THE UNIVERSITY OF CHICAGO

# CONSUMPTION INSURANCE VIA INTRA-HOUSEHOLD ALLOCATION OF RESOURCES

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE SOCIAL SCIENCES
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

KENNETH C. GRIFFIN DEPARTMENT OF ECONOMICS

BY
MOHSEN MIRTAHER

CHICAGO, ILLINOIS
AUGUST 2018

To my parents

To make a vow is a greater sin than to break one.

*Georg Christoph Lichtenberg*

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

## ACKNOWLEDGMENTS

I am deeply indebted to my advisors, Stéphane Bonhomme, Alessandra Voena, and Christian Hansen, for their support, insight, and encouragement. I am grateful for many conversations with Ehsan Azarmsa, Jim Heckman, Erik Hurst, Greg Kaplan, Thibaut Lamadon, David Malison, and Larry Schmidt. I thank the Institute for Research on Household Economics, Tokyo, Japan for allowing me to use the Japanese Panel Survey of Consumers data set. I also thank Kentaro Asai for his help with acquiring the data.

# ABSTRACT

It is well known that marriage can function as a form of insurance against labor market shocks. However, most of the economics literature is focused on the labor supply margin. In the first part of this dissertation, we focus on a less studied margin: spouses' adjustment of the excludable part of their consumption (i.e. private consumption) to support one another in the face of earnings shocks. We examine household panel data from Japan to observe the composition of total household consumption in terms of the public and private consumption of each spouse. Our main empirical finding is a disparity between genders in consumption insurance against permanent shocks to household earnings. Women's consumption is more insured than that of men, a finding which is robust to a variety of specifications. We propose two mechanisms, illustrated by way of a stylized theoretical framework, to explain this finding. The first mechanism is a disparity in the degree of risk aversion between genders, whereby a higher level of risk aversion in females leads to higher levels of insurance. The second mechanism is the threat of divorce by the wife, motivating the husband to provide her with a smoother consumption path. We find empirical evidence in support of both proposed mechanisms; however, some evidence suggests that the threat of divorce dominates in terms of effect magnitude. Finally, we consider the labor supply margin. We find that there is substitutability between labor supply and private consumption: higher hours of work are compensated with more private consumption.

Underscoring the importance of the threat of divorce on risk sharing within the household, the second part of this dissertation focuses on the interaction of divorce and risk sharing in the household. We examine how allowing for endogenous marriage dissolution weakens the function of marriage as a provision of insurance against labor market shocks. We present a model of marriage dissolution and risk sharing in the face of wage shocks. We provide an algorithm to solve the model and obtain the reduced

form policy functions of the structural model. Next, drawing from the non-linear measurement error literature, we show the identification of the reduced form policy functions and specify the required assumptions to obtain the identification. We illustrate how our Japanese panel data provide us with the necessary observable variables for the identification.

# Part I

# Intra-Household Disparity in Consumption Insurance

# CHAPTER 1

# INTRODUCTION

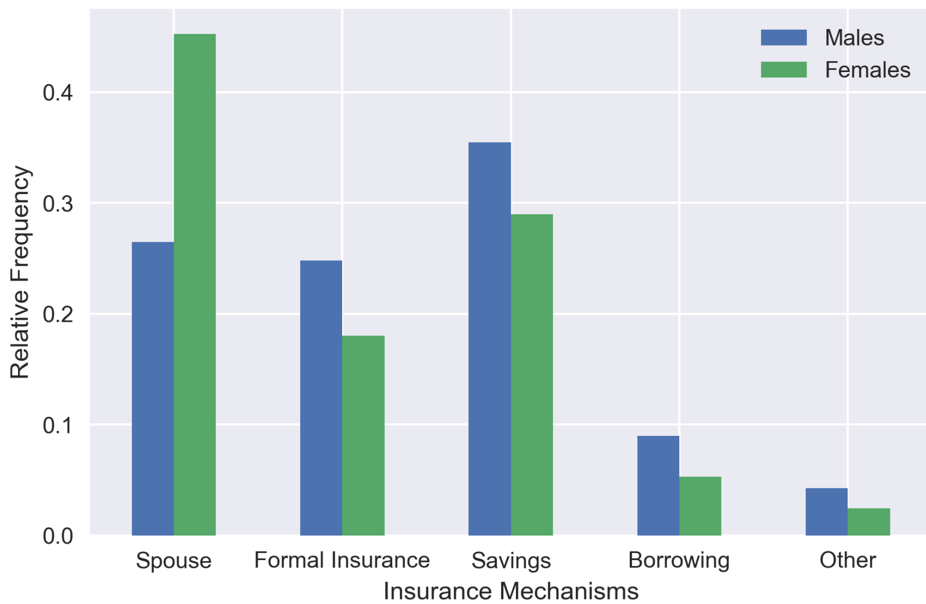
Since the introduction of the Permanent Income Hypothesis by Milton Friedman, a vast economics literature has been devoted to the study of how households insure against income shocks to smooth consumption profiles throughout their lifecycles. Different consumption insurance mechanisms are identified in this literature, including savings, the government safety net, the network of family, and marriage. Marriage is shown to play an essential role in providing insurance against labor market shocks Blundell et al. (2015).

As an example, Figure 1.1 highlights the crucial role of marriage in providing insurance against labor market shocks in our Japanese data sample. In particular, the Figure 1.1 demonstrates how unemployed workers made up lost income in the case of a job loss with search for new employment exceeding one month. The sample includes only the married. The figure shows that relying on the spouse's earnings is an important form of insurance, especially for females [1]. While not the most invoked form of insurance for men, it is nevertheless as important as formal insurance.

In studying the role of marriage in providing insurance, the literature is largely focused on the labor supply margin. Specifically, the case of the added worker effect: when an adverse shock impacts the husband, the wife can start working if she has been out of the labor force. Alternatively, if she is already employed, she can adjust her intensive margin of labor supply, for instance by switching from part-time employment to full-time.

1. The terms "male"/"man" and "female"/"woman" are used interchangeably throughout with the terms "husband" and "wife," respectively.

Figure 1.1: The invoked insurance mechanism after a job loss among the married




Livelihood of workers without income after a job loss episode in the past twelve months. The figure demonstrates the importance of marriage in providing insurance against labor market shocks, particularly temporary or permanent job loss in this case. The sample includes only the married. To exclude instances in which the worker finds a new job promptly, we include only workers who have searched for a new job for at least one month.

One can rephrase the provision of insurance by way of the labor supply margin in terms of leisure as a private good. By assuming household expenditures to be public consumption, the only private good that spouses consume is their leisure time. Thus, a wife can support her husband during periods of economic distress by reducing her leisure time, compensating for an adverse shock to the husband's earnings. Though an adverse shock involuntarily reduces the husband's labor supply, it should be noted that he receives a gain in leisure time. Thus, intra-household insurance can be deemed a mechanism to reallocate leisure as a private good. Should a husband face an adverse labor market shock that induces compensatory behavior from his wife, the husband would enjoy more leisure while the wife would utilize less leisure. For this mechanism to work, the existence of a private good is essential. In focusing on the labor supply margin, the literature has focused on leisure as this private good.

In this thesis, instead of leisure, we focus on the excludable component of expenditures. Excludable expenditures are by definition excludable and arguably rivalrous. Thus, they can be considered to be a private good. Therefore we call this part of expenditures *private consumption* herein. For instance, as we will show in chapter 4, clothes constitute a significant share of private consumption. Clothes are evidently a private good as an item of a woman's clothing cannot generally be worn by a man.

Private consumption can open up another margin of intra-household insurance, in addition to the widely discussed leisure margin. Facing an adverse shock to the household's earnings, the husband can insure his wife's private consumption by reducing his private consumption disproportionately. This dissertation contributes to the family economics literature by studying this novel intra-household margin of insurance.

In order to leverage private consumption as a currency for intra-household insurance, we need to observe the private consumption. The Japanese Panel Survey of Consumers (JPSC) is one of very few panel data sets that provide the intra-household breakdown of consumption. Thus it allows us to separate the shares of the husband's private consumption, the wife's private consumption, and the public consumption in a household. We call these three components the *intra-household components of consumption* or simply *components of consumption*. Men's and women's private consumption, on average, make up 15.6% and 8.4% of the household's consumption, respectively. However, there are complex dynamics for these shares during the lifecycle. The share of both men's and women's private consumption declines until their mid-forties, but rebounds thereafter. It seems that spending on children drives both the decrease and subsequent rebound in private consumption. Spending on children increases until the onset of the children's adulthood.

Our main empirical result is a disparity in insurance for private consumption between husband and wife. The wife's private consumption is more insured than the husband's against a permanent shock to the household's earnings. While we cannot reject the null hypothesis of full insurance against transitory shocks for both genders, there is a gap in the passthrough coefficients for a permanent shock to the husband's and wife's current consumption. 31.1% of the permanent shock is passed to the husband's current consumption, which translates to 68.9% insurance against a permanent shock. 12.9% of the permanent shock is passed to the wife's current consumption, which translates to 87.1% insurance against a permanent shock. Therefore there is an 18.2% gap in the passthrough coefficients or, equivalently, in the insurances between husband and wife.

The gap in passthrough coefficients is very robust and statistically significant at the conventional levels. It does not collapse against a variety of alternative specifications. For instance, taking into account tax impacts does not eliminate the gap. In fact if anything, the gap widens with after-tax earnings. As another example, when we allow for asymmetry in response to an adverse shock and a beneficial shock, the gap still persists.

But, it must be asked whether the gap in passthrough is an artifact of the drastic compositional dissimilarities between men's and women's private consumption bundles, especially given that we find significant heterogeneity in passthrough across different categories of consumption. While necessities such as rent, utilities, and health exhibit low passthrough (higher insurance), clothes, durables, and transportation exhibit high passthrough (lower insurance). Though we do not observe the breakdown of each component of consumption in terms of different categories, we do observe such components for the total household's consumption. Studying the co-movement of the categories' shares with the share of each component within a household sheds some light on the categories that play a larger role in the makeup of each component. We find that the most important contributing category in both men's and women's private consumption is clothing. In general, we find little evidence in support of dramatic compositional dissimilarities between men's and women's bundles of consumption. In most categories, the contribution is alike across both private consumption bundles. The only notable exception is health, which has a higher contribution to the composition of the woman's bundle, likely due to cosmetic product consumption.

Ruling out compositional effects, what mechanisms can rationalize this gap in passthrough? We propose two: The first mechanism is heterogeneity in risk aversion across gender: women are more risk-averse than men. With heterogeneity in risk aversion, it is more efficient for the household that the husband bears the burden of an adverse shock to the household's earnings, because his marginal utility loss is smaller than the wife's loss in marginal utility. Alternatively, with a beneficial shock to the household's earnings, the marginal utility gain for the husband is higher. Thus, it is more efficient for the household to pass a higher share of the favorable shock to the husband. In section 5.1, we formalize this intuition and provide additional simulation results. Our theoretical results also equip us with two testable predictions that help craft empirical strategies to implement tests of the predictions.

The first testable prediction from Proposition 2 implies that if at one level of a household's earnings, the husband has the higher consumption, but at another level of that household's earning the wife has the higher consumption, then the risk preferences must be heterogeneous. In other words, if we plot private consumption against household earnings, the crossing of the husband's and wife's consumption functions provides evidence against homogeneity in preferences. To implement the crossing test, we obtain a uniform simultaneous band for the non-parametric function of the difference between the husband's and wife's consumption. We show that the uniform band of the function contains zero at lower levels of resources. Thus, we reject the null hypothesis of risk-preference homogeneity.

The asset portfolio of the household also provides an avenue to test risk preference heterogeneity. Based on optimal portfolio choice theory, among risky and risk-free assets, the share of investment in risky assets is determined by the risk-adjusted return of the assets and the risk aversion of the investor. Different individuals in the market face the same risk-adjusted return on risky investment. Thus, the variation in the share of investment in risky assets across individuals emanates from variation in risk aversion. Therefore the share of investment in risky assets is a good proxy for the risk preference of the investor.

Helpfully for this topic, the JPSC collects the details of saving and investment behavior of households in the sample. In addition, the survey asks wives about their personal portfolio as well as their family's portfolio. The family's portfolio is managed overwhelmingly by husbands. In section 5.4, we explain how Japanese divorce law encourages women to keep their personal savings. This distinction between the family's portfolio and the wife's portfolio presents an opportunity to infer risk preference heterogeneity among genders. We can compare the share of investment in risky assets between the two portfolios. On average, 27% of the male's portfolio is invested in risky assets whereas the share of risky investment is 21% in the female's portfolio. The difference is even starker at the median. The lower share of risky asset investment among women is more evidence to support the hypothesis that women are more risk averse.

The second testable prediction from Proposition 3 implies that the gap in passthrough coefficients should be larger when risk-aversion heterogeneity between husband and wife is greater. Our empirical strategy for this exercise is to estimate the passthrough coefficients on a subsample of data that demonstrates a high degree of heterogeneity in risk aversion between the husband and wife. To implement this empirical strategy, first, we need to identify a shifter that varies the degree of heterogeneity in risk-aversion. For this shifter, we use the share of human wealth. The individuals in this subsample are more willing to take risk as they have greater incentive to diversify their large amounts of non-tradable human capital. As expected, the estimated gap in passthrough grows 24% in excess of the baseline gap, but this difference is not statistically significant. The result should be received with caution. Individuals with a higher share of human wealth are also more likely to have binding credit constraints, which inflates their passthrough due to their inability to smooth consumption. In other words, the credit constrained effect confounds the effect of higher risk tolerance in the same direction, in this subsample.

The second mechanism to rationalize the gap in passthrough is the threat of divorce. In section 6.1, in a stylized model, we show how the threat of divorce can generate the gap in passthrough. In particular, we consider a repeated game of specialization. By specialization, we mean a setting in which only the husband works and specializes in labor market productivity, whereas the wife specializes in home production outside the labor market. Specialization is a suitable assumption in our data where the attachment of Japanese women to the labor market is not strong. Women's extensive margin of labor supply is rather small. Conditional on working, women work far fewer hours than men. Their average wage rate is almost half as much as men's, and they work disproportionately in occupations with hourly pay as opposed to men, who work overwhelmingly in salaried jobs.

Given the specialization scheme, we assume that it is the husband who decides about the allocation of his earnings between his own consumption and his wife's. In return, it is up to the wife to stay in the marriage or seek a divorce. Since couples specialize, the wife's outside option is independent of the husband's earnings. Thus the volatility in the husband's earnings should not affect the wife's outside option. Therefore, the husband has little incentive to transfer his earnings volatility to his wife's consumption path. This would lead to greater levels of responsiveness to earnings shocks in the husband's consumption path.

Next, we test whether the threat of divorce can explain the gap in passthrough with an empirical strategy as follows. We estimate the gap in subsamples of households who have a systematically higher or lower propensity to divorce. We use two shifters for the propensity to divorce: happiness with the marital relationship and the number of children. The single most important predictor of divorce is the level of satisfaction with the marital relationship. Each higher level of dissatisfaction increases the likelihood of divorce substantially. Households who have at least two children are less likely to divorce in our sample. Consistent with what the threat of divorce mechanism predicts, households in unhappy marriages exhibit a gap in passthrough that is 41% greater than the baseline. On the other hand, households with a higher number of children show a gap in passthrough that is 76% lower than the baseline.

We have provided empirical evidence in support of both the risk-aversion heterogeneity mechanism and the threat of divorce mechanism. Next, we ask which effect is dominant in terms of magnitude. Some evidence suggests that the threat of divorce is more important quantitatively than risk-aversion heterogeneity. The shifters of divorce propensity are able to alter the gap to a greater extent than the shifter of risk-aversion heterogeneity.

Moreover, after controlling for risk aversion by conditioning on households with a high human wealth share, the introduction of marital happiness can still swing the gap by about 25% in both directions. In other words, among households controlled by a higher degree of risk aversion, those who are happy about their marriage exhibit a 25% smaller gap. Conversely, the households who are unhappy about their relationship exhibit a 25% larger gap. In contrast, the conditional change in the gap caused by risk heterogeneity is much smaller. That is, among households with a higher propensity to divorce due to unhappiness with marriage, the introduction of a higher degree of risk-aversion heterogeneity moves the gap by only 10% in either direction. Therefore, there is some persuasive evidence that the threat of divorce is more important than risk-aversion heterogeneity in terms of the magnitude of the effect on the gap in passthrough.

Finally, in chapter 8 we also add the labor supply margin to our analysis. We separate hours from wages and study how hours interact with components of consumption, especially private consumption. To estimate labor supply elasticity and determine whether private consumption and hours are complements or substitutes, we estimate the Frisch elasticities by extending the framework of Blundell et al. (2015), which allows for three components of consumption. We find that the labor supply elasticity is positive, meaning that the substitution effect dominates the income effect of changes in wages. Furthermore, the sign of the male's private consumption elasticity with respect to wages demonstrates the substitutability between leisure and private consumption. In other words, the male requires compensation in the form of private consumption when he works higher hours.

The outline of the first part of the thesis is as follows. In chapter 2, we describe the data and our sample. We also highlight the striking difference across gender in the labor market outcomes in Japan. Chapter 3 presents the main empirical finding and the robustness checks. Chapter 4 discusses the compositional effects. Chapter 5 demonstrates the evidence regarding our first proposed mechanism that is the heterogeneity in risk preference across gender. Chapter 6 analyzes the threat of divorce as the second rationalizing mechanism for the main empirical finding. 7 discusses the quantitative importance of each one of the proposed mechanisms. Chapter 8 studies the non-separability of consumption and leisure. Chapter 9 concludes and provides some directions for the future research.

## 1.1 Related literature

The dissertation is related to several segments of the literature in economics. First, it is related to the earnings dynamics literature, which is an enormous body of work including that of Krueger and Perri (2006) and Blundell et al. (2008) , who study the effect of earnings shocks on consumption with exogenous labor supply. Heathcote and Violante (2014), Blundell and Preston (2004), and Attanasio et al. (2008) model labor supply as well. The majority of these papers find a considerable degree of consumption insurance, even with respect to permanent shocks. More recent work has focused on non-Gaussianity (Bonhomme and Robin (2010)), heterogeneous processes (Alvarez et al. (2010)), and non-linear processes (Arellano et al. (2018)).

Next, this dissertation relates to Blundell et al. (2015), who try to find the quantitative importance of marriage insurance mechanisms in comparison with self-insurance by way of savings and government provided insurance such as transfers, tax credits, and progressivity of taxes. In chapter 8, we extend their framework to allow for three components of consumption instead of the household's total consumption. In short, they find that risk sharing within the family is an important insurance mechanism against income volatility.

Lise and Yamada (2014) is related to this dissertation by virtue of its use of the same JPSC data set that we examine here. They empirically test the hypothesis of partial commitment and find that it cannot be rejected. Consistent with partial commitment, they find that the extent of insurance within the family is limited. If realized income shocks are small, the family provides insurance, but large realized shocks cannot be insured unless the Pareto weight between couples is updated accordingly. Therefore, when realized shocks are small, a marriage remains in tact and couples enjoy the benefit of risk sharing within the family, but large realized shocks can dissolve a marriage and halt risk sharing precisely when the need for insurance is greatest.

This dissertation is also related to the literature studying mutual insurance within marriage by way of adjustment at the labor supply margin. Risk sharing by way of labor supply operates such that an agent's wage can be compensated by the change in (intensive or extensive margin of) the spouse's labor supply. For instance, when the husband is hit by a health shock and becomes disabled, the wife can start working (extensive margin) or increase her hours of working by switching from a part-time job to a full-time one (intensive margin). The response in the extensive margin is known in the literature as the *added worker effect* (Hyslop, 2001). Juhn and Potter (2007) finds that this insurance mechanism has weakened by a recent increase in correlation of employment and hours of work among couples.

In chapter 5, we focus on risk-preference heterogeneity across gender. Our result is in line with a significant strand of the literature in experimental and behavioral economics. These studies usually employ an experimental design and rather consistently find that women are more risk-averse than men. Some examples of the studies are Borghans et al. (2009) and Harbaugh (2002) . For a review of these studies refer to Eckel and Grossman (2008). Hryshko et al. (2011) finds gender to be a significant determinant of risk preference in the Panel Study of Income Dynamics (PSID). Confirming the experimental studies, they find that female subjects in the PSID exhibit higher risk aversion than male subjects.

In chapter 6, we study the role of the threat of divorce. Broadly, this chapter is related to modeling the marriage as a contract with a two-sided lack of full commitment. Marriage is a contract written by partially committed parties; they are committed up to the point that they are no longer better off with marriage than separation. Some examples of the studies in this literature are Chiappori and Mazzocco (2014) , Mazzocco et al. (2013), and Voena (2015).

# CHAPTER 2

# DESCRIPTIVE STUDY OF LABOR MARKET OUTCOMES AND CONSUMPTION AMONG JAPANESE HOUSEHOLDS

## 2.1 Data

The Japanese Panel Survey of Consumers (JPSC) is a longitudinal survey that traces the economic conditions of Japanese households. The survey is administered to women in each household. It consists of 22 waves which are followed annually from 1993 to 2014. It is comprised of five cohorts of young women. Starting in 1993, the first cohort consisted of 1500 women aged between 24 and 34, selected from across Japan for an in-home survey. The second cohort consisted of 500 women aged between 24 and 27 who were added to the sample in 1997. The third cohort, which was added to the original sample in 2003, consists of 836 women aged between 24 and 29. The fourth cohort consists of 636 women aged between 24 and 28, added in 2008. Finally, in 2013, 648 women aged between 24 and 28 were added to the sample as the fifth cohort of the study. Thus the survey in total has followed 4084 subjects.

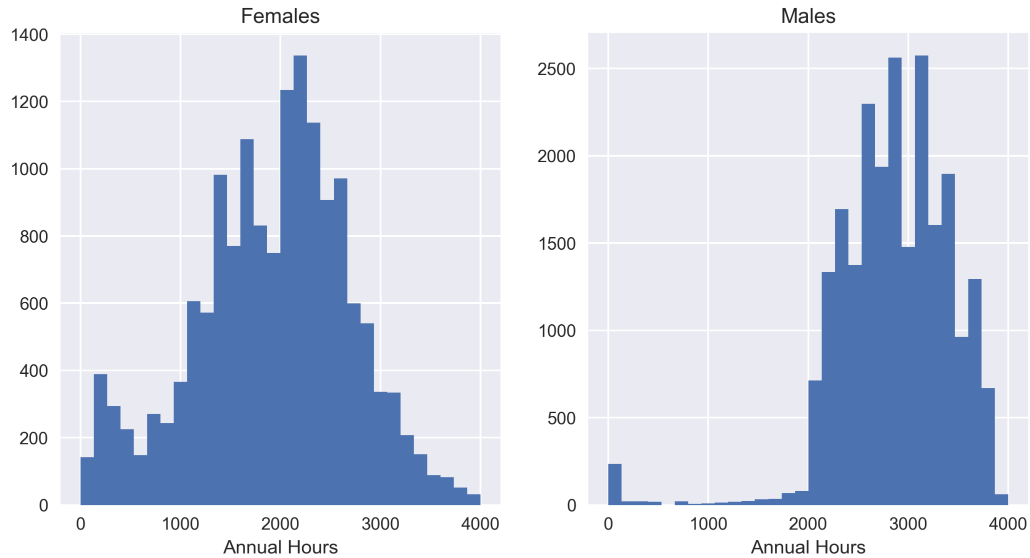
The survey collects data on a wide spectrum of economic factors, including income, savings, work patterns, and family relationships. One of the appealing features of the survey is its low attrition rate in follow-ups and its relatively high response rate. A great advantage of JPSC for our application is the distinctive way it reports consumption. As opposed to similar household surveys that report only total household consumption, JPSC breaks down intra-household components of consumption. We observe the intra-household allocation of consumption among the husband's private consumption and public consumption. In addition, the survey collects the details of savings and investment behavior of the households; we take advantage of this detail in our analysis in chapter 4.1. For a breakdown and analysis of the asset portfolios of the households,

Table 2.1: Summary Statistics

| | Mean | Median | Standard Deviation |
|---|---|---|---|
| ***Consumption*** | | | |
| Male Private Consumption | 43.31 | 35.55 | 38.81 |
| Female Private Consumption | 22.76 | 15.00 | 28.72 |
| Public Consumption | 209.35 | 189.00 | 135.50 |
| ***Marital Variables*** | | | |
| Very Much Satisfied with The Relationship | 0.17 | 0 | 0.37 |
| Quite Satisfaction with The Relationship | 0.40 | 0 | 0.49 |
| Moderate Satisfaction with The Relationship | 0.30 | 0 | 0.46 |
| A Little Satisfaction with The Relationship | 0.09 | 0 | 0.29 |
| Not At All Satisfied with The Relationship | 0.04 | 0 | 0.19 |
| Marriage Duration | 11.7 | 12 | 7.2 |
| Divorce Rate | 0.12 | 0 | 0.11 |
| ***Assets*** | | | |
| Household Assets | 37047 | 20200 | 62839 |
| ***Labor Market Outcomes*** | | | |
| Male Hourly Wage | 1.90 | 1.68 | 1.93 |
| Female Hourly Wage | 0.96 | 0.69 | 1.55 |
| Male Annual Earnings | 5288 | 4800 | 2881 |
| Female Annual Earnings | 1831 | 1200 | 1610 |
| Male Annual Hours of Work | 2902 | 2850 | 698 |
| Female Annual Hours of Work | 1143 | 1208 | 1091 |
| ***Demographics*** | | | |
| Male Age | 38.6 | 38 | 7.6 |
| Female Age | 36.0 | 35 | 6.7 |
| Male Is High School Graduate | 0.96 | 1 | 0.20 |
| Female Is High School Graduate | 0.98 | 1 | 0.12 |
| Male Is College Graduate | 0.37 | 0 | 0.48 |
| Female Is College Graduate | 0.14 | 0 | 0.35 |
| Residence in Large Cities | 0.25 | 0 | 0.43 |
| Residence in rural areas | 0.15 | 0 | 0.36 |
| Number of Children | 1.71 | 2 | 0.94 |
| Observations | 15003 | | |

Monetary values are in of 1000s Yen. The observations count the number of household-year data points. Our sample follows 1304 households in its 22 years of follow-up.

Figure 2.1: Histograms of hours of work from time diary




The hours of work can also be obtained from the time diary portion of the survey. However, these numbers are less accurate and may unreasonably inflate the hours of work.

refer to Table 5.1.

For our empirical analysis we focus on a sample of the JPSC data that meets the following criteria: First, we select only married subjects, as our research question concerns the intra-household interactions between spouses. Second, since our empirical stagey is based on rates of growth, we choose only households with at least two consecutive waves of presence in the survey. Third, we keep observations with non-missing values in consumption variables, hours, and earnings. Fourth, we select the 28-55-year-old age range. The lower bound is picked in order to select the households for whom educational choice and marriage formation decisions are more likely to be complete. In addition, it helps us avoid unusually high earnings shocks due to unstable early years of one's career. The upper bound is picked so that we have enough observations to gain statistical power. With these selections, our samples include 1304

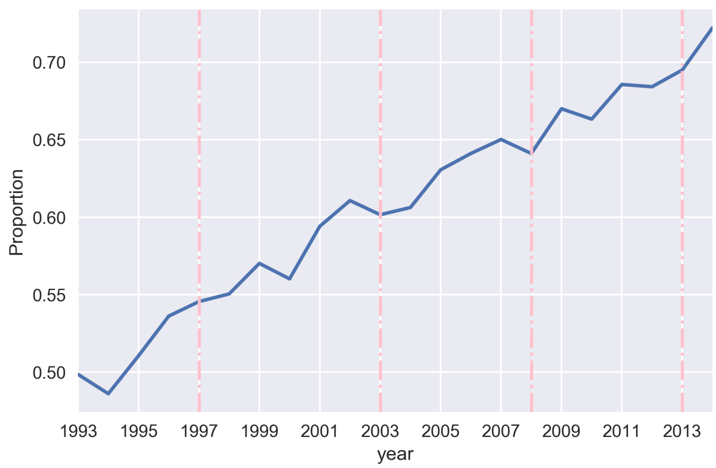
Figure 2.2: The evolution of work hours throughout the lifecycle


households with 15003 household-year observations.

Table 2.1 shows the summary statistics of the data. The first block regards consumption, which will be discussed in greater details in section 2.3. The second block displays statistics regarding marriages. We have five indicators describing marital relationship quality. These are self-reported through assessments of the wife about the relationship. The majority of the households, 57%, are in happy marriages, meaning that they are very much or quite satisfied with their relationship. The average duration of a marital spell in our sample is 11.7 years. 12% of marital spells have ended in divorce. Japan has, in general, lower rates of divorce than the United States. However, our sample is younger than the representative population, which leads to undercounting of the number of divorces. The fourth block is on labor market outcomes, which will be discussed in greater details in section 2.2.

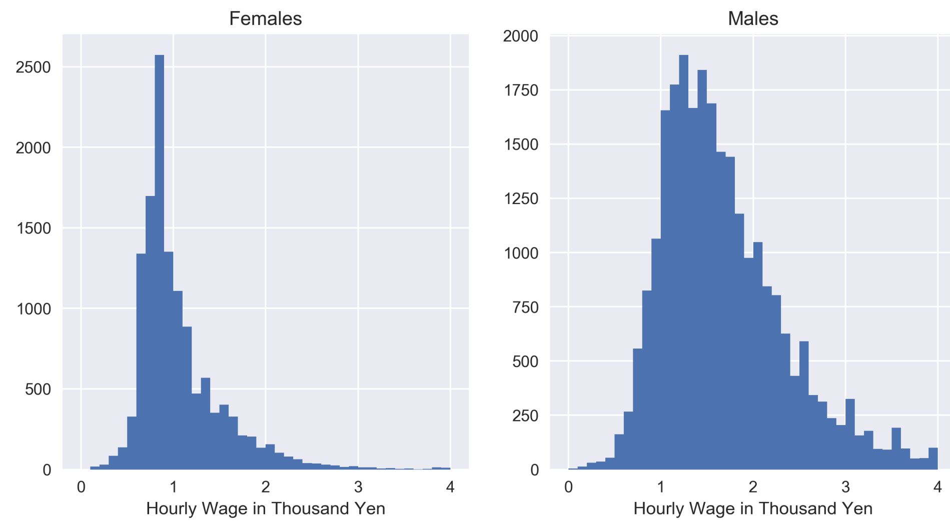
The fifth block in Table 2.1 summarizes the demographic variables. The median ages

Figure 2.3: The proportion of married women who work




This figure demonstrates the proportion of married women who have been employed in each year of our sample. An overall increasing trend is apparent, which is consistent with the aggregate Japanese data. However, this trend is partly also due to the cohort effect. Every few years, about 800 younger women (married or single) join the sample. The red vertical lines show the year in which new subjects enter the sample. The women in the younger cohorts have a higher propensity to work.

Figure 2.4: The histograms of wages



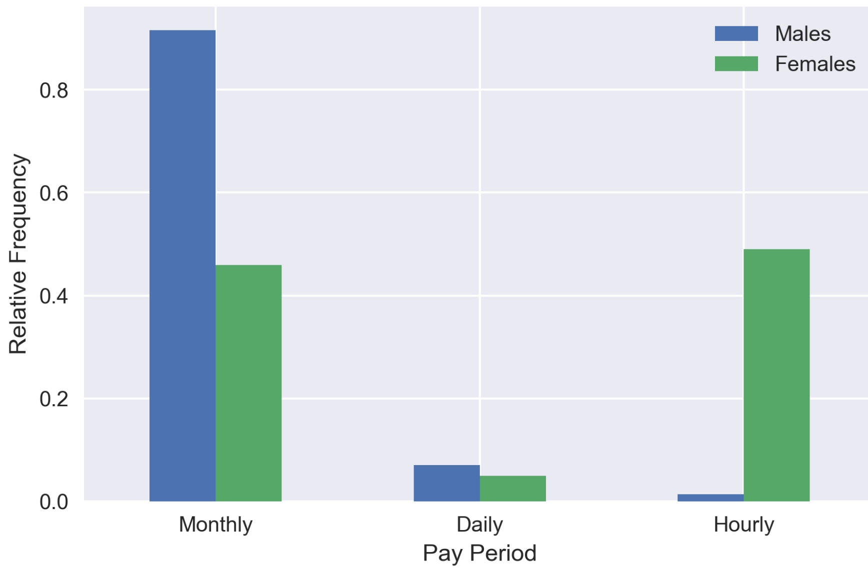

The figure demonstrates the hourly wages in thousands of Yen. To make sense of the wage rate, one can multiply the numbers by 10 to obtain a rough estimate in terms of USD. The mean of the wage rate for women is lower but the variance of the wage rate is higher for men.

of the husband and wife are 38 and 35, respectively. The vast majority of both males and females have graduated from high school. 37% of males and 14% of females have a college degree. 25% of households live in the thirteen largest Japanese cities and 15% live in rural areas. The rest of the households live in smaller towns. Finally, the median number of children is two.

## 2.2 The striking difference in labor market outcomes between genders

In this section, we document the labor market outcomes of Japanese households. One striking feature is common in almost every aspect of the labor market: there is a marked difference in outcomes across gender. Women and men do not behave similarly in many

Figure 2.5: The distribution of pay period among genders




The plot suggests drastic differences between genders in terms of pay period.

respects.

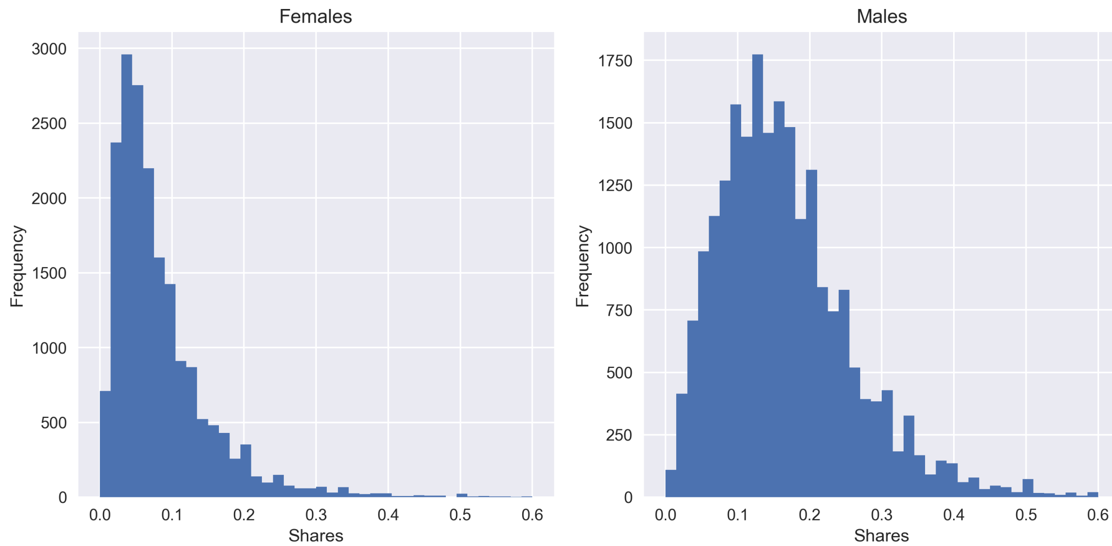
Figure 2.1 show the distribution of annual hours of work. It displays the intensive margin of labor supply, namely hours of work conditional on working. One can confirm common anecdotes of extremely high hours of work in portions of the Japanese workplace by looking at men's work-hour distribution. The median male worker works 2850 hours annually. In addition, very few men work fewer than 2000 hours, and there is a considerable number of men who work well above 3500 hours. In contrast, conditional on working, women work far fewer hours. The median woman in our sample works 1208 hours annually. A considerable number of women work fewer than 500 hours but only a small number of women work over 3000 hours. Overall, women do far less employed work than men in our data.

Figure 2.2 displays the evolution of hours of work in the lifecycle. Marked differences between men and women appear here as well. While men's hours of work tend to decline after a peak in the mid-thirties, women tend to increase their hours of work after that same point, in their mid-thirties. This behavior is likely related to motherhood and the fact that some women return to the labor market after a break for pregnancy and raising young children.

Figure 2.3 shows the extensive margin of labor supply for women. The figure displays the evolution of the female's labor force participation in the duration of our sample. Although the average rate of participation throughout the sample is rather small, it has risen sharply during the period of our sample. However, this is partly also due to the cohort effect. Every few years, about 800 younger women (married or single) join the sample. The red vertical lines show the year in which new subjects enter into the sample. The women in younger cohorts have a higher propensity to work. The labor force participation of men in our sample is consistently very high.

Figure 2.4 displays the hourly wage distribution. The average male's wage rate is almost twice as much as the average female's. In addition, the men's wage distribution has significant spread, whereas the distribution for women is tighter. This observation is consistent with Figure 2.5. The Figure 2.5 shows the distribution of pay period. This figure indicates a drastic difference in the type of jobs held between men and women. While the vast majority of men are full-time employees who are paid by monthly salaries, about half of women are employed in jobs with hourly rate compensation schemes. These are typically lower paid jobs and are often also part-time. Thus, the stark difference in wage rate across gender is partly due to those types of jobs for which men and women are hired in different proportions.

Figure 2.6: The histograms shares of private consumption




Note that observations with zero private consumption are excluded. The plot suggests that there are not large disparities among households in terms of shares of private consumption.

