

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. I first provide new estimates of long-term trends in the child care market using the Survey of Income and Program Participation. The hourly price rose by 32%, hours of daycare used declined by 27%, and parents shifted their child care arrangements from market care to non-market family/relative care. In the child care supply side, there was a drastic decline in the number of home-based child care workers such as family daycare providers, babysitters, nannies, etc. This paper argues that the massive increase in child care subsidies for low-income families, which was supposed to stimulate child care demand, unexpectedly pushed down the home-based supply. The home-based workers are also mainly low-income working mothers; hence, the subsidies might distort their incentives. I provide its supportive evidence, simple model and its quantitative extension to capture the channel in detail. I also build a quantitative life-cycle model of married couples and show that the rising child care price significantly changed female labor supply and child care arrangements. I also use state-level variations and changes in child care regulations and find that it's a minor but significant factor in the price.

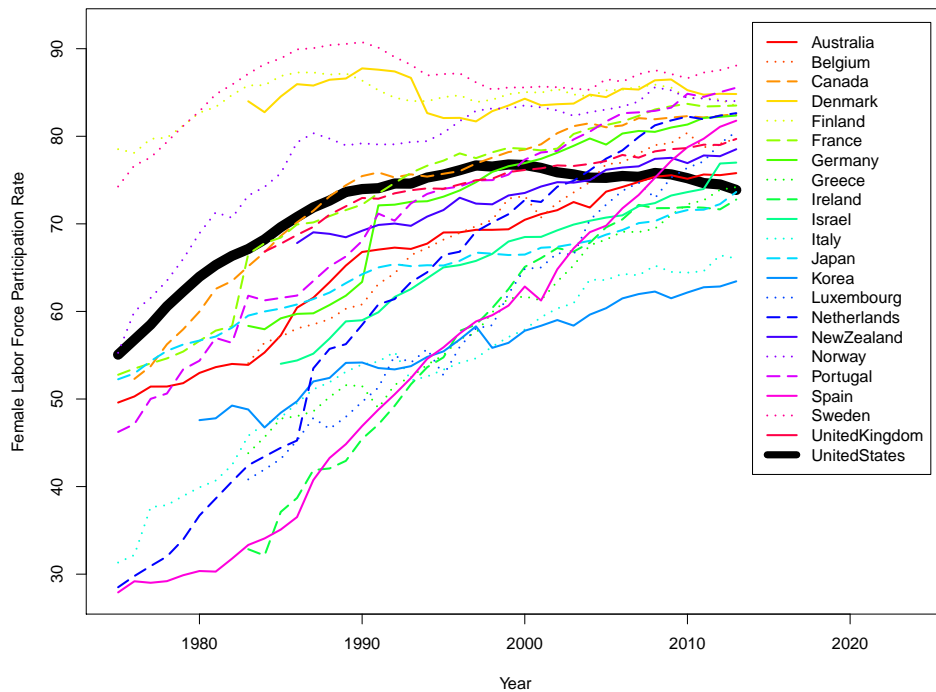
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1 Introduction

There has been a global trend of falling fertility rates and increasing female labor force participation rates around the world. 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 as follows: first, I report evidence on rising costs and shrinking hours of child care, secondly I argue that the rising child care subsidies lead to the unexpected



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

Figure 1: Female labor force participation rates of OECD countries

downward shift of child care supply and cause the price increase in a static analytical model, then quantitative models confirm the effects. As a supplemental factor, restricting child care regulations is also evaluated by micro-econometric methods.

Although public interest in child care costs is intense, its evidence is limited. The first contribution of this paper is to create consistent measures of prices 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 supplied 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.

This paper next proposes a hypothesis that massive increases in child care subsidies for low-income families in 1990s and 2000s, which was supposed to lower the consumer price of child care, unexpectedly suppress child care supply and lead to increase its cost. There was a large decline in the numbers of home-based child care workers, e.g., family daycare home, nanny, babysitters. They are mainly low-income mothers working with their children at home and save on childcare costs themselves. But, with the arrival of subsidies, many of these mothers placed their children in affordable daycare and changed the jobs to relatively higher-paying ones. The decline of home-based child care supply caused overall price increase; then eventually pushed back the increasing trends of female labor force participation.

The data support the hypothesis. The federal child care subsidies such as Child Care Development Fund and Head Start, and also State pre-K programs have been massively expanded. In my estimation, the fraction of working mothers receiving subsidies raised from 3% in 1990 to 29% in 2005 in my estimation. Home-based child care workers were in particular affected by subsidies by two reasons: the fraction having had children under 12 is 51% while it was 31% for all the others in 1990, and 43% of home-based working mothers were eligible for subsidies due to low wage while 25% of all the others are eligible. Then, the number of working mothers in home-based child care dropped by 41% although the labor supply by the other child care workers was almost unchanged. Besides, 30% wage gap between center-based and home-based child care workers in 1990, which can be interpreted as home-based workers' costs saving by keeping their kids at home, almost disappeared in 2010. The fact suggests that the subsidies get rid of the home-based care's advantage and equalize its wage to center-based one. Also, state-level differences confirm that a region where more working mothers in home-based child care sector tend to push up their wage.

The hypothesis is further studied by a simple static model. Although it emphasizes the subsidy's negative supply effects in the child care market, the subsidies must also positively stimulate its demand. The model provides necessary economic environment that the downward shifts of the child care supply dominate the positive demand one to push up its price. The subsidies should in particular change home-based child care worker's behaviors more. The model's analytical solution suggests two conditions are required: (i) the subsidy is highly mean-tested so that it targets low-income families and (ii) the skill distribution is non-uniform so that the population low-income families directly affected by subsidies is larger enough. A calibrated version of the model shows that possibly the negative supply effects dominated in the U.S. The quantitative model captures more than half of the raising child care price and declining working mother's labor supply.

Besides, 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. Holding all else constant, 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. Besides, the model almost entirely captures the observed child care arrangement substitution from market toward non-market.

[To be added: The life-cycle model with child care market evaluating the subsidies' effects through market.]

To complement the subsidies' channel above, I finally consider the effects of licensing. While almost all of the center-based child care providers are licensed, at most 42% of home-based providers got licensed in 1990. But it significantly increased in the 1990s to 54%. I use state variations in the extent of licensing and conduct an econometric analysis. Controlling difference in licensing, time, and home-based sector's relative change compared to center-based providers, the Difference-in-Difference-in-Difference (DDD) estimation finds a statistically significant effect of the expansion of licensing on child care costs explaining 8% of the increase in overall rising prices. It is interpreted as another source of negative supply shocks.

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 disaggregated 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 life-cycle 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 modelling of child care arrangement choice and its comparison with data. This paper also contributes to the large literature on 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. In section 3, I provide a hypothesis of rising child care costs and analyze with a simple static model both analytically and quantitatively. Section 4 further studies the household behaviors responding to rising child care price. Section 5 conducts applied microeconomic analysis on child care regulation's effects. Then, Section 6 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 include 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

¹For 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 $(30 + 10 + 5) \times 3$.

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 are defined as hours while the designated parent (mainly mother) is working.
- 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 the 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 are 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 the five youngest kids in each household. The hours of child care are changed to total hours including before/after work hours².

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 small³.

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

²The 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.

³In 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.

child care, while hours are limited to those at which mothers are at work. To fix the inconsistency, I adjust the variables derived from Survey B so that its 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 1997⁴.

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 advanced countries which have continued a 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.

⁴In Appendix B, I follow Herbst (2015) and plot a child care costs measure defined as expenditure divided by mother’s hours of work. This measure overcomes the inconsistency between Survey B and Survey C because it does not use hours of child care. There seems no jump between 1994 and 1997 in this measure; hence, the no structural break assumption seems reliable.

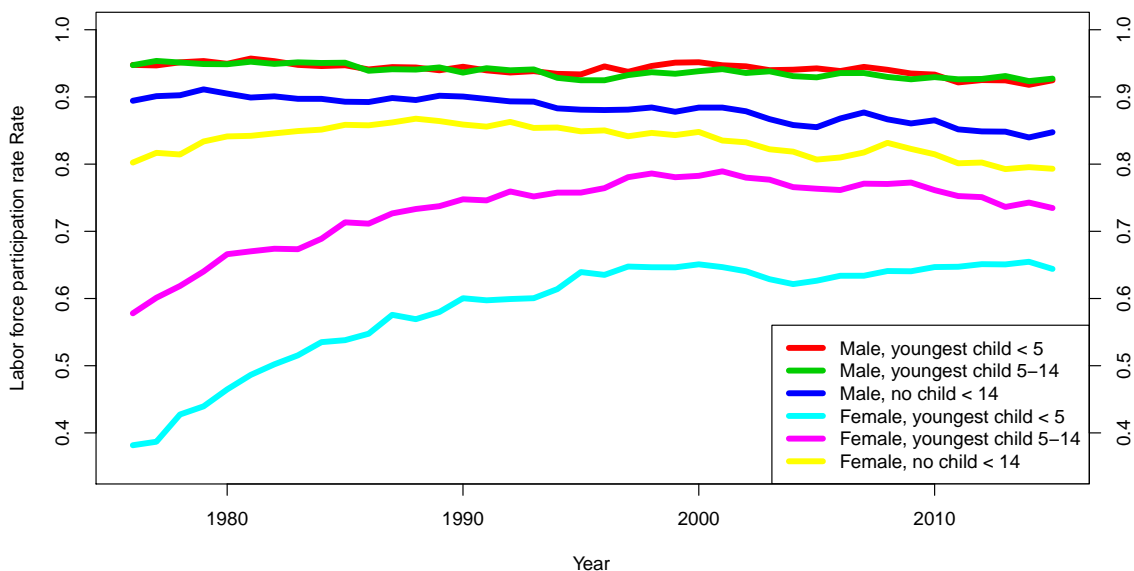


Figure 2: Labor force participation rates by sex and child status, age 25-44

I also plot the female labor force participation rate and its trend in Figure 3. I plot the time-series of young women age 25-39 and middle-age 40-54. The trend is estimated by Logit function because the labor force participation rate has lower and upper bounds. The Logit trend is fitted to time-series between 1968 to 1990 with male labor market participation rate as the upper bound. As in Figure 3, the young group's deviation from the trend started around 1990, while that of middle-age was around 2000. It may suggest that the rising child care price affect young group fast, then it also caused long-term effects. The one-time human capital loss of a woman when she has small children may also prevent her labor market participation in later life.

