^*(1-\tau_B)}{\partial \tau_B} = p^* \left[\frac{2(1-\theta)(1-\tau_B)f_B}{\theta(1-\tau_A)f_A + 2(1-\theta)(2-\tau_B)f_B} - 1\right] < 0$$

Therefore, the supply is also decreasing in p^*. □

Lemma 7. *Suppose $\tau_A = \tau_B = \bar{\tau}$ initially, and the government marginally increase τ_B. The average net price $NE(\tau_A, \tau_B)$ increases.*

Proof.

$$\frac{\partial NE(p^*, \tau_A, \tau_B)}{\partial \tau_B} = \frac{\partial p^*}{\partial \tau_B} \cdot [(1-\bar{\tau})W_A + (1-\bar{\tau})W_B] - p^* W_B + p^*(1-\bar{\tau}) \left[\frac{\partial W_A}{\partial \tau_A} + \frac{\partial W_B}{\partial \tau_A} \right]$$

The last term is zero. Then,

$$\frac{\partial NE(p^*, \bar{\tau}, \bar{\tau})}{\partial \tau_B} = p^* \left[\frac{2(1-\theta) f_B (1-\bar{\tau})(W_A + W_B)}{\theta(1-\bar{\tau}) f_A + 2(1-\theta)(2-\bar{\tau}) f_B} - W_B \right]$$

The sufficienet condition is

$$2(1-\theta) f_B (1-\bar{\tau}) W_A > [\theta(1-\bar{\tau}) f_A + 2(1-\theta) f_b] W_B$$

$$\Leftrightarrow \; 2 f_B (1-\bar{\tau})(1-F_A) > \left[(1-\bar{\tau}) f_A + 2 \left(\frac{1-\theta}{\theta} \right) f_B \right] (1-F_B)$$

□

Because θ and F_B are large enough in the real word, the condition is likely to be satisfied.