## 2.3 Intra-household components of consumption

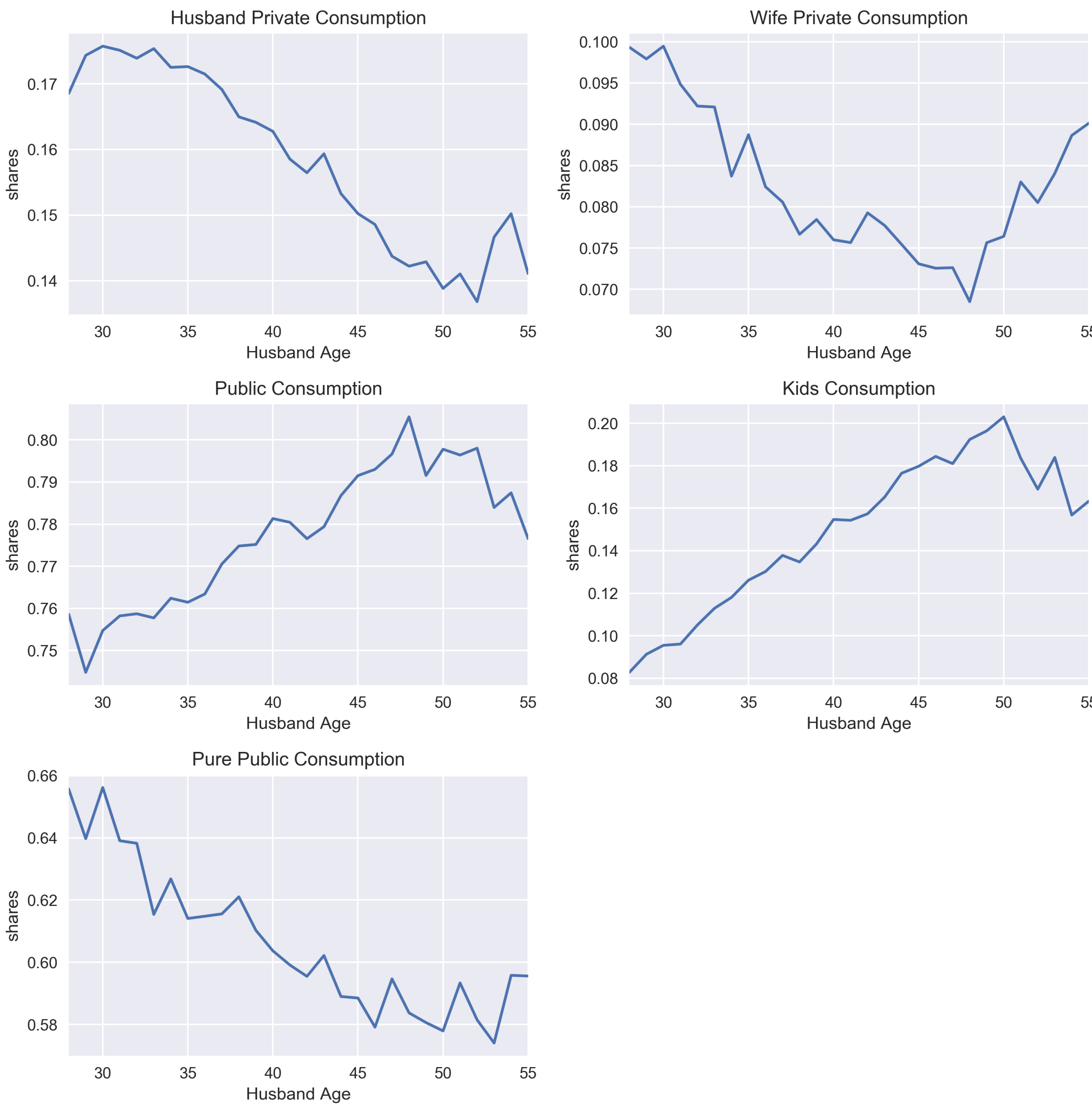
In this section, we provide some descriptive statistics on intra-household components of consumption. We obtain data on the intra-household breakdown of consumption from the survey question that asks the following of the female respondent: what amount of expenditures did you pay this September?

1. Family
2. Family expenses for me (wife)
3. Expenses for my husband
4. Expenses for my child(ren)
5. Expenses for the other(s)

We designate (1) + (4) + (5) as public consumption, (2) as the private consumption of the wife, and (3) as the private consumption of the husband. In some cases, we separate the expenses for children from public consumption. In those instances, we call the remainder, i.e. (1) + (5), *pure public consumption*. Figure 2.6 presents the distribution of the shares of men's and women's private consumption from total household consumption. There is a fair amount of variation in both genders' shares of private consumption. However, the male's private consumption exhibits higher mean and higher variance. On average, from total household consumption, 15.6% and 8.4% are allocated to the male's and female's private consumption, respectively.

Figure 2.7 demonstrates the evolution of the intra-household components of consumption shares. One pattern of interest is that the male's and female's consumption declines until their late-forties, from where it then rebounds. This pattern can be attributed to expenses on children, which trends inversely with private consumption. The share of expenditures on children rises until the age of late-forties and then declines. Thus it seems that the rebound in private consumption in the late-forties is driven by a reduction in spending on children. The share of pure public consumption declines until the mid-forties and stabilizes thereafter. Figure in Appendix B shows the trend in the levels of each component of consumption. The level of all components of consumption is rising throughout the lifecycle, and the household's earnings grow throughout the lifecycle as well.

Figure 2.7: The evolution of shares of consumption



# CHAPTER 3

# MAIN EMPIRICAL FINDING

In this chapter, we derive our main empirical finding. We find that there is a significant gap in the passthrough coefficients, with respect to permanent shocks to earnings, between husband's and wife's consumption. In particular, the husband's passthrough coefficient is larger than the wife's. In other words, when a household is hit by a permanent shock to its earnings, the wife's current consumption is less responsive than the husband's. Thus, the wife exhibits a higher degree of consumption insurance. On the other hand, the male's current consumption responds more. Thus, he exhibits a lower degree of consumption insurance. In what follows, we explain how we derive this result. Moreover, we show that this gap is very robust to a variety of alternative specifications.

## 3.1 Disparity in partial insurance between the husband and wife

### *3.1.1 Earnings and consumption process*

To abstract from the difficulty of dealing with the labor force participation margin, in this section we estimate the partial insurance parameters using total household earnings. We specify the following process for total household earnings:

$$\log Y_t = X_t'\beta_Y + F_t + u_t$$

$$F_t = F_{t-1} + v_t$$

$v_t$ denotes the permanent shock and $u_t$ denotes the transitory shock. We assume an i.i.d. process for the transitory shock. As the Table 3.1 shows, we tested for a more persistent process, MA(1) in particular, but it was rejected. Thus, we maintain the i.i.d. assumption concerning the transitory shock. We also keep the standard assumptions of no serial correlation in permanent shocks and no correlation between transitory and permanent shocks. Thus,

$$\Delta y_t = v_t + \Delta u_t$$

where $y \equiv \log(Y)$. Also, inspired by Blundell et al. (2008), we specify the rate of growth in each component of consumption as follows:

$$\Delta c_{p,t} = \phi_p v_t + \psi_p \Delta u_t + \eta_{p,t} + \Delta \zeta_{p,t}$$
$$\Delta c_{m,t} = \phi_m v_t + \psi_m \Delta u_t + \eta_{m,t} + \Delta \zeta_{m,t}$$
$$\Delta c_{f,t} = \phi_f v_t + \psi_f \Delta u_t + \eta_{f,t} + \Delta \zeta_{f,t}$$

where $c \equiv \log(C)$ and $C_{p,t}$, $C_{m,t}$, and $C_{f,t}$ denote public consumption, husband's private consumption, and wife's private consumption, respectively. $\phi$ and $\psi$ are the partial insurance parameters of permanent and transitory shocks, respectively. These parameters are the main parameters of interest as they capture what proportion of earnings shocks are transmitted to consumption. Herein, we call these passthrough coefficients, as they capture how much of the transitory and permanent shocks are passed through to each component of consumption. Smaller values of passthrough coefficients, $\phi$ and $\psi$, show greater insurance against permanent and transitory shocks, respectively.

$\eta_t$ denotes the innovation in consumption growth which is independent of income shocks. This could be interpreted as taste shocks, or innovation to higher moments of earnings. Note that though we assume $\eta_t$ follows a serially uncorrelated process, we allow the contemporaneous correlation between innovations to three components of consumption denoted by $\rho^{\eta}_{p,m}$, $\rho^{\eta}_{p,f}$, and $\rho^{\eta}_{m,f}$. Finally, $\zeta_t$ represents the measurement error of consumption. We assume measurement errors are uncorrelated across the components of consumption.

### 3.1.2 *Estimating moments*

Given the structure for income and consumption processes, we estimate the parameters using GMM via a set of moment conditions as follows:

## Earnings moments

$$\begin{aligned} E(\Delta y_t^2) &= 2\sigma_u^2 + \sigma_v^2 \\ E(\Delta y_t \Delta y_{t-1}) &= -\sigma_u^2 - \sigma_r^2 \end{aligned}$$

## Public consumption moments

$$\begin{aligned} E(\Delta c_{p,t}^2) &= \phi_p^2 \sigma_v^2 + 2\psi_p^2 \sigma_u^2 + \sigma_{\eta,p}^2 + 2\sigma_{me,c_p}^2 \\ E(\Delta c_{p,t} \Delta c_{p,t-1}) &= -\psi_p^2 \sigma_u^2 - \sigma_{me,c_p}^2 \\ E(\Delta c_{p,t} \Delta y_t) &= \phi_p \sigma_v^2 + \psi_p \sigma_u^2 \\ E(\Delta c_{p,t} \Delta y_{t-1}) &= -\psi_p \sigma_u^2 \\ E(\Delta y_t \Delta c_{p,t-1}) &= -\psi_p \sigma_u^2 \end{aligned}$$

Male's private consumption moments

$$
\begin{aligned}
E(\Delta c_{m,t}^2) &= \phi_m^2\sigma_v^2 + 2\psi_m^2\sigma_u^2 + \sigma_{\eta,m}^2 + 2\sigma_{me,c_m}^2 \\
E(\Delta c_{m,t}\Delta c_{m,t-1}) &= -\psi_m^2\sigma_u^2 - \sigma_{me,c_m}^2 \\
E(\Delta c_{m,t}\Delta y_t) &= \phi_m\sigma_v^2 + \psi_m\sigma_u^2 \\
E(\Delta c_{m,t}\Delta y_{t-1}) &= -\psi_m\sigma_u^2 \\
E(\Delta y_t\Delta c_{m,t-1}) &= -\psi_m\sigma_u^2 \\
E(\Delta c_{m,t}\Delta c_{p,t}) &= \phi_h\phi_p\sigma_v^2 + 2\psi_m\psi_p\sigma_u^2 + \rho_{p,m}^{\eta} \\
E(\Delta c_{m,t}\Delta c_{p,t-1}) &= -\psi_m\psi_p\sigma_u^2 \\
E(\Delta c_{p,t}\Delta c_{m,t-1}) &= -\psi_m\psi_p\sigma_u^2
\end{aligned}
$$

Female's private consumption moments

$$
\begin{aligned}
E(\Delta c_{f,t}^2) &= \phi_f^2\sigma_v^2 + 2\psi_f^2\sigma_u^2 + \sigma_{\eta,f}^2 + 2\sigma_{me,c_f}^2 \\
E(\Delta c_{f,t}\Delta c_{f,t-1}) &= -\psi_f^2\sigma_u^2 - \sigma_{me,c_f}^2 \\
E(\Delta c_{f,t}\Delta y_t) &= \phi_f\sigma_v^2 + \psi_f\sigma_u^2 \\
E(\Delta c_{f,t}\Delta y_{t-1}) &= -\psi_f\sigma_u^2 \\
E(\Delta y_t\Delta c_{f,t-1}) &= -\psi_f\sigma_u^2 \\
E(\Delta c_{f,t}\Delta c_{p,t}) &= \phi_f\phi_p\sigma_v^2 + 2\psi_f\psi_p\sigma_u^2 + \rho_{p,f}^{\eta} \\
E(\Delta c_{f,t}\Delta c_{p,t-1}) &= -\psi_f\psi_p\sigma_u^2 \\
E(\Delta c_{p,t}\Delta c_{f,t-1}) &= -\psi_f\psi_p\sigma_u^2
\end{aligned}
$$

### 3.1.3 *First Stage: Residualize growth rate of earnings and consumption*

In the first stage, we exclude the part of the variation in growth rates of wages, earnings, and consumption explained by the observables. We obtain the residual growth rates of consumption, earnings, and wages by regressing the total growth rates on covariates, generally of the following three types: levels, differences in time-varying covariates, and calendar year interactions.

- Consumptions (private and public consumption), total household earnings, and the husband's earnings
  - wife's age, husband's age, earnings from household members other than the husband or wife, household size, husband's education, wife's education, urban/rural residence of the household, number of kids, wife's employment status including: employed, unemployed, or out of labor force, calendar year
  - difference in wife's employment status, difference in the number of kids, difference in urban residence, difference in earnings from other household members
  - year-wife's education, year-husband's education, year-urban residence, year-number of kids, year-wife's employment
- Husband's wages
  - calendar year, husband's age, husband's education, urban/rural residence of the household, wife's employment
  - year-husband's education, year-urban

We run the probit regression of women's labor force participation to obtain the inverse of the Mill's ratio. Note that since we are not dealing with growth rates, we drop the difference of time-varying covariates in this model.

- Wife’s labor force participation
  - wife’s age, husband’s age, earnings from household members other than the husband or wife, household size, husband’s education, wife’s education, urban/rural residence of the household, number of kids, calendar year
  - year-wife’s education, year-husband’s education, year-urban residence, year-number of kids
  - indicator of having a mortgage and its interaction with calendar year
- Wife’s earnings and wages
  - All of the husband’s covariates + difference in Mill’s ratio

Table C.2 in Appendix C shows the autocovariance matrix of earnings growths. Some results worth highlighting: Females’ variance of earnings is significantly larger than males’. Since men have higher variance of wages, as Table C.3 in Appendix C demonstrates, the females’ higher variance of earnings is due to higher volatility in labor supply. In addition, there is little evidence of change in the volatility of earnings for men throughout the lifecycle. However, the variance of earnings for women drops significantly as the sample grows older. Furthermore, the covariance of the rate of growth in earnings between spouses is small. Finally, the evidence suggests that there is a negative serial correlation in the rate of growth of earnings for both men and women.

Table C.3 in Appendix C shows the autocovariance matrix of wage growths. As mentioned before, males’ volatility of wages is higher than females’. There is no evidence of a trend in volatility of wages for men or women over the life cycle. The covariance in rate of growth of wages between spouses is small. Finally, like earnings, there is a negative serial correlation in the rate of growth of earnings for both men and women.

Table C.4 in Appendix C shows the autocovariance matrix of consumption growths. Total consumption is less volatile than each one of its components. Volatility of private consumption is higher than that of public consumption. This is due to the fact that private consumption constitutes a smaller portion of the total consumption (about 8.4 % and 15.6% of total consumption for female's and male's, respectively). Also, the measurement error in private consumption is likely to be higher, as it is harder to be measured accurately relative to public consumption. In addition, despite the fact that covariance between private and public consumption is small, there is strong evidence suggesting high correlation between rates of growth in the wife's and husband's private consumptions.

### *3.1.4 Partial insurance parameters estimation results*

Table 3.1 shows the results of estimation using the general method of moments (GMM) and standard errors clustered at the household level. Column (1) shows the estimation of variance of transitory and permanent shocks to the total household earnings, assuming that transitory shocks are i.i.d. Column (2) allows for transitory shocks to be MA(1). However, the persistence parameter, $\theta$, is not statistically different than zero. Thus, we maintain the i.i.d. specification for transitory shocks. Column (3) shows the estimation of partial insurance parameters for total household consumption. Results suggest high levels of insurance. Transitory shocks are fully insured as the coefficient on $\psi$ is not statistically different than zero. In addition, 76.4% (1 - 23.6%) of a permanent shock is also insured.

Column (4) estimates the partial insurance parameter for intra-household components of consumption. Again, transitory shocks are fully insured, as they are all not statistically different than zero. However, there is a different level of partial

Table 3.1: Estimation of partial insurance parameters with total household earnings

| | (1) iid Transitory | (2) MA(1) Transitory | (3) Total Consumption | (4) Consumption Breakdown |
|---|---|---|---|---|
| $\sigma_v^2$ | 0.025*** | 0.033*** | 0.024*** | 0.025*** |
| | (6.17) | (8.54) | (6.00) | (6.24) |
| $\sigma_u^2$ | 0.034*** | 0.026*** | 0.034*** | 0.032*** |
| | (6.91) | (4.79) | (6.81) | (6.54) |
| $\theta$ | | 0.144 | | |
| | | (1.33) | | |
| $\phi$ | | | 0.243*** | |
| | | | (4.07) | |
| $\psi$ | | | -0.002 | |
| | | | (-0.06) | |
| $\sigma_\eta^2$ | | | 0.024*** | |
| | | | (8.06) | |
| $\phi_m$ | | | | 0.311*** |
| | | | | (2.97) |
| $\psi_m$ | | | | -0.026 |
| | | | | (-0.49) |
| $\sigma_{\eta_m}^2$ | | | | 0.072*** |
| | | | | (6.73) |
| $\phi_f$ | | | | 0.129 |
| | | | | (1.24) |
| $\psi_f$ | | | | -0.025 |
| | | | | (-0.49) |
| $\sigma_{\eta_f}^2$ | | | | 0.109*** |
| | | | | (7.58) |
| $\phi_p$ | | | | 0.198*** |
| | | | | (3.36) |
| $\psi_p$ | | | | 0.029 |
| | | | | (0.84) |
| $\sigma_{\eta_p}^2$ | | | | 0.034*** |
| | | | | (9.09) |
| $\rho_{m,f}^\eta$ | | | | 0.179*** |
| | | | | (18.37) |
| $\rho_{p,m}^\eta$ | | | | 0.021*** |
| | | | | (4.24) |
| $\rho_{p,f}^\eta$ | | | | 0.023*** |
| | | | | (4.04) |
| $N$ | 14737 | 14737 | 15029 | 14999 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$\sigma_v$ and $\sigma_u$ denote the variance of permanent and transitory shocks, respectively. $\phi's$ denote the passthrough coefficient on permanent shocks to the household's earnings. $\psi's$ denote the passthrough coefficient on transitory shocks to the household's earnings. $m$, $f$, $p$, and $k$ denote male, female, public, and children's consumption.

insurance against a permanent shock across different components of consumption. Note that the coefficient of permanent shocks in all three types of consumption is statistically significant. The husband's private consumption is less insured against private insurance (68.9%), whereas the wife enjoys higher levels of insurance (87.1%) against permanent shocks. The results suggest the husband's private consumption is the most responsive type of consumption in the face of a permanent shock to household earnings. In other words, the husband overcompensates to support the wife's private consumption. In the next section, we show that this gap in passthrough is robust to a variety of specifications. Later, in chapters 4, 4.1, and 6, we further analyze what can explain this gap in passthroughs between males' and females' private consumption.

## 3.2 Robustness

In this section, we do conduct several robustness checks to assess the survival of our main empirical finding given alternative specifications. In other words, we determine whether the gap in passthrough between the husband's and wife's private consumption collapses in alternative specifications. The results are collected in Table 3.2, in which the gap in passthrough coefficients is displayed in various specifications.

### *3.2.1 After-tax earnings*

The baseline specification is estimated by pre-tax earnings. In this specification, we use the after-tax earnings instead. We expect the passthrough coefficients to be larger for all consumption components, since the progressivity of the tax system provides an additional insurance mechanism, the absence of which should lead to higher passthrough of earnings shocks to all components of consumption. In line with our expectations, the passthrough of the male's consumption, the female's consumption, and public consumption rise by 11.3%, 17.8%, and 6.6%, respectively. Also, the gap in passthrough

Table 3.2: Robustness checks in the transmission coefficient of the permanent shock

| | (1) Baseline | (2) After Tax | (3) Direct Consumption | (4) Unresidualized | (5) Nondurables |
|---|---|---|---|---|---|
| $\phi$ | 0.243*** | 0.258*** | 0.260*** | 0.240*** | 0.221*** |
| | (4.07) | (4.31) | (4.16) | (4.24) | (3.63) |
| $\phi_m$ | 0.311*** | 0.346*** | 0.276*** | 0.309*** | 0.309*** |
| | (2.97) | (3.25) | (2.95) | (2.97) | (2.94) |
| $\phi_f$ | 0.129 | 0.152 | 0.109 | 0.118 | 0.119 |
| | (1.24) | (1.36) | (1.10) | (1.13) | (1.13) |
| $\phi_p$ | 0.198*** | 0.211*** | 0.244*** | 0.207*** | 0.188*** |
| | (3.36) | (3.28) | (3.51) | (3.45) | (3.18) |
| $\phi_m - \phi_f$ | 0.182* | 0.194* | 0.167 | 0.192* | 0.190* |
| | (0.083) | (0.087) | (0.100) | (0.069) | (0.069) |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$\phi$, $\phi_m$, $\phi_f$, and $\phi_p$ are the passthrough coefficients of permanent shocks to total consumption, the male's consumption, the female's consumption, and public consumption, respectively. The t-statistics are reported in parentheses, save for the last row (the difference in male's and female's passthrough), in which the p-value of the Wald statistic is reported. The baseline specification uses the shares of public and private consumption, which are multiplied by the total consumption obtained by summing over consumption in different categories. The transmission coefficients are larger with respect to after-tax earnings shocks. With direct consumption, the total consumption and public consumption transmission coefficients become larger relative to the baseline. However, the male's private consumption transmission coefficient is significantly smaller. When we use unresidualized rates of growth, the response of public consumption is stronger but the transmission coefficients of total consumption and the male's private consumption do not change substantially. If we only use the nondurable part of consumption, the transmission coefficients are smaller, as durables are among the most responsive categories of consumption. The transmission coefficient is particularly reduced in total and public consumption.

coefficients between the male's and female's private consumption widens by 6.6%, and it is statistically significant at conventional levels.

### 3.2.2 Direct consumption

The survey collects information about categories of consumption and consumption components in two different questions in the questionnaire. In the first question, the survey asks about the family's expenditure on different categories of consumption. In the second question, the survey asks about the intra-household breakdown of consumption. In the baseline, we use the first question's data to obtain the share of each member's consumption. But, we do not take the reported levels of each member's consumption at their face value. Instead, to obtain the level of total household consumption, we use the data from the first question.

However, in this specification, we use the direct numbers reported as the level of components of consumption in the second question. In this specification, the passthrough of both private consumption diminishes but the passthrough of public consumption grows. The gap in private consumption passthroughs is still positive and significant at 10%.

### 3.2.3 Unresidualized moments

In the baseline, we extract the variation in rates of growth of consumption explained by the observable controls in the first stage. The motivation for this exercise is to focus on changes in consumption resulting from unexpected changes in earnings. In this specification, we forfeit the first stage. Instead, we use the gross observable rate of growth in consumption to form moments. With unresizualized moments, the only sizable change is a modest increase in passthrough of public consumption by 4.5%. The passthrough of private consumption hardly changes. Thus the gap in private consumption passthroughs is still positive and statistically significant at 7%.

### *3.2.4 Non-durable consumption*

In the baseline, we include both durable and nondurable consumption. In this specification, we exclude the durable items in the estimation of passthrough coefficients. The response of nondurable consumption to permanent shocks is weaker than the baseline in this specification because durables are one of the categories of consumption with higher passthrough coefficients. The private consumptions' passthrough barely changes, but the public consumptions' passthrough decreases by over 5 %. This suggests that the share of durables in private consumption is much less than public consumption. This result is consistent with our analysis in section 4.2. The gap between the husband's and wife's consumption passthrough does not disappear and is positive and statistically significant at the conventional levels.

# CHAPTER 4

# COMPOSITIONAL EFFECTS

In this chapter, we investigate what categories of consumption constitute each component of consumption. Note that we do not directly observe the breakdown of each component of consumption. We only observe the breakdown of the total household consumption based on different categories of consumption. First, we review the categories of consumption and what items they include. There are ten categories of consumption, as follows:

1. Food: which includes all purchases of groceries, dining out, take-out meals, and food-dispensing items.

2. Rent: which includes housing rent and land rent in the case that the land is not owned by the household. This item also includes home repairs. It does not include housing loans. Note that we have not imputed the rent for the homeowners because in this paper we are working mostly with the changes in the rent rather than the level of it. So long as the price changes in housing are not dramatic and the home-owners do not buy and sell houses frequently, this assumption will not introduce large measurement error.

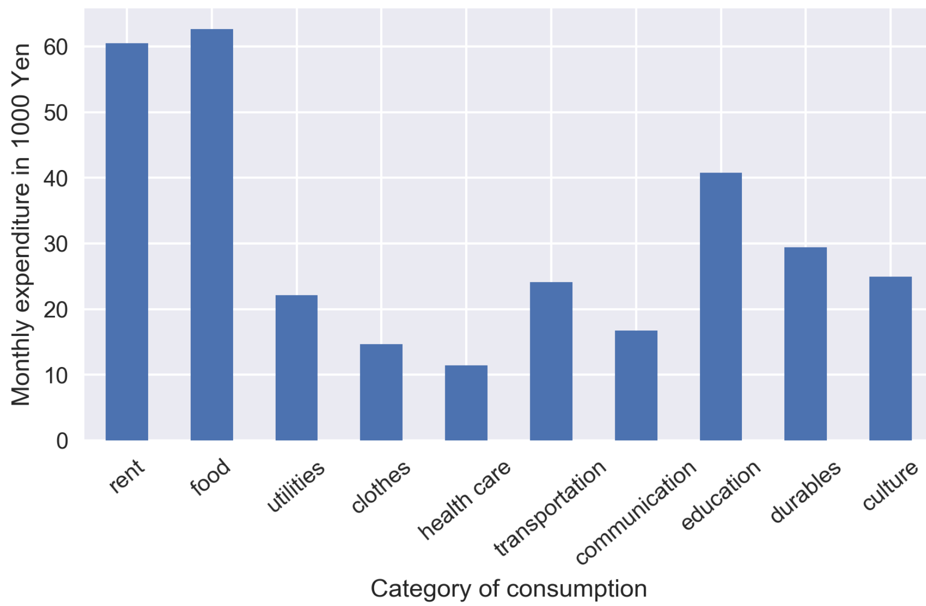
3. Utilities: which includes expenditures on light, fuel, electricity, water, and sewage.

4. Durables: which includes furnitures, electronics, appliances, kitchen utensils, toys, and cars.

5. Clothes: which includes clothes and shoes.

6. Health: which includes health insurance premiums in addition to taxes paid for public health insurance entitlements. It also includes expenditures on nutritious drinks, health foods, beauty products, and wellness.

Figure 4.1: The distribution of categories of consumption




7. Transportation: which includes car maintenance and insurance costs, cost of using public transit, commuter pass, and other traveling expenses.

8. Communication: which includes postal fees, phone service, and Internet and mobile services.

9. Education: Note that our sample includes households of which the head is age 28 to 55. Thus, the educational level of the husband and wife is almost invariant through the sample. Therefore, education costs in this section are entirely the children's educational expenses. These costs include school fees, private tutoring for entrance exams or supplementary lessons, textbooks, and reference books.

10. Culture: includes entertainment, lessons–except for those for entrance exam or supplementary tutoring–or durable goods for culture and entertainment, and costs associated with socializing and relationships such as alcohol and clubbing.

Figure 4.1 shows the distribution of household consumption over different categories of consumption. Food and rent are the two largest categories on which households spend.

## 4.1 Heterogeneity across categories of consumption

One of the underlying factors that can explain the gap in passthroughs is a drastic compositional dissimilarity between males' and females' bundles of private consumption. In particular, consider a case where the bundle of goods that constitute the male's consumption is comprised of commodities with high elasticities of income. In contrast, the female's bundle is comprised of commodities with low elasticities of income. This dissimilarity in the composition of bundles can explain the gap in passthroughs.

However, the compositional effect is a viable explanation only if there is a significant difference in passthroughs across different categories. To test this hypothesis, we estimate the passthrough coefficients with respect to the permanent and transitory shocks in different categories of total household consumption. Table 4.1 reports the results.

Table 4.1 demonstrates the variation in passthrough coefficients across different categories of consumption. As was the case with total consumption, the consumption in almost all categories with respect to a transitory shock is fully insured, as the passthrough coefficient with respect to a transitory shock is statistically insignificant in almost all categories. However, there is sizable variation in responses to permanent shocks. In Table 4.1, we have placed the categories in ascending order with respect to the permanent shock passthrough coefficient.

The absolute necessity categories of consumption (namely rent, utilities, and health) exhibit the smallest passthrough coefficients, and the coefficients are statistically insignificant. Thus we cannot reject the null hypothesis of full insurance with respect to permanent shocks in these categories of necessities. Cultural consumption's coefficient also shows up as insignificant, though it is not a necessary consumption item per se. Communications have a higher than average rate of insurance.

Table 4.1: Estimation of partial insurance parameters in different categories of consumption

| | (1) Rent | (2) Utilities | (3) Health | (4) Culture | (5) Communication | (6) Food | (7) Transportation | (8) Clothes | (9) Education | (10) Durables |
|---|---|---|---|---|---|---|---|---|---|---|
| $\sigma_v^2$ | 0.025*** | 0.025*** | 0.025*** | 0.025*** | 0.025*** | 0.025*** | 0.025*** | 0.025*** | 0.025*** | 0.025*** |
| | (6.01) | (6.01) | (6.01) | (6.01) | (6.01) | (6.01) | (6.01) | (6.01) | (6.01) | (6.01) |
| $\sigma_u^2$ | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** |
| | (6.81) | (6.81) | (6.81) | (6.81) | (6.81) | (6.81) | (6.81) | (6.81) | (6.81) | (6.81) |
| $\phi$ | -0.027 | 0.022 | 0.189 | 0.145 | 0.123* | 0.195*** | 0.265*** | 0.280** | 0.303*** | 0.364*** |
| | (-0.43) | (0.48) | (1.16) | (1.28) | (1.72) | (3.24) | (2.67) | (2.22) | (2.66) | (3.32) |
| $\psi$ | -0.003 | 0.012 | -0.028 | 0.023 | 0.021 | -0.028 | -0.032 | -0.039 | -0.015 | -0.085* |
| | (-0.13) | (0.48) | (-0.40) | (0.40) | (0.57) | (-0.96) | (-0.74) | (-0.61) | (-0.30) | (-1.74) |
| $\sigma_\eta^2$ | 0.037*** | 0.032*** | 0.107*** | 0.146*** | 0.058*** | 0.031*** | 0.089*** | 0.105*** | 0.322*** | 0.137*** |
| | (6.37) | (10.43) | (3.40) | (7.96) | (7.80) | (6.72) | (5.67) | (5.49) | (12.38) | (6.37) |
| $N$ | 13749 | 13924 | 13800 | 13832 | 13901 | 13937 | 13895 | 13801 | 13818 | 13922 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$\phi$ and $\psi$ denote the passthrough with respect to permanent and transitory shocks, respectively. There is full insurance against transitory shocks in all categories of consumption. However, there is sizable variation in responses to a permanent shock. The absolute necessities such as rent, utilities, and health care are fully insured, whereas transportation, clothes, education, and durable goods are more responsive to permanent shocks.

In the middle range, food's coefficient is about the same level as total consumption's. Although one may expect food, as a necessity, to have lower than average passthrough, the category also includes dining out and restaurant expenses, which exhibit the characteristics of a luxury good.

Finally, there are four categories with higher than average passthrough coefficients. Transportation appears with a large passthrough coefficient, as it includes traveling expenses. There is also a rather large variety in different means of transportation, which ultimately makes this component highly responsive to earnings shocks. The clothes and durable goods categories are highly responsive to permanent shocks as well. Since the purchase of durable goods provides a stream of service, they are comparable to an investment expense. Therefore, households disproportionately increase the share of expenditure in this category during good economic times and reduce it disproportionately in bad economic times, as they can still enjoy the service of previously purchased items. Education exhibits low levels of insurance as well. Note that these educational expenses are mainly spent on children, as our sample includes only subjects older than the ages at which individuals commonly enroll in higher education. One reason for the high passthrough coefficient might be the wide variety of school quality, which in turn translates into a wide variety of tuition amounts.

An overall conclusion from Table 4.1 is that despite the fact that a transitory shock is fully insured in almost all categories, there is considerable variety in the levels of insurance with respect to permanent shocks across various categories.

## 4.2 Categories of consumption in consumption components

As we mentioned before, we observe the breakdown of consumption in terms of categories only for total household consumption. However, in order to gain some insight about the categories that are the most prominent for each component of consumption, we proceed by regressing the share of each component of consumption on the share of each category of consumption.

We decompose the total household consumption in two ways. First, we break down the total consumption to its components, namely the intra-household allocation that includes the male's private consumption, $\alpha_{m,t}$, the female's private consumption, $\alpha_{f,t}$, and public consumption, $\alpha_{p,t}$ where $t$ index represents time. Second, we break down the total household consumption by different categories of consumption such as food, rent, health, etc. We denote these shares by $\kappa_{i,t}$ where $i$ denotes the share of category $i$ in household's total consumption in period $t$. $C$ represents the number of categories. We run the models below and estimate them both without household fixed effects, in Table 4.3, and with the household fixed effects, in Table 4.4.

$$\alpha_{m,t} = \beta_0^m + \sum_{i=1}^{C} \beta_i^m \kappa_{i,t}$$

$$\alpha_{f,t} = \beta_0^f + \sum_{i=1}^{C} \beta_i^f \kappa_{i,t}$$

$$\alpha_{p,t} = \beta_0^p + \sum_{i=1}^{C} \beta_i^p \kappa_{i,t}$$

The category $\tilde{i}$ for which $\beta_{\tilde{i}}^m$ is estimated as a large positive number indicates the category that comprises a large share in the male's bundle of consumption. As the share of category $\tilde{i}$ in the household's consumption expands, a rather large expansion in the male's share follows. On the other hand, consider category $\hat{i}$ for which $\beta_{\hat{i}}^m$ is

Table 4.3: The co-movement of shares of different categories of consumption with the shares of private and public consumption

| | Husband | Wife | Kids | Pure Public | Public |
|---|---|---|---|---|---|
| Rent | -0.109*** | -0.00210 | -0.0627*** | 0.203*** | 0.0983*** |
| | (-6.32) | (-0.21) | (-4.24) | (6.28) | (3.96) |
| Utilities | -0.201*** | -0.194*** | 0.0782** | 0.344*** | 0.566*** |
| | (-3.81) | (-5.70) | (2.22) | (3.55) | (3.26) |
| Health | -0.104*** | 0.159*** | 0.149*** | -0.223*** | -0.120* |
| | (-3.08) | (3.05) | (2.94) | (-3.30) | (-1.65) |
| Culture | 0.0409 | 0.0706*** | 0.0242 | -0.135** | -0.0155 |
| | (1.39) | (3.83) | (1.21) | (-2.38) | (-0.16) |
| Communication | -0.0516 | 0.0351 | -0.0168 | 0.132 | 0.00856 |
| | (-1.28) | (1.23) | (-0.50) | (1.60) | (0.09) |
| Food | -0.151*** | -0.0627*** | 0.0213 | 0.227*** | 0.134* |
| | (-7.01) | (-3.98) | (1.16) | (5.37) | (1.83) |
| Transportation | 0.0572 | -0.0255 | 0.0675* | -0.231** | 0.0401 |
| | (1.20) | (-0.74) | (1.74) | (-2.11) | (0.36) |
| Clothes | 0.0933** | 0.380*** | 0.0530* | -0.307*** | -0.399*** |
| | (2.27) | (8.30) | (1.76) | (-3.58) | (-4.90) |
| Education | -0.0926*** | -0.114*** | 0.888*** | -0.692*** | 0.152*** |
| | (-3.55) | (-7.79) | (26.20) | (-18.75) | (3.57) |
| Durables | -0.0798** | 0.0300 | -0.0370 | 0.192** | 0.00659 |
| | (-1.96) | (0.91) | (-1.28) | (2.04) | (0.10) |

*t* statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The pooled regression of shares of private and public consumption on the share of different categories of consumption. The categories with positive coefficients are the ones with higher transmission to a category of consumption as the household increases the share of spending on that category. Clothes have the largest and most significant coefficient for both the male and the female. Culture modestly contributes to private consumption as well, especially for women. Health is another positive contributor which might capture a higher proportion of beauty and wellness expenditures by women. Children's consumption is almost entirely driven by education expenses. The categories with highest contribution to public consumption are the intuitive ones: rent, utilities, food, and durable goods. The standard errors are clustered at the household level.

Table 4.4: The co-movement of shares of different categories of consumption with the shares of private and public consumption - with fixed effects

| | Husband | Wife | Kids | Pure Public | Public |
|---|---|---|---|---|---|
| Rent | -0.0661*** | -0.0198 | -0.0369** | 0.106*** | 0.0633** |
| | (-3.38) | (-1.59) | (-2.03) | (2.85) | (2.27) |
| Utilities | -0.0570 | -0.158*** | -0.0509 | 0.398*** | 0.393* |
| | (-1.05) | (-4.72) | (-1.20) | (3.54) | (1.78) |
| Health | -0.0617* | 0.133** | 0.109* | -0.208*** | -0.0773 |
| | (-1.66) | (2.31) | (1.77) | (-2.98) | (-1.19) |
| Culture | 0.0184 | 0.0226 | -0.0312 | -0.0325 | 0.103 |
| | (0.54) | (1.25) | (-1.57) | (-0.40) | (0.64) |
| Communication | -0.0379 | -0.00220 | 0.0261 | 0.0657 | -0.0879 |
| | (-0.92) | (-0.07) | (0.69) | (0.79) | (-0.69) |
| Food | -0.106*** | -0.0382** | -0.0377* | 0.206*** | 0.0312 |
| | (-3.99) | (-2.35) | (-1.92) | (3.68) | (0.27) |
| Transportation | 0.0189 | -0.0470 | 0.0637 | -0.118 | 0.0285 |
| | (0.39) | (-1.40) | (1.23) | (-0.94) | (0.40) |
| Clothes | 0.108*** | 0.207*** | -0.0218 | -0.148* | -0.284*** |
| | (2.75) | (5.85) | (-0.78) | (-1.65) | (-3.23) |
| Education | -0.0785*** | -0.0704*** | 0.654*** | -0.459*** | 0.115*** |
| | (-3.22) | (-4.36) | (18.28) | (-12.22) | (3.27) |
| Durables | -0.0208 | 0.0488 | -0.0570 | 0.113 | -0.0434 |
| | (-0.47) | (1.50) | (-1.47) | (0.99) | (-0.63) |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The pooled regression of shares of private and public consumption on the share of different categories of consumption. The categories with positive coefficients are the ones with higher transmission to a category of consumption as the household increases the share of spending on that category. Clothes have the largest and most significant coefficient for both men and women. Culture modestly contributes to private consumption as well, especially for women. Health is another positive contributor which might capture a higher proportion of beauty and wellness expenditures by women. Children's consumption is almost entirely driven by education expenses. The categories with the highest contribution to the public consumption match intuition: rent, utilities, food, and durables. The standard errors are clustered at the household level.

estimated as a very negative number. Category $\hat{i}$ indicates a category that comprises a small share in the male's bundle of consumption. As the share of category $\hat{i}$ in the household's consumption dwindles, a rather large drop in the male's share follows. A similar argument can distinguish between the categories that are large contributors and those that are small contributors in the female's consumption and public consumption components.