Price and hours of child care in aggregate

Figure 4 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 1998, 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 5 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

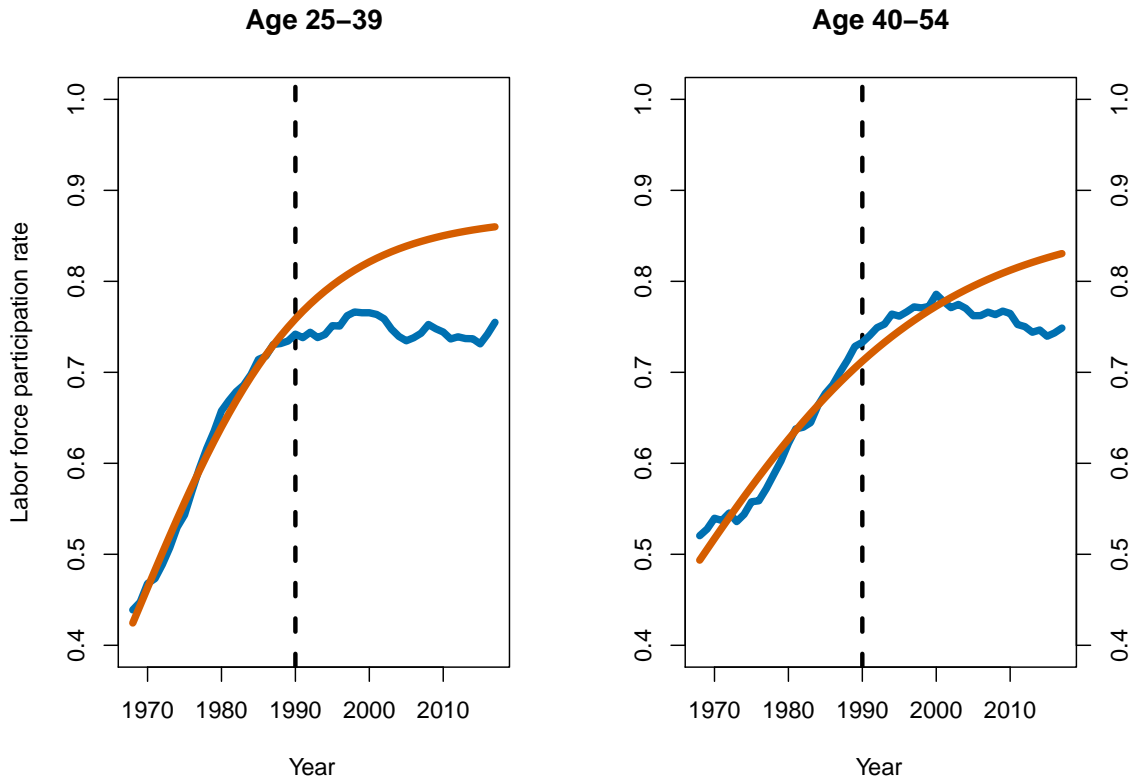


Figure 3: Labor force participation rate and its Logit trend by age group

database).

Price and Hours of child care by category

To explore the trends in greater 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 nanny⁵.

⁵In SIPP, these are defined as cares by non-relatives.