Appendix B: Miscellaneous diagrams

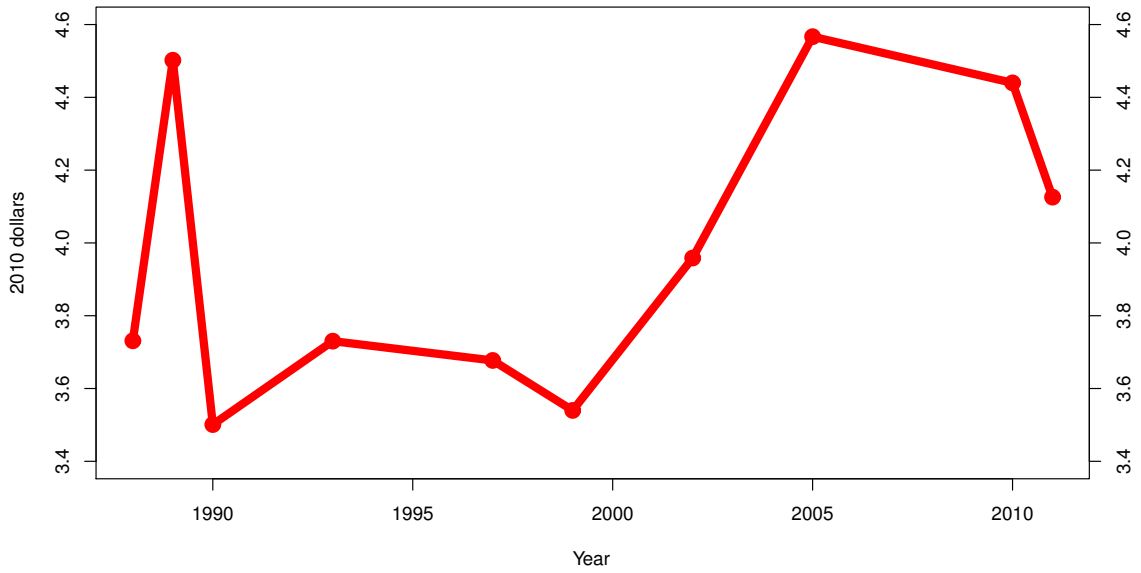


Figure 15: Mean hourly child care costs of school-age children age 5-15

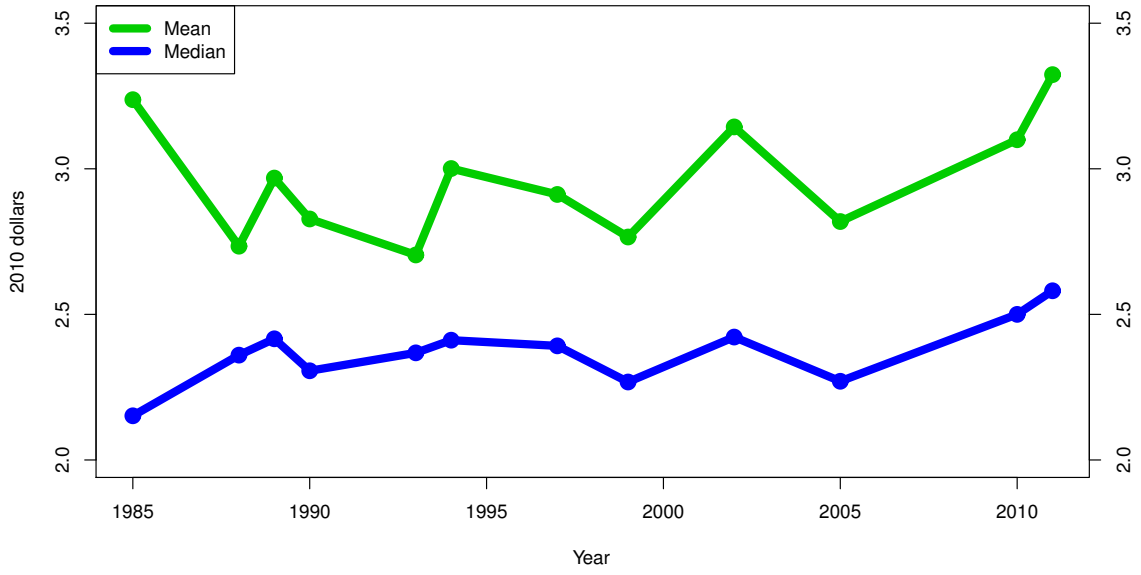
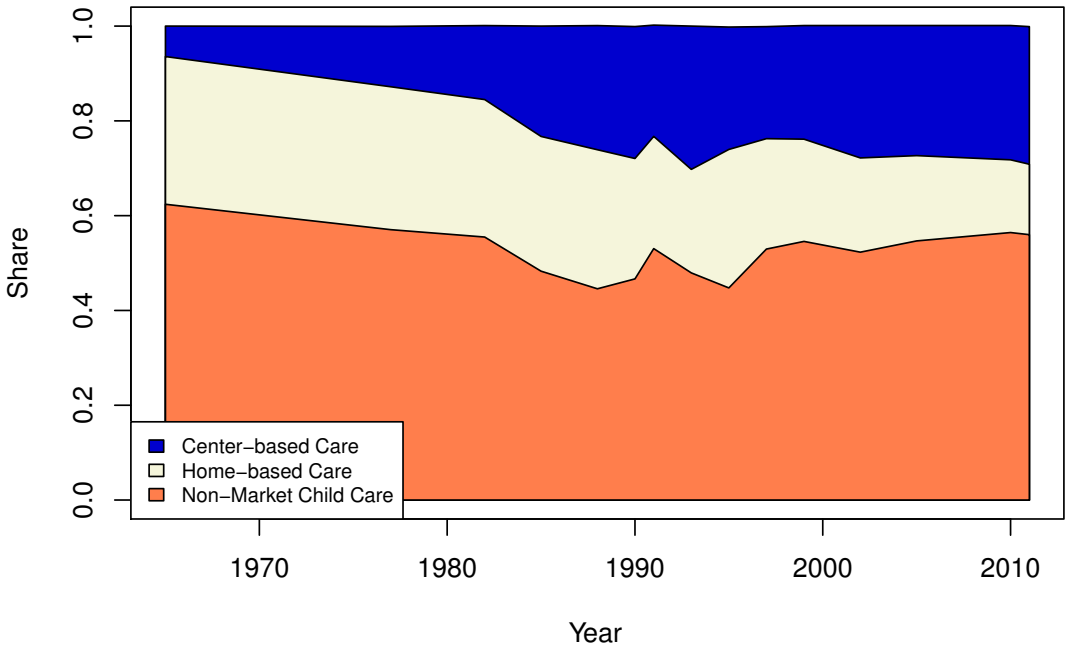


Figure 16: Mean and median child care costs defined as expenditure divided by mother's hours of work



Data Source: for 1965 to 1982, "Trends in Child Care Arrangements of Working Mothers," Current Population Reports, P-23, No.117, and "Child Care Arrangements of Working Mothers: June 1982", Current Population Reports, P-23, No.129. From 1984, Lynda Laughlin "Who's Minding the Kids? Child Care Arrangements: Spring 2011" Current Population Reports, P70-135, 2013. I eliminate "No regular arrangement" from the data.

Figure 17: The long-term share of child care arrangements

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