Table 4.3 shows estimates in the pooled models and Table 4.4 shows estimates with the inclusion of household fixed effects. The results are qualitatively similar between the two tables. By far, the most important contributor in both men's and women's private consumption is clothes. This result is sensible, as clothing is the single most excludable category of consumption. There is some evidence that cultural expenditure is also a contributor in both spouses' private consumption. Though the evidence is weaker with a fixed effects specification. Health is the only category that is estimated significantly with different signs across gender. It is estimated positively for the females and negatively for the males. That health is a large contributor in the female's private consumption but a small contributor in the male's is probably due to the fact that women spend more on cosmetic products and wellness items.

The major contributors in public consumption are rent, utilities, and food, which is consistent with our prior assumptions. Education by far is the largest contributor to children's consumption. Note the education category also includes day-care expenses.

Overall, there is little evidence in support of dramatic compositional dissimilarities between the male's and female's bundles of consumption. For most categories, the signs line up, in that the main contributing categories are alike across the two private consumption bundles. The only significant exception is health. The clothes category by far has the largest share in both spouses' consumption. Therefore it is unlikely that the gap in passthrough coefficients is an artifact of the drastic compositional dissimilarities across gender.

# CHAPTER 5

# MECHANISM I: HETEROGENEITY IN RISK-AVERSION ACROSS GENDER

In this section, we study heterogeneous risk preferences as a potential mechanism that could explain our main finding that the husband's private consumption is more responsive to the household's earnings than the wife's. In section , in a stylized theoretical framework, we illustrate how risk-aversion heterogeneity can explain the gap in passthrough coefficients.

This model equips us with two testable predictions, paving the way for our empirical strategy. First, we show that if the husband's and wife's optimal consumption functions cross, then the risk preferences are heterogeneous across gender. Second, we show that greater risk-aversion heterogeneity leads to a wider gap in passthroughs.

To formally test the first prediction, we construct the uniform band for the functions, which represents the difference between the male's and female's optimal consumption functions. To test the second prediction we estimate the passthrough in a subsample of households with greater risk-aversion heterogeneity and test whether the passthrough is larger than the baseline.

## 5.1 Theoretical illustration

In this section, in a simple theoretical frame, we explain how women's higher risk aversion brings about their sluggish consumption response to earnings shocks. The framework is inspired by Mazzocco and Saini (2012). In this section, we abstract from strategic interaction within the family. We model the household decision mode as the planner problem, of which the goal is to achieve efficiency. In the section 6, we revisit the strategic interaction's implications.

Consider that the total household's earnings, $y_t$, follows an i.i.d. process which is distributed with c.d.f. of $F(y)$ on a positive support such as $(0, y_{max}]$. The household is composed of a male and female who cooperatively decide about the allocation of the household's earnings between themselves efficiently. No separation is allowed and Pareto weight stays fixed. Thus, given their constant Pareto weight, they maximize the following household welfare function:

$$\max_{c_{m,t}, c_{f,t}} \mu u_m(c_{m,t}) + (1-\mu) u_f(c_{f,t}) \tag{5.1}$$

$$\text{s.t.} \quad c_{m,t} + c_{f,t} = y_t$$

No saving technology exists. Given the i.i.d. earnings process and lack of savings, we can solve each period's problem independently. We also abstract from the public consumption. $u_m(.)$ and $u_f(.)$ are strictly increasing and concave in consumption. $u_m$ and $u_f$ could potentially be heterogeneous in terms of their levels of risk aversion. We denote the optimal solution of the optimization by $c^*_m(y_t)$ and $c^*_f(y_t)$. In the following proposition, we show that optimal consumption functions are strictly increasing.

**Proposition 1.** *The optimal consumption functions, $c^*_m(y_t)$ and $c^*_f(y_t)$, are strictly increasing in household earnings, $y_t$.*

*Proof.* We prove the theorem by way of contradiction. Assume that there is an interval, $\mathcal{I} = \{y_a, y_b\}$, a subset of of support of $y_t$, such that on which at least one of the optimal consumption functions, say $c^*_{m,t}(y_t)$, is decreasing. Thus, for $\tilde{y}_t \in \mathcal{I}$ and $\bar{y}_t \in \mathcal{I}$, without loss of generality we assume $\tilde{y}_t > \bar{y}_t$. Thus

$$c^*_m(\tilde{y}) \leq c^*_m(\bar{y}) \tag{5.2}$$

because $c_m^*(y_t)$ is decreasing on $\mathcal{I}$. Since $u_m(.)$ is strictly concave

$$\begin{aligned} u_m'(c_m^*(\tilde{y})) &\geq u_m'(c_m^*(\bar{y})) \\ \Rightarrow \mu u_m'(c_m^*(\tilde{y})) &\geq \mu u_m'(c_m^*(\bar{y})) \end{aligned} \tag{5.3}$$

Moreover the FOC of the optimization problem implies

$$\mu u_m'(c_m^*(y_t)) = (1-\mu)u_f'(c_f^*(y_t)) \tag{5.4}$$

Combining (5.3) and (5.4)

$$(1-\mu)u_f'(c_f^*(\tilde{y}_t)) \geq (1-\mu)u_f'(c_f^*(\bar{y}_t))$$

Thus by strict concavity of $u_f(.)$

$$c_f^*(\tilde{y}) \leq c_f^*(\bar{y}) \tag{5.5}$$

Thus by combining (5.2) and (5.5)

$$c_m^*(\tilde{y}) + c_f^*(\tilde{y}) \leq c_m^*(\bar{y}) + c_f^*(\bar{y})$$

Thus by budget constraint of optimization problem

$$\tilde{y} \leq \bar{y} \tag{5.6}$$

where (5.6) contradicts the initial assumption of $\tilde{y} > \bar{y}$. □

The intuition behind the proof is as follows. The planner's problem of an efficiency condition requires that the Pareto weighted marginal utilities be equal. Consider the case that the household's earnings increase but the consumption of one of the spouses, say the male, decreases. Since the marginal utilities are strictly decreasing, this situation cannot be optimal. While the male's marginal utility is increased, the female's has decreased. Thus there is no way for the Pareto weighted marginal utilities to equalize.

In the next proposition, we provide a testable prediction to test the preference heterogeneity across gender. In particular, we show that if the optimal consumption functions cross, the preferences ought to be heterogeneous.

**Proposition 2.** *If optimal consumption functions $c_m^*(y_t)$ and $c_f^*(y_t)$ cross, the preferences are heterogeneous across gender. In other words, if there exists $\tilde{y} \in (0, y_{max}]$ and $\bar{y} \in (0, y_{max}]$ and $\tilde{y} \neq \bar{y}$ such that*

$$c_m^*(\tilde{y}) > c_f^*(\tilde{y}) \tag{5.7}$$

$$c_m^*(\bar{y}) < c_f^*(\bar{y}) \tag{5.8}$$

*then $u_m(.)$ and $u_f(.)$ cannot be identical.*

*Proof.* We prove the proposition by way of contradiction. Without loss of generality, assume that $\tilde{y} < \bar{y}$. Assume the contradiction of the results in that preferences are identical, $u_m(.) = u_f(.) = u(.)$. By strict concavity of $u(.)$, (5.7) implies

$$u'(c_m(\tilde{y})) < u'(c_f(\tilde{y}))$$
$$\Rightarrow (1-\mu)u'(c_m(\tilde{y})) < (1-\mu)u'(c_f(\tilde{y}))$$

Moreover the FOC of the optimization problem implies

$$\mu u_m'(c_m^*(y_t)) = (1-\mu)u_f'(c_f^*(y_t))$$

Thus

$$(1-\mu)u'(c_m(\tilde{y})) < \mu u'(c_m(\tilde{y}))$$
$$\Rightarrow \mu > \frac{1}{2} \tag{5.9}$$

On the other hand, strict concavity of $u(.)$ and (5.8) implies

$$u'(c_m(\bar{y})) > u'(c_f(\bar{y}))$$
$$\Rightarrow \mu u'(c_m(\bar{y})) > \mu u'(c_f(\bar{y}))$$

By FOC 's of the optimization problem

$$(1-\mu)u'(c_f(\bar{y})) > \mu u'(c_f(\bar{y}))$$
$$\Rightarrow \mu < \frac{1}{2} \tag{5.10}$$

which contradicts (5.9) □

The intuition behind the proof is simple. The fact that optimal consumption functions cross implies that that there is an earnings level, $\tilde{y}$, in which the male has higher consumption and there is another earnings level $\bar{y}$ in which female has higher consumption. With identical preferences the only way that the former case could happen is when the male has higher Pareto weight. By the same token, the only way that the latter case could happen is when the female has higher Pareto weight. Since the Pareto weight is assumed to be fixed, this yields a contradiction. Thus, risk preferences ought to be heterogeneous across gender.

In the next proposition, we focus on the utility functional form with constant relative risk aversion, or the CRRA utility function. With CRRA functional form we can represent the degree of risk-aversion in a single parameter of the utility function, namely the relative risk aversion parameter. This provides a feasible framework to further study the implication of heterogeneity in the relative risk aversion parameter across gender on the optimal consumption functions.

**Proposition 3.** *Assume a CRRA individual's preferences. Then, the share of optimal consumption in the household's earnings is strictly increasing for the spouse with lower risk-aversion, and it is strictly decreasing for the spouse with higher risk-aversion. Furthermore, as the difference in risk aversion increases, the spouse's share with lower risk-aversion grows at a higher rate, and the spouse's share with higher risk aversion declines at a higher rate.*

*Proof.* With CRRA utility function

$$u(c) = \frac{c^{1-\gamma} - 1}{1-\gamma}$$

where $\gamma \geq 0$ represents the relative risk aversion parameter. For a risk-neutral agent $\gamma = 0$. As the agent becomes more risk-averse, $\gamma$ grows. Without loss of generality assume that it is the female who has the higher relative risk-aversion parameter. Thus

$$\delta = \gamma_f - \gamma_m$$

where $\delta > 0$ represents the difference in relative risk aversions between the male and female. Denote the share of household earnings allocated to the male's private consumption by $s$ where $0 < s < 1$. Then we can parametrize the optimal consumption functions as follows

$$c_m^*(y) = sy$$

$$c_f^*(y) = (1-s)y$$

Then the optimality conditions of the problem (8.1) with respect to optimal $s$ impliy

$$\frac{u'_m(sy)}{u'_f((1-s)y)} = \frac{1-\mu}{\mu}$$

with CRRA utility function we can rewrite this equation as follows

$$\frac{(sy)^{-\gamma_m}}{((1-s)y)^{-\gamma_m-\delta}} = \frac{1-\mu}{\mu} \tag{5.11}$$

Then, by applying the Implicit Function Theorem to the optimality condition (5.11) we have

$$\frac{\partial s}{\partial y} = \frac{\frac{\delta}{y}}{\gamma_m(\frac{1}{1-s}+\frac{1}{s})+\frac{\delta}{1-s}} > 0$$

Thus

$$\frac{\partial(1-s)}{\partial y} < 0$$

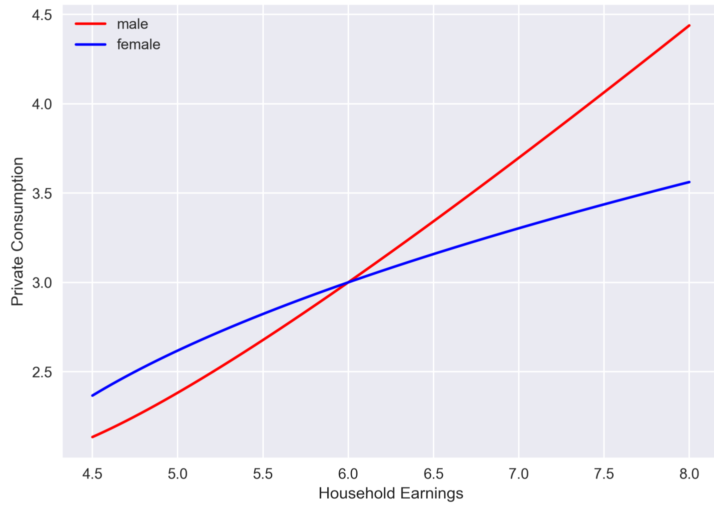
Furthermore

$$\frac{\partial^2 s}{\partial y \partial \delta} = \frac{\frac{\gamma_m(\frac{1}{1-s}+\frac{1}{s})}{y}}{\left(\gamma_m(\frac{1}{1-s}+\frac{1}{s})+\frac{\delta}{1-s}\right)^2} > 0$$

□

We have already shown in proposition 1 that the level of optimal consumption is increasing in earnings for both spouses. However, proposition 3 shows that the share of males whom we assume have lower risk-aversion would increase with the level earnings. This implies that when the household faces an advantageous earnings shock, both

Figure 5.1: Optimal Consumption Functions



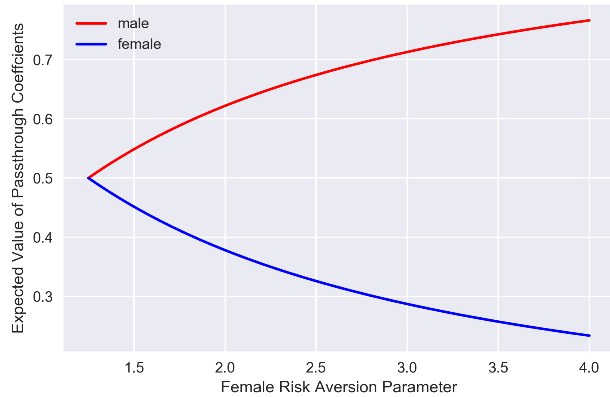

The Pareto weight is set to 0.5. The subsistence levels are the same across gender: $a_m = a_f = -2$. The spouses are heterogeneous in terms of risk aversion, specifically in that the female is more risk-averse, $\gamma_m = 1.25$ and $\gamma_f = 2.5$. Due to the heterogeneity in preferences, as the proposition 3 implies, the optimal consumption functions cross.

spouses' consumption will increase but the male's consumption increases to a greater extent because his share of earnings, in addition to the level of earnings, is increased.

On the other hand, when the household faces an adverse earnings shock, both spouses' consumption will drop. But, the male's consumption will drop to a greater extent as, in addition to the level of earnings, his share of earnings has dropped relative to the baseline as well. Thus proposition 3 provides a theoretical explanation for our main empirical finding that the male's passthrough in response to household earnings shocks is greater than the female's passthrough.

Moreover, proposition 3 predicts that the level of disparity between the male's and female's passthrough coefficients in response to earnings shocks is increasing in the difference in the degree of risk aversion. In other words, the greater disparity in degree

Figure 5.2: The gap in passthrough as a function of the gap in risk-aversion




The Pareto weight is set to 0.5. The subsistence levels are the same across gender $a_m = a_f = -2$. The risk-aversion parameter of the male is held fixed at $\gamma_m = 1.25$ while we let the female's risk aversion grow larger, starting at a level equal to that of male. As the the spread of risk aversion across spouses grows larger, the divergence in the expected value of passthrough coefficients increases. $\phi_m = E_y \frac{\partial c_{m,t}}{\partial y_t}$ and $\phi_f = E_y \frac{\partial c_{f,t}}{\partial y_t}$

of risk aversion between the male and female would be translated into a wider gap between the male's and female's passthrough coefficients.

## 5.2 Simulation results

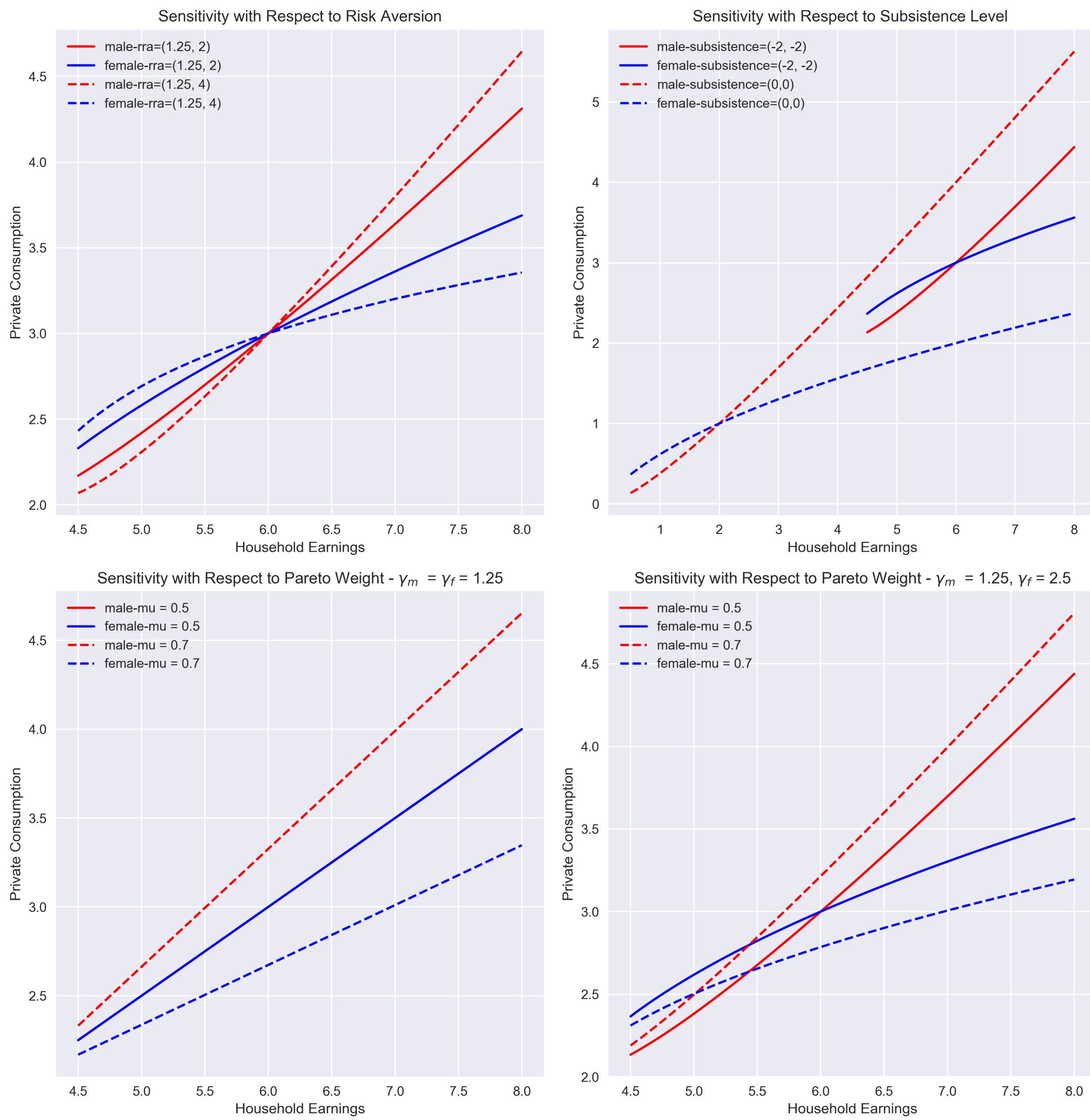
To gain a better understanding of the implications of the model, we present some simulated results. The functional form in the simulations is hyperbolic absolute risk-aversion (HARA). Figure 5.3 demonstrates the males's and female's optimal consumption function as a function of the household's earnings. The figure depicts very clearly how the heterogeneity in risk averse leads to the gap in passthroughs.

First, as we proved in proposition 1, both optimal consumption functions are increasing in the household's earnings. In addition, at lower levels of the household's earnings, the female's consumption outweighs the male's. But as the household's earnings grow, the male's consumption overtakes the female's. It also does so at an increasing rate. In fact, as the household's earnings grow, the difference in rate of growth of consumption increases. This result is effectively the graphical representation of the proposition 3 that by an increase in the household's earnings, the male's share of the household's earnings grows. Therefore it leads to a situation where the difference in levels of consumption diverges at an ever increasing rate.

Figure 5.2 displays the expected value of the male's and female's passthrough coefficients, where the expectation is taken with respect to random household earnings. We use a beta distribution for earnings in our simulation. Figure 5.2 plots the passthroughs as a function of the difference in risk aversion across gender. At the starting point, the risk aversion is homogeneous and both spouses have the same risk aversion. At this point the passthroughs are identical and equal to 0.5. Then, while fixing the male's risk aversion, we increase the female's risk aversion. As a result, the female's passthrough declines, the male's rises, and the gap in passthroughs emerges. The gap grows wider as the difference in risk aversion between couples expands.

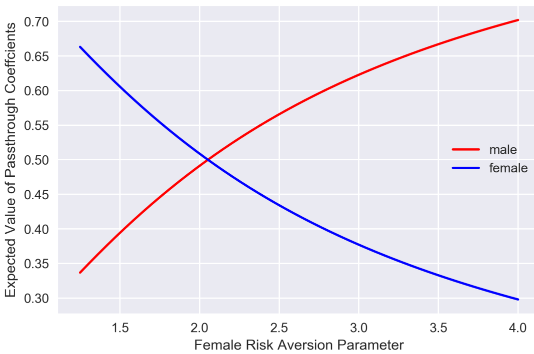
Figure 5.3 exhibits the results of comparative statics with respect to the parameters of the model. The top left panel shows the comparative static with respect to the difference in risk-aversion. As the the degree of heterogeneity in risk-aversion increases, the optimal consumption functions diverge from one another. Thus, as was shown in Figure 5.2, the gap in passthroughs widens. The top high panel shows comparative statics with respect to sustenance levels. The smaller levels of sustenance make the optimal consumption functions cross at a lower level of household earnings. Other than that, it does not change our main findings qualitatively. The zero sustenance level that is depicted in this panel

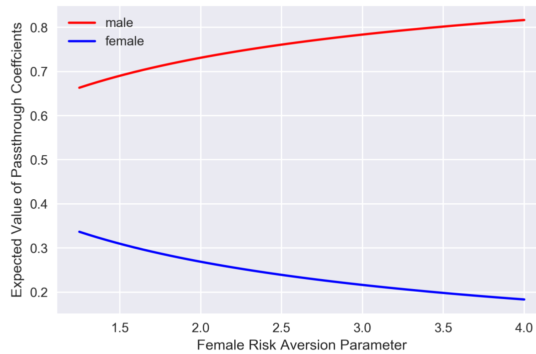
Figure 5.3: Optimal consumption functions comparative statics




The Pareto weight is set to 0.5. The subsistence levels are the same across gender $a_m = a_f = -2$. The spouses are heterogeneous in terms of risk aversion in that the female is more risk-averse, $\gamma_m = 1.25$ and $\gamma_f = 2.5$. Due to the heterogeneity in preferences, as proposition 3 implies, the optimal consumption functions cross.

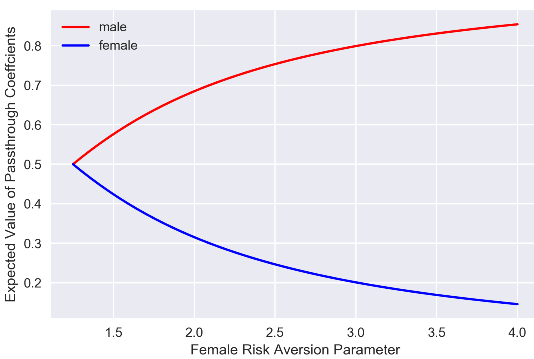
Figure 5.4: Comparative statics of divergence of passthrough coefficients with respect to the female's risk aversion

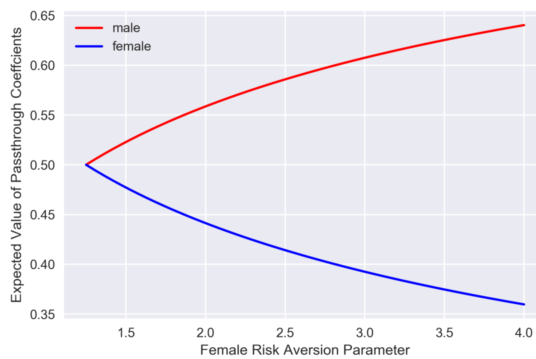



$\mu = 0.3$

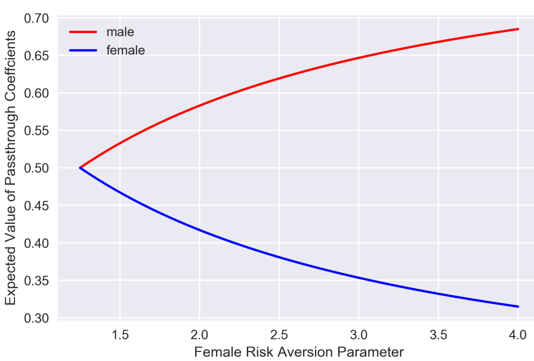
$\mu = 0.7$

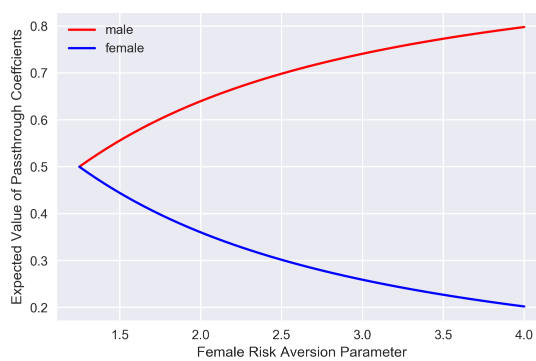



$a_m = a_f = 0$

$a_m = a_f = -3$




The left leaning earnings distribution

The right leaning earnings distribution

corresponds to the CRRA utility function.

The bottom left panel in Figure 5.3 shows the comparative static with respect to Pareto weight in the case of homogeneity in risk aversion. With homogeneity in risk preference, if the Pareto weights are equal, the optimal consumption functions are identical and lie on top of each other. Now assume imbalance in Pareto weights, such that the male has higher Pareto weight. Then the male's optimal consumption function always dominates the female's. Note, as we showed in Proposition 2, the optimal consumption functions do not cross because risk aversion is homogenous, despite the fact that Pareto weights are heterogeneous. So, there is a clear theoretical distinction in terms of the implication of heterogeneity in risk aversion as opposed to heterogeneity in Pareto weight. Finally, in the bottom right panel we have heterogeneity both in terms of risk aversion and Pareto weight. Because of heterogeneity in risk aversion, the consumption functions cross. Since the male has lower risk aversion and higher Pareto weight, the heterogeneity in Pareto weight reinforces the gap emanating from the heterogeneity in risk aversion.

Figure 5.4 displays comparative statics of passthrough functions with respect to the parameters of the model. The top panels explore the sensitivity to the Pareto weight. With lower Pareto weight for the male, the gap in passthrough functions shrinks. At lower risk-aversion heterogeneity, now, it might even be the case that the female exhibits higher passthrough. But, as we will explain in section 8.1, there is empirical evidence against lower Pareto weight for the male. The right panel shows the case with higher Pareto weight for the male. In this case, heterogeneity in Pareto weight amplifies the gap generated from heterogeneity in risk aversion.

The middle panels in Figure 5.4 display the sensitivity of passthrough functions with respect to sustenance level. The left panel shows the passthrough functions in the case of

CRRA whose sustenance level is zero. Higher sustenance levels shrink the gap between passthrough functions.

Finally, the bottom panels display sensitivity to the distribution of random earnings. In particular, we vary the skewness of the earnings distribution. Recall that we use a symmetric beta distribution to generate the baseline simulated results. In the left panel, we instead use a left leaning (right skewed) beta distribution and in the right panel we use a right leaning (left skewed) beta distribution. With a right leaning earnings distribution, the gap in passthrough functions slightly widens.

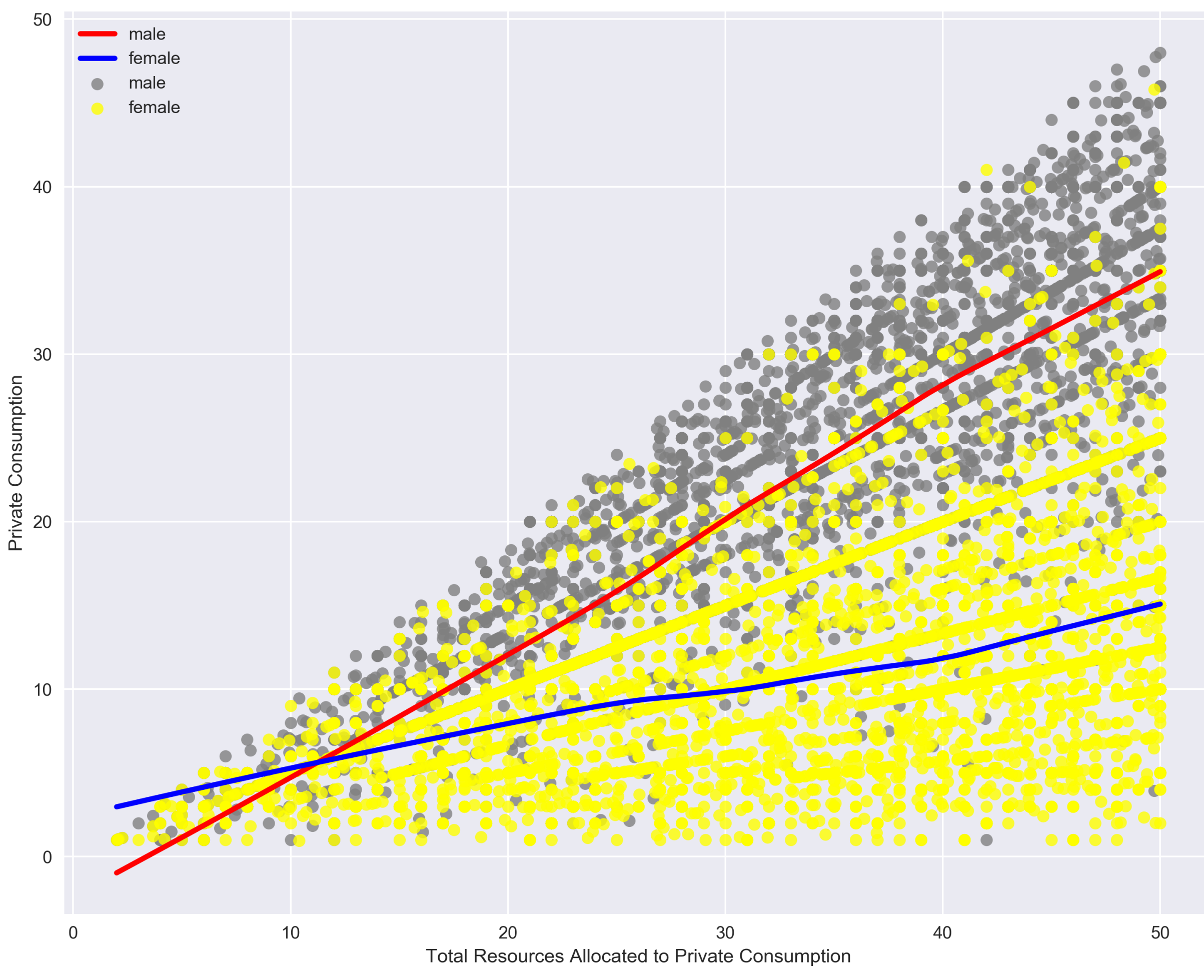
## 5.3 Test of preference heterogeneity: consumption functions crossing test

In this section, we test the prediction of Proposition 2. Recall that the proposition implies that if the optimal consumption functions cross, then we can reject the null hypothesis of risk preference homogeneity.

Figure 5.5 plots the realized consumption against the total resources allocated to private consumption. The red and blue curves demonstrate the nonparametric consumption functions for the male and female, respectively. Specifically, we use a locally weighted regression to fit the nonparametric consumption functions. A crossing point around 10.1 thousand Yen is apparent visually. It suggests that the null hypothesis of risk preference homogeneity can be rejected in our data.

To formalize the idea of a consumption functions crossing test, we use *simultaneous confidence band* for a function. To visualize the sample uncertainty simultaneously, for

Figure 5.5: The graphical test of the null hypothesis of risk preference homogeneity across gender




The graphs provides suggestive evidence against the null hypothesis of homogeneous risk preferences across gender.

a group of parameters, simultaneous confidence bands are a very effective approach. This approach is also a natural way of implementing multiple hypothesis testing. Our treatment in this section follows the *sup-t confidence band* procedure proposed in Olea and Plagborg-Møller (2018).

To implement the test, we define the *consumption difference function*, $\hat{h}(y)$, as the difference between the nonparametric estimation of the optimal consumption function of the male and female as follows:

$$\hat{h}(y) = \hat{c}_m(y) - \hat{c}_f(y)$$

Then by discretizing the support of $\hat{h}(y)$ to $k$ bins, we treat function $\hat{h}(y)$ as a $k$-dimensional vector of parameters named $\hat{\theta}$. Then we construct a simultaneous band for these $k$ parameters. If the band contains zero then we can reject the null hypothesis of homogeneity that $\hat{h}(y) > 0$ for all $y$.

To construct the band we assume that the vector of parameters is asymptotically Normal

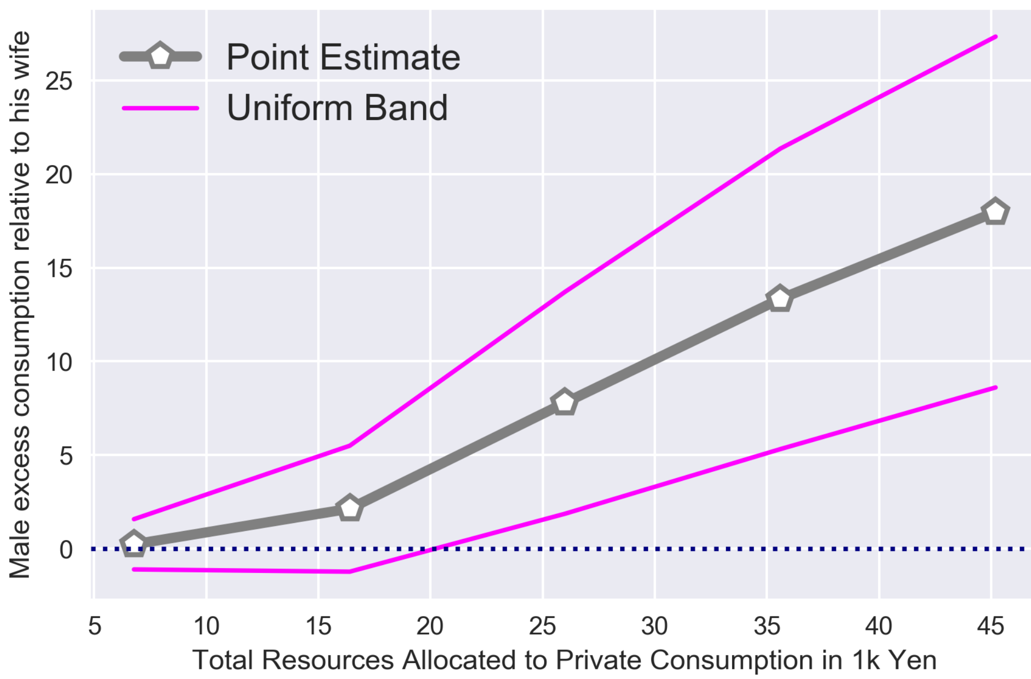
$$\sqrt{n}(\hat{\theta} - \theta) \xrightarrow{d} \mathcal{N}(\mathbf{0_k}, \Sigma)$$

We estimate each element of $\hat{\theta}$ by the sample mean difference between male's and female's consumption within each bin. We obtain $\Sigma$ by the block bootstrap. Then for any critical value $c > 0$, we define the *one-parameter confidence band* as

$$\hat{B}(c) \equiv [\hat{\theta}_1 - \hat{\sigma}_1 c, \hat{\theta}_1 + \hat{\sigma}_1 c] \times \cdots \times [\hat{\theta}_k - \hat{\sigma}_k c, \hat{\theta}_k + \hat{\sigma}_k c]$$

which is the Cartesian product of the scaled-up conventional confidence intervals. The

Figure 5.6: The uniform band for the function representing the difference of the male's consumption from the female's consumption




The band demonstrates the 90 percent uniform band. The uniform band is constructed using the Sup-t band by discretizing the support of total resources allocated to private consumption. In this case, we use grid size of 5. The uniform band contains zero when the total resources allocated to private consumption is less than about 20 thousand Yen. Thus we are able to reject the null that individual utilities are homogeneous. Note how simultaneous bands can effectively control for multiple hypotheses, in that we fail to reject the homogeneity of individual utilities for higher levels of total private consumption whereas we are able to reject the homogeneity for lower levels of total private consumption.

last step of the procedure is to pin down the critical value $c$. To do so, we use the *sup-t* procedure. We obtain it by choosing the smallest $c$ that ensures uniform coverage. In effect, via a min-max approach, we pick $c$ such that it guarantees the widest interval is within the confidence band. Thus, we pick the $(1-\alpha)$-quantile of the following random variable to obtain a band that covers the true parameters simultaneously with $1-\alpha$ probability

$$q_{1-\alpha}(\Sigma) = Q_{1-\alpha}(\max_{i=1,\ldots,k} |\Sigma_{i,i}^{-\frac{1}{2}} \hat{\theta}_i|)$$

Figure 5.6 demonstrates the 90 percent simultaneous uniform band for the consumption difference function. The uniform band contains zero when total resources allocated to private consumption is less than about 20 thousand Yen. Thus we are able to reject the null that individual utilities are homogeneous. Note how simultaneous bands can effectively control for multiple hypotheses. We fail to reject the homogeneity of individual utilities for higher levels of total private consumption, whereas we are able to reject the homogeneity for lower levels of total private consumption.

Our test depends on the number of bins in discretization of the support of the function. Our result in Figure 5.6 is obtained by the bin size of 5. To check robustness, in Figure B.4 in Appendix B, we vary the number of bins. With a higher number of bins the band changes in two ways: it becomes less smooth and wider.