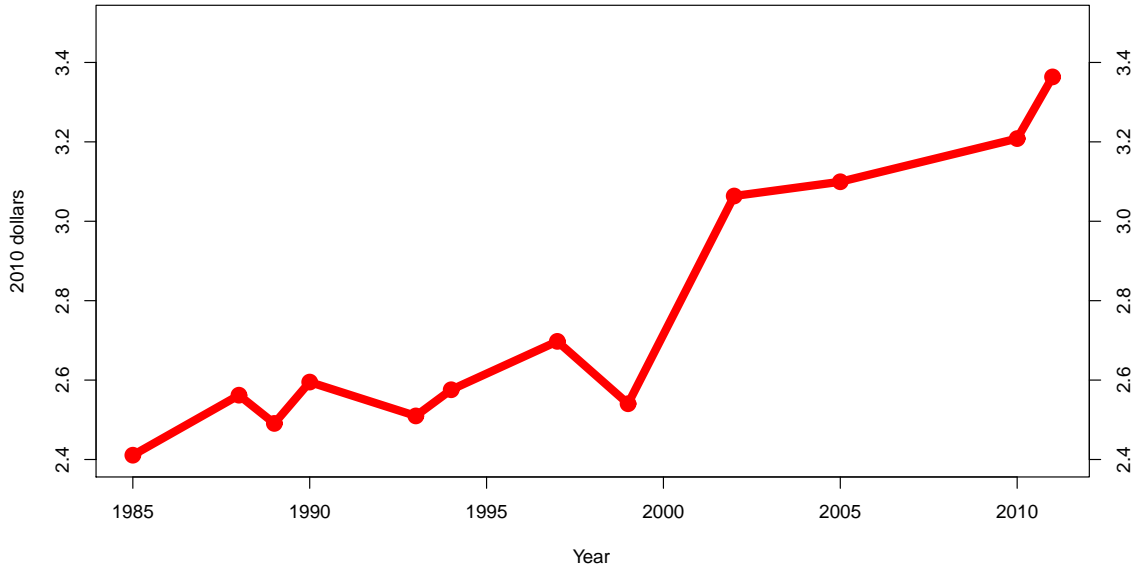


Figure 4: Mean real hourly expenditure on child care

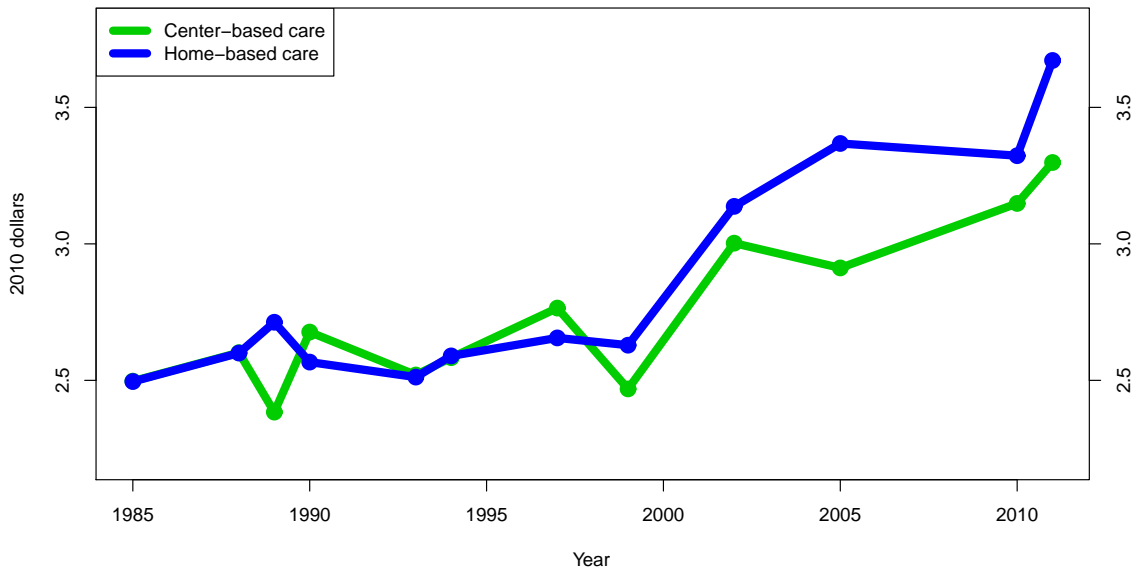


Figure 6: Real hourly costs of child care by category

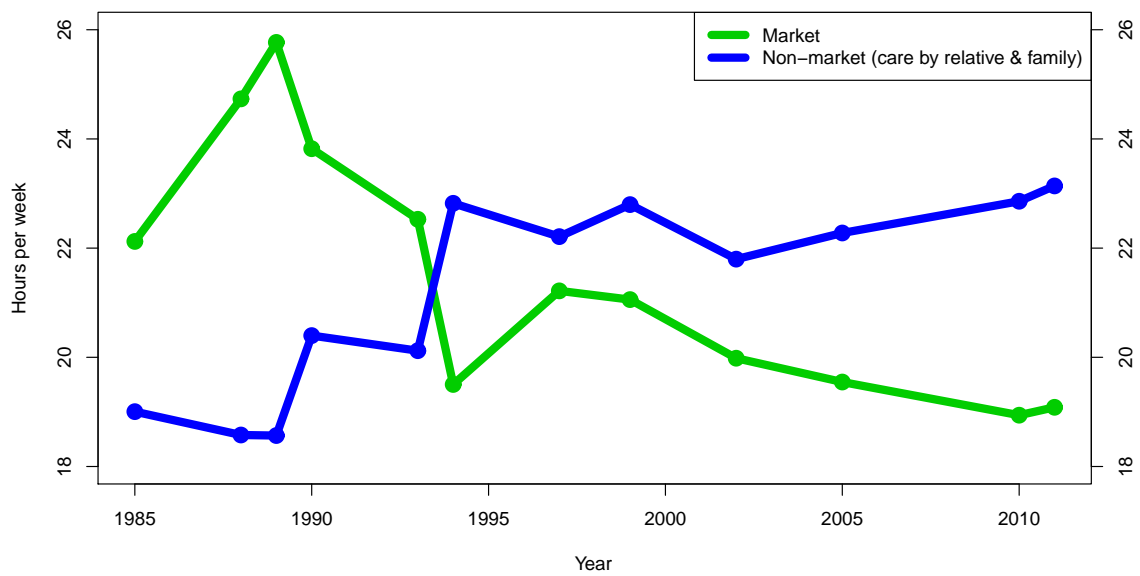


Figure 5: Hours of child care

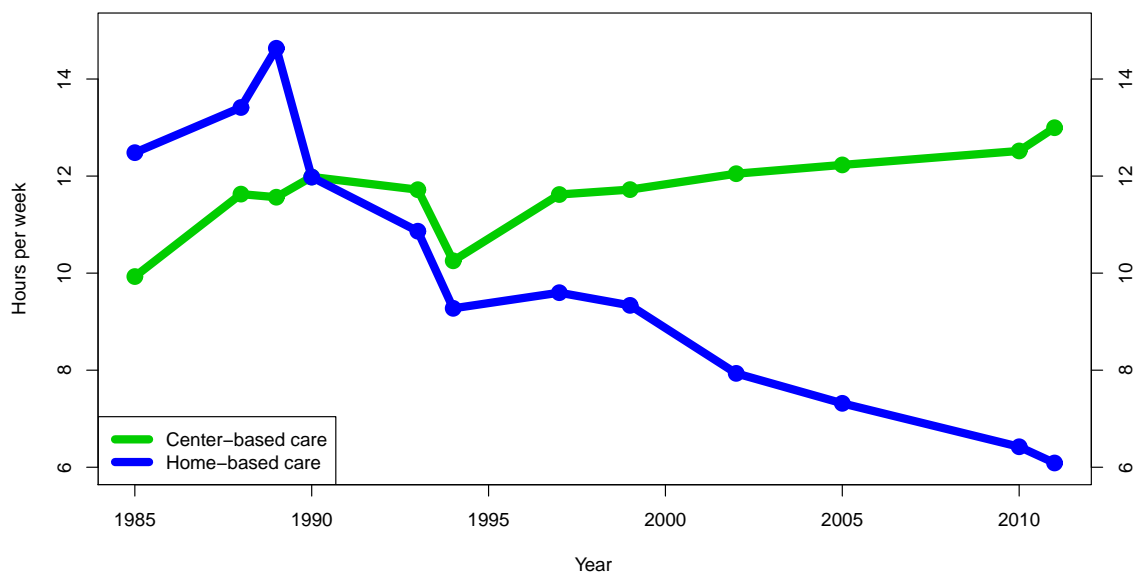


Figure 7: Hours of child care by category

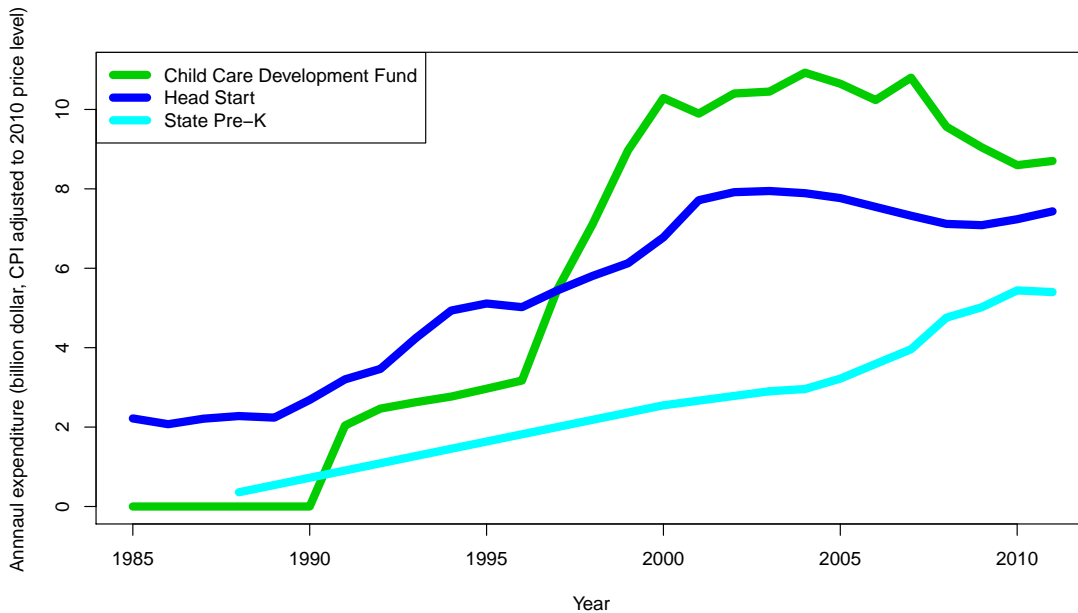


Figure 8: Real annual expenditure of child care subsidy programs

Figure 6 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 7. 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 behaviors 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 programs⁶: (i) The Child

⁶As 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.

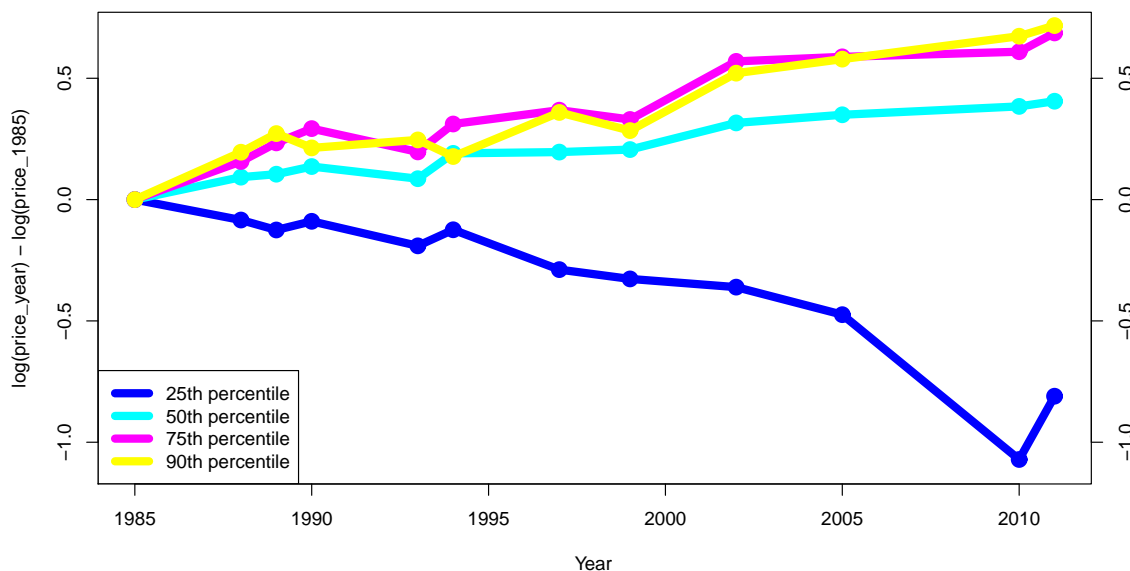


Figure 9: Cumulative log change of real hourly child care costs by percentile

Care Development Fund (CCDF), (ii) Head Start, and (iii) Pre-K schooling by each state⁷. 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 fundings⁸ into a single new funding stream. The funds are mainly provided as vouchers, that cover nearly all costs of child care⁹. 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.

⁷Data 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.

⁸Prior to 1996, the CCDF line on Figure 8 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.

⁹In my estimation by Child Care and Development Fund Administrative Data in 2005, 90.3% of total child care

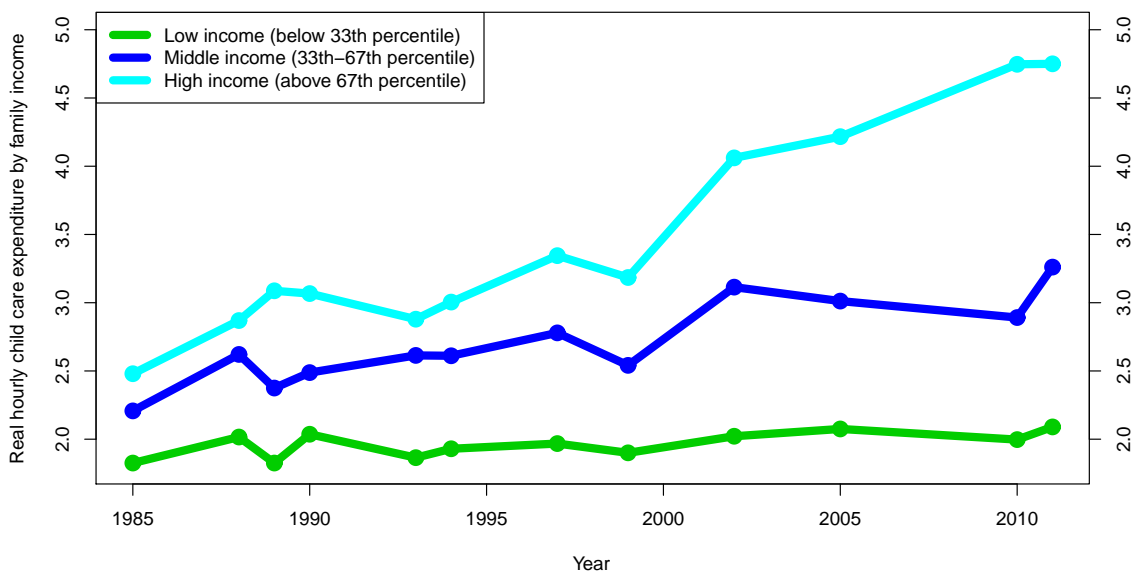


Figure 10: Real hourly child care costs by family income

The subsidy impacted the distribution of child care costs. Figure 9 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 median¹⁰.

expenditure is covered by the subsidy.

¹⁰Herbst (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

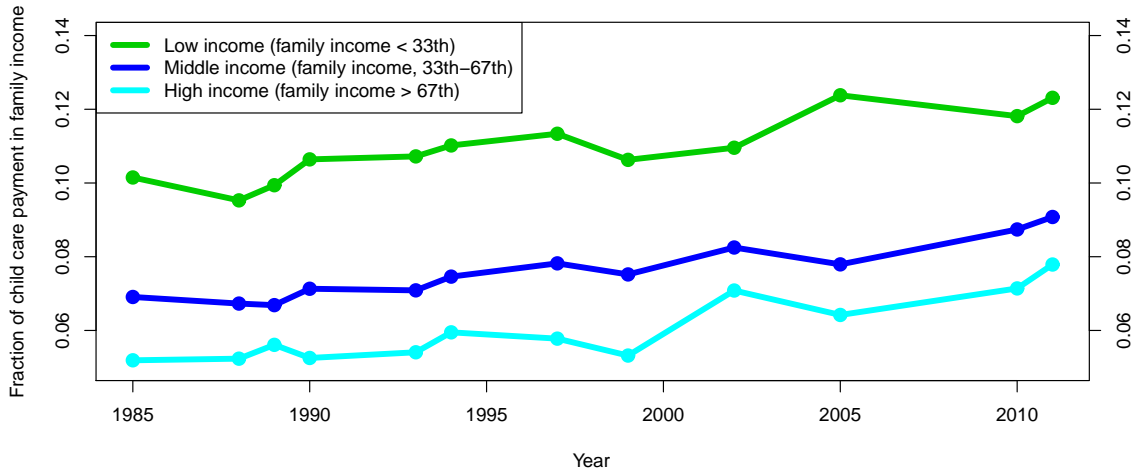


Figure 11: Fraction of child care payment in family income

The factor driving inequality of child care costs is income inequality. Figure 10 plots 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 11 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 child care prices plotted in Figure 10 have emerged mainly by rising dispersion of income.

Finally, Figure 12 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 10. 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 11.

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 5.

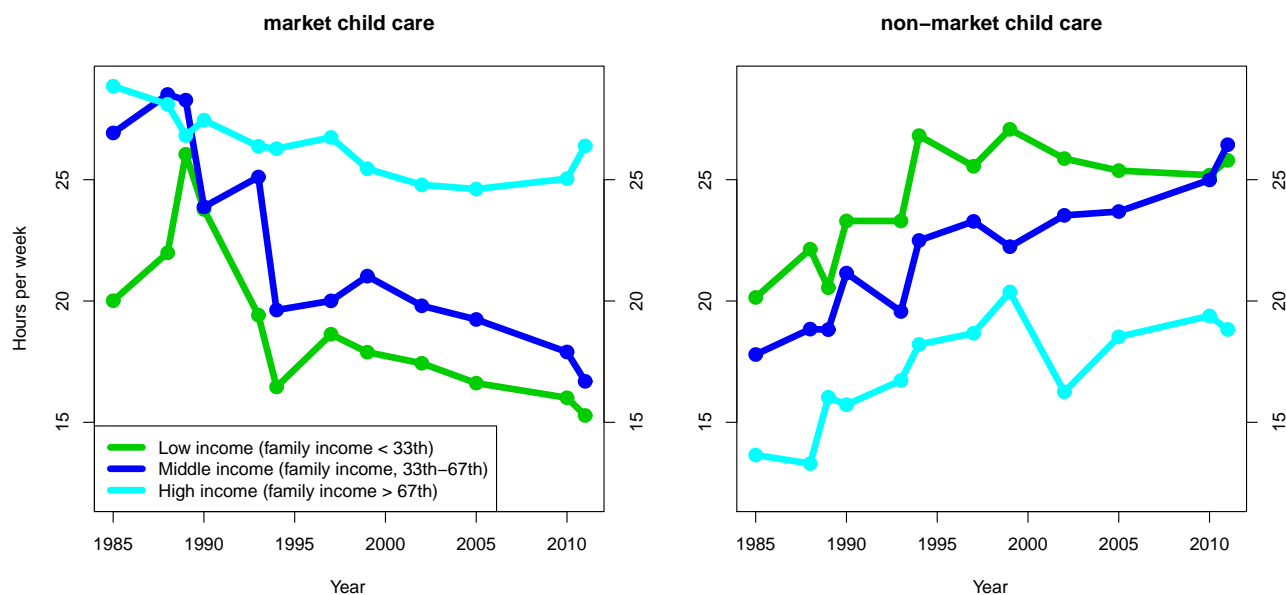


Figure 12: Weekly hours of child care by family income

3 The expanded subsidies and stagnation in the child care market

This section further studies the cause of the increase in child care costs in the 1990s and 2000s. Although the rise in child care costs was large, it is a puzzle because changes in child care policies during this time were supposed to decrease these costs. Public opinion led to increase in both federal and state expenditures on child care. The fraction of children who received almost the full subsidy for enrolling child care increased from 3% in 1990 to 26% in 2010¹¹. This expansion was supposed to lower the consumer price of child care, but the estimated net hourly price jumped up by 32% in the same period.