One obvious reason for the widening of the band is the bias-variance tradeoff. With a high number of bins, the number of observations per bin diminishes and as a result the variance suffers. However, there is another mechanism that reinforces the widening of the confidence band. As the Figure in Appendix B demonstrates, the critical value is also increasing in the number of bins. Thus with a higher number of bins, in addition to higher variance per bin, the critical value would also be greater. Despite this widening in the band, our finding perseveres. The band contains zero for smaller levels of resources and is positive for larger levels of resources. Overall, we are able to reject the null hypothesis of homogeneity, which requires positive values for the consumption difference function in *all* levels of resources.

## 5.4 Inference on risk aversion by studying the assets portfolio

Looking at the assets portfolio of the household could provide us with some suggestive evidence about the risk preferences. Based on optimal portfolio choice theory, between risky and risk-free assets, in the absence of taxes, the share of investment in risky assets by individual $i$ is given by

$$\alpha_i = \frac{E(r_m - r_f)}{Var(r_m)} \tilde{T}_i(W_i)$$

where $r_m$ is the return on market portfolio of risky assets and $r_f$ is the return on risk-free assets. $T_i(W_i)$ is the relative risk-tolerance of individual $i$. Different individuals in the market face the same risk-adjusted return on risky investment, $\frac{E(r_m - r_f)}{Var(r_m)}$. Thus, the variation in the fraction of investments in risky assets across individuals emanates from variation in relative risk-aversion. Therefore, the share of investment in risky assets is a good proxy of risk preference of the investor.

Fortunately, in our data set we have detailed information about the asset portfolios of the households. In particular, the survey documents the position of the households in risky and risk-free assets. The risk-free assets include fixed-term installment and general deposits in banks and credit associations, in-house deposits, gold investment accounts, gold savings accounts, and national medium-term bond funds. The risky assets include stocks, bonds, and stock investment trusts.

Table 5.1: The summary statistics of assets broken across different categories and across gender

| | Male | | Female | |
|---|---|---|---|---|
| | Mean | Median | Mean | Median |
| ***Financial Assets*** | | | | |
| Risk Free Assets | 9.78 | 6.00 | 3.27 | 2.00 |
| Risky Assets | 3.93 | 1.50 | 1.18 | 0.10 |
| Financial Assets | 13.71 | 8.70 | 4.45 | 2.30 |
| Share of Risky Assets | 27.43 | 22.22 | 21.38 | 4.41 |
| ***Real Estate*** | | | | |
| Lot Value | 9.42 | 0.00 | 0.10 | 0.00 |
| House Value | 5.60 | 0.00 | 0.17 | 0.00 |
| Parents Lot Value | 12.46 | 0.00 | 1.63 | 0.00 |
| Parents House Value | 7.26 | 0.00 | 3.63 | 0.00 |
| Mortgage | -5.75 | 0.00 | -0.07 | 0.00 |
| Land Value Conditional on Ownership | 32.33 | 20.00 | 12.56 | 12.10 |
| House Value Conditional on Ownership | 16.16 | 11.00 | 13.28 | 11.50 |
| HH Own The Lot | 0.65 | 1.00 | 0.65 | 1.00 |
| HH Own The House | 0.70 | 1.00 | 0.70 | 1.00 |
| Own The Lot | 0.64 | 1.00 | 0.02 | 0.00 |
| Own The House | 0.55 | 1.00 | 0.02 | 0.00 |
| Own The Lot + Parents | 0.81 | 1.00 | 0.19 | 0.00 |
| Own The House + Parents | 0.69 | 1.00 | 0.31 | 0.00 |
| ***Physical Wealth*** | | | | |
| Financial + Real Estate | 20.55 | 10.80 | 4.61 | 2.40 |
| Financial + Parents Real Estate | 23.41 | 12.00 | 5.82 | 2.70 |
| ***Human Wealth*** | | | | |
| Human Wealth | 115.98 | 119.81 | 32.41 | 28.22 |
| Ratio of Human over Financials | 23.02 | 13.50 | 38.80 | 12.42 |
| Ratio of Human over Financials+RE | 18.27 | 10.33 | 38.60 | 12.14 |
| Ratio of Human over Financials+Parents RE | 17.31 | 8.90 | 34.39 | 9.95 |
| Observations | 1941 | | 1941 | |

The assets are expressed in terms of million Yen. The rather large gap between share of risky assets in positions held by the male and female is suggestive evidence in favor of higher degrees of risk aversion in women's preferences.

In addition, the survey asks females to whom the survey is administered about their own portfolio in addition to their family's portfolio. The family portfolios are managed overwhelmingly by the males. This distinction between the family's portfolio and female's portfolio presents an opportunity to infer the risk-preference heterogeneity across gender. We can compare the share of investment in risky assets across two portfolios. Note that for this exercise to work, we do not require a perfect separation in ownership of assets across the two portfolios. Even if it is the case that assets in both portfolios are owned by ”the household,” these are two portfolios managed by each one of the spouses. It is not unreasonable to assume that the portfolio the female manages is influenced more by her risk preferences. Similarly, the family's portfolio that the male manages is influenced more by his risk preferences.

There are legal structures in Japan that incentivize women to have separately owned assets. According to Japanese divorce law, the splitting rule of assets upon divorce is rather vague and traditionally unfavorable to women as we delineate below.

The general rule of asset division upon divorce is that the assets that are accumulated since the start of marriage, which is called *matrimonial assets*, should be divided between the couple. However, there are important caveats that makes the situation murkier compared to the US, where in the absence of prenuptial agreements, the matrimonial assets would be split equally by law (Suzuki, 2012).

First, the properties that are inherited or ”given” to a spouse are not considered matrimonial assets. Therefore, they is excluded from division in the case of divorce. These assets are called ”separate assets.” Note that even if the marriage predates the possession of the asset, it would not be divided. Second, the owner of the asset can sell

Table 5.2: The fixed effects regression of fraction of investment in risky assets across gender with clustered standard errors

| | Financial Assets | | Financials + Real Estate | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Physical Wealth | 0.152 | 0.0285 | 0.111* | 0.0462 |
| | (1.64) | (0.11) | (1.93) | (0.18) |
| Female Share in HH Wealth | −5.201 | −8.998** | −4.705 | −9.073** |
| | (−1.52) | (−2.24) | (−1.41) | (−2.27) |
| Human Wealth Ratio | 0.0609*** | 0.0328* | 0.0329** | 0.0325* |
| | (3.15) | (1.70) | (2.04) | (1.67) |
| Age | −0.106 | 0.496** | −0.132 | 0.489** |
| | (−0.70) | (2.48) | (−0.93) | (2.41) |
| Number of Kids=1 | 0.836 | −1.305 | 0.910 | −1.286 |
| | (0.33) | (−0.45) | (0.36) | (−0.44) |
| Number of Kids=2 | 1.412 | −1.630 | 1.515 | −1.598 |
| | (0.52) | (−0.51) | (0.57) | (−0.49) |
| Number of Kids=3 | 1.496 | −0.592 | 2.197 | −0.517 |
| | (0.40) | (−0.12) | (0.59) | (−0.10) |
| Own The Lot | 5.252 | 5.471 | 5.258 | 5.433 |
| | (0.65) | (0.57) | (0.65) | (0.56) |
| Own The House | −2.593 | −5.123 | −2.643 | −5.060 |
| | (−0.32) | (−0.53) | (−0.32) | (−0.53) |
| Observations | 1932 | 1932 | 1931 | 1932 |

*t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All of the regressions control for the household fixed effects. Since education is time-invariant, it has been taken into account through the fixed effects approach. The units on physical wealth are one million Yen, which is roughly 9000 USD based on the average exchange rate in the course of our sample. The dependent variable is the percentage of each spouse's savings fund which is invested in risky assets. We check the robustness of results by using different definitions for the physical wealth in the columns of the table. In the first column, we only use the total investment in risk-free and risky investments. In the second column, in addition to investments, we include the value of real estate if the household owns a house. Since we know the owner of the real estate, we augment each spouse's physical wealth with his or her value of owning real estate. Standard errors are clustered at the household level.

it at any time. There is no legal barrier to prohibit the owner from exercising his/her right before the asset division. Third, the court has no power to enforce the disclosure of properties. Fourth, Japanese law does not provide a clear division ratio. In fact, the division ratio of the assets has been traditionally in favor of men. In practice, it has been somewhere between 70/30 and 50/50. Thus, even in the case of division, it is hardly an equal distribution. Overall, this legal environment provides incentives for spouses, especially women, to have their names on deeds and accumulate their own assets, separate from the family's fund (Otani, 2012).

Table 5.1 shows the breakdown of males' and females' portfolios. The monetary value of assets are expressed in terms of millions of Yen. The first block demonstrates the financial assets, which are the focus of our discussion. By average, 27% of the male's portfolio is invested in risky assets whereas the share of risky investment is 21% in the female's portfolio. There is a starker difference across gender at the median. The median male's portfolio holds 21% of its position in risky assets whereas only 4% of the median female's portfolio takes a position in risky assets. The rather large gap between share of risky assets in positions help by the male and female is suggestive evidence in favor of higher degrees of risk aversion among women.

The second block of Table 5.1 breaks down the ownership of real estate. Though tangential to our focus, it is interesting to explore. In Japan, the value of building is assessed separately than the value of a lot. 70% of households own the building in which they live. 65% own the lot in addition to the building. The owner of the real estate is overwhelmingly the male. The table demonstrate the mean value of assets invested in real estate, which includes zeros for the household members who are not homeowners. We also report the mean value of the building and lot for the homeowners. A considerable number of households live in the houses owned by the male's or female's parents. We report the value of the real estates for the households in this living arrangement.

Note that the test presented in this section has power only when at least either the wife or husband holds risky assets in his/her portfolio. As the number of observations in Table 5.1 indicates, only a rather small fraction of households would ever invest in risky assets. It amounts to about 13% of households. It is worth noting that the sample of households who hold positions in risky assets are more educated than the full sample.

## 5.5 Estimates in a subsample with greater disparity in risk-aversion

In this section, we test the prediction of proposition 3. The proposition implies that the gap in the passthrough coefficients should be larger when the risk-aversion disparity between husband and wife is greater. Our empirical strategy for this exercise is to estimate the passthrough coefficients on a subsample of data that demonstrate a greater degree of heterogeneity in risk aversion between the husband and wife. According to Proposition 3, in a subsample where the disparity in risk aversion is larger than that of the full sample, we expect the gap in passthroughs to soar.

To implement this empirical strategy, first, we need to find a shifter that varies the degree of heterogeneity in risk aversion. One candidate that is suggested in the literature is the share of human wealth to physical wealth. Human wealth at any given time is the sum of expected future labor earnings until retirement. Wachter and Yogo (2010) find that individuals with higher human wealth to total wealth ratios are more willing to take risks and take higher positions in risky assets in their investment portfolios. The economic rationale is that these individuals have greater incentive to diversify their large amounts of non-tradable human capital. Table 5.1 reports the mean value of estimated human wealth across gender. Given the low attachment of Japanese women to the labor force, the female's human wealth is considerably smaller than the male's. Figure B.5 demonstrates the evolution of the ratio of human wealth to physical wealth in the lifecycle. The human wealth ratio decreases as the individual grows older.

However, individuals with higher human wealth to physical wealth ratios are less able to smooth labor market shocks due to their lower levels of physical wealth. Lack of physical wealth makes it more likely for the credit constraint to be binding. Thus it diminishes the ability of an individual to smooth shocks. In fact, as we will demonstrate in section 8.2 in equation A.13, the passthrough coefficients of a permanent shock are increasing in the human wealth ratio. Therefore theoretically, we expect the individuals with a higher human wealth ratio to have a higher passthrough coefficient due to their higher risk tolerance, in addition to their inability to smooth shocks because of their binding credit constraint. Although the human wealth ratio as a shifter for risk tolerance is confounded by the credit constraint, we can at least interpret the results as an upper bound for risk aversion. Because, as equation A.13 demonstrates, the risk aversion effect and credit constraint effect affect the the passthrough coefficient in the same direction.

To test whether in our data the risk aversion which is represented in the share of risky assets can be explained by the share of human wealth, we run a model to explain the share of investment in risky assets. We do this exercise only on a subset of households who ever invest in risky assets, which constitutes about 13% of our sample. To control for confoundedness of the credit constraint, we include the level of physical wealth as a control as well. In addition, we control for demographics and the total share of assets held in the female's portfolio. We also include the household fixed effects. Table 5.2 reports the results of this model. The coefficient on the share of human wealth in both male's and female's portfolio is positive and significant at the conventional levels. This is true whether in the definition of the physical wealth we exclude the real estate (the first

Table 5.3: The estimation of partial insurance parameters on a subsample with different degrees of spread in risk aversion between husband and wife

| | (1)<br>Full Sample | (2)<br>High Human Wealth Ratio |
|---|---|---|
| $\phi_f$ | 0.105 | 0.303* |
| | (0.300) | (0.066) |
| $\phi_m$ | 0.308*** | 0.553*** |
| | (0.003) | (0.006) |
| $\sigma_u^2$ | 0.032*** | 0.040*** |
| | (0.000) | (0.000) |
| $\sigma_v^2$ | 0.025*** | 0.026*** |
| | (0.000) | (0.000) |
| $\phi_m - \phi_f$ | 0.203** | 0.250* |
| | (0.033) | (0.079) |
| $\Delta(\phi_m - \phi_f)$ | | 0.048 |
| | | (0.334) |
| Observations | 15003 | 7501 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The partial insurance parameters are estimated using GMM. The p-values are reported in parentheses in the last three rows, which are calculated by block bootstrap. $\Delta(\phi_m - \phi_f)$ denotes the difference in the gap in passthroughs between the specified subsample and the full sample. High human wealth ratio specifically includes the subjects above the median ratio of human wealth to physical wealth.

column) or include the real estate (the second column).

Given the identified predictors of risk aversion, we construct the following binary shifters to partition the sample into two subsamples with differential degree of heterogeneity in risk aversion. We define *High Human Wealth* as the households whose husband's ratio of human wealth to physical wealth is above the median. This would slice the households whose husband is more risk tolerant, which in turn increases the difference in degree of risk aversion with their wives. All this assumes no perfect positive correlation between the ratios of human wealth of the husband and wife. In our data, there is a positive correlation at 0.46, which dampens the effect to some extent, but it is far from perfect correlation. Again, one should take the results of this shifter with caution due to the confounding effect of the credit constraint.

Table 5.3 demonstrates the estimates of passthroughs in the subsamples. $\phi_m - \phi_f$ row shows the the estimates of the passthrough in the full sample and each one of the subsamples. $\Delta(\phi_m - \phi_f)$ denotes the difference in the gap in passthroughs between the specified subsample and the full sample. As the theory predicts, the gap is larger for the households whose husband has a higher share of human wealth. Also note that both the male's and female's passthroughs are greater than their counterparts in the full sample. The male's passthrough is larger by construction, as we condition on the husband's human wealth ratio. But, due to positive correlation in human wealth across couples, we also get a larger passthrough coefficient for females. The sign of the difference in the gap between high human wealth and the sample as a whole is positive. However, the standard error is large.

## 5.6 Evidence from experimental studies

Our finding about the heterogeneity in risk aversion is in line with a significant strand of literature in experimental and behavioral economics. These studies employ experimental designs that rather consistently find women are more risk averse than men. The experiment designs include abstract gamble experiments, contextual environmental experiments, and evidence from filed studies. Some examples of the studies are Borghans et al. (2009) and Harbaugh (2002) . For a review of these studies refer to Eckel and Grossman (2008).

Moreover, using PSID, Hryshko et al. (2011) finds gender as a significant determinant of risk preference. Confirming the experimental studies, they find that female subjects in PSID exhibit higher risk aversion than male subjects. Paola Sapienzaa and Maestripieri (2009) investigate whether women's higher risk aversion can be explained by the differences in testosterone levels between men and women.

# CHAPTER 6

# MECHANISM II: THE THREAT OF DIVORCE

In the previous section, we modeled the household's decision making in the absence of strategic interaction. The spouses' objective was to achieve efficiency. Thus, they solved the planner's problem. In this section, we allow for the violation of efficiency and strategic behavior. In particular, we consider a repeated game of specialization with the threat of divorce. By specialization, we mean a setting in which only the husband works and specializes in labor market productivity, whereas the wife stays at home and specializes in home production. Specialization is a suitable assumption given our data, where the attachment of Japanese women to the labor force is not strong.

Given the specialization scheme, we assume that it is the husband who decides about the allocation of his earnings between his own consumption and his wife's. In return, it is up to the wife to stay in the marriage or seek divorce. She makes the decision about divorce by comparing the value she would receive in the marriage with the value of her outside option. We consider a framework with a two-sided lack of commitment.

The main intuition behind our theoretical result is as follows: If couples specialize, the female's outside option is independent of the male's earnings. Thus the volatility in the male's earnings should not affect the female's outside option. Therefore, as we will explain in more detail, the husband has little incentive to transfer his earnings volatility to his wife's consumption path. The outline of this chapter is as follows: In the section 6.1, we formalize our intuition. Then in the section 6.2, we provide empirical evidence in support of the existence of this mechanism.

## 6.1 Theoretical illustration

In this section, we write a model to provide an economic interpretation for our main empirical result, that the male's private consumption is less insured than his wife's. To rationalize this asymmetry, we base our model on the most apparent difference between males and females in our data: the fact that women substantially work less both in the intensive and extensive margins.

To model the observed difference in labor market productivity across gender, we take the extreme case of specialization, in that we assume that only men can work and have earnings. The male's random earnings, $y_t$, follows an i.i.d. process which is distributed with c.d.f. of $F(y)$ on a positive support such as $(0, y_{max}]$.

On the other hand, women are productive in household production. Men are not equipped with household production technology. Women are heterogeneous in terms of time-invariant household production's productivity, $x$ that lies on the continuum $(0, x_{max}]$. The female converts her productivity to household production by way of an identity technology $g(x) = x$.

The marriage provides a means for males and females to improve social welfare by taking advantage of specialization. The husband earns money and the wife produces household production. To focus on private consumption, we assume that there is no public consumption. Moreover, there is no saving. Therefore, the husband's earnings should be divided between the spouses' private consumption in each period. The wife gets utility only from her private consumption, $c_f$. The female's utility in her private consumption is strictly increasing

$$\frac{\partial u_f(c_f)}{\partial c_f} > 0$$

The male gets utility from his own private consumption and his wife's household production. His utility with respect to private consumption and household production is strictly increasing

$$\frac{\partial u_m(c_m, x)}{\partial c_m} > 0$$
$$\frac{\partial u_m(c_m, x)}{\partial x} > 0$$

In addition, assume that the male prefers marrying to any type of woman to singlehood so long as his private consumption is positive

$$u_m(y_{max}, 0) < u_m(c_m, x) \quad \text{s.t.} \quad 0 < c_m < y_{max} \quad 0 < x \leq x_{max} \tag{6.1}$$

The spouses are infinitely lived. They engage in a repeated game. In each period, after realization of the male's random earnings, the male proposes part of his earnings to his wife, $c_{f,t}$. Since there is no storage mechanism, he consumes the rest of his earnings as his own private consumption, $c_{m,t}$. Finally, the female either accepts $c_{f,t}$ offer and the marriage survives for one more period or she rejects the $c_{f,t}$ offer and seeks divorce. Thus the male decides about the transfer and the female decides about divorce in each period.

If the marriage is dissolved, the female will collect her time-invariant autarky value, $v(x)$, which is heterogeneous with respect to her household production's productivity. In the case of divorce, the male stays single forever. This assumption plus (11.3) implies that the male's value of marrying to any type of female is greater than singlehood.

In the following proposition, we show that this repeated game has a simple equilibrium.

**Proposition 4.** *The following profile strategy is an equilibrium of the repeated game of specialization. In every period $t$, the male allocates $c_{f,t} = c^*$ to his wife where $c^*$ satisfies the following property:*

$$u_f(c^*) + \sum_{s=1}^{\infty} (1 - F(c^*))^{s-1} F(c^*) \frac{1 - \beta^s}{1 - \beta} u_f(c^*) = v(x) \tag{6.2}$$

*The female decides to divorce in the first period when $y_t \leq c^*$.*

*Proof.* We prove the proposition by way of contradiction. The negation of the stated strategy profiles necessitate that there is at least one period in which deviation from the profile strategy is advantageous for either the male or female. We call that period, period $t$.

The value of marriage for a married female at time $t$ is as follows

$$V_t = u_f(c_{f,t}) + \sum_{s=1}^{\infty} P_{t+s} \sum_{j=0}^{s-1} \beta^j u_f(c_{f,t+j}) \tag{6.3}$$

where $P_{t+s}$ is the probability that divorce happens at period $t + s$ where by that point the female has received $\sum_{j=0}^{s-1} \beta^j u_f(c_{f,t+j})$ worth of utility in terms of consumption from her husband.

First, we show that given the female's strategy, it is not optimal for the male to deviate from his strategy at time $t$. Assume that the male allocates something less than $c^*$ at time

$t$ to his wife, i.e., $c_{f,t} = c^* - \varepsilon$ for $\varepsilon > 0$. Then

$$\begin{aligned} V_t &= u_f(c^* - \varepsilon) + \sum_{s=1}^{\infty} Pr(y_{t+s} \leq c^*) \sum_{j=0}^{s-1} \beta^j u_f(c^*) \\ &= u_f(c^*) - \tilde{\varepsilon} + \sum_{s=1}^{\infty} (1 - F(c^*))^{s-1} F(c^*) \frac{1-\beta^s}{1-\beta} u_f(c^*) \\ &= v(x) - \tilde{\varepsilon} \end{aligned} \tag{6.4}$$

where the second equality is because of the i.i.d. assumption about the earnings process. Moreover $\tilde{\varepsilon} > 0$ due to the fact that $\dfrac{\partial u_f(c_f)}{c_f} > 0$. Since $V_t < v(x)$, the female seeks divorce. However, due to (11.3) and the fact that the male will stay single forever after divorce, the male would be worse off by setting $c_{f,t} < c^*$. This contradicts the assumption that a downward deviation from $c^*$ is optimal.

Now, we show that setting $c_{f,t}$ above $c^*$ is not optimal either. With a similar argument to (6.4), one can show that in that case $V_t = v(x) + \tilde{\varepsilon}$. Whereas setting $c_{f,t} = c^*$ results in $V_t = v(x)$. Either way, the female would not seek divorce. However, the male would receive strictly less utility in period $t$ by setting $c_{f,t}$ above $c^*$ because

$$u_m(y_t - (c^* + \varepsilon), x) < u_m(y_t - c^*, x)$$

as $u_m(c_m, x)$ is strictly increasing in $c_m$. This contradicts the assumption that an upward deviation from $c^*$ is optimal.

Second, we need to show that given the male's strategy, it is not optimal for the female to deviate from the $D = \mathbf{1}\{y_t \leq c^*\}$ divorce strategy. By way of contradiction, assume that $t$ is the first period in which $y_t$ falls below $c^*$ , but the female decides to deviate from her strategy and keep the marriage. Since $y_t \leq c^*$, this implies that she has accepted a proposal $c_{f,t} < c^*$. As we showed in (6.4), this implies that $V_t < v(x)$, which contradicts the assumption that the deviation is optimal. □

Proposition 1 formalizes a simple intuition. The male makes a decision about consumption allocation and the wife's decision affects separation. The wife's autarky value is independent of the male's earnings but depends on her own productivity. Imagine that the husband's earnings are hit by an advantageous shock. The husband has little incentive to transfer a large part of his excessive earnings to the wife because neither his consumption nor household production in the current period rise. Nor does the transfer make the marriage more stable in the future, when he would face a disadvantageous shock, as the female cannot commit to not exercise her outside option.

On the other hand, consider the case of facing an adverse shock in earnings. Again, the wife's outside option has not lessened. But, the husband would like to prevent the separation as he will prefer being married over singlehood. Thus, he refuses to pass a large part of the adverse shock to the wife by substantially cutting her consumption. Therefore, the wife's consumption would respond less to the changes in earnings than the husband's. This result is readily available from proposition 1 , and we state it in the following proposition.

**Proposition 5.** *The passthrough of earnings volatility to the male's consumption is higher than the passthrough of earnings volatility to the female's consumption.*

*Proof.* Since we showed in Proposition 4 $c_{f,t} = c^*$ for all $t$

$$\frac{\partial c_{f,t}}{\partial y_t} = \frac{\partial c^*}{\partial y_t} = 0$$
$$\frac{\partial c_{m,t}}{\partial y_t} = \frac{\partial (y_t - c_{f,t})}{\partial y_t} = \frac{\partial (y_t - c^*)}{\partial y_t} = 1$$

Thus

$$\frac{\partial c_{m,t}}{\partial y_t} > \frac{\partial c_{f,t}}{\partial y_t}$$

□

Our frictionless environment captures the extreme case that all of the earnings volatility is born by the male and the female's consumption enjoys full insurance.

## 6.2 Empirical evidence

In order to test whether we find empirical evidence in support of the the threat of divorce mechanism, our empirical strategy is as follows. We estimate the gap in passthroughs in subsamples of households who have a systematically higher or lower propensity to divorce. For the household whose propensity to divorce is higher, the threat of divorce is more substantial. Our theoretical framework has two testable predictions for this subsample. First, we expect to see higher levels of insurance in the females's consumption. As the threat of divorce is more real for these households, the husband is more willing to provide insurance to his wife, who is on the edge of leaving the marriage. Second, we expect the gap in passthroughs to be greater. Since the husband has to provide more insurance to his wife, he bears the bigger portion of earnings volatility on his own consumption.

Alternatively, for the household whose propensity to divorce is lower, the threat of divorce is less substantial. Thus we expect to see lower levels of insurance in the females's consumption and a lower gap in passthroughs. Thus, the husband feels less compelled to provide insurance to his wife, as he sees her far from the threshold of leaving the marriage.

Table 6.1: The model explaining divorce

| | Logit | Probit |
|---|---|---|
| ***Relationship Quality*** | | |
| Quite Satisfaction with The Relationship | 0.315 | 0.111 |
| | (0.65) | (0.69) |
| Moderate Satisfaction with The Relationship | 1.592*** | 0.575*** |
| | (3.53) | (3.74) |
| A Little Satisfaction with The Relationship | 2.545*** | 0.952*** |
| | (5.49) | (5.87) |
| Not At All Satisfied with The Relationship | 3.772*** | 1.520*** |
| | (7.93) | (8.70) |
| ***Demographics*** | | |
| Number of Children ≥ 2 | -0.587*** | -0.225*** |
| | (-3.21) | (-3.15) |
| Female Is Out of Labor Force | -0.880*** | -0.335*** |
| | (-4.06) | (-4.12) |
| Reside in Small Cities | 0.058 | 0.040 |
| | (0.27) | (0.48) |
| Reside in Rural Areas | -0.144 | -0.054 |
| | (-0.44) | (-0.42) |
| Male Is College Graduate | -0.641 | -0.277 |
| | (-1.45) | (-1.57) |
| Female Is College Graduate | -1.046 | -0.402 |
| | (-1.32) | (-1.28) |
| ***Time Variables*** | | |
| Duration of The Marriage | 0.089 | 0.042 |
| | (0.82) | (0.99) |
| Square of Duration of The Marriage | -0.007 | -0.003 |
| | (-1.13) | (-1.34) |
| Wife's Age | 0.077 | 0.006 |
| | (0.29) | (0.06) |
| Square of Wife's Age | -0.001 | -0.000 |
| | (-0.40) | (-0.17) |
| Husband's Age | -0.215 | -0.083 |
| | (-1.22) | (-1.18) |
| Square of Husband's Age | 0.002 | 0.001 |
| | (1.07) | (1.03) |
| Observations | 14668 | 14668 |

The dependent variable in both logit and probit specifications is the occurrence of divorce in a given household-time instance. The model includes all calendar time dummy variables as additional controls that are not reported in the table for brevity. The standard errors are clustered at the household level.

To implement the test on the predictions of the theory, first, we need to find some shifters that vary the likelihood of divorce. Table 6.1 reports the coefficients of a logit and probit prediction model of divorce. Among the many predictors, only a few are statistically different than zero at the conventional levels. The single most important predictor of divorce is the level of satisfaction with the marital relationship. Each higher level of dissatisfaction increases the likelihood of divorce substantially. Given the importance of love in a relationship to sustain the marriage, our finding is hardly surprising.

The next significant predictor of divorce is a higher number of children. In particular households who have at least two children are less likely to divorce. This result is also not surprising as more stable marriages are conducive to having a higher number of children. In addition, by reverse causality, higher numbers of children increase the cost of divorce and can act as a deterrent to the female's decision to seek divorce.

Given the identified predictors of divorce, we construct the following binary shifters to partition the sample into two subsamples with differential likelihoods of divorce. We define *unhappy marriage* as the marriage whose relationship satisfaction level is only moderate, little, or not at all. The happy marriages are the ones with a quite or very much level of satisfaction with the relationship. With this partitioning, we split the sample such that the number of households in each partition is not too different. We also define the shifter, *high number of children*, as having at least two children. Thus the subsample, *low number of children*, is defined as households with no children or at most one child. Therefore, in the subsample of unhappy marriages, the threat of divorce is more substantial, whereas in the subsample of households with high numbers of children, the threat of divorce is less substantial.

Table 6.2: The estimation of partial insurance parameters on subsamples of data with differential propensity to divorce

| | (1)<br>Full Sample | (2)<br>Unhappy Marriages | (3)<br>More Children |
|---|---|---|---|
| $\phi_f$ | 0.105 | -0.012 | 0.201 |
| | (0.300) | (0.935) | (0.111) |
| $\phi_m$ | 0.308*** | 0.276** | 0.250** |
| | (0.003) | (0.049) | (0.031) |
| $\sigma_u^2$ | 0.032*** | 0.031*** | 0.027*** |
| | (0.000) | (0.000) | (0.000) |
| $\sigma_v^2$ | 0.025*** | 0.034*** | 0.029*** |
| | (0.000) | (0.000) | (0.000) |
| $\phi_m - \phi_f$ | 0.203** | 0.287* | 0.049 |
| | (0.033) | (0.057) | (0.339) |
| $\Delta\phi_f$ | | 0.117 | 0.096 |
| | | (0.176) | (0.186) |
| $\Delta(\phi_m - \phi_f)$ | | 0.084 | -0.154** |
| | | (0.270) | (0.049) |
| Observations | 15003 | 5598 | 7521 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$\phi's$ denote the passthrough coefficient on permanent shocks to the household's earnings. $\psi's$ denote the passthrough coefficient on transitory shocks. $m$, $f$, $p$, and $k$ denote male, female, public, and children's consumption. $\Delta\phi_f$ denotes the difference in the female's passthrough coefficient between the specified subsample and the full sample. Similarly, $\Delta(\phi_m - \phi_f)$ denotes the difference in the gap in passthroughs between the specified subsample and the full sample. The partial insurance parameters are estimated using GMM. The p-values are reported in parentheses in the last three rows, which are calculated by block bootstrap.

Table 6.2 demonstrates the estimates of passthroughs in the subsamples. $\phi_m - \phi_f$ row shows the estimates of the passthrough in the full sample and each one of the subsamples. $\Delta(\phi_m - \phi_f)$ denotes the difference in the gap in passthroughs between the specified subsample and the full sample. As the theory predicts, the gap is larger for the unhappy marriages and smaller for the households with higher numbers of children. The sign of the difference in the gap between unhappy marriages and the sample as a whole is positive. However, the standard error is not small. The gap in in the households with high numbers of children is smaller than the sample as a whole and the difference is statistically significant at the five percent level.

Moreover, the theory predicts that the female's passthrough should be smaller in the unhappy marriages than the full sample. But, it should be larger in the subsample of households with high numbers of children than in the full sample. These predictions are in line with our empirical results. $\Delta\phi_f$ denotes the difference in the female's passthrough coefficient between the specified subsample and the full sample in Table 6.2. Consistent with theoretical expectations, the sign of $\Delta\phi_f$ is positive in unhappy marriages and is negative in households with high numbers of kids. The p-values on these differences, though not smaller than 0.1, are not too large.

To sum up this chapter, we introduce the threat of divorce as a possible mechanism that can explain the emerging gap in passthroughs. We illustrate theoretically how a two-sided lack of commitment along with specialization can generate the gap in passthroughs. We present empirical evidence in support of this mechanism. In particular, we verify two testable predictions of the theory that, in the households where the threat of divorce is more serious, the female's passthrough is smaller but the gap in passthroughs is larger. We use two shifters to vary the intensity of the threat of divorce as a mechanism.

The shifters are the household with unhappy marriage and the household with high numbers of children.

# CHAPTER 7

# DISCUSSION ON MECHANISMS

In the previous two chapters, we provide some empirical evidence in support of both the risk-aversion heterogeneity mechanism and the threat of divorce mechanism. But, in terms of the magnitude of effect, which mechanism is the dominant one? In this section, we shed some light on this question.

First, we compare the extent that predictors of each mechanism are able to move the gap in passthrough in the expected direction from the baseline, namely the full sample estimate of the gap. To facilitate comparison, Table 7.1 collects these results from Table 5.3 and Table 6.1. Table 7.1 demonstrates that predictors of the threat of divorce mechanism are able to drive the gap in passthroughs further from its estimate in the full sample. In addition, the deviations associated with the threat of divorce are estimated more precisely. In other words, the point estimates of deviations generated by the threat of divorce are larger and also statistically more significant.

In the subsample with greater heterogeneity in risk aversion, the gap grows by 24% relative to the baseline. On the other hand, in the subsamples of households with less satisfying relationships and those with higher numbers of children, the gap deviates from the baseline by 41% and 76%, respectively. As explained in the section 6, the threat of divorce in these subsamples is less substantial and more substantial, respectively. Comparison of the standard errors is also in line with the demonstrated pattern in point estimates. While the p-value of the deviation induced by risk aversion is fairly large, the corresponding p-value for the unhappy marriages is smaller and the corresponding p-value for the subsample with higher numbers of children is significant at the 5 % level.

Table 7.1 reports the results from deviation from the baseline in only one direction. In

Table 7.1: Comparing the magnitude of the risk-aversion heterogeneity and the threat of divorce mechanism in explaining the gap in passthroughs

| | (1)<br>Mechanisms | (2)<br>Estimates of The<br>Gap in Passthroughs | (3)<br>Difference from<br>Full Sample |
|---|---|---|---|
| High Human Wealth Ratio | Risk Aversion<br>Heterogeneity | 0.250*<br>(0.079) | 0.048<br>(0.334)<br>[24 %] |
| Unhappy Marriage | Threat of<br>Divorce | 0.287*<br>(0.057) | 0.084<br>(0.270)<br>[41 %] |
| High Number of Children | Threat of<br>Divorce | 0.049<br>(0.339) | - 0.154**<br>(0.049)<br>[- 76 %] |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To compare the relative magnitude of the effect of the mechanisms, the table collects the estimates of the gap in passthroughs that can be attributed to each one of the proposed mechanisms. The second column reports the estimated gap in passthroughs in the described subsample. The third column reports the difference of the gap in the passthrough estimate between the second column and the full sample estimate. This difference is an indication of the strength of the mechanism in widening or narrowing the gap in passthroughs. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.11 in Appendix C, in a more congested table, we report the results from deviation in both directions. The aforementioned pattern survives when one studies the other directions too. In the next subsection, we do a more careful exercise to compare the magnitude of the mechanisms.

## 7.1 The conditional power of mechanisms

The question motivating this exercise is as follows: after controlling for one of the two mechanisms, what amount of power is left for the other mechanism to explain the gap in passthroughs? To implement the idea we study the interaction of mechanisms by estimating the gap in the *double conditioned* subsamples. The double conditioned subsamples are the ones for which we control for both mechanisms.

In the double conditioned subsamples, both mechanisms can move in the same direction such that, by reinforcing each other, the gap is driven to very high or low levels. Alternatively, the two mechanisms can move in the opposite direction, where the gap moves in the direction that the dominant mechanism dictates. The latter case is of particular interest for our purpose in this section. Because, in the horse race between the two mechanisms, the realized direction of deviation of the gap from the baseline can reveal the underlying relative power of the mechanisms.

Table 7.2 shows the residual effect of the threat of divorce after controlling for risk-aversion heterogeneity. The second column reports the gap in the single conditioned control group. The control group slices the households with greater risk-aversion heterogeneity, which subsequently leads to a higher gap than the baseline. In the first column, we pick a segment of households in the control group for whom the threat of divorce is less substantial, by virtue of being a more satisfying relationship. For this segment, the threat of the divorce mechanism works against risk-aversion heterogeneity.

Table 7.2: The effect of the thereat of divorce mechanism after controlling for the risk-aversion heterogeneity mechanism

| | (Smaller Gap) High Human Wealth Happy Marriage | High Human Wealth | (Larger Gap) High Human Wealth Unhappy Marriage |
|---|---|---|---|
| Subsamples | 0.187 | 0.250* | 0.317* |
| | (0.216) | (0.079) | (0.099) |
| | | | |
| Differences | - 0.063 | | 0.066 |
| | (0.383) | | (0.372) |
| | [- 25%] | | [26 %] |
| Observations | 3376 | 7501 | 3305 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the level of heterogeneity in risk aversion. In particular, we focus on the subsample in which the heterogeneity is higher than the full sample. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on households with a higher ratio of human wealth to physical wealth for the male, namely the below-median observations. The table uses self-reported happiness about the marital relationship as the predictor of divorce. The first and third columns report the gap in passthrough between the two groups within the controlling subsamples that have differential propensity to divorce. The first column is the group with a smaller propensity to divorce and the third column is the group with a larger propensity to divorce. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third column from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses, which are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Therefore, the gap is diminished by 25% relative to the control group as a whole.

In contrast, the third column picks a segment of the households from the control group for whom the threat of divorce is more substantial due to their less satisfying marital relationship. In this segment, the threat of divorce in fact reinforces the effect of risk-aversion heterogeneity. Therefore, the gap is amplified by 26% relative to the control group as a whole. Thus one would expect the estimated gap to be increasing from the first column to the third column.

We can interpret the negative 25% and positive 26% deviations from the control as the residual power of the threat of divorce mechanism in moving the gap, in addition to the risk-aversion heterogeneity mechanism, while controlling for the degree of risk-aversion heterogeneity. Now we need to flip the roles and estimate, while controlling for the threat of divorce, how much extra deviation can be attributed to the risk-aversion heterogeneity.