3.1 How child care subsidies reduce its supply

I provide a hypothesis that the increase in child care subsidies as implemented in the U.S. during the period induced negative impacts on its supply. In general, a subsidy lowers the net price and stimulates the demand. This chapter argues that the supply decreases through a unique channel.

The key factor of this hypothesis is home-based child care, i.e., child care provided by individuals in private residences such as family daycare homes, nannies, and babysitters. Compared to center-

¹¹Author's calculation by enrollment statistics of the Child Care Development Fund (CCDF), Head Start, and Pre-K schooling. See Figure 8 for the detail.

based child care, which is provided by an organization at a school style building, home-based child care services are provided by many working mothers. In the 1990 census data, 51.5% of home-based child care providers have children under 12 living in the same household. The percentage is significantly higher than the equivalent figures of 34.1% for center-based child care workers and 29.2% for all female workers in all occupations. Additionally, the wage for home-based child care workers was significantly lower than for center-based child care workers before the subsidies expanded, despite the fact that these occupations are almost the same: the log difference in mean hourly wages was 0.362 in the 1990 census data. This difference is compensated by a home-based child care’s special advantage that they are able to take care of their own children in their private residences. The traditional business model of home-based child care is a method of child care at work: care for both one’s own and neighbor’s children at the same time. It allows child care workers to save the costs of child care for their own kids. Kontos et al. (1995) report that the biggest reason that workers choose the family daycare job is to stay with their own children. Due to the low wage, 43% of working mothers in home-based child care were eligible to use nearly free child care provided by Head start, CCDF, or state pre-K service in 2010, while only 25% of working mothers were eligible¹².

The expansion of child care subsidies causes a strong incentive for home-based child care worker to change their occupation. The main reason working mothers chose home-based child care was to save the child care costs for their children. It made home-based child care jobs competitive with others, although the wage was significantly lower. But after the child care subsidies were expanded, this advantage diminished because many home-based care workers became eligible to receive subsidies and send their children to other daycare services. They have less incentive to stay in the low-wage occupation. Therefore, the expansion of child care subsidies might make the home-based child care occupation less attractive and decrease its supply.

3.2 Supportive Evidence

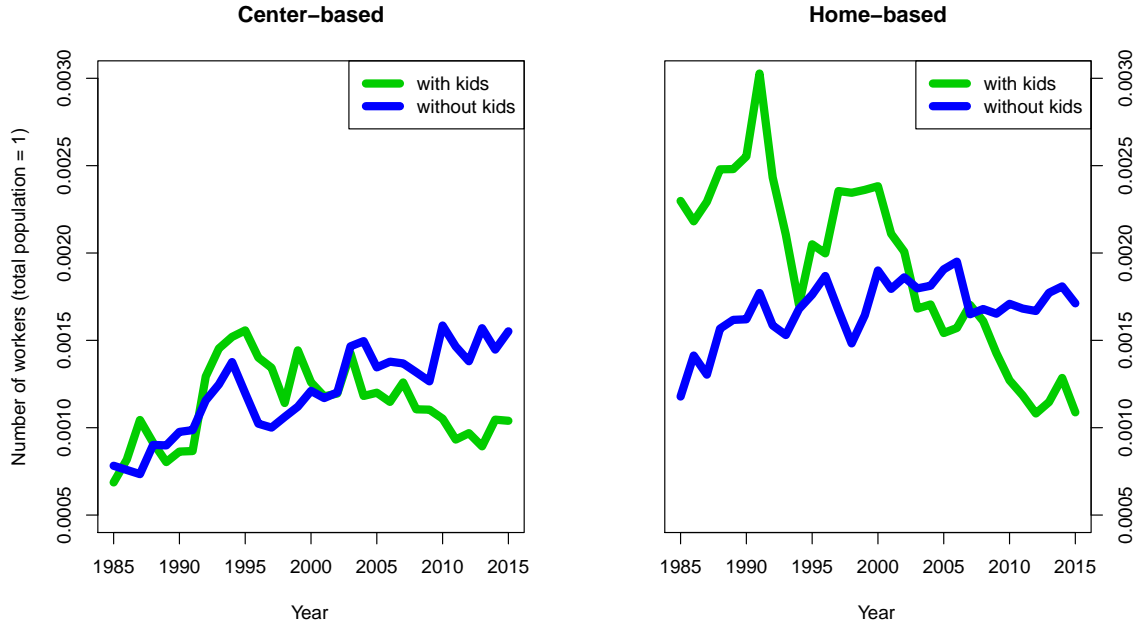
I provide three pieces of evidence supporting the hypothesis that the child care subsidy decreased female labor supply by making home-based child care unattractive.

First, Figure 13 shows the number of child care workers divided by arrangement (center vs. home) and child status¹³ (having children under age 15 or not). There has been a sharp decline in

¹²Author’s estimation by IPUMS American Community Survey and the CCDF administrative data.

¹³Total female population each year is normalized to 1. The data source is Annual Social and Economic Supplement of the Current Population Survey obtained by IPUMS 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

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



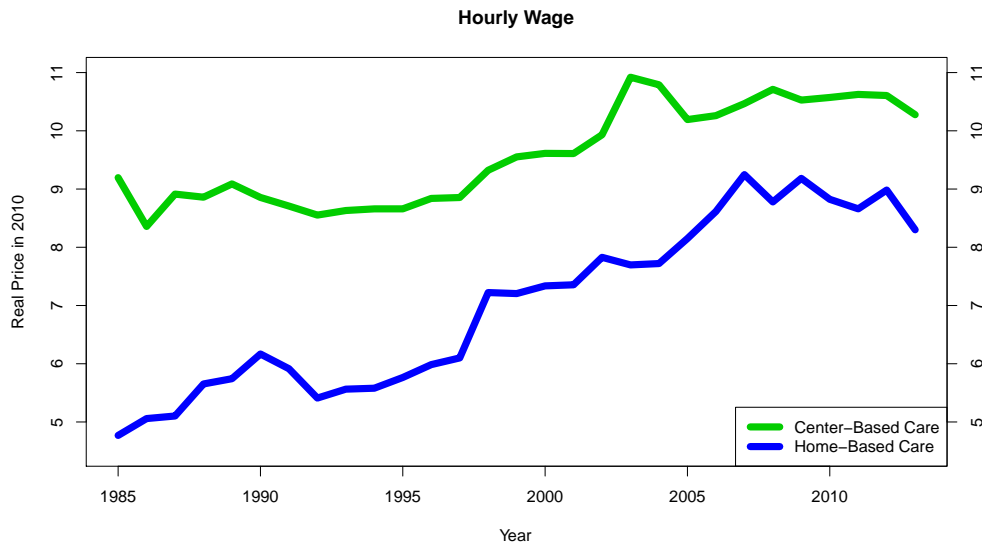
the labor supply of working mothers in the home-based sector in the 2000s, while the labor supply to the other categories has been almost stable. This is consistent with the hypothesis's prediction that the discouraging effects of the child care subsidies affected only the working mothers in home-based child care.

Secondly, Figure 3.2 shows the mean real hourly wages of child care workers in center-based and home-based sectors. As the subsidies expanded, home-based workers' wages rose significantly, and the gap with center-based workers diminished. The wage gap reflected the child care costs of home-based child care workers' own children; hence the vanishing gap is consistent with the introduction of child care subsidies.

Finally, cross-sectional facts also support the hypothesis. Figure 3.2 plots the regional correlation between the fraction of working mother's in home-based child care and the wage growth of child care workers. The x-axes of both diagrams are the fraction of working mothers having at least one child aged less than 12 in the home-based child care sector in 1990. The y-axis of the left diagram is home-based child care worker's mean wage growth rate between 1900 and 2005, and that of the right one shows the wage growth rate of center-based child care workers. The sample of child care workers in the U.S. are grouped by 543 Public Use Microdata Area (PUMA); each circle represents one area. Note again that the child care sector is highly labor-intensive; hence the wage is the most significant factor of total child care costs.

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.

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



The price level is adjusted by CPI to 2010 level.

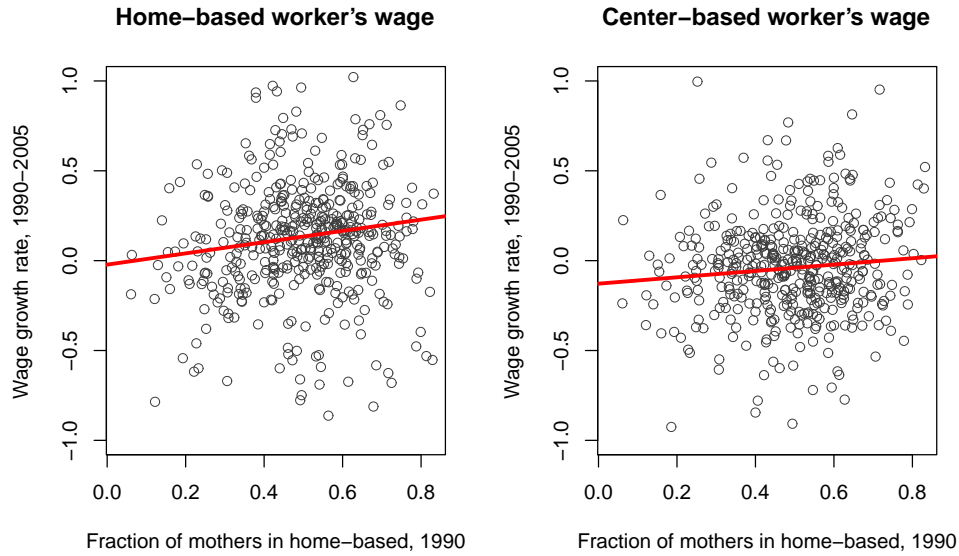
There is a strong correlation on the left diagram. A region with a higher fraction of mothers in home-based child care sector experiences a faster wage growth rate. In this kind of area, more women left the home-based child care sector after the introduction of the subsidies. A moderate correlation is also observed in the right diagram, although the y-axis is the wage growth rate of the center-based workers. It can be interpreted as a general equilibrium effect, i.e., higher price in home-based child care sector shifts the consumers to center-based market, and the higher wage also moves the center-based workers to the home-based sector.

3.3 Analytical model of the hypothesis

I develop a tractable model of child care market to illustrate how the child care subsidies can reduce child care supply. In general, a subsidy lowers the consumer price, stimulates the demand, raises the supplier price and increases the equilibrium supply. But in the case of the child care market, I will show that the subsidy may also cause a negative supply shock because home-based child care becomes less attractive.