Table 7.3 shows the residual effect of risk heterogeneity after controlling for the threat of divorce mechanism. The second column reports the gap in the single conditioned control group. The control group slices the households with a more substantial threat of divorce, which subsequently leads to a higher gap than the baseline. In the first column, we pick a segment of households in the control group for whom risk aversion is less heterogeneous across gender by virtue of having a husband for whom the ratio of human wealth to physical wealth is smaller. For this segment, the risk-aversion heterogeneity is weakened and therefore works against the heightened threat of divorce in the control group. Thus, the gap is diminished by 11% relative to the control group as a whole.

In contrast, the third column picks a segment of the households from the control group for whom the risk-aversion heterogeneity is more pronounced due to the husband's

Table 7.3: The effect of the risk-aversion heterogeneity mechanism after controlling for the thereat of divorce mechanism

| | (Smaller Gap)<br>Unhappy Marriage<br>Low Human Wealth | Unhappy Marriage | (Larger Gap)<br>Unhappy Marriage<br>High Human Wealth |
|---|---|---|---|
| Subsamples | 0.253 | 0.287* | 0.317* |
| | (0.141) | (0.057) | (0.099) |
| | | | |
| Differences | - 0.034 | | 0.029 |
| | (0.438) | | (0.414) |
| | [- 11%] | | [10 %] |
| Observations | 2174 | 5598 | 3305 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the intensity of the threat to divorce by the female. In particular, we focus on the sample in which the propensity to divorce is higher and subsequently the threat of divorce is more substantial. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on households with lower levels of satisfaction in their marital relationship. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have differential levels of risk-aversion heterogeneity. The table uses the male's ratio of human wealth to physical wealth as the predictor of risk-aversion heterogeneity. The first column is the group with a smaller ratio of human wealth to physical wealth and the third column is the group with a larger ratio of human wealth to physical wealth. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third column from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses, which are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

higher ratio of human wealth. In this segment, the risk-aversion heterogeneity reinforces the threat of divorce. Therefore the gap is amplified by 10% relative to the control group as a whole. Thus, one would expect that the estimated gap increases from the first column to the third column.

Putting the Tables 7.2 and 7.3 beside one another presents a persuasive picture of the relative power of each mechanism. After controlling for the threat of divorce, risk-aversion heterogeneity can only move the gap by about 10% in either direction. Whereas the threat of divorce is able to move the gap by over 25% in either direction while the risk-aversion heterogeneity is controlled. Although both estimates are imprecise, the deviations induced by the threat of divorce are also statistically more significant than the ones induced by risk-aversion heterogeneity.

In Tables 7.2 and 7.3 we use satisfaction about the marital relationship as a shifter for the threat of divorce mechanism. The alternative is to use the number of children as the shifter. Moreover, to identify the control group in Table 7.3, we condition on unhappy marriages whereas, alternatively, we could condition on the other direction, namely happy marriages. Similarly, to identify the control group in Table 7.2, we condition on high levels of human wealth ratio whereas, alternatively, we could condition on the other direction, namely low levels of human wealth ratio. In Table C.12 through Table C.20 in Appendix C, we explore these alternative arrangements. However, the pattern that the threat of divorce is relatively stronger than risk-aversion heterogeneity persists. The threat of divorce, controlling for risk-aversion heterogeneity, varies the gap more markedly and with tighter confidence intervals.

We calculate the standard errors of the differences across subsamples by block bootstrap. These standard errors in general are fairly large, partly due to the small size of subsamples, especially in the double conditioned subsamples. However, in our vigorous robustness study presented in Table C.12 through Table C.20 in Appendix C, with no exception, the differences in the gap swing in the expected theoretical direction. Thus, despite the fact that the individual estimates of differences might suffer from large standard errors, the fact that, after trying assorted arrangements, all of the differences show up with correct signs is validating.

To sum up this chapter, in terms of the magnitude of the effect, we find evidence implying that the threat of divorce is more important than risk-aversion heterogeneity. We present two arguments in support of this statement. First, the estimates of the gap in passthroughs in subsamples with a more substantial threat of divorce is larger than the ones in subsamples with a greater degree of risk-aversion heterogeneity. Second, after controlling for risk-aversion heterogeneity, the variations in the threat of divorce are more capable of swinging the gap than the other way around, in which, after controlling for the threat of divorce, we vary the degree of risk-aversion heterogeneity. In other words, after controlling for the threat of divorce, there is less room for variation in risk-aversion heterogeneity to move around the gap in passthroughs.

# CHAPTER 8

# CONSUMPTION AND HOURS

Thus far we had focused solely on the household 's earnings without separating hours from wages. In this section, we do separate hours from wages and study how the hours interact with components of consumption. We also illustrate how non-separability of consumption and hours affects the passthrough coefficients of the labor market shocks. Finally, we estimate the Frisch elasticities of consumption components to determine whether private consumption and hours are substitutes or complements.

## 8.1 Theoretical illustration

Consider the case where there is disparity in market productivity between male and female in that the wage rates of men are higher than women, which is in line with our data. Consider an extreme view of this economy such that women's wage is zero. Thus, women do not work at all. Since we are abstracting from strategic interactions in this section, we consider a cooperative environment in which the couple solves the planner problem to achieve efficiency as follows:

$$\max_{c_m, c_f, l} \quad \mu u(c_m, l) + u(c_f, 1) \tag{8.1}$$

$$\text{s.t.} \quad c_m + c_f = w(1-l) \quad 0 \leq l \leq 1$$

where the fixed male's relative Pareto weight is denoted by $\mu$. Each spouse is endowed with one unit of time. Since the woman does not work, she spends all of her time endowment on leisure. Note that in this case individual utilities are identical. The optimality conditions of this planner problem requires that

$$\mu u_c(c_m^*, l^*) = u_c(c_f^*, 1) = \frac{1}{w} u_l(c_m^*, l^*) \tag{8.2}$$

After taking total differentiation of the first order conditions of the problem 8.1 we will have the following system of equations

$$\underbrace{\begin{bmatrix} \mu u_{cc}(c_m^*, l^*) & 0 & \mu u_{c,l}(c_m^*, l^*) & -1 \\ 0 & u_{cc}(c_f^*, 1) & 0 & -1 \\ \mu u_{c,l}(c_m^*, l^*) & 0 & \mu u_{l,l}(c_m^*, l^*) & -w \\ -1 & -1 & -w & 0 \end{bmatrix}}_{\mathcal{J}} \begin{bmatrix} dc_m \\ dc_f \\ dl \\ d\lambda \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \lambda^* dw \\ -(1-l^*)dw \end{bmatrix}$$

where $\lambda > 0$ is the marginal utility of wealth. Note that to insure the uniqueness of the solution to the system of equations, we assume that the objective function of the problem 8.1 is strictly quasi-concave. This implies that the Bordered-Hessian matrix $\mathcal{J}$ is negative semi-definite, requiring the border-preserving minor-principles alternate in sign starting with a negative. $\mathcal{J}$ is the third minor principle thus $|\mathcal{J}| < 0$. In the expressions below where we are concerned with the sign of solutions, we drop $|\mathcal{J}| < 0$ and only take into consideration its negative sign in our arguments.

First, we show that non-separability has an important role in explaining how hours would respond to the changes in wage rate.

$$\begin{aligned} \frac{dl^*}{dw} = -\frac{dh^*}{dw} = & \underbrace{\lambda^* \Big( \mu u_{c,c}(c_m^*, l^*) + u_{c,c}(c_f^*, 1) \Big)}_{\text{Substitution Effect}} \\ & + \underbrace{\mu (1-l^*) u_{c,c}(c_f^*, 1) \Big( w u_{c,c}(c_m^*, l^*) - u_{c,l}(c_m^*, l^*) \Big)}_{\text{Income Effect}} \end{aligned} \tag{8.3}$$

Note that the substitution effect is unambiguously negative. The necessary condition for the income effect to undermine the substitution effect is

$$u_{c,l}(c_m^*, l^*) > w u_{c,c}(c_m^*, l^*)$$

In general, as consumption and hours become more complementary, i.e. as $u_{c,l}(c_m^*, l^*)$ gets larger, it is more likely for the income effect to dampen the substitution effect.

Next, we are interested in comparing the male's passthrough coefficient for wages with the female's.

$$\frac{dc_m^*}{dw} - \frac{dc_f^*}{dw} = \underbrace{\lambda^*[\overbrace{-2\mu u_{c,l}(c_m^*, l^*)}^{\text{consumption-leisure complementarity effect}} + \overbrace{w\left(u_{c,c}(c_f^*, 1) - \mu u_{c,c}(c_m^*, l^*)\right)}^{\text{consumption concavity effect}}]}_{\textit{Substitution Effect}}$$
$$+ \underbrace{(1-l^*)[\overbrace{\mu u_{c,l}(c_m*, l^*)\left(\mu u_{c,l}(c_m^*, l^*) - w u_{c,c}(c_f^*, 1)\right)}^{\text{consumption-leisure complementarity effect}} + \overbrace{\mu u_{l,l}(c_m^*, l^*)\left(u_{c,c}(c_f^*, 1) - \mu u_{c,c}(c_m^*, l^*)\right)}^{\text{consumption concavity effect}}]}_{\textit{Income Effect}} \tag{8.4}$$

Each one of substitution and income effects in itself is comprised of the term representing the effect of concavity in consumption, i.e. the own second derivative, and the other term representing the effect of complementarity between the male's and female's consumption, i.e. the cross second derivative.

The interpretation of the consumption concavity effect is straightforward. If the concavity of the utility with respect to consumption is higher for the female at her optimum consumption, her marginal utility is more sensitive to changes in consumption; therefore, a smaller change in consumption would be needed to maintain the optimality conditions following a change in wages.

As expected, the degree of complementarity between consumption and leisure plays a major role in determining the wedge between the male's and female's consumption response to a change in the wage. First, consider the consumption-leisure margin in the substitution effect. The larger the $u_{c,l}(c_m^*, l^*)$ is, the more complementary are the male's consumption and his leisure. Thus, as shown in (8.3), the response of hours to a change in the wage rate would be more muted. Subsequently, the ensuing male's consumption adjustment would be smaller.

On the contrary, higher complementarity between consumption and leisure amplifies the male's consumption response from the perspective of the income effect. First, consider the case of super-modular utility, i.e. $u_{c,l} > 0$, where larger amounts of the cross derivative correspond to a higher degree of complementary. Since it is the income effect, consider the problem of allocating a non-labor shock in earnings between the male and female. With complementarily between consumption and leisure, as the male enjoys less leisure, his marginal utility of consumption is less responsive than his wife's, because equal changes in consumption result in lower changes in the male's marginal utility of consumption due to his smaller level of leisure. This requires higher changes in his consumption so that the planner can equalize the Pareto weighted marginal utilities according to the optimality conditions. As a result, as the complementarity between consumption and leisure grows stronger, the discrepancy in consumption responsiveness heightens.

Now, consider the case of sub-modular utility, $u_{c,l} < 0$, where more negative values indicate higher degrees of substitutability. The argument is made in a parallel fashion. In the sub-modular case, an equal change in consumption generates higher change in marginal utility of consumption for the male as he enjoys less leisure. Thus, the male's marginal utility is more responsive to consumption changes. Thus, the planner can adjust the Pareto weighted marginal utilities with a smaller change in the male's consumption.

Before concluding the theoretical discussion, it is worth noting that even though the observed pattern in consumption changes does not have an unambiguous theoretical implication, the pattern in levels of consumption has a notable theoretical ramification. In particular, empirically we observe that on average, men consume higher levels of private consumption but enjoy less leisure. The following proposition explores an implication of this specific pattern in level of consumption.

**Proposition 6.** *If the individual utility is super-modular and the male's optimal consumption is greater than female's optimal consumption, $c^*_m(w) > c^*_f(w)$, in the problem 8.1, then the male must have a higher Pareto weight, i.e. $\mu > 1$.*

*Proof.* We prove the proposition by way of contradiction, so assume that $\mu \leq 1$. The individual utility is super-modular if marginal utility of consumption is strictly increasing in leisure, $\frac{\partial^2 u}{\partial c \partial l} > 0$, which implies (given that $w > 0$)

$$wu_c(c^*_m, 1) > wu_c(c^*_m, l^*) \tag{8.5}$$

Since the $u_c(., 1)$ is strictly decreasing and $w > 0$, $c^*_m > c^*_f$ implies

$$wu_c(c^*_m, 1) < wu_c(c^*_f, 1) \tag{8.6}$$

On the other hand the optimality conditions of the problem 8.1 imply

$$\mu u_l(c_m^*, l^*) = w u_c(c_f^*, 1) \tag{8.7}$$

Combining (8.6) and (8.7)

$$w u_c(c_m^*, 1) < \mu u_l(c_m^*, l^*) \tag{8.8}$$

Combining (8.8) and (8.5)

$$w u_c(c_m^*, l^*) < \mu u_l(c_m^*, l^*)$$

if $\mu \leq 1$ then

$$w u_c(c_m^*, l^*) < u_l(c_m^*, l^*)$$

which contradicts the optimality condition of the problem 8.1 requiring

$$w u_c(c_m^*, l^*) = \mu u_l(c_m^*, l^*)$$

□

The proposition implies that, with the super-modular utility, we cannot have a situation where the male's consumption is higher, unless the Pareto weight is tilted enough in favor of the male. In other words, we observe a pattern in the data that in the representative household the male has higher consumption and lower leisure. The only way that super-modular utility *can* generate the observed pattern is when the male's Pareto weight is large.

What if the utility is sub-modular? It turns out that with sub-modular utility, it is not required for the male's Pareto weight to be higher in order to generate the empirical pattern. In other words, it might be the case that the female has higher weight but still the male enjoys higher consumption but less leisure. However, if the male has higher Pareto weight, with sub-modular utility, it must be case that the male's consumption is higher. We prove this point in the next proposition.

**Proposition 7.** *If the individual utility is sub-modular and male has higher Pareto weight in the problem 8.1, i.e. $\mu \geq 1$, then the male's optimal consumption is greater than female's optimal consumption, $c_m^*(w) > c_f^*(w)$.*

*Proof.* First, we show sub-modularity implies $c_m^* > c_f^*$. The individual utility is sub-modular if marginal utility of consumption is strictly decreasing in leisure, $\frac{\partial^2 u}{\partial c \partial l} < 0$. We prove the result by way of contradiction in that we show that $c_m^* \leq c_f^*$ leads to contradiction. If $c_m^* \leq c_f^*$, since the $u_c(.,1)$ is strictly decreasing

$$u_c(c_m^*, 1) \geq u_c(c_f^*, 1) \tag{8.9}$$

where equality happens if and only if $c_m^* = c_f^*$. Since $l^* < 1$, by sub-modularity

$$u_c(c_m^*, l^*) > u_c(c_m^*, 1) \tag{8.10}$$

Combining (8.9) and (8.9) yields

$$u_c(c_m^*, l^*) > u_c(c_f^*, 1)$$

if $\mu \geq 1$ then

$$\mu u_c(c_m^*, l^*) > u_c(c_f^*, 1)$$

which contradicts the optimality condition of problem 8.1 requiring

$$\mu u_c(c_m^*, l^*) = u_c(c_f^*, 1)$$

□

Therefore, assigning a higher relative Pareto weight to the male in the problem (8.1) is consistent with our data; either the underlying individual utility is super-modular or sub-modular. If the utility is super-modular, as is the case for the common utility functional form in the economic literature, this is a necessary outcome. But this result is also consistent with sub-modularity in utility function. The implication that the male ought to have a higher Pareto weight is also in line with the fact that Japan is still a country with fairly strong gender norms. In addition, the observed facts that men are the dominant bread-winner in the household and female labor force participation is not strong are more evidence in favor of assigning a higher Pareto weight to the male within the household.

But how large does the male's Pareto weight need to be? The short answer is that it depends on the degree of complementarity between consumption and leisure. This is another instance demonstrating the crucial role of complementarity between consumption and leisure. To get some sense about the the interaction of $\mu$ and the degree of complementarity, we provide some simulation results in the case of a constant elasticity of substitution (CES) utility function.

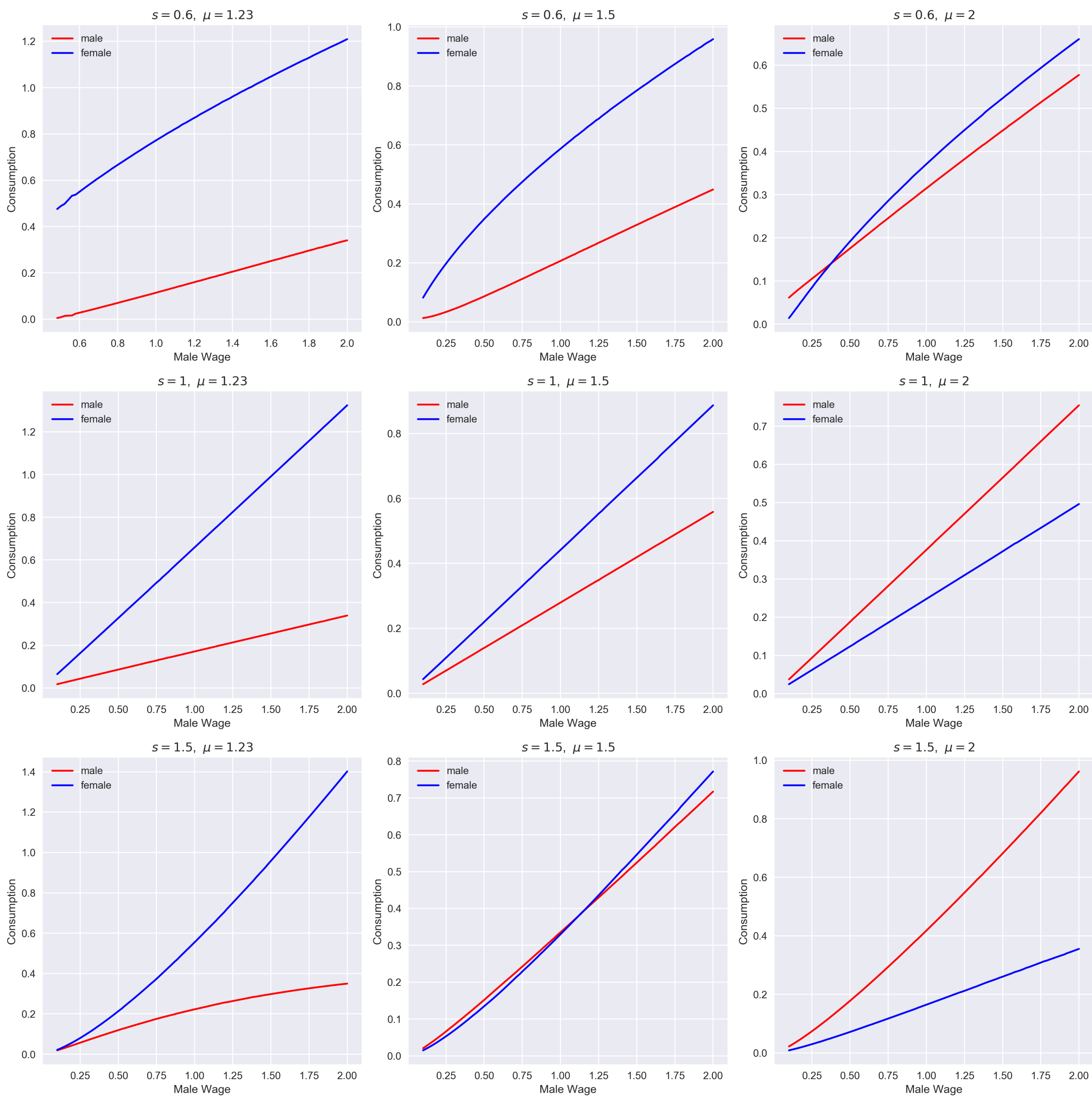
The simulated plots in Figure 8.1 demonstrate the optimal level of the male's and female's consumption as a function of the wage in the problem 8.1. The simulation is run with CES individual utility functional form with elasticity of substitution of $s = \frac{1}{1-r}$, $u(c,l) = (\frac{1}{2}c^r + \frac{1}{2}l^r)^{\frac{1}{r}}$. The plots in a row share the same elasticity of substitution and the plots in a column share the same relative Pareto weight, $\mu$. The advantage of the CES utility function is that the degree of substitutability (or complementarity) can be parametrized by way of a single parameter, namely the elasticity of substitution. The higher the elasticity of substitution is, the more a substitute (lower complement) consumption and leisure are.

For a given level of Pareto weight (within a column), as the consumption and leisure become more substitute (moving down along a column), the male's allocated consumption increases. Because, as complementarity between consumption and leisure weakens, the female loses her advantage in terms of having higher marginal utility of consumption due to her higher levels of leisure. On the other hand, for a given level of substitutability (within a row), as the male's Pareto weight increases, his consumption grows as well. Therefore as the degree of substitutability (complementarity) between consumption and leisure decrease (increases) the male's Pareto weight needs to be higher to generate the empirical pattern in terms of levels of consumption and leisure.

## 8.2 Estimation of structural Frisch elasticities

To estimate the labor supply elasticity and the complementarity of consumption and hours we estimate the Frisch elasticities by adopting a modified version of Blundell et al. (2015). Consider a version of the problem (8.1) that is agnostic about the Pareto weight

Figure 8.1: The interaction of Pareto weight and degree of substitutability




The plots demonstrate the optimal level of the male's and female's private consumption as a function of the male's wage in the problem 8.1. The simulation is run with CES individual utility functional form with elasticity of substitution of $s = \dfrac{1}{1-r}$, $u(c,l) = (\dfrac{1}{2}c^r + \dfrac{1}{2}l^r)^{\dfrac{1}{r}}$. The plots in a row share the same elasticity of substitution and the plots in a column share the same relative Pareto weight, $\mu$.

as follows

$$\max_{P_t,M_t,F_t,A_{t+1},H_{m,t+1}} U(P_t, M_t, F_t, H_{m,t+1})$$
$$s.t. \quad P_t + M_t + F_t + \frac{A_{t+1}}{1+r} = W_{m,t}H_{m,t} + A_t$$
$$\Delta w_{m,t} = \Delta u_{m,t} + v_{m,t}$$

where $P_t$, $M_t$, and $F_t$ represent the public consumption, the male's private consumption and the female's private consumption, respectively. $H_t$ denotes hours of work by the male and $W_{m,t}$ denotes his wage rate. We assume that the residualized wage rate can be decomposed into transitory and permanent shocks, as was the case in the previous sections. $A_t$ denotes the assets held by the household.

Note that we allow for non-separability between the male's hours of work and three kinds of consumption. Again, due to lower levels of labor force participation by Japanese women in our sample, we ignore modeling the female's earnings explicitly. Instead, we control for the female's earnings in the first stage in which we calculated the residualized rate of growth in consumption and hours.

In Appendix A.1, we show that we can derive the the residualized rate of growth in three kinds of consumption and the male's hours of work as a function of the wage's transitory and permanent shocks as follows

$$\Delta p_{t+1} = (\gamma_{p,\lambda}\alpha_{m,t+1} + \gamma_{p,w_m})v_{m,t+1} + \gamma_{p,w_m}\Delta u_{m,t+1}$$
$$\Delta m_{t+1} = (\gamma_{m,\lambda}\alpha_{m,t+1} + \gamma_{m,w_m})v_{m,t+1} + \gamma_{m,w_m}\Delta u_{m,t+1}$$
$$\Delta f_{t+1} = (\gamma_{f,\lambda}\alpha_{m,t+1} + \gamma_{f,w_m})v_{m,t+1} + \gamma_{f,w_m}\Delta u_{m,t+1}$$
$$\Delta h_{m,t+1} = (\gamma_{h,\lambda}\alpha_{m,t+1} + \gamma_{h_m,w_m})v_{m,t+1} + \gamma_{h,w_m}\Delta u_{m,t+1}$$

where $\gamma_{j,w_m}$ is the Frisch elasticity of $j$ with respect to the male's wage for $j \in \{p,m,f,h_m\}$. Also,

$$\gamma_{j,\lambda} = \eta_{j,p_p} + \eta_{j,p_m} + \eta_{j,p_f} + \gamma_{j,w_m}$$

for $j \in \{p,m,f,h_m\}$. $\eta_{j,p_p}$, $\eta_{j,p_m}$, and $\eta_{j,p_f}$ are the demand elasticities of $j$ with respect to the price of public goods, the male's private consumption, and the female's private consumption. Note that we cannot identify the demand elasticities separately as we do not observe the price of public and private consumption bundles separately. Instead, we can identify the sum of demand elasticities. This is not a problem for our purpose, as demand elasticities are nuisance parameters to begin with. The parameters of interest are the elasticities with respect to wages, $\gamma_{j,w_m}$, which are identified. $\alpha_{m,t}$ is a function of elasticities and some share parameters as follows

$$\alpha_{m,t} = \frac{\pi_t(1+\gamma_{h_m,w_m}) + -S^c_{p,t}\gamma_{p,w_m} - S^c_{m,t}\gamma_{m,w_m} - S^c_{f,t}\gamma_{f,w_m}}{\gamma_{p,\lambda}S^c_{p,t} + \gamma_{m,\lambda}S^c_{m,t} + \gamma_{f,\lambda}S^c_{f,t} - \pi_t\gamma_{h_m,\lambda}} \tag{8.11}$$

where $\pi_t$ is the share of human wealth in total wealth of the household, i.e. the sum of physical and human wealth. $\pi_t$ is calculated as follows

$$\pi_t = \frac{\sum_{s=0}^{T-t} e^{E_{t-1}\ln Y_{t+s} - s\ln(1+r)}}{\sum_{s=0}^{T-t} e^{E_{t-1}\ln Y_{t+s} - s\ln(1+r)} + e^{E_{t-1}\ln A_t}}$$

$S^c_{p,t}$ is the share of total household consumption allocated to public consumption in the lifetime of the household

$$S^c_{p,t} = \frac{\sum_{s=0}^{T-t} \frac{e^{E_{t-1}p_{t+s}}}{(1+r)^s}}{\sum_{s=0}^{T-t} \frac{e^{E_{t-1}p_{t+s}}}{(1+r)^s} + \sum_{s=0}^{T-t} \frac{e^{E_{t-1}m_{t+s}}}{(1+r)^s} + \sum_{s=0}^{T-t} \frac{e^{E_{t-1}f_{t+s}}}{(1+r)^s}}$$

and similar expressions hold for $S^c_{m,t}$ and $S^c_{f,t}$ as the share of total household consumption allocated to the male's and female's private consumption, respectively. To calculate the consumption shares, we use a a similar procedure used to forecast the future earnings in order to calculate the human wealth. We forecast the share of private and public consumption of the household of all the wages until the retirement age. Then we calculate the sum of the discounted present values of each kind of consumption to calculate the consumption share parameters. The evolution of $S^c_{m,t}$, $S^c_{f,t}$, and $S^c_{p,t}$ throughout the lifecycle resembles the trend of raw shares demonstrated in Figure B.1 qualitatively.

The first step to estimate the elasticities is to estimate the variances of the male's wage process. To do so we use the moments of the wage process. As Meghir and Pistaferri (2004) note, the measurement error in the wage process is not identified. Failure to take into account the measurement error does affect the estimate of the variance of permanent shocks. However, it would make the estimates of the transitory shock biased upward. The upward bias leads to large estimates of the transitory shocks' variance that seem unrealistic. To solve this issue, we use the external estimates of measurement in the wage rate reported in survey validation studies. In particular, we assume that 20 percent of the log hourly wage variance is due to measurement error. This is within the range of the fraction of variation in log hourly wages that is attributed to the measurement error in validation studies such as Bound et al. (1994).

Table 8.1 reports the estimates of the male's wage process variances. The first column reports the stationary estimated variances. The second column relaxes the stationary assumption by estimating the variances for three age subgroups. We divide the male's population based on the tercile of the age distribution as follows: 28 – 35, 36 – 42, and 43 – 55 groups. We estimate variance of age process separately for each group. The estimates of the variance of the permanent shock are very similar across three age groups and stationary estimates.

To estimate the Frisch elasticities, we use the second order own and cross moments of three kinds of consumption, male's hours of work, and male's wage moments. The empirical moments are obtained in terms of the share parameters, variance of wage process parameters, and elasticities as we delineated above. We have pre-estimated the share parameters and variance of the wage process. Therefore, the only parameters that need to be estimated are the elasticities.

Table 8.2 demonstrates the estimated elasticities. The first column shows the results for the baseline estimation, in which the consumption is broken down to the male's and female's private consumption, in addition to public consumption. In this specification, we allow for non-separability between the male's hours of work and the three kinds of consumption. The male's wage process is stationary. The second column reports the results by feeding the non-stationary estimates of the wage process to moments

Table 8.1: The variance of the male's wage process

| | (1)<br>Stationary | (2)<br>Non-Stationary |
|---|---|---|
| $\sigma_v^2$ | 0.026*** | |
| | (7.20) | |
| $\sigma_u^2$ | 0.017*** | |
| | (4.40) | |
| $\sigma_{v,1}^2$ | | 0.027*** |
| | | (3.72) |
| $\sigma_{u,1}^2$ | | 0.012* |
| | | (1.89) |
| $\sigma_{v,2}^2$ | | 0.023*** |
| | | (3.35) |
| $\sigma_{u,2}^2$ | | 0.021*** |
| | | (3.21) |
| $\sigma_{v,3}^2$ | | 0.027*** |
| | | (3.73) |
| $\sigma_{u,3}^2$ | | 0.019*** |
| | | (3.18) |
| $N$ | 18893 | 18893 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

$v$ represents the permanent shock to the male's wage process and $u$ represents the transitory shock to the male's wage process. The non-stationary specification divides the male's population based on the tercile of the age distribution as follows: $\leq 35$, $36 - 42$, and $43 \geq$ groups. It estimates variance of the age process separately for each group. The estimates of the variance of the permanent shock is very similar across three age groups.

estimating the elasticities.

First of all, the labor supply elasticity is positive in all specifications, in that the substitution effect dominates the income effect of changes in wages. The sign of consumption elasticities demonstrates the substitutability between leisure and private consumption for the male. In other words, the male needs to be compensated in terms of private consumption when he works higher hours. The point estimates of the elasticity of the female's private consumption with respect to the husband's wage is smaller than the male's, but it is estimated imprecisely. In addition, the total consumption also demonstrates substitutability with the male's hours of work. This sign is expected given the positively estimated labor supply elasticity. As the male starts working higher hours in response to higher wages, it is expected that the boost in the male's earnings be reflected in the total household's consumption, unless the extra earnings are dedicated fully to savings.

The labor supply elasticity is fairly similar across the both specifications. The estimates of elasticities are very similar between a stationary and non-stationary wage process. The point estimates of elasticity of the male's consumption are greater than the female's. However, as demonstrated in the last row of the Table 8.2 the difference is estimated imprecisely.

Table 8.2: Frisch elasticities of male's hours of work and different kinds of consumption with respect to the male's wage

| | (1) Baseline | (2) Non-Stationary Wages |
|---|---|---|
| $\gamma_{p,w}$ | 0.566 | |
| | (1.61) | (1.60) |
| $\gamma_{m,w}$ | 0.486* | |
| | (1.96) | (1.88) |
| $\gamma_{f,w}$ | 0.534 | |
| | (1.52) | (1.52) |
| $\gamma_{h,w}$ | 0.229** | 0.224** |
| | (2.15) | (2.09) |
| $N$ | 7544 | 7544 |

$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

The first column shows the results for the baseline estimation, in which the consumption is broken down to the male's and female's private consumption in addition to public consumption. In this specification, we allow for non-separability between the male's hours of work and the three kinds of consumption. The male's wage process is stationary. In the second column we relax the stationary assumption. The substitution effect dominates the income effect of changes in wages as the elasticity of hours with respect to wages is positive. The sign of consumption elasticities demonstrates the complementarities between hours of work and private consumption for the male. In other words, the male needs to be compensated in terms of private consumption when he works higher hours. The point estimates of elasticity of the female's private consumption with respect to the husband's wage are smaller than the male's, but it is estimated imprecisely. The estimates of elasticities are very similar between a stationary and non-stationary wage process. T-statistics are denoted in the parentheses.

# CHAPTER 9

# CONCLUSION

In the first part of the thesis, we demonstrate how observing private consumption can reveal an overlooked margin of mutual insurance within the family. We describe the dynamics of private consumption in the lifecycle. We demonstrate a disparity in the level of insurance in private consumption across gender. That is, the household's earnings volatility is passed to the male's consumption more than it is to the female's. We check that this result is robust against a wide range of specifications including consideration of income tax and asymmetry in response between pleasant and adverse shocks. We demonstrate that the evidence in support of vast compositional differences across male's and female's bundles is weak. Thus, it is unlikely that the disparity in insurance is an artifice of the compositional effects.

To rationalize our main empirical finding, we propose two potential mechanisms. First, we show how the heterogeneity in risk preference can generate the disparity in insurance. In particular, we find evidence in support of the fact that women are more risk averse by establishing the interaction of the optimal private consumption functions, in addition to the lower tendency of women to invest in risky assets. The second mechanism studies the role of the threat of divorce in a repeated game of specialization with two-sided lack of commitment. We describe patterns that Japanese women's attachment to the labor market is weak. Thus, specialization is a suitable framework for our data. Given specialization, the volatility in the male's earnings would not affect the female's outside option. Thus, the male has no incentive to transfer the earnings volatility to the female's consumption path. We provide supporting evidence for this mechanism by showing that the disparity is greater in samples where the threat of divorce is more substantial. To compare the two mechanisms, we provide some suggestive evidence that, quantitatively, the threat of divorce mechanism is more significant. Specifically, by controlling for risk-aversion heterogeneity, the variation in seriousness of the divorce threat can swing the disparity considerably. In contrast, after controlling for threat of divorce, the variation in risk-aversion heterogeneity is only able to move the disparity in a limited fashion. Finally, we allow for the labor supply margin. We estimate the Frisch elasticities of components of consumption with respect to the wage. We find evidence in support of substitutability between hours of work and private consumption. That is, as the male starts to work higher hours, he is compensated by more generous private consumption.

Next, we suggest a few directions for future research. First, in studying the consumption and hours non-separability, we ignore the female's earnings. Due to the significant role of the extensive margin of labor supply among Japanese women, the estimated variance of women's permanent shocks is unrealistically large. In unreported results, we tried to control for the extensive margin using selection correction by assuming joint normality of shocks and using the receipt of a mortgage as the shifter for the female's labor force participation, following Blundell et al. (2015). However, the correction makes little difference in estimates, as it is hard to justify the exclusion restriction. In general, the linear moment conditions framework is not a suitable framework to tackle the extensive margin of labor supply. We suggest following a nonlinear panel advocated in Arellano et al. (2018) to address the highly nonlinear nature of women's labor force participation in this data.

Second, to compare the quantitative importance of the two proposed mechanisms, it is fruitful to estimate a structural model which incorporates both mechanisms. The difficulty would be the modeling of divorce. As we will show in the second part of the thesis, estimating the value of divorce in the context of a search model, which is a natural framework to think about remarriage, is not easy.

Third, in studying the interaction of consumption and hours, we can decompose the hours to leisure and household production. The inclusion of household production and its interaction with private consumption could bring more insight. In Tables C.17 through C.22 we provide some descriptive statistics on the correlation of labor supply, home production, and leisure. We also provide some results on the correlation of each one of the components of consumption with labor supply, home production, and leisure.

# Part II

# Risk Sharing within Households with Endogenous Marriage Dissolution

# CHAPTER 10

# INTRODUCTION

It is well documented in the literature that households tend to smooth their consumption path by utilizing insurance against labor market shocks. Different consumption insurance mechanisms are identified, including savings, government safety net, the network of family, and marriage. In the face of permanent and transitory income shocks, Blundell et al. (2015) try to find the quantitative importance of marriage insurance mechanisms in comparison with self-insurance by way of savings and government-provided insurances such as transfers, tax credits, and progressivity of taxes. They find that the role of marriage is qualitatively more critical than other mechanisms.

Nonetheless, Blundell et al. (2015)'s finding of the substantial contribution of marriage in providing insurance may partly be because they focus only on stable marriages. What if the arrival of income shocks makes couples seek separation? In other words, although couples are supposed to share their risk when shocks hit either spouse, the other spouse can walk away from the marriage instead of supporting the stricken partner. Allowing for the endogenous unraveling of marriage in the face of big adverse shocks, precisely when there is the most need for risk sharing, attenuates the insurance capacity of the marriage. Subsequently, this mechanism can weaken the effectiveness of marriage as a tool to ensure a smooth consumption profile.

Thus, the question of this part of the thesis is as follows. Given that wage shocks can trigger divorce, how much can the capacity of marriage in providing insurance weaken by accounting for the endogenous marriage dissolution margin? Other studies have found a large role for marriage in insuring against wage shocks, but those studies have been based on the full commitment assumption, which rules out the possibility of divorce. This assumption misses empirical evidence that shows wage shocks can trigger separation and thereby could potentially weaken the insurance capacity of marriage. In this part of the thesis, we allow both marriage dissolution and risk sharing to be endogenously determined.

In chapter 11, we develop a model that endogenously allows for marriage dissolution and risk sharing. However, modeling divorce cannot be truly done without modeling marriage formation, because an important component of divorce value is the optional value of remarriage. Thus, we adopt a random search framework to secure the value of divorce. From the perspective of the modeling of the marriage market by way of a search model, our framework is similar to Goussé et al. (2017) and Shimer and Smith (2000). For simplicity, we consider only a single marriage market; that is, we do not distinguish between divorced singles and never-married singles. Furthermore, we only consider the case of working women and abstract from the extensive margin of labor supply in the model, as we are interested in mutual insurance of wage shocks.

Singles care about their consumption and leisure. But the married, in addition to consumption and leisure, get utility from the psychic benefit of the marriage that evolves randomly as a state variable over time. In addition to the marriage psychic benefit, there are three other state variables including the family's assets and male's and female's wages. We assume both male's and female's wages follow a Markov process. We assume that the assets are split equally upon divorce. Thus, during random search in the marriage market, a single person is characterized by his or her wage and assets. Also, with the same level of wages and assets, different matches are distinguished from one another by the amount of psychic benefit perceived to be generated in that match.