The main question addressed here is under what conditions the negative supply effect dominates the positive demand effect. The simple model will reveal the importance of distributional effects of the policy. The magnitude of the positive demand effect depends on how many women change their labor supply decision due to the subsidy. The negative supply shock is determined by (i) the number of home-based child care workers that change their occupation due to the subsidy and

Figure 15: Cross section correlation between home-based child care share and wage growth



Note: The child care workers' occupation and hourly wage data are obtained from IPUMS USA census in 1990 and American Community Survey in 2005.

(ii) the number of women that leave the labor market due to an increase of gross child care price. As a means-tested program, the child care subsidy in the United States is mainly distributed to low-income families.

Model setup

I consider a static partial equilibrium model of the child care market. There is a unit continuum of single women who choose one occupation among office worker, home-based child care worker and homemaker, a la Roy model. Women are classified into two types by availability of occupations: Type A women decide between office worker or homemaker, while Type B women choose between office worker or home-based child care worker. The fraction of Type A women in the population is given by θ . Type A individuals capture the positive demand effect on child care policy that more women enter the labor market, whereas Type B individuals represent the potential negative supply effect if child care workers leave to take other jobs. Restricting each woman's available occupations to two generates tractability as occupational choice is characterized with simple cutoff rules. The model has no labor supply decision other than occupational choice, i.e., hours of work is fixed at 1.

Each women has one child¹⁴. Office work requires that women purchase child care services. Home-based child care workers and homemakers are able to care for their own children at home. Home-based child care workers also accept z number of children from other women and receive service fees. The competitive child care market determines the gross child care price p . Other types of child care such as daycare centers are unavailable in this economy. The government provides a subsidy for child care payments of office workers. The subsidy rate is a function of income. It is defined as $\tau(w; s)$ where w is income and s is the shape parameter of the subsidy schedule.

Office workers and child care workers incur a fixed disutility δ . Income is used to purchase a consumption good which produces utility via a linear utility function $u(c) = c$. The consumption good price is normalized to 1. The potential wages in office work follow distributions: $F_A(w)$ for Type A and $F_B(w)$ for Type B. I assume that each distribution has domain between 0 and some sufficiently large upper bound. I assume that each distribution also has a density, denoted by f_A and f_B .

Optimization problems and equilibrium

The decision problem for a Type A woman is given by

$$\max_{n \in \{0,1\}} c - \delta n \quad \text{s.t.} \quad c = wn - p[1 - \tau(w; s)]n,$$

where $n = 1$ means office work and $n = 0$ is homemaker. The term $p[1 - \tau(w)]n$ represents the payment for child care services. The optimal decision is

$$n_A(w) = \begin{cases} 1 & \text{if } w - \delta > p[1 - \tau(w; s)] \\ 0 & \text{otherwise} \end{cases}.$$

The decision problem of a Type B woman is given by

$$\max_{n \in \{0,1\}} c - \delta \quad \text{s.t.} \quad c = \{w - p[1 - \tau(w; s)]\}n + (1 - n)zp,$$

where $n = 1$ means office work and $n = 0$ is home-based child care. Because she has no choice to be homemaker, δ does not affect her decision. Given the child care price p , her income from child care is zp . A home-based child care worker does not receive the child care subsidy because she does

¹⁴In 1990 Census data, among households with children age under 5, the average number of children age under 5 is 1.29, and the median is 1.

not use child care in market for her own child. The optimal decision of a Type B worker is

$$n_B(w) = \begin{cases} 1 & \text{if } w > p[1 + z - \tau(w; s)] \\ 0 & \text{otherwise} \end{cases}$$

Equilibrium in the child care market requires that demand for child care services be equal to the supply of child care services. Given the above characterization of optimal occupational choices, this equilibrium condition can be written as:

$$\theta \int n_A(w) dF_A(w) + (1 - \theta) \int n_B(w) dF_B(w) = (1 - \theta)z \int [1 - n_B(s)] dF_B(s), \quad (2)$$

where the left-hand side is the demand for child care services and the right hand side is the supply of child care. Given the shape parameter of the subsidy schedule s , the equilibrium equation (2) determines the equilibrium price $p(s)$. For later use, I define the labor force participation rate of Type A as $m_A = \int n_A(w) dF_A(w)$. The equilibrium impact of changing child care policy s on the labor force participation rate of Type A women is defined as

$$\frac{\partial m_A}{\partial s} + \frac{\partial m_A}{\partial p} \frac{\partial p}{\partial s}.$$

Note that the overall labor force participation rate of women in this economy depends only on m_A because Type B workers always participate.

Equilibrium with linear subsidy

Before introducing a means-tested policy, I first consider a linear child care subsidy in order to derive intuition. Later I will show that the distributional effects of a means-tested policy are able to generate sufficiently strong negative supply effects so as to generate decreases in labor market participation. The distributional effect of means-tested policy is necessary to reverse the child care policy. Here, I will show that a linear subsidy always increases participation.

Assume that the subsidy rate is independent from income, i.e., $\tau(w; s) = s$ for all w . In this case, the shape parameter s defines the linear rate. The optimal decisions become:

$$n_A(w) = 1 \text{ if and only if } w > p(1 - s) + d,$$

$$n_B(w) = 1 \text{ if and only if } w > p(1 + z - s).$$

Then, the equilibrium condition (2) becomes:

$$\theta[1 - F_A(p(1 - s) + d)] + (1 - \theta)[1 - F_B(p(1 + z - s))] = (1 - \theta)zF_B(p(1 + z - s)). \quad (3)$$

The following proposition shows that the linear subsidy always stimulates participation, i.e., the positive demand effect overcomes the negative supply side effect.

Proposition 1. $\frac{\partial m_A}{\partial s} + \frac{\partial m_A}{\partial p} \frac{\partial p}{\partial s} > 0$ for all $s \in (0, 1)$.

Proof. The equilibrium condition (3) can be rewritten as:

$$\theta F_A(p(1 - s) + d) + (1 - \theta)(1 + z)F_B(p(1 + z - s)) = \text{const.}$$

The implicit function theorem implies that:

$$\frac{\partial p}{\partial s} = \frac{\theta p f_A(p(1 - s) + d) + (1 - \theta)(1 + z) p f_B(p(1 + z - s))}{\theta(1 - s) f_A(p(1 - s) + d) + (1 - \theta)(1 + z)(1 + z - s) f_B(p(1 + z - s))}.$$

The equilibrium effect of increasing the subsidy rate s defined as (??) is

$$\begin{aligned} & \frac{\partial m_A}{\partial s} + \frac{\partial m_A}{\partial p} \frac{\partial p}{\partial s} \\ &= p f_A - (1 - s) f_A \left[\frac{\theta p f_A + (1 - \theta)(1 + z) p f_B}{\theta(1 - s) f_A + (1 - \theta)(1 + z)(1 + z - s) f_B} \right] \\ &= p f_A - f_A \left[\frac{\theta p f_A + (1 - \theta)(1 + z) p f_B}{\theta f_A + (1 - \theta)(1 + z) \left(\frac{1+z-s}{1-s}\right) f_B} \right] \\ &= p f_A \left[1 - \frac{\theta f_A + (1 - \theta)(1 + z) f_B}{\theta f_A + (1 - \theta)(1 + z) \left(\frac{1+z-s}{1-s}\right) f_B} \right] \\ &> p f_A \left[1 - \frac{\theta f_A + (1 - \theta)(1 + z) f_B}{\theta f_A + (1 - \theta)(1 + z) \left(\frac{1-s}{1-s}\right) f_B} \right] = 0. \end{aligned}$$

□

This result is very intuitive. As noted previously, the effect on participation depends solely on the effect of participation of Type A women. The direct effect of the subsidy is to increase participation of Type A women and to cause more Type B women to choose effective work. These direct responses serve to increase the demand for child care and decrease the supply of child care, thereby creating upward pressure on the price. But the participation rate of Type A women will increase as long as the price net of subsidy does not increase. But it is easy to see that this cannot

happen. If the price net of subsidy were to increase, then more Type B women would become child care workers, and it follows that the price could not have increased. That is, as the price increases in response to the direct effects, demand decreases and supply increases. If the price increase were to be larger than the subsidy, demand would be lower and supply would be higher than in the no-subsidy case, contradicting that the price is higher.

Equilibrium with means-tested subsidy

The distributional effects of child care subsidies are the key factors to reverse the effects of child care on participation. To show that, I consider a simple means-tested child care subsidy policy:

$$\tau(w; s) = \begin{cases} 1 & \text{if } w \leq s \\ 0 & \text{if } w > s \end{cases}.$$

Women with income less than s are eligible to receive the full subsidy, while those with income more than s are not eligible to receive anything. The shape parameter s defines the income requirement. Although extreme, this means-tested policy captures the U.S. child care policy well. While the actual child care subsidy policy allows a continuous subsidy rate between 0 and 1, the rate jumps dramatically between the poverty threshold and its double.

This non-linear subsidy generates several distinct cases for the equilibrium depending on the eligibility income level s . For the sake of reality, I consider the case in which both Type A and Type B have positive numbers of women work in office both with and without subsidy. The decision to choose office work requires $w - d > p[1 - \tau(w; s)]$ for Type A and $w > p[1 + z - \tau(w; s)]$ for Type B. In this case, the decision is changed at the eligibility requirement s , i.e., $0 < s - d < p$ for Type A and $pz < s < p(1 + z)$ for Type B. Then, the optimal decisions can be written as:

$$n_A(w) = 1 \text{ if and only if } w \in (d, s] \text{ or } w > p + d,$$

$$n_B(w) = 1 \text{ if and only if } w \in (pz, s] \text{ or } w > p(1 + z).$$

Then, the equilibrium condition (2) becomes:

$$\theta[F_A(\bar{s}) - F_A(d) + 1 - F_A(p + d)] + (1 - \theta)(1 + z)[F_B(\bar{s}) - F_B(zp) + 1 - F_B((1 + z)p)] = (1 - \theta)z \quad (4)$$

The following proposition shows that in this case the child care subsidy can lead to a decrease in participation.

Proposition 2. $\frac{\partial m_A}{\partial s} + \frac{\partial m_A}{\partial p} \frac{\partial p}{\partial s} < 0$ if and only if

$$\frac{f_A(s)}{f_B(s)} > \frac{zf_B(pz) + (1+z)f_B((1+z)p)}{f_A(p+d)} \quad (5)$$

Proof. The implicit function theorem applied to the equilibrium condition (4) implies:

$$\frac{\partial p}{\partial s} = \frac{f_A(s) + (1-\theta)(1+z)f_B(s)}{\theta f_A(p+d) + (1-\theta)(1+z)[zf_B(pz) + (1+z)f_B((1+z)p)]}$$

Using $\frac{\partial m_A}{\partial s} = f_A(s)$ and $\frac{\partial m_A}{\partial p} = f_A(p+d)$, rearrangements of the equation leads to the condition. \square

The left-hand side of Equation (5) captures the direct effect of the increase in the income eligibility of subsidy s . The number of marginal Type B women who leave the market because of the increase in s , $f_B(s)$ should be sufficiently larger than that of Type A women who are encouraged to enter the market, $f_A(s)$. The right-hand side summarized the indirect effect by an increase in gross child care price p . The numerator, the marginal effect on Type B women attracted by child care job through increasing price, should be sufficiently smaller than the denominator, that on Type A women to leave the market.