The singles in each period meet a potential match and decide whether to consummate the match or stay single. In their decision, they compare the value of that match with the value of their singlehood. The value of a match depends on the total household assets resulting from pooling individual assets, wages, and the psychic benefit drawn from the match. In our model, consummating a match requires the mutual agreement that both parties should find the match superior to their value of singlehood. However, we show that in equilibrium, if the match is preferable for one party, it must be preferable for the other party as well. This result emanates from our bargaining process. The married couples in each period decide their consumption, leisure, and assets by way of a Nash bargaining problem. The Nash bargaining process implies that if there is a surplus in a match, the surplus should be divided such that each party has a positive share of the surplus.

In section 11.4, we lay out an algorithm to solve the problem. By backward induction, it is easy to find the value of singlehood, as there is no continuation. Now, since the value of singlehood as the outside option of marriage dissolution is determined, the Nash bargaining problem determines whether either is an allocation of consumption and leisure that can generate a positive surplus. If the positive surplus is achievable, then spouses remain married in the last period. A similar argument can be applied to the earlier periods. Finally, we obtain the policy functions of the model, which include the optimal consumption paths and optimal decision to divorce.

After obtaining the policy functions of the model, the chapter 12 rigorously shows the identification of the policy functions. We lay out the required assumptions and necessary observable variables to obtain the identification. In particular, we highlight the identifying power of observing the intra-household components of consumption and the proxy of the psychic benefit of marriage, i.e. the level of satisfaction with the marital relationship, in the JPSC data.

Our identification strategy follows the approach advocated in the non-linear measurement error literature. Specially, we draw on results from Hu and Schennach (2008), Hu and Shum (2012), Cunha et al. (2010), and Arellano et al. (2018). One additional difficulty which is specific to our application is the selection endogeneity caused by the decision to divorce. In other words, divorce is not a simple discrete outcome. Instead, it is a regime change indicator that causes a switch from the marriage's potential consumption to the singlehood's potential consumption. To deal with the selection, we propose two solutions including one based on fixed effects and the other based on the exclusion restriction.

As a solution to the selection problem, the fixed effect approach is intuitively a matching on unobservables strategy. That is, conditioning on fixed effects eliminates the selection endogeneity. In section 12.4, we show that if we assume that, after controlling for the fixed effects, the error term on the divorce equation, i.e. the selection equation, is independent of the error terms on the consumption equations, i.e. the outcome equations, one can obtain the identification of the reduced form policy functions. But, what if we are not willing to accept such assumptions? Then we need to find an exclusion restriction.

For the exclusion restriction to solve the selection problem, we need to find shifters in the selection equation, i.e. the divorce equation, that do not enter into potential outcome equations, i.e. consumption equations. As an exclusion restriction, we propose using income management configurations. Income management configuration refers to the specific way that the husband and wife manage their total income. There are many configurations and we will explain them in section 12.6. Figure 12.1 also depicts them in a tree graph. We aggregate them into two groups. The households where all of the earnings in the household are transferred into a single bank account and the households who have multiple bank accounts whether they are joint or personal bank accounts.

To check the satisfaction of the rank condition, we find that, even after controlling for a large number of controls, a negative association is left between divorce likelihood and the indicator of single bank account configuration. The association is statistically significant enough to warrant the satisfaction of the rank condition. An explanation for the negative association is that the households with the single bank account are more transparent about their finances and therefore enjoy higher levels of trust in one another. Subsequently, more trusting relationships diminish the likelihood of divorce. Finally, income configurations can be used as an exclusion because they do not change the total household resources. They do not even affect how much each one of the spouses makes. They only vary the way that the household manages its shared resources.

The outline of the second part of the thesis is as follows. In chapter 11, we develop the theoretical framework to model risk sharing and marriage dissolution endogenously and obtain the reduced form policy functions. Chapter establishes the identification of the reduced form policy functions. Chapter 13 concludes and provides some directions for future research.

# CHAPTER 11
# THE MODEL

## 11.1 Environment

We develop a search and match model of a marriage market. There are two sides in this matching game; males and females. There are $\mathcal{I}$ types of males and $\mathcal{J}$ types of females. Agents are either single or married; therefore, the model does not distinguish between the never-married and divorcees. Types are time-invariant: say, exogenous educational levels. There are three sources of shocks in the model: spouses' wage shocks and shocks to marital utility (or match quality). There are two economic gains of marriage: risk-sharing and tax benefits.

## 11.2 Wage Process

We assume that individuals' wages follow a Markov process. Note that the wage is not affected by marriage.

$$f_{W_{g,t}|W_{g,t-1}\Omega_{t-2}} = f_{W_{g,t}|W_{g,t-1}} \quad g \in \{m, f\}$$

where $\Omega_{t-2}$ denotes the history of shocks at $t-2$ and before. Furthermore, the singles' initial wage is drawn from the $f^0_{W_g}$ distribution.

## 11.3 Dynamic Programming

We develop the model in a discrete time dynamic programming framework. We have dropped the time indexing for brevity and variables with marked prime refer to the next period realizations. We have three exogenous stochastic state variables: males' and females' wages and marital utility. In addition, the model includes one endogenous state variable of assets, which moves deterministically. Therefore, these state variables enter as arguments in the value functions. $A$ denotes the assets held by a household and $a$ denotes the assets held by single individuals. Per period, single agents draw utility from private consumption and leisure as a married or single agent. $u_g^k(c_g, 1-h_g)$ denotes the utility of an agent of gender $g$ and type $k$. In addition to this "economic utility," married couples enjoy "marital utility" as well. Consider a marriage in which a man of type $i$ marries to a woman of type $j$. Then per period utility of each spouse is as follows

$$U_m^i = u_m^i(c_m^i, 1-h_m^i, \zeta^{i,j})$$
$$U_f^j = u_f^j(c_f^j, 1-h_f^j, \zeta^{i,j})$$

Note that we have assumed that marital utility is a public good produced by marriage. In our dynamic setting, $\zeta^{i,j}$ follows a Markov process $f_{\zeta'|\zeta}(\zeta)$ with initial distribution $f_\zeta^0$. We also assume that shocks to marital utility are independent of wage shocks.

We define value functions as follows

- $V_m^{i,j}(A, w_m, w_f, \zeta)$: the value function of a married male of type $i$ who is married to a female of type $j$ with marital utility $\zeta$ and household-level assets of $A$
- $V_f^{i,j}(A, w_m, w_f, \zeta)$: the value function of a married female of type $j$ who is married to a man of type $i$ with marital utility $\zeta$ and household-level assets of $A$
- $S_g^k(a_g, w_g)$: the value function of a single person of gender $g \in \{m, f\}$ and type $k$ with individual-level assets of $a_g$

### 11.3.1 *The value of being single*

In each period, singles, given the level of assets that is going to be sent to the following period, pick their optimal level of consumption and labor supply in a static problem as follows

$$\max_{c,h} \quad u_g^k(c, 1-h) \tag{11.1}$$
$$s.t. \quad c + a' = (1+r)a + T_0(w_g h)$$

The indirect utility function for singles can be written as follows

$$\psi_g^k(a, a', w_g) \equiv u_g^k(c^*(a, a', w_g), 1 - h^*(a, a', w_g)) \tag{11.2}$$

Singles' tax/transfer mapping from pre-tax income, $T_0(y)$ is defined as before

$$T_0(w_g^k h) = (1 - \chi_0)(w_g h)^{(1-\iota_0)}$$

The level of assets in the next period is the only inter-temporal control variable which determines by solving the Bellman equation. Denote the equilibrium distribution of single women's assets of type $j$ by $f_{A_f^j}(a_f)$ over support $\mathcal{A}_{\mathcal{J}}^{\mathcal{F}}$. Also, $n_f(j)$ denotes the density of single females of type $j$. Then, we can represent the value of singlehood as follows

$$
\begin{aligned}
S_m^i(a, w_m) = &\max_{a'} \Big\{ \psi_m^i(a, a', w_m) + \\
\beta \int_{\mathcal{Z}} \int_{\mathcal{A}_{\mathcal{J}}^{\mathcal{F}}} \int_{\mathcal{J}} \int_{\mathcal{W}_{\mathcal{F}}} \int_{\mathcal{W}_{\mathcal{M}}} & S_m^i(a', w_m') \\
& + \max \Big\{ V_m^{i,j}(a' + a_f, w_m', w_f', \zeta') - S_m^i(a', w_m'), 0 \Big\} \\
& \times \mathbf{1} \Big\{ V_f^{i,j}(a' + a_f, w_m', w_f', \zeta') - S_f^j(a_f, w_f') \geq 0 \Big\} \\
& f_{W_m'|W_m}(w_m'|W_m = w_m) f_{W_f}^0(w_f') \\
& f_{\tilde{A}_f^j}(a_f) n_f(j) f_{\zeta'|\zeta}(\zeta') dw_m' dw_f' dj da_f d\zeta' \Big\}
\end{aligned} \tag{11.3}
$$

where we have assumed that upon marriage the spouses pool their assets. A similar Bellman equation can be written for $S_f^j(a, w_f)$. In the continuation part of equation (11.3), the choice of assets by a male agent affects and will be affected by the equilibrium distribution of assets held among female agents, which makes matters complicated. One simplifying assumption is to assume that there are a large number of agents, and thus, the actions of a single agent do not affect the the distribution of females' assets on the other side of the matching market. In other words, any agent takes the distribution of assets held by the opposite gender as given. In practice we can use the *observed distribution* of assets instead in equation (11.3) to calculate the continuation value. Denote the *observed distribution* of single women's assets of type $j$ by $f_{\tilde{A}_f^j}(\tilde{a}_f)$ over support $\tilde{\mathcal{A}}_{\mathcal{J}}^{\mathcal{F}}$. We will use this distribution in lieu of $f_{A_f^j}(a_f)$.

### *11.3.2 Bargaining*

In each period, the married couples jointly determine their private consumption, labor supply, and next period level of assets by way of a Nash bargaining mechanism. Furthermore, this bargaining process determines whether the couple should divorce in the current period or not. In fact, as we will show later, the first order conditions of the bargaining process imply that marriage would dissolve if the marriage's total surplus is negative after picking the optimal level of control variables, meaning consumption, labor supply, and next period assets. We formulate the Nash bargaining problem as follow

$$\max_{c_m,c_f,h_m,h_f,A'} \left[V_m^{i,j}(A,w_m,w_f,\zeta) - S_m^i(\gamma A,w_m)\right]^{\rho}$$
$$\left[V_f^{i,j}(A,w_m,w_f,\zeta) - S_f^j((1-\gamma)A,w_f)\right]^{1-\rho}$$
$$s.t. \quad c_m + c_f + A' = T_1(w_m h_m + w_f h_f) + (1+r)A$$

This model is, in fact, an *Imperfectly Transferable Utility* matching framework in which private consumption and leisure are the means for concession and transfer of utility between spouses. However, the transferability is imperfect because the lost marginal utility as a result of conceding a unit of consumption or leisure by the conceding spouse is not necessarily equal to the gained marginal utility by the receiving spouse. $\rho$ denotes the husband's relative bargaining power. But, note that here *Bargaining power* is different than *sharing rule*, i.e. the way that joint resources divide. The sharing rule determines endogenously and is updated with the arrival of wage shocks in each period. $\gamma$ denotes the husband's share from savings after divorce. According to US law, assuming $\gamma = 0.5$ is appropriate.

Since spouses pool their labor incomes and decide their level of consumption, labor supply, and next period assets jointly, they share the risk of wage shocks. However, they are not fully committed to cover one another in the face of any shock. They are committed up to their reservation value or threat point, which is the value of singlehood. After picking the optimal level of consumption, labor supply, and next period assets, spouses calculate their own marriage surplus. They would seek divorce in the current period if at least one of the spouses obtains a negative marriage surplus. However, as we explain later, the bargaining first order conditions imply that spouses' surplus should have the same signs. In other words, when marriage dissolves, in fact, both spouses would be better off with seeking divorce.

Denoting pre-tax income by $y$, $T(y)$ is a mapping determining the after-tax income. $T_0, T_1$ denote singles and married couple mappings, respectively. The US tax system is more generous toward the married, thus, this represents the second motive for getting married. This mapping allows us to incorporate the complementarity between spouses' labor supply, which arises from strategic decision making in regard to the tax code. In particular, we use the following specification for mapping

$$T(y) = (1-\chi)y^{(1-\iota)}$$

where $\chi$ and $\iota$ can vary over time and by household characteristics such as family size and number of children. One advantage of this mapping is that it can capture the progressivity of taxes. To see that, note that the marginal tax rate (MTR) is

$$MTR = 1 - T'(y) = 1 - \frac{(1-\chi)(1-\iota)}{y^{\iota}}$$

which implies the higher the pre-tax household labor income is, the higher is the marginal tax rate. $\iota$ captures the degree of progressivity where progressivity is increasing in $\iota$. Proportional taxation is a special case of this mapping with no progressivity, characterized by $\iota = 0$. Finally, note that the effective marginal tax rate could be negative due to transfers.

### 11.3.3 The value of being married

Denote the optimal level of consumption, labor supply, and next period assets by $\bar{c}_m$, $\bar{c}_f$, $\bar{h}_m$, $\bar{h}_f$, $\bar{A}'$, respectively. Then, the value of marriage can be represented through the following Bellman equation

$$V_m^{i,j}(A,w_m,w_f,\zeta) = u_m^i(\bar{c}_m(A,w_m,w_f),1-\bar{h}_m(A,w_m,w_f),\zeta)+$$
$$\beta\int_{\mathcal{Z}}\int_{\mathcal{W}_{\mathcal{F}}}\int_{\mathcal{W}_{\mathcal{M}}}\max\left\{V_m^{i,j}(A'(A,w_m,w_f,\zeta),w'_m,w'_f,\zeta'),S_m^i(\gamma A'(A,w_m,w_f,\zeta),w'_m)\right\}$$
$$\times f_{W'_m,W'_f|W_m,W_f}\left(w'_m,w'_f|W_m=w_m,W_f=w_f\right)f_{\zeta'|\zeta}(\zeta')\Big\}$$

$$V_f^{i,j}(A,w_m,w_f,\zeta) = u_f^j(\bar{c}_f(A,w_m,w_f),1-\bar{h}_f(A,w_m,w_f),\zeta)+$$
$$\beta\int_{\mathcal{Z}}\int_{\mathcal{W}_{\mathcal{F}}}\int_{\mathcal{W}_{\mathcal{M}}}\max\left\{V_f^{i,j}(A'(A,w_m,w_f,\zeta),w'_m,w'_f,\zeta'),S_f^j((1-\gamma)A'(A,w_m,w_f,\zeta),w'_m)\right\}$$
$$\times f_{W'_m,W'_f|W_m,W_f}\left(w'_m,w'_f|W_m=w_m,W_f=w_f\right)f_{\zeta'|\zeta}(\zeta')\Big\}$$

The instantaneous component of the value function determines via Nash bargaining as in the preceding. The continuation value depends on the decision of the couple of whether to separate given the new revelations of wages and marital utility shocks and the amount of assets sent from the preceding period as part of a bargaining process.

## 11.4 Solving the model

### *11.4.1 Period T*

To illustrate how the model works, we consider solving the model backwards for period $T$, i.e. the last period. Solving the model for the preceding periods follows the same logic. We need to pin down the optimal values of consumption and labor supply for the married and single agents, in addition to the decision to divorce for the married and the decision to get married for singles at period $T$.

## Solving singles' problem

Since this is the last period, $a^i_{m,T+1} = a^j_{f,T+1} = A^{i,j}_{T+1} = 0$.

Agents who have been single at $T-1$, after realization of wage shocks at period $T$, solve problem (11.1). Thus, $S_{m,T}, S_{f,T}$ can be derived as follows

$$S^k_{g,T}(a_{g,T}, w_{g,T}; \boldsymbol{\vartheta_{g,T}}) = \psi^k_g(a_{g,T}, 0, w_{g,T}; \boldsymbol{\vartheta_{g,T}}) \equiv u^k_g(c^*(a_{g,T}, w_{g,T}; \boldsymbol{\vartheta_{g,T}}), 1 - h^*(a_{g,T}, w_{g,T}; \boldsymbol{\vartheta_{g,T}})$$

where $\boldsymbol{\vartheta_{g,T}}$ is the vector parameters of the model

$$\boldsymbol{\vartheta_{g,T}} = \{r_T, \chi_T, \iota_T, \boldsymbol{\delta_{g,T}}\}$$

where $\boldsymbol{\delta_g}$ are preference parameters for an agent of gender $g$.

## Solving bargaining problem

Agents who have been married at $T-1$ solve the following bargaining problem at the beginning of period $T$, after realization of period $T$ wage shocks.

$$\max_{c^i_{m,T}, c^j_{f,T}, h^i_{m,T}, h^j_{f,T}} \left[u^i_m(c^i_{m,T}, h^i_{m,T}, \zeta) - \psi^i_m(\gamma A^{i,j}_T, w_{m,T})\right]^\rho$$
$$\left[u^j_f(c^j_{f,T}, h^j_{f,T}, \zeta) - \psi^j_f((1-\gamma) A^{i,j}_T, w_{f,T})\right]^{1-\rho}$$
$$s.t. \quad c^i_{m,T} + c^j_{f,T} = T_1(w_{m,T} h^i_{m,T} + w_{f,T} h^j_{f,T}) + (1 + r_T) A^{i,j}_T$$

Denote the Lagrange multiplier corresponding to the budget constraint by $\lambda_T$. First order conditions imply

$$\frac{\rho}{u_m^i - \psi_m^i}\frac{\partial u_m^i}{\partial c_{m,T}^i} = \lambda_T \tag{11.4}$$

$$\frac{1-\rho}{u_f^j - \psi_f^j}\frac{\partial u_f^j}{\partial c_{f,T}^j} = \lambda_T \tag{11.5}$$

$$\frac{\rho}{u_m^i - \psi_m^i}\frac{\partial u_m^i}{\partial h_{m,T}^i} = -\lambda_T w_{m,T} T'(w_{m,T} h_{m,T}^i + w_{f,T} h_{f,T}^j) \tag{11.6}$$

$$\frac{1-\rho}{u_f^j - \psi_f^j}\frac{\partial u_f^j}{\partial h_{f,T}^j} = -\lambda_T w_{f,T} T'(w_{m,T} h_{m,T}^i + w_{f,T} h_{f,T}^j) \tag{11.7}$$

This nonlinear system of equations can be solved generally. Denote the solution of this system by $\bar{c}_{m,T}(A_T, w_{m,T}, w_{f,T}, \zeta_t; \boldsymbol{\theta_T})$, $\bar{c}_{f,T}(A_T, w_{m,T}, w_{f,T}, \zeta_T; \boldsymbol{\theta_T})$, $\bar{h}_{m,T}(A_T, w_{m,T}, w_{f,T}, \zeta_T; \boldsymbol{\theta_T})$, $\bar{h}_{f,T}(A_T, w_{m,T}, w_{f,T}, \zeta_T; \boldsymbol{\theta_T})$. $\boldsymbol{\theta_T}$ is the vector of parameters of the model

$$\boldsymbol{\theta_T} = \{\rho, r_T, \chi_T, \iota_T, \gamma_T, \boldsymbol{\delta_{m,T}}, \boldsymbol{\delta_{f,T}}\}$$

where $\boldsymbol{\delta_m}, \boldsymbol{\delta_f}$ are the preference parameters of males and females, respectively.

## Finding economic value functions and surpluses

Thus, we can calculate $V_{m,T}, V_{f,T}$ as follows

$$V_{m,T}^{i,j}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) = u_m^i\left(\bar{c}_{m,T}(A_T^{i,j}, w_{m,T}, w_{f,T}; \boldsymbol{\theta_T}), 1 - \bar{h}_{m,T}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T; \boldsymbol{\theta_T})\right)$$
$$V_{f,T}^{i,j}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) = u_f^j\left(\bar{c}_{f,T}(A_T^{i,j}, w_{m,T}, w_{f,T}; \boldsymbol{\theta_T}), 1 - \bar{h}_{f,T}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T; \boldsymbol{\theta_T})\right)$$

Finally, the couple should decide to get divorced or stay married at period $T$. They seek divorce if the marriage surplus of at least one of the spouses is negative. After calculating the value functions, each spouses' surplus can be calculated handily

$$\Gamma^{i,j}_{m,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) = V^{i,j}_{m,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) - S^i_m(\gamma A^{i,j}_T, w_{m,T}; \boldsymbol{\vartheta_{g,T}})$$
$$\Gamma^{i,j}_{f,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) = V^{i,j}_{f,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) - S^j_f((1-\gamma) A^{i,j}_T, w_{m,T}; \boldsymbol{\vartheta_{g,T}})$$

Note that $\boldsymbol{\vartheta_{g,T}} \subset \boldsymbol{\theta_T}$. We can also define the total surplus of the marriage as the sum of the spouses' surpluses

$$\Gamma^{i,j}_{T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) = \Gamma^{i,j}_{m,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) + \Gamma^{i,j}_{f,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T})$$

## Finding decisions to divorce and consummate a match

Thus the couple get divorced if

$$D^{i,j}_{d,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) = 1 - \mathbf{1}\{\Gamma^{i,j}_{m,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) \geq 0, \quad \Gamma^{i,j}_{f,T}(A^{i,j}_T, w_{m,T}, w_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}) \geq 0\} \tag{11.8}$$

However, we can simplify (11.8) using the first order conditions of the bargaining problem. Equations (11.13) and (11.14) imply

$$\frac{\rho \dfrac{\partial u^i_m}{\partial c^i_{m,T}}}{\Gamma^{i,j}_{m,T}} = \frac{(1-\rho)\dfrac{\partial u^j_f}{\partial c^j_{f,T}}}{\Gamma^{i,j}_{f,T}} = \frac{\rho \dfrac{\partial u^i_m}{\partial c^i_{m,T}} + (1-\rho)\dfrac{\partial u^j_f}{\partial c^j_{f,T}}}{\Gamma^{i,j}_{T}} \tag{11.9}$$

since the marginal utilities, $\dfrac{\partial u^i_m}{\partial c^i_{m,T}}, \dfrac{\partial u^j_f}{\partial c^j_{f,T}}$, are strictly positive

$$sign(\Gamma^{i,j}_{m,T}) = sign(\Gamma^{i,j}_{f,T}) = sign(\Gamma^{i,j}_{T}) \tag{11.10}$$

Note that it can be shown that the result (11.9) holds at all periods preceding $T$ as well. Thus, the divorce decision rule (11.9) can be simplified as follows

$$\begin{aligned} D_{d,T}^{i,j}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) &= \mathbf{1}\{\Gamma_{m,T}^{i,j}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) < 0\} \\ &= \mathbf{1}\{\Gamma_{f,T}^{i,j}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) < 0\} \\ &= \mathbf{1}\{\Gamma_T^{i,j}(A_T^{i,j}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) < 0\} \end{aligned} \tag{11.11}$$

To close the model at period $T$ we need also to specify the decision rule for consummating a match for singles. It can be derived from a similar argument as the divorce decision rule as follows:

$$\begin{aligned} D_{c,T}^{i,j}(a_{m,T}, a_{f,T}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) &= \mathbf{1}\{\Gamma_{m,T}^{i,j}(a_{m,T} + a_{f,T}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) > 0\} \\ &= \mathbf{1}\{\Gamma_{f,T}^{i,j}(a_{m,T} + a_{f,T}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) > 0\} \\ &= \mathbf{1}\{\Gamma_T^{i,j}(a_{m,T} + a_{f,T}, w_{m,T}, w_{f,T}, \zeta_T^{i,j}; \boldsymbol{\theta_T}) > 0\} \end{aligned} \tag{11.12}$$

### *11.4.2 Period $T-1$*

## Solving singles' problem

The difference between the last period and preceding periods is that the agents decide about the optimal level of assets in the next period in addition to decisions made in the last period. Here we demonstrate results for period $T-1$ , but they can be written for any other preceding period without loss of generality.

First, we start by solving the problem of singles. Given that next period value functions $V_{m,T}^{i,j}, S_{m,T}^{i}$, are known, male singles of type $i$ determine the next period's optimal holding of assets as follows (conditional on $a_{m,T-1}$)

$$S^i_{m,T-1}(a_{m,T-1}, w_{m,T-1}) \equiv \max_{a_{m,T}} \Big\{ \psi^i_m(a_{m,T-1}, a_{m,T}, w_{m,T-1}) + \\ \beta E_{\zeta_T, \tilde{a}_f, k, w^i_{m,T}, w^k_{f,T}} \max \Big\{ V^{i,j}_{m,T}(a_{m,T} + \tilde{a}_f, w_{m,T}, w_{f,T}, \zeta^{i,k}_T), S^i_{m,T}(a_{m,T}, w_{m,T}) \Big\} \Big\}$$

which implies the following first order condition

$$\frac{\partial \psi^i_m}{\partial a'} + \beta E_{\zeta_T, \tilde{a}_f, k, w^i_{m,T}, w^k_{f,T}} \left[ \frac{\partial V^{i,j}_{m,T}}{\partial A} D^{i,k}_{c,T} + \frac{\partial S^i_{m,T}}{\partial a} (1 - D^{i,k}_{c,T}) \right] = 0$$

This yields the value function $S^i_{m,T-1}(a_{m,T-1}, w_{m,T-1})$ and policy functions as follows

$$c^*_{m,T-1}(a_{m,T-1}, w_{m,T-1})$$
$$h^*_{m,T-1}(a_{m,T-1}, w_{m,T-1})$$
$$a^*_{m,T}(a_{m,T-1}, w_{m,T-1})$$

## Solving bargaining problem

Next, couples solve the following bargaining problem in period $T-1$

$$
\max_{c^i_{m,T-1}, c^j_{f,T-1}, h^i_{m,T-1}, h^j_{f,T-1}, A^{i,j}_T} \Big[u^i_m(c^i_{m,T-1}, h^i_{m,T-1}, \zeta_{T-1}) +
$$
$$
\beta E_{\zeta_T, w_{m,T}, w_{f,T}} \max\{V^{i,j}_{m,T}(A^{i,j}_T, w^i_{m,T}, w^j_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}), S^i_{m,T}(\gamma A^{i,j}_T, w^i_{m,T}; \boldsymbol{\vartheta_{m,T}})\} -
$$
$$
\psi^i_m(A^{i,j}_{T-1}, \gamma A^{i,j}_T, w^i_{m,T-1}) -
$$
$$
\beta E_{\zeta_T, \tilde{a}_f, k, w_{m,T}, w_{f,T}} \max\{V^{i,k}_{m,T}(\gamma A^{i,j}_T + \tilde{a}^k_f, w^i_{m,T}, w^k_{f,T}, \zeta^{i,k}_T; \boldsymbol{\theta_T}), S^i_{m,T}(\gamma A^{i,j}_T, w^i_{m,T}; \boldsymbol{\vartheta_{m,T}})\}\Big]^{\rho}
$$
$$
\Big[u^j_f(c^j_{f,T-1}, h^j_{f,T-1}, \zeta_{T-1}) +
$$
$$
\beta E_{\zeta_T, w_{m,T}, w_{f,T}} \max\{V^{i,j}_{f,T}(A^{i,j}_T, w^i_{m,T}, w^j_{f,T}, \zeta^{i,j}_T; \boldsymbol{\theta_T}), S^j_{f,T}((1-\gamma)A^{i,j}_T, w^j_{f,T}; \boldsymbol{\vartheta_{f,T}})\} -
$$
$$
\psi^j_f(A^{i,j}_{T-1}, (1-\gamma)A^{i,j}_T, w^j_{f,T-1})
$$
$$
-\beta E_{\zeta_T, \tilde{a}_m, k, w_{m,T}, w_{f,T}} \max\{V^{k,j}_{f,T}((1-\gamma)A^{i,j}_T + \tilde{a}^k_m, w^k_{m,T}, w^j_{f,T}, \zeta^{k,j}_T; \boldsymbol{\theta_T}), S^j_{f,T}((1-\gamma)A^{i,j}_T, w^j_{f,T}; \boldsymbol{\vartheta_{m,T}})\}\Big]^{1-\rho}
$$
$$
s.t. \quad c^i_{m,T-1} + c^j_{f,T-1} + A^{i,j}_T = T_1(w^i_{m,T-1}h^i_{m,T-1} + w^j_{f,T-1}h^j_{f,T-1}) + (1 + r_{T-1})A^{i,j}_{T-1}
$$

Note the fact that $sign(\Gamma^{i,j}_m) = sign(\Gamma^{i,j}_f)$ simplifies the continuation value for singles. Denote the Lagrange multiplier corresponding to the budget constraint by $\lambda_{T-1}$. First order conditions with respect to $c_m, c_f, h_m, h_f$ are similar to those for the last period. Note that, given assets, the continuation values are independent of these choice variables.

$$
\underbrace{\frac{\rho}{u^i_{m,T-1} + \beta E_{\zeta_T, w_{m,T}, w_{f,T}}\left[V^{i,j}_{m,T}(1 - D^{i,j}_{d,T}) + S^i_{m,T}D^{i,j}_{d,T}\right] - S^i_{m,T-1}}}_{\Gamma^{i,j}_{m,T-1}} \frac{\partial u^i_{m,T-1}}{\partial c^i_{m,T-1}} = \lambda_{T-1} \tag{11.13}
$$

$$
\underbrace{\frac{1-\rho}{u^j_{f,T-1} + \beta E_{\zeta_T, w_{f,T}, w_{f,T}}\left[V^{i,j}_{m,T}(1 - D^{i,j}_{d,T}) + S^j_{f,T}D^{i,j}_{d,T}\right] - S^j_{f,T-1}}}_{\Gamma^{i,j}_{f,T-1}} \frac{\partial u^j_{f,T-1}}{\partial c^j_{f,T-1}} = \lambda_{T-1} \tag{11.14}
$$

$$
\frac{\rho}{u^i_{m,T-1} + \beta E_{\zeta_T, w_{m,T}, w_{f,T}}\left[V^{i,j}_{m,T}(1 - D^{i,j}_{d,T}) + S^i_{m,T}D^{i,j}_{d,T}\right] - S^i_{m,T-1}} \frac{\partial u^i_{m,T-1}}{\partial h^i_{m,T-1}} = -\lambda_{T-1} w_{m,T-1} T'(w_{m,T-1}h^i_{m,T-1} + w_{f,T-1}h^j_{f,T-1}) \tag{11.15}
$$

$$
\frac{1-\rho}{u^j_{f,T-1} + \beta E_{\zeta_T, w_{f,T}, w_{f,T}}\left[V^{i,j}_{m,T}(1 - D^{i,j}_{d,T}) + S^j_{f,T}D^{i,j}_{d,T}\right] - S^j_{f,T-1}} \frac{\partial u^j_{f,T-1}}{\partial h^j_{f,T-1}} = -\lambda_{T-1} w_{f,T-1} T'(w_{m,T-1}h^i_{m,T-1} + w_{f,T-1}h^j_{f,T-1}) \tag{11.16}
$$

The first order condition with respect to the next period level of assets is as follows:

$$
\frac{\rho}{\Gamma^{i,j}_{m,T-1}}\left[-\gamma\frac{\partial \psi^i_m}{\partial a'} + \beta E_{w_{m,T}, w_{m,T}}\left(\frac{\partial V^{i,j}_{m,T}}{\partial A}(1 - D^{i,j}_{d,T}) + \gamma\frac{\partial S^i_{m,T}}{\partial a}D^{i,j}_{d,T}\right) - \beta\gamma E_{\tilde{a}_f, k, w_{m,T}, w_{f,T}}\left(\frac{\partial V^{i,k}_{m,T}}{\partial A}D^{i,k}_{c,T} + \frac{\partial S^i_m}{\partial a}(1 - D^{i,k}_{c,T})\right)\right] =
$$
$$
\frac{1-\rho}{\Gamma^{i,j}_{f,T-1}}\left[-(1-\gamma)\frac{\partial \psi^j_f}{\partial a'} + \beta E_{w_{m,T}, w_{f,T}}\left(\frac{\partial V^{i,j}_{f,T}}{\partial A}(1 - D^{i,j}_{d,T}) + (1-\gamma)\frac{\partial S^j_{f,T}}{\partial a}D^{i,j}_{d,T}\right) - \beta(1-\gamma)E_{\tilde{a}_f, k, w_{m,T}, w_{f,T}}\left(\frac{\partial V^{k,j}_{m,T}}{\partial A}D^{k,j}_{c,T} + \frac{\partial S^j_f}{\partial a}(1 - D^{k,j}_{c,T})\right)\right]
$$

This nonlinear system of equations can be solved in principle. The solution of this system results in policy functions as follows:

$$
\begin{aligned}
\bar{c}_{m,T-1} &= \bar{c}_{m,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) \\
\bar{c}_{f,T-1} &= \bar{c}_{f,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) \\
\bar{h}_{m,T-1} &= \bar{h}_{m,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) \\
\bar{h}_{f,T-1} &= \bar{h}_{f,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) \\
\bar{A}_{T} &= \bar{A}_{T}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1})
\end{aligned}
$$

## Finding decisions to divorce and consummate a match

By substituting the policy functions into utility functions, we can derive the value functions and subsequently the marital decisions as follows:

$$
\begin{aligned}
D^{i,j}_{d,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) &= \mathbf{1}\{\Gamma^{i,j}_{m,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) < 0\} \quad (11.17) \\
&= \mathbf{1}\{\Gamma^{i,j}_{f,T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) < 0\} \\
&= \mathbf{1}\{\Gamma^{i,j}_{T-1}(A_{T-1}, w_{m,T-1}, w_{f,T-1}, \zeta_{T-1}) < 0\}
\end{aligned}
$$

The model in the earlier periods can be solved using the same algorithm laid out for period $T-1$.

# CHAPTER 12

# IDENTIFICATION

Consider the following reduced form equations derived from the the theory. The disturbance terms are

$$\{e_{a,t}, e_{d,t}, e_{m,t}, e_{c,1,m,t}, e_{c,0,m,t}, e_{h,1,m,t}, e_{h,0,m,t}, e_{c,1,f,t}, e_{c,0,f,t}, e_{h,1,f,t}, e_{h,0,f,t}\}$$

$$A_t = A_t(A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}, e_{a,t}) \tag{12.1}$$

$$D_{d,t} = \mathbf{1}\left\{D_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, e_{d,t}) \geq 0\right\} \tag{12.2}$$

$$c_{m,t} = \bar{c}_{m,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, e_{c,0,m,t})[1 - D_{d,t}] + c^*_{m,t}(A_t, w_{m,t}, e_{c,1,m,t})D_{d,t} \tag{12.3}$$

$$c_{f,t} = \bar{c}_{f,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, e_{c,0,f,t})[1 - D_{d,t}] + c^*_{f,t}(A_t, w_{f,t}, e_{c,1,f,t})D_{d,t} \tag{12.4}$$

$$c_{p,t} = \bar{c}_{p,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, e_{p,t})[1 - D_{d,t}] \tag{12.5}$$

$$h_{m,t} = \bar{h}_{m,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, e_{h,0,m,t})[1 - D_{d,t}] + h^*_{m,t}(A_t, w_{m,t}, e_{h,1,m,t})D_{d,t} \tag{12.6}$$

$$h_{f,t} = \bar{h}_{f,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, e_{h,0,f,t})[1 - D_{d,t}] + h^*_{f,t}(A_t, w_{f,t}, e_{h,1,f,t})D_{d,t} \tag{12.7}$$

## 12.1 Identification of assets equation

We start with an identification of assets equation. Equation (12.1) cannot be separately identified from the distribution of $e_{a,t}$. In other words, a modification in functional form can cancel out changes to the distribution of $e_{a,t}$. Thus, we need to normalize the marginal distribution of $e_{a,t}$. (12.1) is identified if the following two assumptions hold

**Assumption 1.** *(i) $e_{a,t}$ follows a standard uniform distribution (ii) $e_{a,t}$ is independent of $e_{a,s}$ for $s \neq t$ and independent of inputs $\{A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}\}$ (iii) $A_t(., e_{a,t})$ is strictly increasing on $(0,1)$ for almost all values in the support of inputs.*

The identification argument is as follows. Because all of the inputs are observable, we can calculate, for any $\bar{a} \in \mathbb{R}$,

$$Pr[A_t \leq \bar{a}|A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}] = F(\bar{a}|A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1})$$

Because of $(ii)$ of assumption 1, we can define the inverse of F as follows:

$$F^{-1}(e_{a,t}|A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}) = \bar{a}|_{F(\bar{a}|A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}) = e_{a,t}}$$

Thus, the asset equation (12.1) is identified as follows:

$$A_t(A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}, e_{a,t}) = F^{-1}(e_{a,t}|A_{t-1}, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1})$$

Note that we have left the contemporaneous correlation of $e_{a,t}$ with other disturbance terms $e_{m,t}$, $e_{f,t}$, $e_{p,t}$ unrestricted.

## 12.2 Unobserved heterogeneities (fixed effects)

In order to identify the model we have to take a stand on two features of the disturbance terms: first, serial correlation of the disturbance terms and their dependence on inputs, which leads to an endogeneity problem, and second, the contemporaneous correlation of disturbance terms across equations. In particular, the correlation exists between disturbance terms in the divorce equation and consumption equations, which leads to a selection problem.

One strategy to address this problem is to adopt (time-invariant) heterogeneity terms in the consumption and divorce equations.