Finally, consider the case in which both F_A and F_B follow uniform distributions. The following corollary proves that the decline in participation never occurs in this case, i.e., twists of income distribution are necessary.

Collorary 1. *Suppose both F_A and F_B follow uniform distributions in which the range allows both Type A and Type B have positive numbers of women work in office both with and without subsidy. Then, $\frac{\partial m_A}{\partial s} + \frac{\partial m_A}{\partial p} \frac{\partial p}{\partial s} > 0$ for all $s \in (0, 1)$.*

3.4 Quantitative exercise of the model

I further carry out some numerical simulations of the model. Although it is simple, the parameters of the model can be calibrated with actual data; hence, this model can be interpreted as a first step in a quantitative study of the U.S. child care market.

I calibrate parameters so that the model matches some feature of the data in 1990, when the child care subsidies were almost negligible, and so use the equilibrium with no subsidy to calibrate parameters. The data used for the calibration are IPUMS 5% sample of 1990 census and the pooled sample of Current Population Surveys (CPS) from 1986 to 1995. From the former one, I use the sub-sample of all mothers with children younger than 6 years old. I use this data to calculate Type A worker parameters including the wage distribution. The latter data is used for the office worker wage distribution of Type B workers. Although the sample size of the CPS is small, it contains

information on the occupation from the previous year. I use the sub-sample of mothers with children younger than 6 year old, who were child care workers last year and work at the other occupations this year. I interpret their current wage distribution as Type B workers' outside options.

In both samples, I use the hourly wage as the measure of income. It is calculated as the reported annual income divided by usual hours of work per week and annual weeks of work. The workers with the highest 1% wages are eliminated from the sample for top-coding. In the CPS sample, wages are adjusted to 1990 levels by using the Consumer Price Index.

Type A's labor market participation rate depends on the child care price p , the potential wage distribution F_A , and the labor disutility parameter δ . Although p is the endogenous variable in the model, I calibrated the other parameters given $p = 1.50$, which is the estimated hourly child care price in 1990. Later I will adjust the population parameter θ so that $p = 1.50$ holds in the equilibrium with no subsidy. The log wage is assumed to follow the normal distribution with mean $\mu_A = 2.09$ and the standard deviation $\sigma_A = 0.82$. They are determined by the maximum-likelihood estimation with only observed wages. Therefore, it possibly contains selection bias. Since δ is an unknown non-zero parameter, the standard Tobit technique cannot be applied¹⁵. Here, I determine $\delta = 7.03$ so that the labor force participation rate given the estimated log-normal distribution matches the observed data 0.47.

Type B behavior is determined by the number of children one worker take cares of z , and the potential wage distribution of office work F_B . The child care productivity parameter $z = 1.96$ is calculated as the median home-based child care worker's hourly wage divided by the estimated child care costs p ¹⁶.

Having calibrated the model, I next solve for the equilibrium with the means-tested policy. I add a constant child care supply term Θ . It represents child care supplies by center-based providers and home-based workers without children.

The analytical model above focuses only a particular type of equilibrium. The general form of equilibrium is written below. I also add constant child care supply term Θ . It includes center-based providers and home-based workers without children.

$$\begin{aligned} & \theta [\max\{F_A(\bar{s}) - F_A(d), 0\} + 1 - \max\{F_A(p + d), F_A(\bar{s})\}] \\ & + (1 - \theta)(1 + z) [\max\{F_B(\bar{s}) - F_B(pz), 0\} + 1 - \max\{F_B[p(1 + z)], F_B(\bar{s})\}] = (1 - \theta)z + \Theta \end{aligned} \tag{6}$$

¹⁵Carson and Sun (2007) suggested to use the cut-off point as $\min\{y_i\}$. However, this approach does not allow the measurement error of the cut-off. It is not the method to derive mean value of individual dependent cut-offs.

¹⁶This number is consistent with direct estimation of home-based child care surveys. Kisker et. al (1991) shows the median number of children enrolled per home-based care is 4. Helburn and Howes (1996) shows that the family child care's labor costs are 53.8% of its total revenue. Therefore, z can be also calculated as $z = 2.15$.

The fraction of Type A workers θ is calibrated by Equation (6) with $\bar{s} = 0$. From the child care workers' data in 1990, Θ is 3.7 times bigger than the home-based child supply by working mothers.
:

$$\theta = \frac{1 - (1 + z)F_B(p(1 + z)) - \Theta}{F_A(p + d) - (1 + z)F_B(p(1 + z))}. \quad (7)$$

Starting from the benchmark equilibrium with $\bar{s} = 0$, Figure 3.4 shows the comparative statistics when the subsidy cut-off level of income \bar{s} increases. Type B women start to use the subsidy to choose office work above $\bar{s} = 2.59$, while Type A began to receive a subsidy above $\bar{s} = 2.94$ as the dotted vertical lines show in Figure ???. It captures that potential child care workers are low-income women; hence, more of them are eligible for the child care subsidy compared to other women. As \bar{s} increases from 2.94 toward 7.03, more Type B workers move from child care to office work. It dampens the child care supply and stimulates the demand, leading the gross price of child care to increase. Since none of Type A workers are eligible to receive the subsidy, the employment rate decreases. This part captures the main hypothesis of this chapter. As \bar{s} increases above 7.03, Type A women are also eligible. Then, it enhances the labor market participation of Type A women. The gross child care price still grows, but the direct effect of receiving subsidy dominates it.

In my estimation, 9% of working mothers in 2005 receive either one of the child care subsidy in Figure 8 by the number of children enrolling in each program. Given the working mother's hourly wage distribution in 1990, the 9 percentile corresponds to \$7.53 per hour, which is slightly higher than the cutoff of Type A workers \$7.03. Although it is a rough simulation, it suggests that the expansion of subsidies likely decreased the female labor supply.

Figure 16: Comparative statics on the simple model

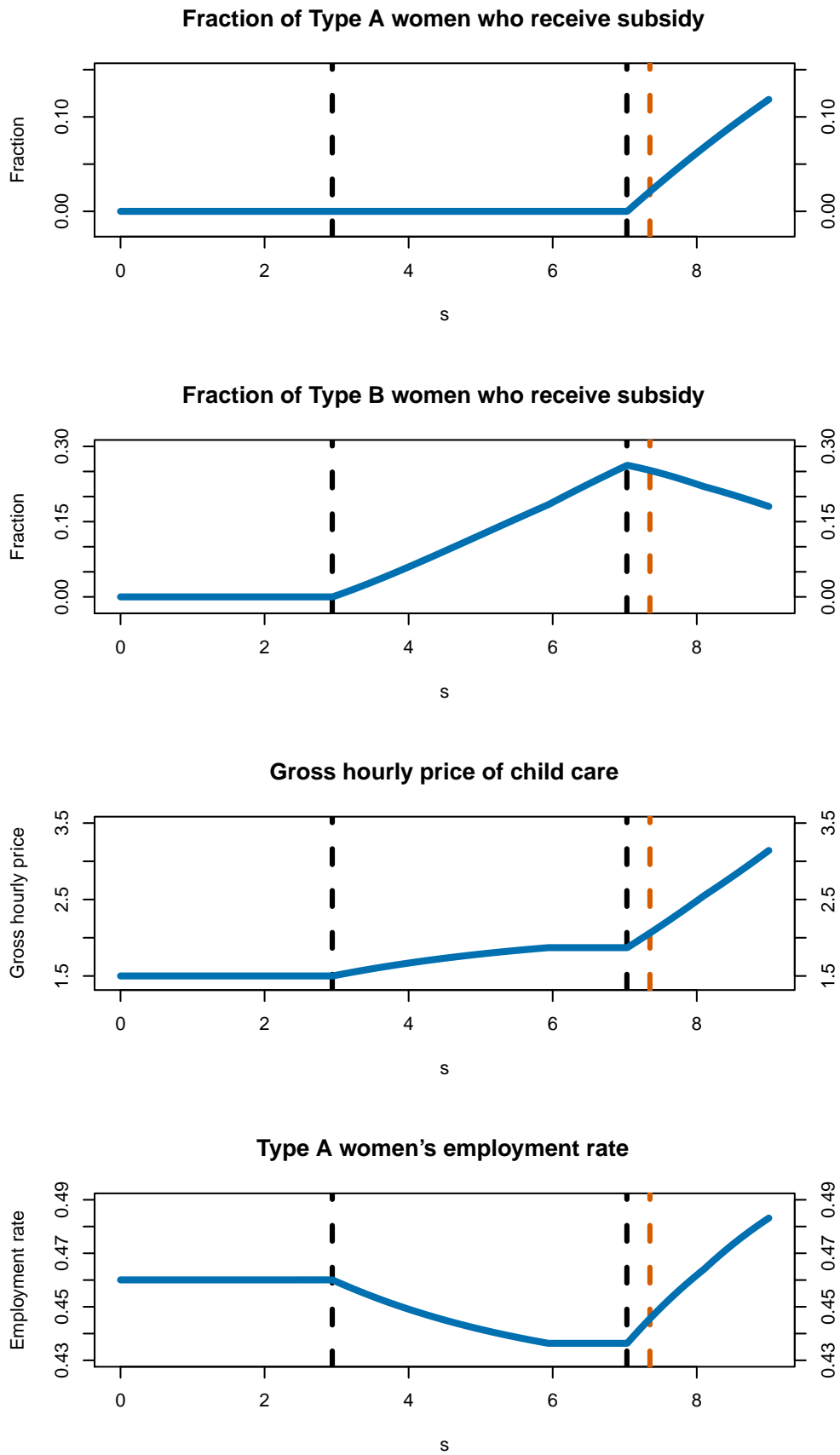


Table 1: Consequences of various subsidy policies

	no subsidy	mean-tested subsidy	linear subsidy	home-based subsidy
Gross child care price	\$1.50	\$2.01	\$1.47	\$0.70
Type A's employment rate	46.0%	44.5%	46.1%	47.1%

I also consider two alternative policies: linear child care subsidy on office workers and direct linear subsidy on home-based childcare suppliers. Table 3.4 summarize the consequences of each policy if the same amount of the subsidy in the case above is granted. As already mentioned, the mean-tested policy reduces child care supply, increase its price and decreases the labor force participation rate. The linear subsidies on office workers crate little effects because it has small reduction on child care price on the marginal workers. The direct subsidies distributed to home-based workers significantly lower the price and enhance female labor market participation. Compared to linear subsidies on office workers, the policy focuses more on critical workers.

4 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 the 1990 data. Then, the rising child care cost estimated in Section 2 is introduced into the model.