**Assumption 2.** *We assume that disturbance terms can be decomposed into two components: time-invariant unobserved (by econometrician) heterogeneity $\alpha$ and a residual term $\varepsilon_t$ as* *follows:*

$$e_{c,k,m,t} = (\alpha_m, \varepsilon_{c,k,m,t}) \quad k \in \{0,1\}$$
$$e_{c,k,f,t} = (\alpha_f, \varepsilon_{c,k,f,t}) \quad k \in \{0,1\}$$
$$e_{d,t} = (\alpha_m, \alpha_f, \varepsilon_{d,t})$$
$$e_{p,t} = (\alpha_m, \alpha_f, \varepsilon_{p,t})$$

**Assumption 3.** *We assume the following assumptions about $\varepsilon_{k,t}$ for $k \in \{d, p, c0m, c1m, c0f, c1f\}$*

1. *Normalizing marginal distribution: $\varepsilon_{k,t}$ follows a standard uniform distribution*
2. *No serial correlation: $\varepsilon_{k,t}$ is independent of $\varepsilon_{k,s}$ for $s \neq t$*
3. *$\varepsilon_{k,t}$ is independent of inputs and factors $\{A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f\}$*
4. *policy equations are strictly increasing in $\varepsilon_{k,t}$ for almost all values in the support of inputs.*

$$D_{d,t} = \mathbf{1}\left\{D_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f, \varepsilon_{d,t}) \geq 0\right\} \tag{12.8}$$
$$c_{m,t} = \bar{c}_{m,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \varepsilon_{c,0,m,t})[1 - D_{d,t}] + c^*_{m,t}(A_t, w_{m,t}, \alpha_m, \varepsilon_{c,1,m,t})D_{d,t} \tag{12.9}$$
$$c_{f,t} = \bar{c}_{f,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_f, \varepsilon_{c,0,f,t})[1 - D_{d,t}] + c^*_{f,t}(A_t, w_{f,t}, \alpha_f, \varepsilon_{c,1,f,t})D_{d,t} \tag{12.10}$$
$$c_{p,t} = \bar{c}_{p,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f, \varepsilon_{p,t})[1 - D_{d,t}] \tag{12.11}$$

## 12.3 Identification of the joint distribution of latent factors and inputs

The next step is to identify the joint distribution of these latent heterogeneity terms and the latent time varying psychic benefit of marriage, which we discuss in the next subsection. Our approach is inspired by Cunha et al. (2010). In the model, the number of latent factors is:

$$L = \tilde{T} + 2$$
$$\tilde{T} = T \quad \text{if} \quad D_{d,T} = 0$$
$$\tilde{T} = T - 1 \quad \text{if} \quad D_{d,T} = 1$$

which comprises of $\tilde{T}$ time-varying factors $\{\zeta_t\}_{t=1}^{\tilde{T}}$ and two time-invariant factor $\alpha_m, \alpha_f$. We would like to identify the joint distribution of factors:

$$f_{\zeta_1,\ldots,\zeta_T,\alpha_m,\alpha_f}$$

The model is identified with an argument based on the main theorem of Hu and Schennach (2008). It requires two sets of continuous measures of size $\tilde{T} + 2$ (the number of latent factors). Given inputs $\{A_t, w_{m,t}, w_{f,t}\}$, private consumption can serve as the noisy measures of psychic benefits of marriage, $\zeta_t$, in each period. Since we observe the private consumption of both husband and wife we have access to two sets of continuous measures of $\zeta_t$. To identify the two time-invariant individual heterogeneities, we need to have access to at least four continuous measures of them. The observed public consumption is a function of both spouses' heterogeneity terms and can serve as the measure of heterogeneity. Thus we need $\tilde{T} \geq 4$ to use the sample of marriages lasting at least four years.

**Assumption 4.** *To identify the model we need $\tilde{T} \geq 2l$ where $l$ is the number of time-invariant heterogeneity terms.*

$$Z_1 = \left( \{c_{m,t}\}_{t=1}^{\tilde{T}}, \{c_{p,t}\}_{t=1}^{l} \right)$$
$$Z_2 = \left( \{c_{f,t}\}_{t=1}^{\tilde{T}}, \{c_{p,t}\}_{t=l+1}^{2l} \right)$$

In addition, we need another measure of factors, $Z_3$, which could be of any dimension and either continuous or discrete. We use the Cartesian product of various discrete measures of latent factors as $Z_3$ which includes the following:

$$Z_3 = \left( \{Z_{\zeta,t}\}_{t=1}^{\tilde{T}}, \{Z_{\alpha,t}\}_{t=1}^{\tilde{T}} \right)$$
$$Z_{\zeta,t} = q_{\zeta,t}(\zeta_t, \varepsilon_{\zeta,t})$$
$$Z_{\alpha,t} = q_{\alpha,t}(\alpha_m, \alpha_f, \varepsilon_{\alpha,t})$$

where $Z_{\zeta,t}$ represents a discrete measures to capture the psychic benefit of marriage. The variable in our JPSC dates that can be used as $Z_{\zeta,t}$ is the self-reported assessment of the female's respondent about her satisfaction with the marital relationship. This marriage happiness assessment is a discrete variable with five levels of satisfaction. $Z_{\alpha,t}$ is a discrete or continuous measure aiming to capture consumption heterogeneity. In our JPSC dataset, we can use the leisure time or hours of home production as continuous variables that are affected by consumption heterogeneity.

**Assumption 5.** *$\varepsilon_{k,t}$ is independent of $\varepsilon_{k,s}$ for $s \neq t$ and $k \in \{\zeta, \alpha\}$*

Since consumption is a noisy measure of psychic benefit, $\zeta_t$, given the inputs, we need to identify the joint distribution of factors and inputs as follows:

$$f_{\zeta_1,\ldots,\zeta_{\tilde{T}},\alpha_m,\alpha_f,A_1,\ldots,A_{\tilde{T}},w_{m,1},\ldots,w_{m,\tilde{T}},w_{f,1},\ldots,w_{f,\tilde{T}}}$$

Assuming that $\{A_t, w_{m,t}, w_{f,t}\}$ are free of measurement error, we can pretend that they are factors and have access to multiple measurements of them, which are basically the repeated actual observed values. Thus we augment our measurement system as follows:

$$Z_1 = \left(\{c_{m,t}\}_{t=1}^{\tilde{T}}, \{c_{p,t}\}_{t=1}^{l}, \{A_t\}_{t=1}^{\tilde{T}}, \{w_{m,t}\}_{t=1}^{\tilde{T}}, \{w_{f,t}\}_{t=1}^{\tilde{T}}\right)$$
$$Z_2 = \left(\{c_{f,t}\}_{t=1}^{\tilde{T}}, \{c_{p,t}\}_{t=l+1}^{2l}, \{A_t\}_{t=1}^{\tilde{T}}, \{w_{m,t}\}_{t=1}^{\tilde{T}}, \{w_{f,t}\}_{t=1}^{\tilde{T}}\right)$$
$$Z_3 = \left(\{Z_{\zeta,t}\}_{t=1}^{\tilde{T}}, \{Z_{\alpha,t}\}_{t=1}^{\tilde{T}}, \{A_t\}_{t=1}^{\tilde{T}}, \{w_{m,t}\}_{t=1}^{\tilde{T}}, \{w_{f,t}\}_{t=1}^{\tilde{T}}\right)$$

**Assumption 6.** *The joint distribution of latent factors and inputs as follows:*

$$\theta = (\zeta_1, ..., \zeta_{\tilde{T}}, \alpha_m, \alpha_f, A_1, ..., A_{\tilde{T}}, w_{m,1}, ..., w_{m,\tilde{T}}, w_{f,1}, ..., w_{f,\tilde{T}})$$

*is identified if the following assumptions hold:*

1. *The joint density of $\theta$ and $(Z_1, Z_2, Z_3)$ is bounded*
2. *Conditional on $\theta$, $Z_1, Z_2, Z_3$ are mutually independent*
3. *$f_{Z_1|Z_2}$ which is indexed by $Z_2$ and $f_{\theta|Z_1}$ which is indexed by $Z_1$ are from a bounded complete family of distributions*
4. *$f_{Z_3|\theta}$ and $f_{Z_3|\tilde{\theta}}$ differ over a set of strictly positive probability for any $\theta \neq \tilde{\theta}$*
5. *There exists a known functional $\Psi$, mapping density to a vector, that has the property that $\Psi[f_{Z_1|\theta}] = \theta$*

We verify the second and fifth assumptions, as the other ones are either innocuous or too technical to verify. The second assumption requires the following three vectors to be mutually independent:

$$
\begin{aligned}
\varepsilon_1 &= \left(\{\varepsilon_{c,0,m,t}\}_{t=1}^{\tilde{T}}, \{\varepsilon_{p,t}\}_{t=1}^{l}\right) \\
\varepsilon_2 &= \left(\{\varepsilon_{c,0,f,t}\}_{t=1}^{\tilde{T}}, \{\varepsilon_{p,t}\}_{t=l+1}^{2l}\right) \\
\varepsilon_3 &= \left(\{\varepsilon_{\zeta,t}\}_{t=1}^{\tilde{T}}, \{\varepsilon_{\alpha,t}\}_{t=1}^{\tilde{T}}\right)
\end{aligned}
$$

One sufficient condition to guarantee this result is given in the following assumption

**Assumption 7.** *$\varepsilon_{k,t}$ is independent of $\varepsilon_{k',t'}$ for $k \in \{p, c0m, c0f, \zeta, \alpha\}$ and $\{t, t'\} \leq \tilde{T}$*

To find sufficient conditions to satisfy the fifth requirement, we normalize the measurement equations as separable with mean zero disturbance, instead of normalizing the marginal distribution as standard normal.

$$
\begin{aligned}
\bar{c}_{m,t} &= g_{c,m}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) + \varepsilon_{c,0,m,t} \\
\bar{c}_{f,t} &= \bar{c}_{c,f}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_f) + \varepsilon_{c,0,f,t} \\
\bar{c}_{p,t} &= g_p(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f) + \varepsilon_{p,t} \\
Z_{\zeta,t} &= g_\zeta(\zeta_t) + \varepsilon_{\zeta,t} \\
Z_{\alpha,t} &= g_\alpha(\alpha_m, \alpha_f) + \varepsilon_{\alpha,t}
\end{aligned}
$$

With this specification, one sufficient condition to satisfy the fifth requirement is the following:

**Assumption 8.** *Mean, mode, or $\tau$th quantile of $\varepsilon_{k,t}$ for $k \in \{p, c0m, c0f, \zeta, \alpha\}$ and $t \leq \tilde{T}$ is zero.*

There are two appealing features in our identification strategy stated in the following remarks.

**Remark 1.** *We have left the the structure of dependence between assets wages, psychic benefit, and heterogeneity terms unrestricted. In addition, the intertemporal structure of psychic benefit* *and wages could be very general. For instance, we do not require wages and psychic benefit to follow a Markov process.*

**Remark 2.** *Because we could afford to not include divorce as a measurement, the joint distribution of factors and inputs is identified even in the presence of selection. In particular, the identification of joint distribution does not require $\varepsilon_{d,t}$ to be independent of $\varepsilon_{k,t}$ for $k \in \{p, c0m, c0f, c1m, c1f\}$, which drives the selection problem.*

**Remark 3.** *For even less restrictive assumptions on the structure of consumption disturbance terms we can use hours instead of private consumption as measures to identify the joint distribution of factors and inputs.*

$$Z_1' = \left(\{h_{m,t}\}_{t=1}^{\tilde{T}}, \{c_{p,t}\}_{t=1}^{l}, \{A_t\}_{t=1}^{\tilde{T}}, \{w_{m,t}\}_{t=1}^{\tilde{T}}, \{w_{f,t}\}_{t=1}^{\tilde{T}}\right)$$
$$Z_2' = \left(\{h_{f,t}\}_{t=1}^{\tilde{T}}, \{c_{p,t}\}_{t=l+1}^{2l}, \{A_t\}_{t=1}^{\tilde{T}}, \{w_{m,t}\}_{t=1}^{\tilde{T}}, \{w_{f,t}\}_{t=1}^{\tilde{T}}\right)$$
$$Z_3 = \left(\{Z_{\zeta,t}\}_{t=1}^{\tilde{T}}, \{Z_{\alpha,t}\}_{t=1}^{\tilde{T}}, \{A_t\}_{t=1}^{\tilde{T}}, \{w_{m,t}\}_{t=1}^{\tilde{T}}, \{w_{f,t}\}_{t=1}^{\tilde{T}}\right)$$

## 12.4 Identification of consumption equations and the decision to divorce

In this section, we show the identification of consumption equations and decision to divorce as they are laid out below. The identification of consumption and divorce equations relies on the identification of the joint distribution latent factors and inputs, $\theta$, as in the previous section. Our approach is motivated by Arellano et al. (2018) and Hu and Shum (2012).

$$D_{d,t} = \mathbf{1}\left\{D_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f, \varepsilon_{d,t}) \geq 0\right\} \tag{12.12}$$

$$c_{m,t} = \bar{c}_{m,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \varepsilon_{c,0,m,t})[1 - D_{d,t}] + c^*_{m,t}(A_t, w_{m,t}, \alpha_m, \varepsilon_{c,1,m,t})D_{d,t} \tag{12.13}$$

$$c_{f,t} = \bar{c}_{f,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_f, \varepsilon_{c,0,f,t})[1 - D_{d,t}] + c^*_{f,t}(A_t, w_{f,t}, \alpha_f, \varepsilon_{c,1,f,t})D_{d,t} \tag{12.14}$$

$$c_{p,t} = \bar{c}_{p,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f, \varepsilon_{p,t})[1 - D_{d,t}] \tag{12.15}$$

$$\theta \equiv (\zeta_1, ..., \zeta_{\tilde{T}}, \alpha_m, \alpha_f, A_1, ..., A_{\tilde{T}}, w_{m,1}, ..., w_{m,\tilde{T}}, w_{f,1}, ..., w_{f,\tilde{T}})$$

We first start with the decision to divorce. The observable LHS can be written as follows

$$\begin{aligned} f_{D_t|A_t,w_{m,t},w_{f,t}} &= \int f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t} f_{\zeta_t|A_t,w_{m,t},w_{f,t}} d\zeta_t \\ &= \mathbb{E}\left(f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t} | A_t, w_{m,t}, w_{f,t}\right) \end{aligned}$$

where expectation is taken with respect to $\zeta_t$ conditional on $A_t, w_{m,t}, w_{f,t}$ for a fixed value of $D_t$. $f_{\zeta_t|A_t,w_{m,t},w_{f,t}}$ is known from the joint distribution of factor and inputs. Thus, by non-parametric IV techniques, $f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t}$ is identified if $f_{\zeta_t|A_t,w_{m,t},w_{f,t}}$ is complete. By Bayes' rule

$$\begin{aligned} f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t} &= \frac{f_{\zeta_t|A_t,w_{m,t},w_{f,t},D_t} f_{D_t|A_t,w_{m,t},w_{f,t}}}{f_{\zeta_t|A_t,w_{m,t},w_{f,t}}} \\ f_{\zeta_t|A_t,w_{m,t},w_{f,t},D_t} &= \frac{f_{\zeta_t|A_t,w_{m,t},w_{f,t}} f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t}}{f_{D_t|A_t,w_{m,t},w_{f,t}}} \end{aligned}$$

Thus, $f_{\zeta_t|A_t,w_{m,t},w_{f,t},D_t}$ is identified.

$$f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t} = \int f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t,\alpha_m} f_{\alpha_m|A_t,w_{m,t},w_{f,t},\zeta_t} d\alpha_m$$

where the expectation is taken with respect to $\zeta_t$ conditional on $A_t, w_{m,t}, w_{f,t}$ for a fixed value of $D_t$. $f_{\zeta_t|A_t,w_{m,t},w_{f,t}}$ is known from the joint distribution of factor and inputs. Thus, by Non-parametric IV techniques, $f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t,\alpha_m}$ is identified if $f_{\alpha_m|A_t,w_{m,t},w_{f,t},\zeta_t}$ is complete. By applying Bayes' rule:

$$f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t,\alpha_m} = \frac{f_{\alpha_m|A_t,w_{m,t},w_{f,t},\zeta_t,D_t} f_{D_t|A_t,w_{m,t},w_{f,t},\zeta_t}}{f_{\alpha_m|A_t,w_{m,t},w_{f,t},\zeta_t}}$$

Thus, $f_{\alpha_m|A_t,w_{m,t},w_{f,t},\zeta_t,D_t}$ is identified.

$$\begin{aligned} D_{d,t} &= \mathbf{1}\left\{D_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \varepsilon_{d,t}) \geq 0\right\} \\ &= \mathbf{1}\left\{g_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) - \varepsilon_{d,t} \geq 0\right\} \end{aligned}$$

Thus

$$\begin{aligned} f_{D_t=1|A_t,w_{m,t},w_{f,t},\zeta_t,\alpha_m} &= \Pr\left(g_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) - \varepsilon_{d,t} \geq 0 \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m\right) \\ &= \Lambda\left(g_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m\right) \end{aligned}$$

Where $\Lambda(.)$ is a strictly increasing c.d.f. of $\varepsilon_{d,t}$. $\Lambda(.)$ is not separately identified from $g_{d,t}$ as a perturbation in $g_{d,t}$ and can be canceled out with a change in $\Lambda(.)$. Thus, it is identified up to an increasing transformation which requires a normalization assumption.

$$g_{d,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) = \Lambda^{-1}\left(f_{D_t=1|A_t,w_{m,t},w_{f,t},\zeta_t,\alpha_m} \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m\right)$$

Next, we turn to identification of the consumption equations. We can write the observable

LHS conditional density as follows

$$\begin{aligned} f_{c_{m,t}\,|\,A_t,w_{m,t},w_{f,t},D_{d,t}=0} &= f_{\bar{c}_{m,t}\,|\,A_t,w_{m,t},w_{f,t},D_{d,t}=0} \\ &= \int f_{\bar{c}_{m,t}|\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0} f_{\zeta_t|A_t,w_{m,t},w_{f,t},D_{d,t}=0} d\zeta_t \\ &= \mathbb{E}\left(f_{\bar{c}_{m,t}|\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0}\,|\,A_t,w_{m,t},w_{f,t}\right) \end{aligned}$$

where expectation is taken with respect to $\zeta_t$ conditional on $A_t, w_{m,t}, w_{f,t}$ for a fixed value of $\bar{c}_{m,t}$. $f_{\zeta_t|A_t,w_{m,t},w_{f,t},D_{d,t}=0}$ as was identified above. Thus, by non-parametric IV techniques $f_{\bar{c}_{m,t}|\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0}$ is identified if $f_{\zeta_t|A_t,w_{m,t},w_{f,t},,D_{d,t}=0}$ is complete.

$$f_{\bar{c}_{m,t}|\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0} = \int f_{\bar{c}_{m,t}\,|\,\alpha_m,\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0} f_{\alpha_m|\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0} d\alpha_m$$

where the expectation is taken with respect to $\alpha_m$ conditional on $A_t, w_{m,t}, w_{f,t}, \zeta_t$ for a fixed value of $\bar{c}_{m,t}$. $f_{\zeta_t,\alpha_m|A_t,w_{m,t},w_{f,t},D_{d,t}=0}$ as was identified above. Thus, by non-parametric IV techniques if $f_{\alpha_m|A_t,w_{m,t},w_{f,t},\zeta_t,D_{d,t}=0}$ is complete then the following conditional density is identified.

$$f_{\bar{c}_{m,t}|\alpha_m,\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0}$$

If we assume that after conditioning on heterogeneity terms, there is no selection problem, then we can identify the consumption equation corresponding to $\bar{c}_{m,t}$. The following assumption formalizes this condition:

**Assumption 9.** *$\varepsilon_{d,t}$ is independent of $\varepsilon_{k,t}$ for $k \in \{p, c0m, c0f, c1m, c1f\}$ and $t \leq T$*

These assumptions imply that $\varepsilon_t$ realize only after all decisions are made by thet agents, so they do not confound with decisions. Thus, by assumption 12 ,

$f_{\bar{c}_{m,t}|\alpha_m,\zeta_t,A_t,w_{m,t},w_{f,t}}$ is identified as follows:

$$f_{\bar{c}_{m,t}|\alpha_m,\zeta_t,A_t,w_{m,t},w_{f,t},D_{d,t}=0} = f_{\bar{c}_{m,t}|\alpha_m,\zeta_t,A_t,w_{m,t},w_{f,t}}$$

Then, with a similar argument to the assets equation, we can identify the male's consumption equation as follows:

$$\bar{c}_{m,t}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \varepsilon_{c,0,m,t}) = F^{-1}_{c_{m,t}}(\varepsilon_{c,0,m,t} \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m)$$
$$F_{c_{m,t}}(\varepsilon_{c,0,m,t} \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) = \int_0^{\varepsilon_{c,0,m,t}} f_{\bar{c}_{m,t}|\alpha_m,\zeta_t,A_t,w_{m,t},w_{f,t}} d\bar{c}_{m,t}$$

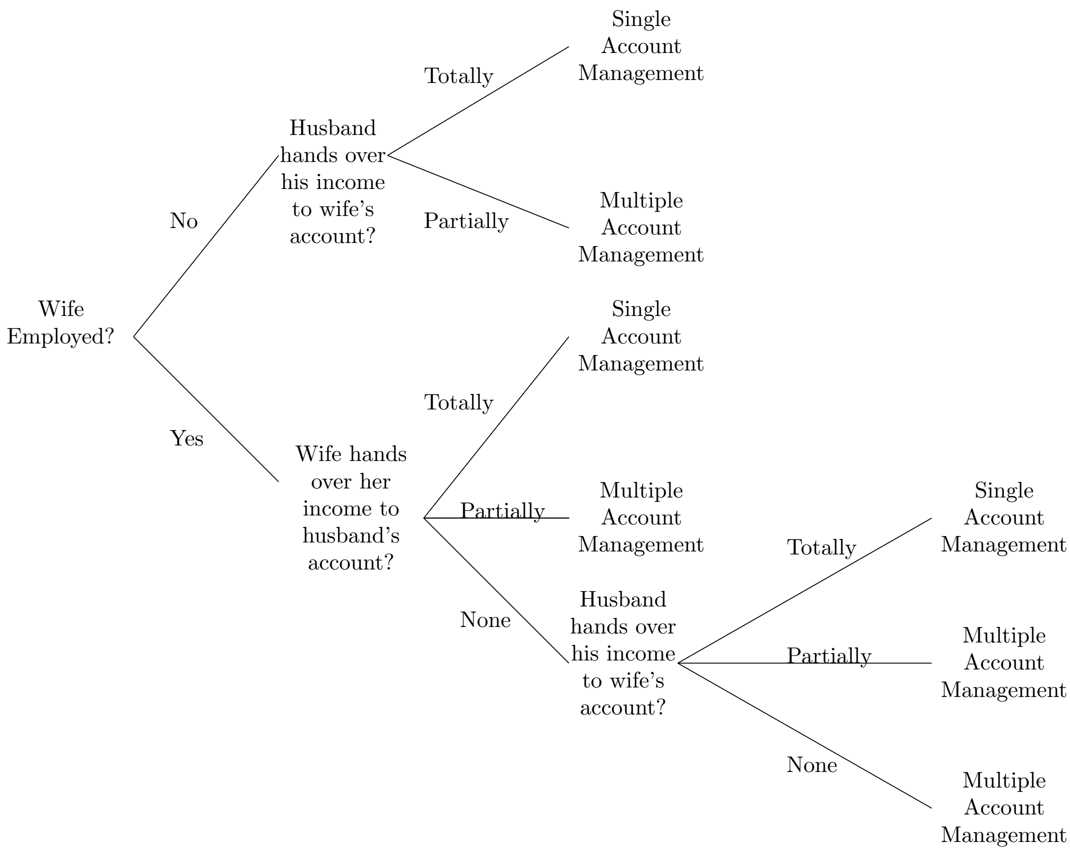
where $F^{-1}_{c_{m,t}}$ is the conditional quantile function of $\bar{c}_{m,t}$. Other consumption equations can be identified in a parallel fashion.

## 12.5 Likelihood function

The complete data likelihood function, which is the joint likelihood of the observed and latent variables for the marriage $i$ whose duration is $T$

$$\begin{aligned}
&\prod_{i=1}^{N} f(A_2,\dots A_T, c_{m,1}, c_{f,1}, c_{p,1}, D_{d,1}, Z_{\zeta,1}, Z_{\alpha,1} \dots c_{m,T}, c_{f,T}, D_{d,T}, Z_{\zeta,T}, Z_{\alpha,T} \,|\, A_1, w_{m,1}, w_{f,1} \dots w_{m,T}, w_{f,T}) \\
=&\prod_{i=1}^{N} \int \cdots \int f(\zeta_1,\dots\zeta_T, \alpha_m, \alpha_f \,|\, A_1, w_{m,1}, w_{f,1} \dots w_{m,T}, w_{f,T}) \\
&\times f(A_2,\dots A_T, c_{m,1}, c_{f,1}, c_{p,1}, D_{d,1}, Z_{\zeta,1}, Z_{\alpha,1} \dots c_{m,T}, c_{f,T}, D_{d,T}, Z_{\zeta,T}, Z_{\alpha,T} \,|\, A_1, \zeta_1, w_{m,1}, w_{f,1} \dots \zeta_T, w_{m,T}, w_{f,T}, \alpha_m, \alpha_f) d\zeta d\alpha \\
=&\prod_{i=1}^{N} \int \cdots \int f(\zeta_1,\dots\zeta_T, \alpha_m, \alpha_f \,|\, A_1, w_{m,1}, w_{f,1} \dots w_{m,T}, w_{f,T}) \\
\times&\prod_{t=1}^{T-1} f(A_{t+1} \,|\, A_t, w_{m,t-1}, w_{f,t-1}, c_{m,t-1}, c_{f,t-1}, c_{p,t-1}) f(\bar{c}_{m,t} \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, D_{d,t}=0) f(\bar{c}_{f,t} \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_f, D_{d,t}=0) \\
&\times f(\bar{c}_{p,t} \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f, D_{d,t}=0) \Pr(D_{d,t}=0 \,|\, A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f) f(Z_{\zeta,t} \,|\, \zeta_t) f(Z_{\alpha_m,t} \,|\, \alpha_m) f(Z_{\alpha_f,t} \,|\, \alpha_f) \\
&\times \left( f(\bar{c}_{m,T} \,|\, A_T, w_{m,T}, w_{f,T}, \zeta_T, \alpha_m, D_{d,T}=0) f(\bar{c}_{f,T} \,|\, A_T, w_{m,T}, w_{f,T}, \zeta_T, \alpha_f, D_{d,T}=0) \right)^{1-D_{d,T}} \\
&\times \left( f(\bar{c}_{p,T} \,|\, A_T, w_{m,T}, w_{f,T}, \zeta_T, \alpha_m, \alpha_f, D_{d,T}=0) \Pr(D_{d,T}=0 \,|\, A_T, w_{m,T}, w_{f,T}, \zeta_T, \alpha_m, \alpha_f) \right)^{1-D_{d,T}} \\
&\times \left( f(Z_{\zeta,T} \,|\, \zeta_T) f(Z_{\alpha_m,T} \,|\, \alpha_m) f(Z_{\alpha_f,T} \,|\, \alpha_f) \right)^{1-D_{d,T}} \\
&\times \left( f(c^*_{m,T} \,|\, A_T, w_{m,T}, \alpha_m, D_{d,T}=1) f(c^*_{f,T} \,|\, A_T, w_{f,T}, \alpha_f, D_{d,T}=1) \right)^{D_{d,T}} \\
&\times \left( \Pr(D_{d,T}=1 \,|\, A_T, w_{m,T}, w_{f,T}, \zeta_T, \alpha_m, \alpha_f) \right)^{D_{d,T}} d\zeta d\alpha_m d\alpha_f
\end{aligned}$$

Figure 12.1: The tree of the household's income management configurations




The end nodes of the tree demonstrate different kinds of intra-household income management configurations. We aggregate these configurations into two types: households who manage their income with a single account and those who use multiple accounts. Note that in a single account household, the manager could be either the wife or husband.

## 12.6 Identification with exclusion restriction

In the previous section, assumption 9 implied that after controlling for the heterogeneity terms (fixed effects), the selection endogeneity is gone. That is, after controlling for the heterogeneity, the error terms in divorce equations and potential consumption equations are uncorrelated. We showed how one can obtain identification of the divorce equation and potential consumption equations by accepting assumption 9 in section .

But, what if we are not willing to accept assumption 9? That is, even after controlling for heterogeneity terms, the error term in the divorce equation is correlated with potential consumption functions. Then we need to find an exclusion restriction. In other words, we need to find shifters in the selection equation (divorce equation) that do not enter into potential outcome equations (consumption equations). By looking at the potential consumption and divorce equations, it is noteworthy that we already have access to an exclusion restriction for the private consumption equation. The other spouse's heterogeneity term (the female's heterogeneity term in the male's consumption equation below) appears in the male's private consumption but not in the divorce equation. However, the heterogeneity term (fixed effect) is not time-varying. Besides, this strategy cannot identify the public consumption equations as both spouses' heterogeneity terms appear in the public consumption equation and divorce decision equation.

$$
\begin{aligned}
\bar{c}_{m,t} &= g_{0,m}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) + \varepsilon_{0,m,t} \\
c^*_{m,t} &= g_{1,m}(A_t, w_{m,t}, \alpha_m) + \varepsilon_{1,m,t} \\
\bar{c}_{p,t} &= g_{0,p}(A_t, w_{m,t}, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f) + \varepsilon_{p,t} \\
c^*_{p,t} &= 0 \\
D_{d,t} &= \mathbf{1}\left\{g_d(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f) - \varepsilon_{d,t} \geq 0\right\}
\end{aligned}
$$

As an exclusion restriction, we propose using income management configurations. JPSC collects data about the income management configuration of the households. Income management configuration refers to the specific way that the husband and wife manage their total income. Figure 12.1 demonstrates different types of income management configurations with a tree graph. First, we split the households based on whether the wife works. In the households where the wife does not work, we have two configurations: either there is only one bank account and the husband deposits all of his income to that account or the husband has his own personal account as well, and only deposits part of his income to the family's bank account.

If the wife also works, the income management configurations get more complicated. There are three kinds of configurations based on how the wife pools her income with the husband. In the first type, there is only one single bank account and the wife deposits all of her income into that account. The second type is the case when she only partially deposits her income to the family's bank account and has her personal account as well. The third type is the case where she keeps all of her income in her personal account and does not deposit any of her income to the family account.

Among the third type of working women, i.e. the women who keep all of their income in their own bank account, there are three additional finer configurations. The first configuration is when the husband transfers all of his income to the wife's account. The second configuration is when the husband hands over part of his income to his wife's account. The third configuration is when the husband also keeps all of his income in his own bank account and does not transfer any part of his income to the wife's account.

To aggregate these various income management configurations, we divide them into two groups. As Figure 12.1 demonstrates, the first aggregate group includes the configurations where there is only one single bank account regardless of whose account it is. In contrast, the second aggregate group includes the configurations where there are multiple bank accounts regardless of how many of them there are. We define the binary variable $\tau_t$, which is one for the households with a single bank account and zero for the households with multiple bank accounts. Note that the income configurations

Table 12.1: The model explaining divorce

| | Logit | Probit |
|---|---|---|
| ***Instrument: Income Management Configuration*** | | |
| Single Bank Account | -0.651*** | -0.257*** |
| | (-3.55) | (-3.49) |
| ***Relationship Quality*** | | |
| Quite Satisfaction with The Relationship | 0.296 | 0.111 |
| | (0.61) | (0.69) |
| Moderate Satisfaction with The Relationship | 1.562*** | 0.575*** |
| | (3.44) | (3.70) |
| A Little Satisfaction with The Relationship | 2.386*** | 0.898*** |
| | (5.10) | (5.47) |
| Not At All Satisfied with The Relationship | 3.631*** | 1.477*** |
| | (7.59) | (8.39) |
| ***Demographics*** | | |
| Number of Kids $\geq 2$ | -0.489*** | -0.189*** |
| | (-2.64) | (-2.59) |
| Female Is Out of Labor Force | -0.760*** | -0.293*** |
| | (-3.50) | (-3.58) |
| Reside in Small Cities | 0.056 | 0.046 |
| | (0.26) | (0.55) |
| Reside in Rural Areas | -0.164 | -0.057 |
| | (-0.49) | (-0.44) |
| Male Is College Graduate | -0.598 | -0.272 |
| | (-1.30) | (-1.49) |
| Female Is College Graduate | -1.121 | -0.425 |
| | (-1.40) | (-1.34) |
| ***Time Variables*** | | |
| Duration of The Marriage | 0.092 | 0.046 |
| | (0.84) | (1.07) |
| Square of Duration of The Marriage | -0.007 | -0.003 |
| | (-1.13) | (-1.38) |
| Wife's Age | 0.063 | 0.005 |
| | (0.24) | (0.05) |
| Square of Wife's Age | -0.001 | -0.000 |
| | (-0.32) | (-0.15) |
| Husband's Age | -0.242 | -0.093 |
| | (-1.35) | (-1.29) |
| Square of Husband's Age | 0.003 | 0.001 |
| | (1.16) | (1.11) |
| Observations | 14433 | 14433 |

The dependent variable in both logit and probit specifications is the occurrence of divorce in a given household-time instance. The model includes all calendar time dummy variables as additional controls that are not reported in the table for brevity. The standard errors are clustered at the household level.

change over time; therefore, we index them by time. In terms of distribution, 68.9% of household-year observations follow the single bank account configuration.

Going back to the idea of the exclusion restriction, we use $\tau_t$ as the exclusion restriction which shifts divorce but does not enter into the consumption equations. That $\tau_t$ does not enter into the consumption equations is because the configuration types do not change the total household resources. They do not even affect how much each one the spouses makes. They just vary the way that households mange their earned income.

$$
\begin{aligned}
\bar{c}_{m,t} &= g_{0,m}(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m) + \varepsilon_{0,m,t} \\
c^*_{m,t} &= g_{1,m}(A_t, w_{m,t}, \alpha_m) + \varepsilon_{1,m,t} \\
D_{d,t} &= \mathbf{1}\left\{g_d(A_t, w_{m,t}, w_{f,t}, \zeta_t, \alpha_m, \alpha_f, \tau_t) - \varepsilon_{d,t} \geq 0\right\}
\end{aligned}
$$

To test the rank condition of the exclusion, Table 12.1 shows the results of the first stage. Even after controlling for many controls, the households with single bank account configurations have a smaller propensity to divorce. The absolute value of the t-statistic on the single bank account indicator is large enough at 3.5 to satisfy the rank condition. How can one interpret the negative sign of the association between the exclusion and divorce? One explanation is that the households with the single bank account are more transparent about their finances and therefore enjoy higher levels of trust in one another. Subsequently, more trusting relationships diminish the likelihood of divorce.

Finally, given access to the exclusion restriction, a set of generalized roy model nonparametric identification arguments can be applied in each period to obtain the identification. Thus we finish the identification of all of the reduced form equations in the model.

# CHAPTER 13

# CONCLUSION

In the second part of the thesis, we investigate how accounting for marriage dissolution weakens the function of marriage in providing mutual insurance against labor market shocks. We develop a model that allows for endogenous risk sharing as well as divorce by the arrival of shocks. The model uses a search framework to model remarriage, which constitutes an essential part of the value of divorce. The married couples bargain by way of a Nash process to split the positive surplus of marriage by allocating consumption and leisure between the husband and wife. We lay out an algorithm to solve the problem by backward induction.

Then, we obtain the policy functions of the model which includes the optimal consumption paths and optimal decision to divorce. Next, we rigorously show the identification of the policy functions. In particular, we provide the required assumptions and necessary observable variables to obtain the identification. In particular, we underscore the valuable identifying power of observing the intra-household components of consumption in JPSC as well as that of observing satisfaction with the marital relationship. Our identification strategy follows the approach advocated in the non-linear measurement error literature. One extra complication in our application is the selection endogeneity caused by the decision to divorce. We provide two solutions for the selection to complete the identification. First a fixed effect approach and second an exclusion restriction. We use the income management configurations as an exclusion. We aggregate the configurations to a binary variable based on whether there is only a single bank account in the household or there are multiple accounts. We check the rank condition. The households with a single bank account are less likely to seek divorce due to higher levels of trust, stemming from higher levels of transparency in their finances.

For future research, the next natural step is to estimate the reduced form policy functions. Due to the highly nonlinear nature of the decision to divorce, the nonlinear panel methods using quantile regressions developed in Arellano and Bonhomme (2016), Arellano and Bonhomme (2017), and Arellano et al. (2018) are a suitable empirical strategy to adopt.