4.1 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 literature¹⁷ 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 $1-\theta$ 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 them¹⁸. 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

$$\ln h_{t+1}^m = \ln h_t^m + g_t + v_{t+1}^m, \quad (8)$$

where h_t^m 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_{t+1}^m is a permanent income shock. For simplicity, Equation (8) 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

$$\ln h_{t+1}^f = \ln h_t^f + \mathcal{I}(n_t > 0)g_t - \mu(n_t)\delta + v_{t+1}^f, \quad (9)$$

¹⁷See, e.g., Attanasio et al. (2008)

¹⁸Bick (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:

$$\mu(n_t) = \begin{cases} 0 & \text{if } n_t = 0.4, \\ \bar{\mu} & \text{if } n_t = 0.2, \\ 1 & \text{if } n_t = 0. \end{cases} \quad (10)$$

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 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 (8) and Equation (9) 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

$$\begin{bmatrix} v_t^m \\ v_t^f \end{bmatrix} \sim N \left(\begin{bmatrix} -\sigma^2/2 \\ -\sigma^2/2 \end{bmatrix}, \begin{bmatrix} \sigma^2 & \sigma^2\rho \\ \sigma^2\rho & \sigma^2 \end{bmatrix} \right) \quad (11)$$

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 $t \in \{1, 2, \dots, 8\}$ 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, $t \in \{1, 2, \dots, 11\}$, 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 hours¹⁹. 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 2005²⁰, which is surprisingly high compared to 10% for pre-school children. However, this number is calculated *only for families who use market child care*. In my estimation with SIPP microdata, only 19% of working mothers of school-age children use market child care in 2005. It is problematic to assume this large amount of costs for all families. Also, the costs may include educational activities such as sports clubs or ballet lessons. In my estimation²¹, 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

$$U_c(c; t, \omega) = \log \left(\frac{c}{\psi(t, \omega)} \right), \quad (12)$$

¹⁹This model also allows to use both care, $x_t = z_t = 0.2$, if wife is full-time employed, $n_t = 0.4$

²⁰They 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>

²¹I 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 OECD²².

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

$$U_n(n; t, \omega) = d(t, \omega) \frac{(1 - n)^{1-1/\gamma}}{1 - 1/\gamma}, \quad (13)$$

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

$$d(t, \omega) = \begin{cases} \bar{d}^1 & \text{if the couple has children age under 5,} \\ & \text{i.e., } (t, \omega) \in \{(1, ya), (1, yb), (2, oa), (2, ob)\} \\ \bar{d}^2 & \text{if the couple has children age 5 to 15,} \\ & \text{i.e., } (t, \omega) \in \{(2, ya), (2, yb), (3, ya), (3, yb), (3, oa), (3, ob), (4, oa), (4, ob)\} \\ \bar{d}^3 & \text{otherwise.} \end{cases} \quad (14)$$

The leisure depends on child status. In the calibration, this assumption captures the idea that labor force participation causes more disutility to 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

$$d_z z_t \quad (15)$$

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

$$c_t + \frac{a_{t+1}}{1+r} = (1 - \tau)[0.4wh_t^m + nwh_t^f] - px_t + a_t \quad (16)$$

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

²²See 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 .

4.2 The optimization problems

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

$$V_t(a_t) = \max_{a_{t+1}, c_t} U_c(c; t, \omega) + \beta V_{t+1}(a_{t+1}), \quad (17)$$

$$\text{s.t. } c_t + \frac{a_{t+1}}{1+r} = a_t, \quad (18)$$

$$a_t \geq -\bar{a}(t, z), \quad (19)$$

$$V_t(a_t) = 0 \text{ for all } a_t \geq 0 \text{ at } t = 12. \quad (20)$$

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, \dots , 8 if $\omega \in \{ya, yu\}$, and at Period 1, 3, 4, \dots , 8 if $\omega \in \{oa, ou\}$.

$$V_t^\omega(h_t^m, h_t^f, a_t) = \max_{a_{t+1}, c_t, n_t} U_c(c; t, \omega) + U_n(n; t, \omega) + \beta \mathbb{E}V_{t+1}^\omega(h_{t+1}^m, h_{t+1}^f, a_{t+1}) \quad (21)$$

$$\text{s.t. } c_t + \frac{a_{t+1}}{1+r} = (1-\tau)[0.4wh_t^m + wh_t^f n] + a_t \quad (22)$$

$$a_t \geq -\bar{a}(t, \omega) \quad (23)$$

$$\ln h_{t+1}^m = \ln h_t^m + g_{t+1} + v_{t+1}^m \quad (24)$$

$$\ln h_{t+1}^f = \ln h_t^f + \mathcal{I}(n_t > 0)g_t - \mu(n_t)\delta + v_{t+1}^f \quad (25)$$

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 $\omega \in \{oa, ou\}$.

$$V_t^\omega(h_t^m, h_t^f, a_t) = \max_{a_{t+1}, c_t, n_t, x_t, z_t} U_c(c; t, \omega) + U_n(n; t, \omega) - d_z z_t + \beta \mathbb{E} V_{t+1}^\omega(h_{t+1}^m, h_{t+1}^f, a_{t+1}), \quad (26)$$

$$\text{s.t. } c_t + \frac{a_{t+1}}{1+r} = (1-\tau)[0.4wh_t^m + wh_t^f n] - px_t + a_t, \quad (27)$$

$$a_t \geq -\bar{a}(t, \omega), \quad (28)$$

$$\ln h_{t+1}^m = \ln h_t^m + g_{t+1} + v_{t+1}^m, \quad (29)$$

$$\ln h_{t+1}^f = \ln h_t^f + \mathcal{I}(n_t > 0)g_t - \mu(n_t)\delta + v_{t+1}^f, \quad (30)$$

$$n_t = x_t + z_t, \quad (31)$$

$$z_t \in \{0, 0.2, 0.4\} \text{ for } \omega \in \{ya, oa\}, \text{ and } z_t = 0 \text{ for } \omega \in \{yu, ou\}. \quad (32)$$

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 $\omega \in \{yu, ou\}$.

4.3 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 state²³.

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, \dots, g_8 are obtained by the difference in mean

²³The model studies life-cycles; hence, repeated cross-section or panel data may be better for calibration. This point will be improved in future research.

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 2: 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 small²⁴. 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 data²⁵. Seven parameters are chosen by the same number of moments as shown in Table 3 and Table 4.

²⁴Two 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.

²⁵The 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 3: 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 4: Moments to match

4.4 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 the facts, I estimate a deviation from the past trend. I estimate Logit trends by the time-series until 1990 as in Figure 3. 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 ²⁶.

This procedure assumes that there were underlying driving forces to enhance female labor supply between 1990 to 2010. In this period, there were many factors to support female market participation such as an increase in higher education enrollment, improvement in home production technology, industrial shifts from manufacturing to service, etc. Notably, male to female wage ratio was increased from 0.62 to 0.71 between 1990 and 2010. Given the high elasticity of female labor

²⁶Since 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	Data	Model
LFPR of women with all child status	-0.090	-0.054
LFPR of women with children age under 5	-0.177	-0.129
LFPR of women with children age 5 to 14	-0.086	-0.046
LFPR of women without children age under 15	-0.050	-0.043
Weekly hours of work of women with all child status	-7.28	-2.38
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 5: Results of the model’s responses compared to deviation from the trends in data

supply on the gender wage gap²⁷, even this sole factor significantly supported to keep the increasing trend. Evaluating the effect of each factor is beyond the scope of this paper. Instead, I assume that these factors still kept increasing female labor supply. Then, the model evaluates how much the rising child care costs discouraged the female labor supply and offset the underlying rising trend.

The results are summarized in Table 5. 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 married women. It explains about over half of the deviation from the trend, 9.0%. The model also succeeds in explaining the higher decline in the labor force participation rate of women with each child status. The model captures its main target, participation rate of mothers with young children. In addition, it does good job in tracing their behaviors later life. About the hours of work, although the sign is consistent, the quantitative performance is less significant. The model predicts some of full-time working mothers change to part-time job, but it’s against data.

The model also succeeds in predicting the large increase in the share of non-market child care (by relative/family) observed in Figure 5. As the child care costs have increased, couples have substituted child cares from market to non-market. The only inconsistency with the data is the decrease in the share of part-time workers. There might be some other factors inducing women to work in full-time jobs more, e.g., improvement in education.

The result emphasizes the importance of child care as a factor to determine female labor supply. Compared to the literature, the model is constructed in a conservative way potentially mitigating the magnitude of child care such as no costs for school-age children and allowing non-market child care. But this model still suggests that the child care costs are dominant factors in female labor supply decision.

²⁷For example, Attanasio et al. (2008) reports that 11% increase in female wage leads to 8% increase in female labor force participation rate.

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 6: Wages and numbers of providers in the child care industry

5 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 licenses²⁸. It is because many providers caring for small numbers of children are exempt from licensing²⁹.

The child care workers' wages and the number of providers are summarized in Table 6. Compared to the real wage for an average female worker and center-based child care worker³⁰, 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

²⁸The 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 6. Actual number is even lower because many unlicensed providers do not file tax return (Kontos (1992)).

²⁹Morgan 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/>

³⁰In Census 1990, 97% of the child care workers are female.

providers between 1990 and 2000. First, some states started to require daycare homes to obtain licenses in this period. The number of states requiring licensing for all family daycare home³¹ 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 improvement³², which possibly enhanced licensing.

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 decreasing in 10 states. The main reason is that states have large discretion 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 subsidies³³. 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 effect³⁴. 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

³¹The 1991 data is obtained from Kisker et al. (1991), and the 2001 data obtained from Morgan et al. (2001)

³²Under the law, at least four percent of CCDF funds must be used to improve the quality of child care.

³³They 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>

³⁴Hotz 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.

$$\ln(W_{it}) = \beta_0 + \beta_1 X_{ijt} + \beta_2 \tau_t + \beta_3 \delta_j + \beta_4 T_i + \beta_5 \tau_t \delta_j + \beta_6 \delta_j T_i + \beta_7 T_i \tau_t + \beta_8 \tau_t \delta_j T_i. \quad (33)$$

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 (33) 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 7. 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 (0.022)	0.045 (0.019)	0.033 (0.011)	0.070 (0.033)	0.058 (0.019)

Table 7: DDD Estimates of the Impact of Increase in Licensed Family Daycare Providers on Worker’s Hourly Wage

Equation (33). 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.

6 Conclusion

[TBA]

Appendix B: Miscellaneous diagrams

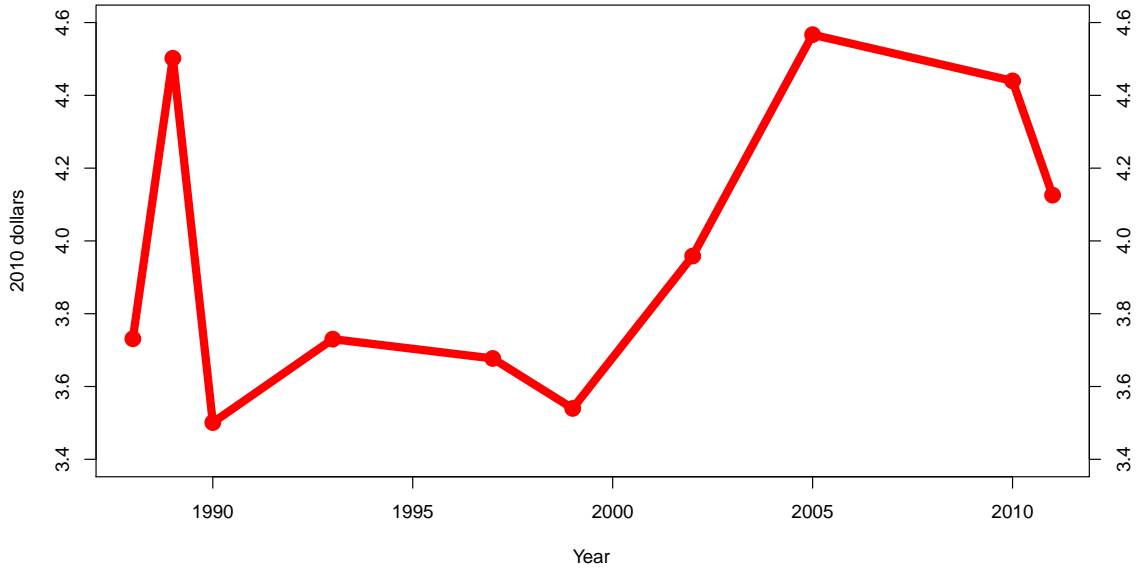


Figure 17: Mean hourly child care costs of school-age children age 5-15

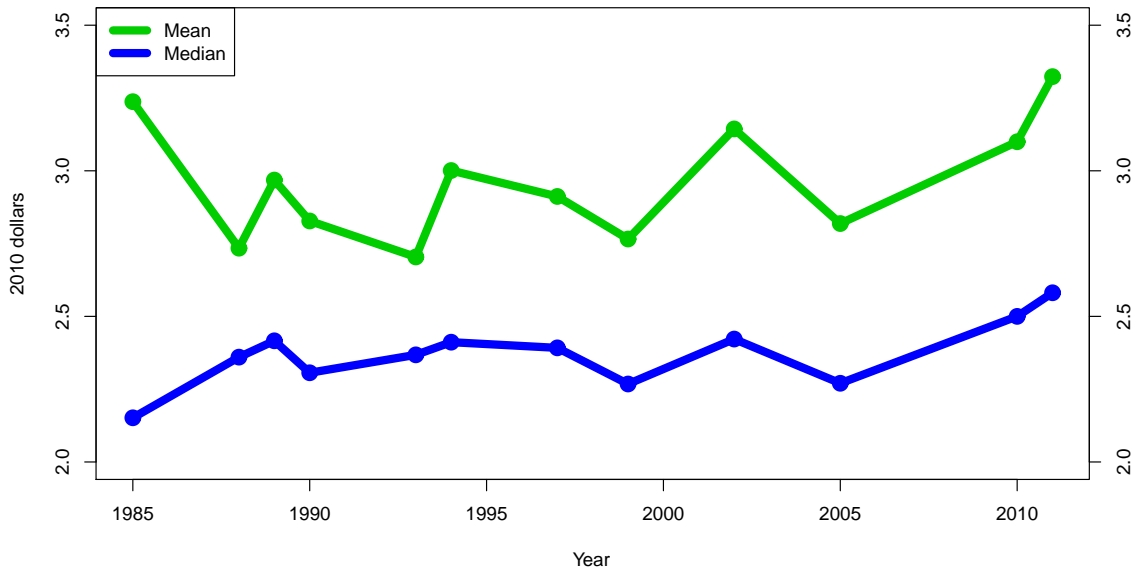
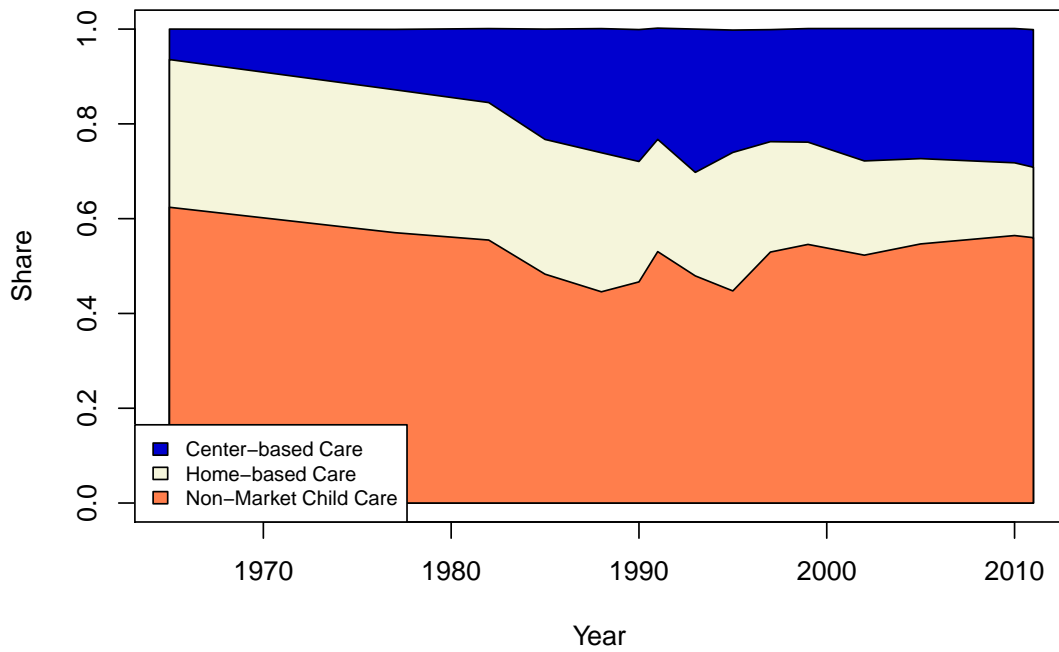


Figure 18: Mean and median child care costs defined as expenditure divided by mother's hours of work



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 19: The long-term share of child care arrangements

References

- Aaronson, Daniel and Eric French (2004), “The effect of part-time work on wages: Evidence from the social security rules.” *Journal of Labor Economics*, 22, 329–252.
- Acemoglu, Daron, David Autor, David Dorn, Gordon H Hanson, and Brendan Price (2016), “Import competition and the great us employment sag of the 2000s.” *Journal of Labor Economics*, 34, S141–S198.
- Aguiar, Mark and Erik Hurst (2007), “Measuring trends in leisure: The allocation of time over five decades.” *The Quarterly Journal of Economics*, 122, 969–1006.
- Aruoba, S Borağan and Jesús Fernández-Villaverde (2015), “A comparison of programming languages in macroeconomics.” *Journal of Economic Dynamics and Control*, 58, 265–273.
- Attanasio, Orazio, Hamish Low, and Virginia Sánchez-Marcos (2008), “Explaining changes in female labor supply in a life-cycle model.” *The American Economic Review*, 98, 1517–1552.
- Barnichon, Regis and Andrew Figura (2015), “Declining desire to work and downward trends in unemployment and participation.” In *NBER Macroeconomics Annual 2015, Volume 30*, University of Chicago Press.
- Bassok, Daphna, Maria Fitzpatrick, Erica Greenberg, and Susanna Loeb (2012), “Regulating early childhood education and care: Assessing compliance, choice, and child outcomes 1997-2007.”
- Bastos, Paulo and Julian Cristia (2012), “Supply and quality choices in private child care markets: Evidence from são paulo.” *Journal of Development Economics*, 98, 242–255.
- Besharov, Douglas J and Caeli A Higney (2003), *Federal and state child care expenditures (1997-2003): Rapid growth followed by steady spending*. Maryland School of Public Policy, Welfare Reform Academy.
- Bick, Alexander (2015), “The quantitative role of child care for female labor force participation and fertility.” *Journal of the European Economic Association*.
- Blau, David M (2007), “Unintended consequences of child care regulations.” *Labour Economics*, 14, 513–538.
- Blau, David M and H Naci Mocan (2002), “The supply of quality in child care centers.” *Review of Economics and Statistics*, 84, 483–496.

- Blau, Francine D and Lawrence M Kahn (2013), “Female labor supply: Why is the united states falling behind?” *The American Economic Review*, 103, 251–256.
- Chipty, Tasneem and Ann Dryden Witte (1997), “An empirical investigation of firms’ responses to minimum standards regulations.” Technical report, National Bureau of Economic Research.
- Doepke, Matthias and Michèle Tertilt (2016), “Families in macroeconomics.” Technical report, National Bureau of Economic Research.
- Fernández, Raquel and Joyce Cheng Wong (2014), “Divorce risk, wages and working wives: A quantitative life-cycle analysis of female labour force participation.” *The Economic Journal*, 124, 319–358.
- Greenwood, Jeremy, Nezih Guner, Guillaume Vandenbroucke, et al. (2015), “Family economics writ large.”
- Gruber, Jonathan (1994), “The incidence of mandated maternity benefits.” *The American economic review*, 622–641.
- Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura (2011), “Taxation and household labor supply.” *The Review of economic studies*, rdr049.
- Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura (2012), “Taxing women: A macroeconomic analysis.” *Journal of Monetary Economics*, 59, 111–128.
- Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura (2013), “Childcare subsidies and household labor supply.”
- Guvenen, Fatih (2011), “Macroeconomics with heterogeneity: a practical guide.” *Economic Quarterly*, 255–326.
- Hamilton, William L, Eric M Stickney, Nancy R Burstein, and Lawrence S Bernstein (2002), “Family child care home participation in the cacfp: Effects of reimbursement tiering.”
- Helburn, Suzanne W and Carollee Howes (1996), “Child care cost and quality.” *The future of children*, 62–82.
- Herbst, Chris M (2015), “The rising cost of child care in the united states: A reassessment of the evidence.”
- Hotz, V Joseph and Mo Xiao (2011), “The impact of regulations on the supply and quality of care in child care markets.” *The American economic review*, 101, 1775–1805.

- Hsieh, Chang-Tai, Erik Hurst, Charles I Jones, and Peter J Klenow (2013), “The allocation of talent and us economic growth.” Technical report, National Bureau of Economic Research.
- Kisker, Ellen Eliason et al. (1991), “A profile of child care settings: Early education and care in 1990.”
- Kontos, Susan (1992), *Family Day Care: Out of the Shadows and into the Limelight*. Research Monograph of the National Association for the Education of Young Children, Volume 5.
- Kontos, Susan, Carollee Howes, Marybeth Shinn, and Ellen Galinsky (1995), *Quality in Family Child Care and Relative Care*. Teachers College Press, New York.
- Laughlin, L (2013), “Who’ s minding the kids? child care arrangements: Spring 2011 (current population reports, pp. 70–135). washington, dc: Us census bureau.”
- Laughlin, Lynda L. (2015), “Census bureau statistics allow for deeper dive into rising costs of child care.”
- Moffitt, Robert A, STEVEN J DAVIS, and ALEXANDRE MAS (2012), “The reversal of the employment-population ratio in the 2000s: Facts and explanations [with comments and discussion].” *Brookings Papers on Economic Activity*, 201–264.
- Morgan, Gwen, Sheri Azer, and S Lemoine (2001), “Family child care: What’ s in a name.” *Boston, MA: Wheelock College Institute for Leadership and Career Initiatives*.
- OECD (2013), *OECD Framework for Statistics on the Distribution of Household Income, Consumption and Wealth*. OECD Publishing.
- Posadas, Josefina and Marian Vidal-Fernández (2013), “Grandparents’ childcare and female labor force participation.” *IZA Journal of Labor Policy*, 2, 1.
- Ramey, Garey and Valerie A Ramey (2010), “The rug rat racecomments and discussion.” *Brookings Papers on Economic Activity*, 129–176.
- Rodgers, Luke P. (2016), “Give credit where? the incidence of child care tax credits.” Technical report, <https://sites.google.com/site/lukeprodgers/research>.