# Appendices

# APPENDIX A

# THEORY APPENDIX

## A.1 Details of deriving the growth rate in consumption and hours in terms of Frisch elasticities and shares parameters

$$\max_{P_t, M_t, F_t, A_{t+1}, H_{m,t+1}, H_{f,t+1}} U(P_t, M_t, F_t, H_{m,t+1}, H_{f,t+1})$$
$$s.t. \quad P_t + M_t + F_t + \frac{A_{t+1}}{1+r} = W_{m,t}H_{m,t} + W_{f,t}H_{f,t} + Y_{n,t} + A_t$$
$$\Delta w_{m,t} = \Delta u_{m,t} + v_{m,t}$$
$$\Delta w_{f,t} = \Delta u_{f,t} + v_{f,t}$$
$$\Delta y_{n,t} = \Delta u_{n,t} + v_{n,t}$$

F.O.C.'s

$$\text{Intra-temporal} \quad U_p = U_M = U_F = \lambda \quad -U_{H_m} = \lambda W_{m,t} \quad -U_{H_f} = \lambda W_{f,t}$$
$$\text{Inter-temporal} \quad \frac{\lambda_t}{1+r} = E_t \lambda_{t+1}$$

Defining $u \equiv \ln(U)$, from the FOC's

$$\begin{bmatrix} \Delta u_{p,t+1} \\ \Delta u_{m,t+1} \\ \Delta u_{f,t+1} \\ \Delta u_{h_m,t+1} \\ \Delta u_{h_f,t+1} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta \ln \lambda_{t+1} \\ \Delta w_{m,t+1} \\ \Delta w_{f,t+1} \end{bmatrix} \tag{A.1}$$

where $\Delta u_{p,t+1} \equiv \Delta \ln U_{p,t+1}$ and $\Delta u_{h_m,t+1} \equiv \Delta \ln(-U_{H_m,t+1})$. Moreover using the Taylor expansion we can linearize the utility function as follows

$$\begin{bmatrix} \Delta u_{p,t+1} \\ \Delta u_{m,t+1} \\ \Delta u_{f,t+1} \\ \Delta u_{h_m,t+1} \\ \Delta u_{h_f,t+1} \end{bmatrix} \simeq \underbrace{\begin{bmatrix} \frac{U_{PP}}{U_P}P & \frac{U_{PM}}{U_P}M & \frac{U_{PF}}{U_P}F & \frac{U_{PH_m}}{U_P}H_m & \frac{U_{PH_f}}{U_P}H_f \\ \frac{U_{MP}}{U_M}P & \frac{U_{MM}}{U_M}M & \frac{U_{MF}}{U_M}F & \frac{U_{MH_m}}{U_M}H_m & \frac{U_{MH_f}}{U_M}H_f \\ \frac{U_{FP}}{U_F}P & \frac{U_{FM}}{U_F}M & \frac{U_{FF}}{U_F}F & \frac{U_{FH_m}}{U_F}H_m & \frac{U_{FH_f}}{U_F}H_f \\ \frac{U_{H_mP}}{U_{H_m}}P & \frac{U_{H_mM}}{U_{H_m}}M & \frac{U_{H_mF}}{U_{H_m}}F & \frac{U_{H_mH_m}}{U_{H_m}}H_m & \frac{U_{H_mH_f}}{U_{H_m}}H_f \\ \frac{U_{H_fP}}{U_{H_f}}P & \frac{U_{H_fM}}{U_{H_f}}M & \frac{U_{H_fF}}{U_{H_f}}F & \frac{U_{H_fH_m}}{U_{H_f}}H_m & \frac{U_{H_fH_f}}{U_{H_f}}H_f \end{bmatrix}}_{\mathcal{J}} \begin{bmatrix} \Delta p_{t+1} \\ \Delta m_{t+1} \\ \Delta f_{t+1} \\ \Delta h_{m,t+1} \\ \Delta h_{f,t+1} \end{bmatrix} \tag{A.2}$$

Note that

$$|\mathcal{J}| = \frac{PMFH_mH_f}{U_pU_MU_FU_{H_m}U_{H_f}} \left| \underbrace{\begin{bmatrix} U_{PP} & U_{PM} & U_{PF} & U_{PH_m} & U_{PH_f} \\ U_{MP} & U_{MM} & U_{MF} & U_{MH_m} & U_{MH_f} \\ U_{FP} & U_{FM} & U_{FF} & U_{FH_m} & U_{FH_f} \\ U_{H_mP} & U_{H_mM} & U_{H_mF} & U_{H_mH_m} & U_{H_mH_f} \\ U_{H_fP} & U_{H_fM} & U_{H_fF} & U_{H_fH_m} & U_{H_fH_f} \end{bmatrix}}_{\mathcal{H}} \right|$$

note that $\mathcal{H}$ is the Hessian of the utility function. Assuming strict concavity, $H$ is not singular. Thus by solving the system of equations in (A.2)and substituting FOC's from (A.1) we have

$$\begin{bmatrix} \Delta p_{t+1} \\ \Delta m_{t+1} \\ \Delta f_{t+1} \\ \Delta h_{m,t+1} \\ \Delta h_{f,t+1} \end{bmatrix} = \mathcal{J}^{-1} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta \ln \lambda_{t+1} \\ \Delta w_{m,t+1} \\ \Delta w_{f,t+1} \end{bmatrix} \tag{A.3}$$

Note that $\mathcal{J}^{-1}$ contains the Frisch elasticities as we derived derivatives holding marginal utility of wealth $\lambda_{t+1}$ constant.

$$\mathcal{J}^{-1} = \begin{bmatrix} \mu_{p,p_p} & \mu_{p,p_m} & \mu_{p,p_f} & \mu_{p,w_m} & \mu_{p,w_f} \\ \mu_{m,p_p} & \mu_{m,p_m} & \mu_{m,p_f} & \mu_{m,w_m} & \mu_{m,w_f} \\ \mu_{f,p_p} & \mu_{f,p_m} & \mu_{f,p_f} & \mu_{f,w_m} & \mu_{f,w_f} \\ \mu_{h_m,p_p} & \mu_{h_m,p_m} & \mu_{h_m,p_f} & \mu_{h_m,w_m} & \mu_{h_m,w_f} \\ \mu_{h_f,p_p} & \mu_{h_f,p_m} & \mu_{h_f,p_f} & \mu_{h_f,w_m} & \mu_{h_f,w_f} \\ & & & & \end{bmatrix}$$

Thus

$$\begin{bmatrix} \Delta p_{t+1} \\ \Delta m_{t+1} \\ \Delta f_{t+1} \\ \Delta h_{m,t+1} \\ \Delta h_{f,t+1} \end{bmatrix} = \mathcal{J}^{-1} \begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta \ln \lambda_{t+1} \\ \Delta w_{m,t+1} \\ \Delta w_{f,t+1} \end{bmatrix} \tag{A.4}$$

$$\begin{bmatrix} \Delta p_{t+1} \\ \Delta m_{t+1} \\ \Delta f_{t+1} \\ \Delta h_{m,t+1} \\ \Delta h_{f,t+1} \end{bmatrix} = \underbrace{\begin{bmatrix} \sum_j \mu_{p,j} & \mu_{p,w_m} & \mu_{p,w_f} \\ \sum_j \mu_{m,j} & \mu_{m,w_m} & \mu_{m,w_f} \\ \sum_j \mu_{f,j} & \mu_{f,w_m} & \mu_{f,w_f} \\ \sum_j \mu_{h_m,j} & \mu_{h_m,w_m} & \mu_{h_m,w_f} \\ \sum_j \mu_{h_f,j} & \mu_{h_f,w_m} & \mu_{h_f,w_f} \end{bmatrix}}_{\Gamma} \begin{bmatrix} \Delta \ln \lambda_{t+1} \\ \Delta w_{m,t+1} \\ \Delta w_{f,t+1} \end{bmatrix} \tag{A.5}$$

Denote Γ's elements by

$$\Gamma = \begin{bmatrix} \gamma_{p,\lambda} & \gamma_{p,w_m} & \gamma_{p,w_f} \\ \gamma_{m,\lambda} & \gamma_{m,w_m} & \gamma_{m,w_f} \\ \gamma_{f,\lambda} & \gamma_{f,w_m} & \gamma_{f,w_f} \\ \gamma_{h_m,\lambda} & \gamma_{h_m,w_m} & \gamma_{h_m,w_f} \\ \gamma_{h_f,\lambda} & \gamma_{h_f,w_m} & \gamma_{h_f,w_f} \end{bmatrix}$$

From inter-temporal FOC

$$E_t \lambda_{t+1} = e^{\rho} \lambda_t$$

$$\Delta \ln \lambda_{t+1} \simeq \rho + \varepsilon_{t+1} \quad \text{where} \quad E_t \varepsilon_{t+1} = 0$$

We solve for $\varepsilon_{t+1}$ in terms of earnings socks using the inter-temporal budget constraint

$$\sum_{s=0}^{T-t} \frac{P_{t+s} + M_{t+s} + F_{t+s}}{(1+r)^s} = \sum_{s=0}^{T-t} \frac{\overbrace{W_{m,t+s} H_{m,t+s} + W_{f,t+s} H_{f,t+s} + Y_{n,t+s}}^{Y_{t+s}}}{(1+r)^s} + A_t$$

By a series of Taylor expansions and the law of iterated expectations

$$\begin{aligned}
\overbrace{E_t \ln LHS - E_{t-1} \ln LHS}^{\substack{\text{New information revealed at time t} \\ \text{about the lifetime consumption path}}} \quad &\simeq \varepsilon_t (\gamma_{p,\lambda} S^c_{p,t} + \gamma_{m,\lambda} S^c_{m,t} + \gamma_{f,\lambda} S^c_{f,t}) + \\
& v_{m,t} (S^c_{p,t} \gamma_{p,w_m} + S^c_{m,t} \gamma_{m,w_m} + S^c_{f,t} \gamma_{f,w_m}) + \\
& v_{f,t} (S^c_{p,t} \gamma_{p,w_f} + S^c_{m,t} \gamma_{m,w_f} + S^c_{f,t} \gamma_{f,w_f})
\end{aligned}$$

$$\begin{aligned}
\overbrace{E_t \ln RHS - E_{t-1} \ln RHS}^{\substack{\text{New information revealed at time t} \\ \text{about the lifetime earnings path}}} \quad &\simeq \varepsilon_t \pi_t (S^y_{m,t} \gamma_{h_m,\lambda} + S^y_{f,t} \gamma_{h_f,\lambda}) + \\
& v_{m,t} \pi_t (S^y_{m,t} (1 + \gamma_{h_m,w_m}) + S^y_{f,t} \gamma_{h_f,w_m}) + \\
& v_{f,t} \pi_t (S^y_{f,t} (1 + \gamma_{h_f,w_f}) + S^y_{m,t} \gamma_{h_m,w_f}) + \\
& v_{n,t} \pi_t S^y_{n,t}
\end{aligned}$$

Thus

$$\begin{aligned}
&\varepsilon_t\left(\gamma_{p,\lambda}S^c_{p,t}+\gamma_{m,\lambda}S^c_{m,t}+\gamma_{f,\lambda}S^c_{f,t}-S^y_{m,t}\pi_t\gamma_{h_m,\lambda}-S^y_{f,t}\pi_t\gamma_{h_f,\lambda}\right)=\\
&v_{m,t}\left(S^y_{m,t}\pi_t(1+\gamma_{h_m,w_m})+S^y_{f,t}\pi_t\gamma_{h_f,w_m}-S^c_{p,t}\gamma_{p,w_m}-S^c_{m,t}\gamma_{m,w_m}-S^c_{f,t}\gamma_{f,w_m}\right)+\\
&v_{f,t}\left(S^y_{f,t}\pi_t(1+\gamma_{h_f,w_f})+S^y_{m,t}\pi_t\gamma_{h_m,w_f}-S^c_{p,t}\gamma_{p,w_f}-S^c_{m,t}\gamma_{m,w_f}-S^c_{f,t}\gamma_{f,w_f}\right)+\\
&v_{n,t}S^y_{n,t}\pi_t
\end{aligned}$$

Thus we obtain $\varepsilon_t$ as follows

$$\begin{aligned}
\varepsilon_t =& v_{m,t}\frac{S^y_{m,t}\pi_t(1+\gamma_{h_m,w_m})+S^y_{f,t}\pi_t\gamma_{h_f,w_m}-S^c_{p,t}\gamma_{p,w_m}-S^c_{m,t}\gamma_{m,w_m}-S^c_{f,t}\gamma_{f,w_m}}{\gamma_{p,\lambda}S^c_{p,t}+\gamma_{m,\lambda}S^c_{m,t}+\gamma_{f,\lambda}S^c_{f,t}-S^y_{m,t}\pi_t\gamma_{h_m,\lambda}-S^y_{f,t}\pi_t\gamma_{h_f,\lambda}}+\\
& v_{f,t}\frac{S^y_{f,t}\pi_t(1+\gamma_{h_f,w_f})+S^y_{m,t}\pi_t\gamma_{h_m,w_f}-S^c_{p,t}\gamma_{p,w_f}-S^c_{m,t}\gamma_{m,w_f}-S^c_{f,t}\gamma_{f,w_f}}{\gamma_{p,\lambda}S^c_{p,t}+\gamma_{m,\lambda}S^c_{m,t}+\gamma_{f,\lambda}S^c_{f,t}-S^y_{m,t}\pi_t\gamma_{h_m,\lambda}-S^y_{f,t}\pi_t\gamma_{h_f,\lambda}}+\\
& v_{n,t}\frac{S^y_{n,t}\pi_t}{\gamma_{p,\lambda}S^c_{p,t}+\gamma_{m,\lambda}S^c_{m,t}+\gamma_{f,\lambda}S^c_{f,t}-S^y_{m,t}\pi_t\gamma_{h_m,\lambda}-S^y_{f,t}\pi_t\gamma_{h_f,\lambda}}
\end{aligned}$$

where $S^c_{p,t}$ is the share of total household consumption allocated to public consumption in the lifetime of the household

$$S^c_{p,t}=\frac{\sum_{s=0}^{T-t}\frac{e^{E_{t-1}p_{t+s}}}{(1+r)^s}}{\sum_{s=0}^{T-t}\frac{e^{E_{t-1}p_{t+s}}}{(1+r)^s}+\sum_{s=0}^{T-t}\frac{e^{E_{t-1}m_{t+s}}}{(1+r)^s}+\sum_{s=0}^{T-t}\frac{e^{E_{t-1}f_{t+s}}}{(1+r)^s}}$$

and similar expressions hold for $S^c_{m,t}$ and $S^c_{f,t}$ as the share of total household consumption allocated to the male's and female's private consumption, respectively.

$\pi_t$ is the share of human wealth in the household's total wealth, as the sum of physical wealth and human wealth, i.e. the expected lifetime earnings as of the current period.

$$\pi_t = \frac{\sum_{s=0}^{T-t} e^{E_{t-1}\ln Y_{t+s} - s\ln(1+r)}}{\sum_{s=0}^{T-t} e^{E_{t-1}\ln Y_{t+s} - s\ln(1+r)} + e^{E_{t-1}\ln A_t}}$$

$S^y_{m,t}$ is the share of the male's lifetime labor earnings in the household's human wealth and is calculated as follows

$$S^y_{m,t} = \sum_{s=0}^{T-t} \alpha_{t+s} q_{m,t+s}$$

where

- $\alpha_{t+s}$: Contributing share of period $s$ in the future stream of the household's labor earnings
- $q_{m,t+s}$: Share of the male's earnings of the household's earnings at period $s$

$$\alpha_{t+s} = \frac{e^{E_{t-1}\ln Y_{t+s} - s\ln(1+r)}}{\sum_{s=0}^{T-t} e^{E_{t-1}\ln Y_{t+s} - s\ln(1+r)}}$$

$$q_{m,t+s} = \frac{e^{E_{t-1}\ln Y_{m,t+s}}}{e^{E_{t-1}\ln Y_{m,t+s}} + e^{E_{t-1}\ln Y_{f,t+s}} + e^{E_{t-1}\ln Y_{n,t+s}}}$$

$S^y_{f,t}$ is derived similarly and represents the share of the female's lifetime labor earnings in the household's human wealth. Finally, $S^y_{n,t}$ represents the share of non-labor earnings in the household human wealth.

For brevity, we name the coefficients in the equation above as follows

$$\varepsilon_t = v_{m,t}\alpha_{m,t} + v_{f,t}\alpha_{f,t} + v_{n,t}\alpha_{n,t} \tag{A.6}$$

where

$$\alpha_{m,t} = \frac{S^y_{m,t}\pi_t(1+\gamma_{h_m,w_m}) + S^y_{f,t}\pi_t\gamma_{h_f,w_m} - S^c_{p,t}\gamma_{p,w_m} - S^c_{m,t}\gamma_{m,w_m} - S^c_{f,t}\gamma_{f,w_m}}{\gamma_{p,\lambda}S^c_{p,t} + \gamma_{m,\lambda}S^c_{m,t} + \gamma_{f,\lambda}S^c_{f,t} - S^y_{m,t}\pi_t\gamma_{h_m,\lambda} - S^y_{f,t}\pi_t\gamma_{h_f,\lambda}} \tag{A.7}$$

$$\alpha_{f,t} = \frac{S^y_{f,t}\pi_t(1+\gamma_{h_f,w_f}) + S^y_{m,t}\pi_t\gamma_{h_m,w_f} - S^c_{p,t}\gamma_{p,w_f} - S^c_{m,t}\gamma_{m,w_f} - S^c_{f,t}\gamma_{f,w_f}}{\gamma_{p,\lambda}S^c_{p,t} + \gamma_{m,\lambda}S^c_{m,t} + \gamma_{f,\lambda}S^c_{f,t} - S^y_{m,t}\pi_t\gamma_{h_m,\lambda} - S^y_{f,t}\pi_t\gamma_{h_f,\lambda}} \tag{A.8}$$

$$\alpha_{n,t} = \frac{S^y_{n,t}\pi_t}{\gamma_{p,\lambda}S^c_{p,t} + \gamma_{m,\lambda}S^c_{m,t} + \gamma_{f,\lambda}S^c_{f,t} - S^y_{m,t}\pi_t\gamma_{h_m,\lambda} - S^y_{f,t}\pi_t\gamma_{h_f,\lambda}} \tag{A.9}$$

Thus we can write the growth rate in marginal utility of wealth, and wages in terms of permanent and transitory earnings shocks as follows

$$\begin{bmatrix} \Delta \ln \lambda_{t+1} \\ \Delta w_{m,t+1} \\ \Delta w_{f,t+1} \end{bmatrix} = \begin{bmatrix} \alpha_{m,t+1} & \alpha_{f,t+1} & \alpha_{n,t+1} & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_{m,t+1} \\ v_{f,t+1} \\ v_{n,t+1} \\ \Delta u_{m,t+1} \\ \Delta u_{f,t+1} \end{bmatrix} \tag{A.10}$$

We plug (A.5) into (A.10)

$$\begin{bmatrix} \Delta p_{t+1} \\ \Delta m_{t+1} \\ \Delta f_{t+1} \\ \Delta h_{m,t+1} \\ \Delta h_{f,t+1} \end{bmatrix} = \begin{bmatrix} \gamma_{p,\lambda} & \gamma_{p,w_m} & \gamma_{p,w_f} \\ \gamma_{m,\lambda} & \gamma_{m,w_m} & \gamma_{m,w_f} \\ \gamma_{f,\lambda} & \gamma_{f,w_m} & \gamma_{f,w_f} \\ \gamma_{h_m,\lambda} & \gamma_{h_m,w_m} & \gamma_{h_m,w_f} \\ \gamma_{h_f,\lambda} & \gamma_{h_f,w_m} & \gamma_{h_f,w_f} \end{bmatrix} \begin{bmatrix} \alpha_{m,t+1} & \alpha_{f,t+1} & \alpha_{n,t+1} & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_{m,t+1} \\ v_{f,t+1} \\ v_{n,t+1} \\ \Delta u_{m,t+1} \\ \Delta u_{f,t+1} \end{bmatrix} \tag{A.11}$$

$$\begin{bmatrix} \Delta p_{t+1} \\ \Delta m_{t+1} \\ \Delta f_{t+1} \\ \Delta h_{m,t+1} \\ \Delta h_{f,t+1} \end{bmatrix} = \begin{bmatrix} \gamma_{p,\lambda}\alpha_{m,t+1} + \gamma_{p,w_m} & \gamma_{p,\lambda}\alpha_{f,t+1} + \gamma_{p,w_f} & \gamma_{p,\lambda}\alpha_{n,t+1} & \gamma_{p,w_m} & \gamma_{p,w_f} \\ \gamma_{m,\lambda}\alpha_{m,t+1} + \gamma_{m,w_m} & \gamma_{m,\lambda}\alpha_{f,t+1} + \gamma_{m,w_f} & \gamma_{m,\lambda}\alpha_{n,t+1} & \gamma_{m,w_m} & \gamma_{m,w_f} \\ \gamma_{f,\lambda}\alpha_{m,t+1} + \gamma_{f,w_m} & \gamma_{f,\lambda}\alpha_{f,t+1} + \gamma_{f,w_f} & \gamma_{f,\lambda}\alpha_{n,t+1} & \gamma_{f,w_m} & \gamma_{f,w_f} \\ \gamma_{h_m,\lambda}\alpha_{m,t+1} + \gamma_{h_m,w_m} & \gamma_{h_m,\lambda}\alpha_{f,t+1} + \gamma_{h_m,w_f} & \gamma_{h_m,\lambda}\alpha_{n,t+1} & \gamma_{h_m,w_m} & \gamma_{h_m,w_f} \\ \gamma_{h_f,\lambda}\alpha_{m,t+1} + \gamma_{h_f,w_m} & \gamma_{h_f,\lambda}\alpha_{f,t+1} + \gamma_{h_f,w_f} & \gamma_{h_f,\lambda}\alpha_{n,t+1} & \gamma_{h_f,w_m} & \gamma_{h_f,w_f} \end{bmatrix} \begin{bmatrix} v_{m,t+1} \\ v_{f,t+1} \\ v_{n,t+1} \\ \Delta u_{m,t+1} \\ \Delta u_{f,t+1} \end{bmatrix} \tag{A.12}$$

In section 8.2, we consider a special case where the female does not work and we also ignore non-labor income. Thus $\alpha_{f,t} = 0$ and $\alpha_{n,t} = 0$. In addition $\alpha_{m,t}$ is modified as follows

$$\alpha_{m,t} = \frac{\pi_t(1 + \gamma_{h_m,w_m}) + -S^c_{p,t}\gamma_{p,w_m} - S^c_{m,t}\gamma_{m,w_m} - S^c_{f,t}\gamma_{f,w_m}}{\gamma_{p,\lambda}S^c_{p,t} + \gamma_{m,\lambda}S^c_{m,t} + \gamma_{f,\lambda}S^c_{f,t} - \pi_t\gamma_{h_m,\lambda}} \tag{A.13}$$

Thus the system of equations of A.12 is modified as follows

$$\Delta p_{t+1} = (\gamma_{p,\lambda}\alpha_{m,t+1} + \gamma_{p,w_m})v_{m,t+1} + \gamma_{p,w_m}\Delta u_{m,t+1}$$

$$\Delta m_{t+1} = (\gamma_{m,\lambda}\alpha_{m,t+1} + \gamma_{m,w_m})v_{m,t+1} + \gamma_{m,w_m}\Delta u_{m,t+1}$$

$$\Delta f_{t+1} = (\gamma_{f,\lambda}\alpha_{m,t+1} + \gamma_{f,w_m})v_{m,t+1} + \gamma_{f,w_m}\Delta u_{m,t+1}$$

$$\Delta h_{m,t+1} = (\gamma_{h,\lambda}\alpha_{m,t+1} + \gamma_{h_m,w_m})v_{m,t+1} + \gamma_{h,w_m}\Delta u_{m,t+1}$$

# APPENDIX B

# ADDITIONAL FIGURES

Figure B.1: The evolution of the level of consumption

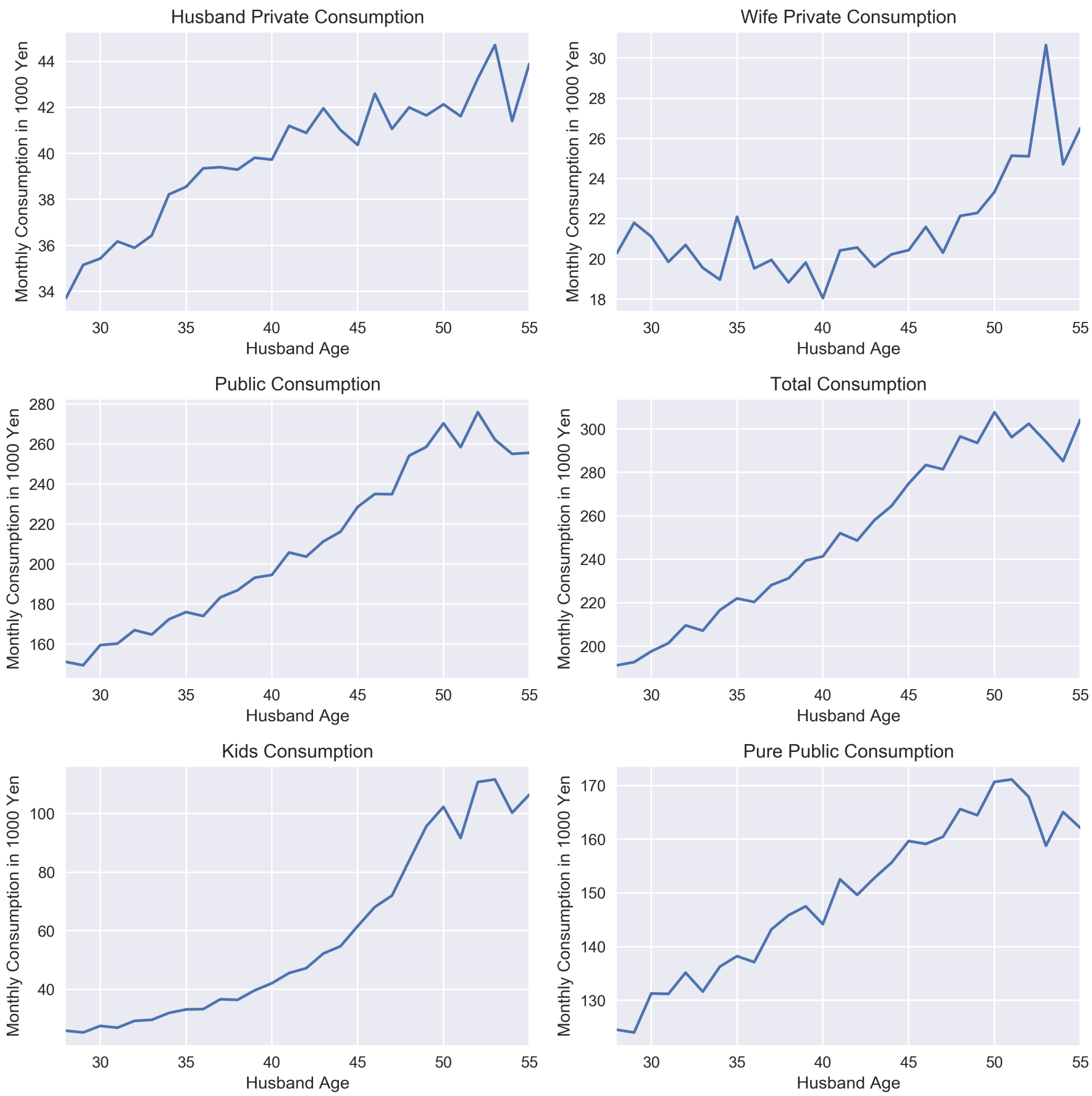
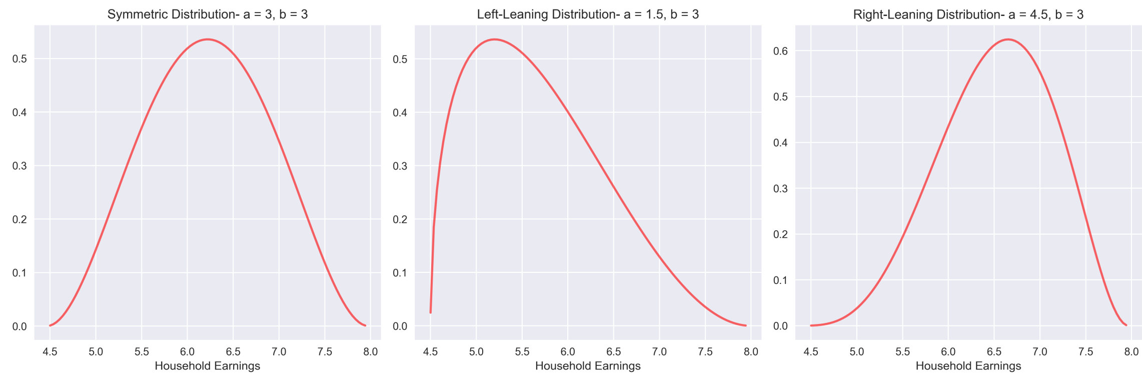
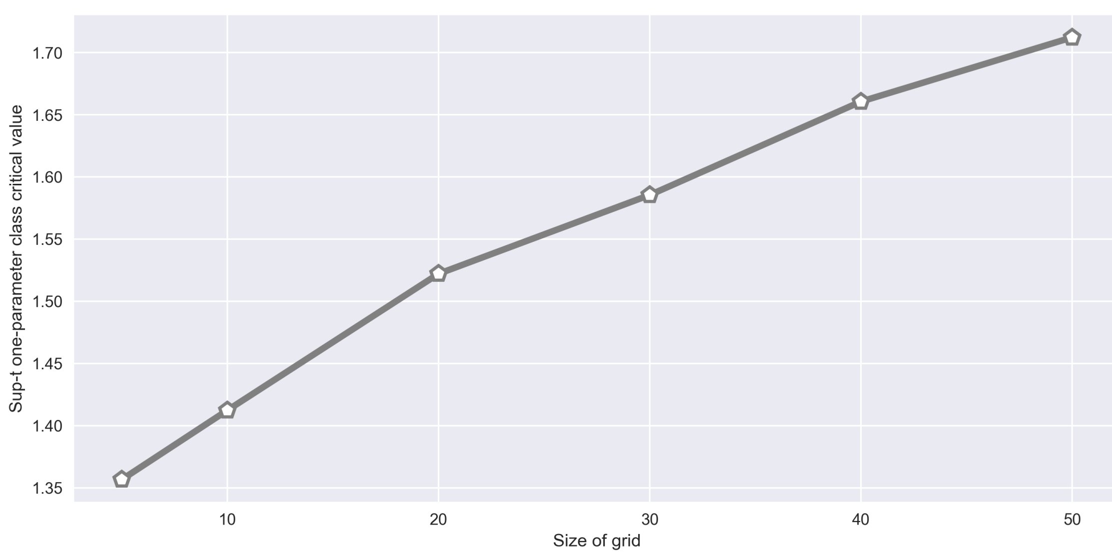


Figure B.2: The household's earnings distributions used in the simulation



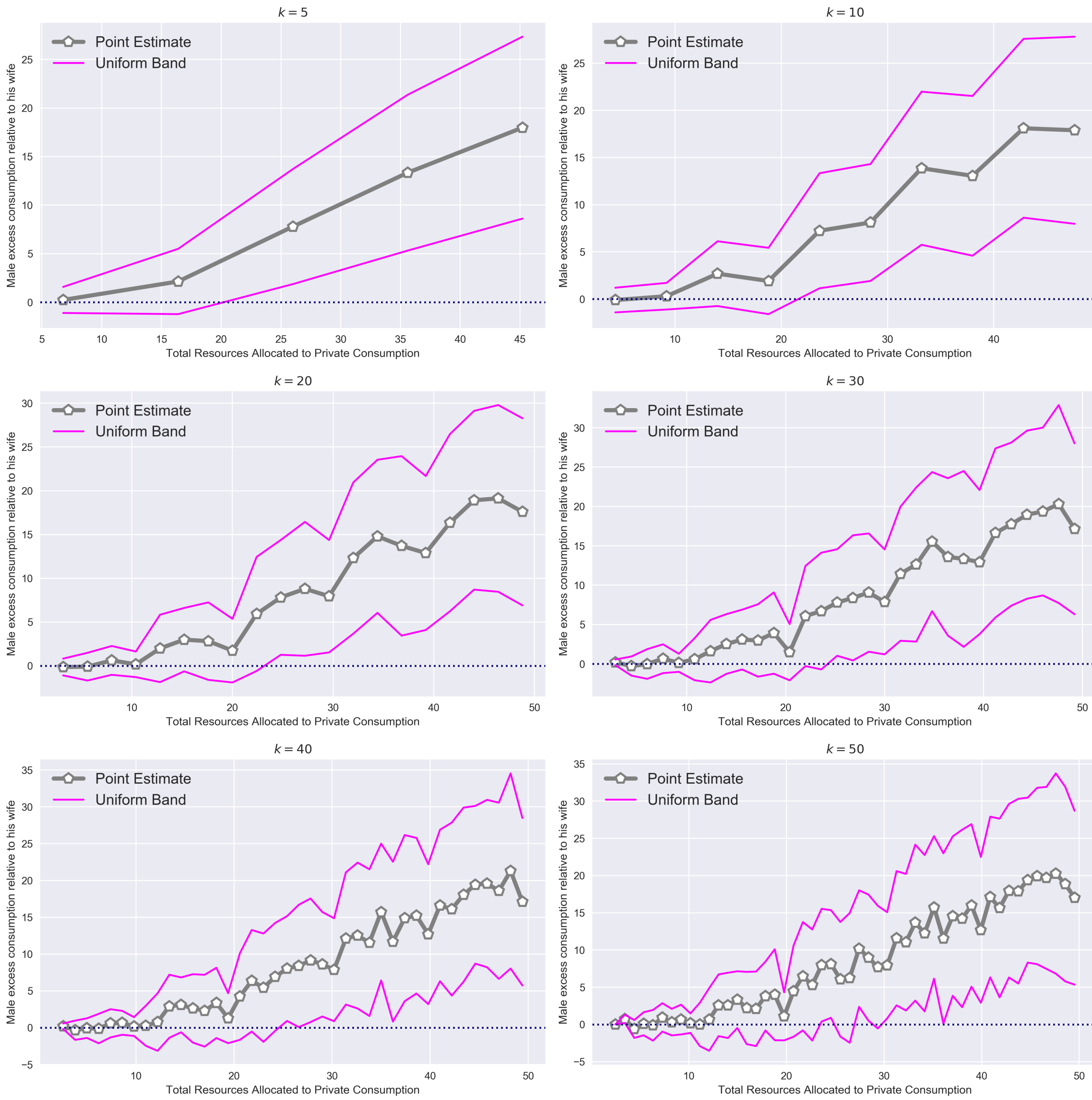

The pareto weight is set to 0.5. The subsistence levels are the same across gender $a_m = a_f = -2$. The spouses are heterogeneous in terms of risk aversion in the sense that the female is more risk averse, $\gamma_m = 1.25$ and $\gamma_f = 2.5$. Due to the heterogeneity in preferences, as proposition 3 implies, the optimal consumption functions cross.

Figure B.3: The dependence of the critical value of the uniform band to the size of grid



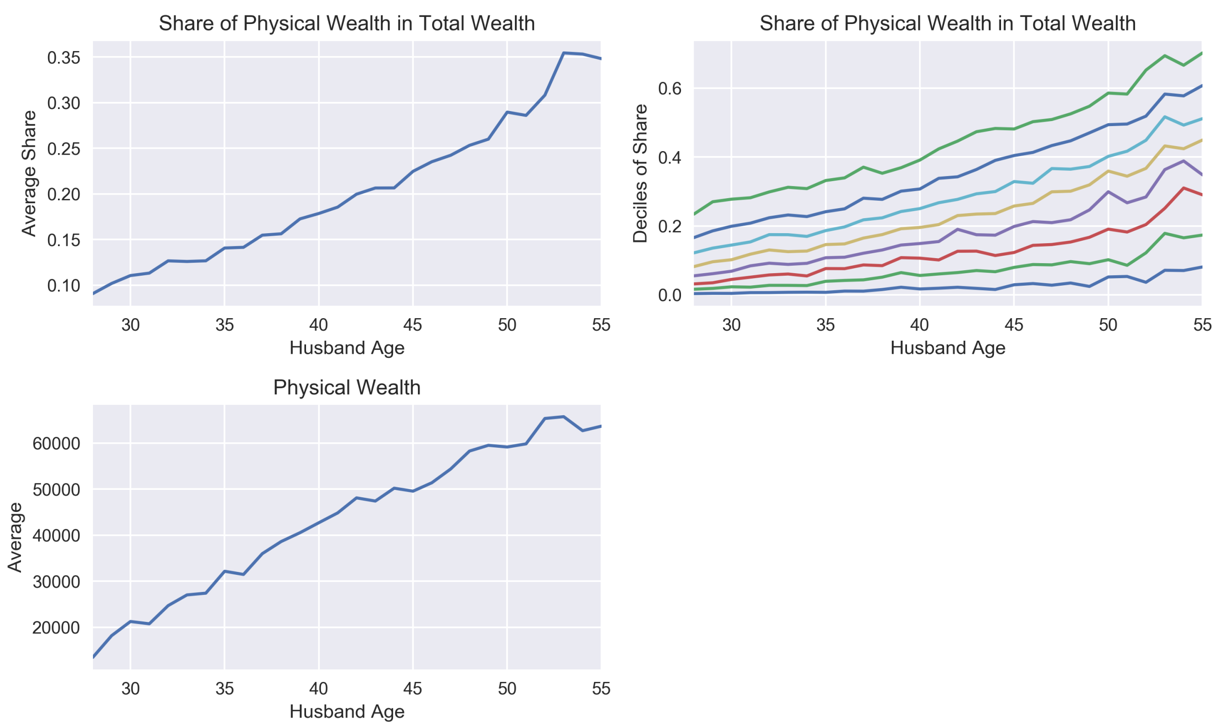

The graph demonstrates how the critical value corresponding to the Sup-t uniform band depends on the size of bins of total private consumption. There is an increasing relationship between the size of the grid and the critical values. This pattern contributes to the widening of the uniform band as the grid size increases.

Figure B.4: The uniform band sensitivity to the size of grid




The band demonstrate the 90 percent uniform band. The uniform band is constructed using the Sup-t band by discretizing the support of total private consumption. $k$ denotes the size of the grid. As the size of the grid increases the band and point estimate of the function becomes less smooth. Also as the grid size increases, the band becomes wider because the number of observations in each bin would decrease. However, the quantitative results do not depend on grid size.

Figure B.5: Evolution of share of physical wealth in the lifecycle




The share of physical wealth from total wealth follows an increasing pattern in the lifecycle.

# APPENDIX C

## ADDITIONAL TABLES

Table C.1: The autocovariance table of earnings growth

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| $var(\Delta y_t)$ | 0.089 | 0.089 | 0.071 |
| $var(\Delta y_{m,t})$ | 0.041 | 0.040 | 0.036 |
| $var(\Delta y_{f,t})$ | 0.130 | 0.108 | 0.070 |
| $cov(\Delta y_t \Delta y_{m,t})$ | 0.035 | 0.034 | 0.029 |
| $cov(\Delta y_t \Delta y_{f,t})$ | 0.032 | 0.025 | 0.015 |
| $cov(\Delta y_{m,t} \Delta y_{f,t})$ | 0.005 | 0.005 | 0.004 |
| $cov(\Delta y_t \Delta y_{t+1})$ | -0.030 | -0.035 | -0.023 |
| $cov(\Delta y_{m,t} \Delta y_{m,t+1})$ | -0.010 | -0.011 | -0.010 |
| $cov(\Delta y_{f,t} \Delta y_{f,t+1})$ | -0.018 | -0.009 | -0.001 |

The groups are the terciles of the husband's age distribution, in that age groups are as follows: $\leq$ 35, $36-42$, and 43 $\geq$.

Table C.2: The autocovariance table of earnings growth

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| $var(\Delta y_t)$ | 0.089 | 0.089 | 0.071 |
| $var(\Delta y_{m,t})$ | 0.041 | 0.040 | 0.036 |
| $var(\Delta y_{f,t})$ | 0.130 | 0.108 | 0.070 |
| $cov(\Delta y_t \Delta y_{m,t})$ | 0.035 | 0.034 | 0.029 |
| $cov(\Delta y_t \Delta y_{f,t})$ | 0.032 | 0.025 | 0.015 |
| $cov(\Delta y_{m,t} \Delta y_{f,t})$ | 0.005 | 0.005 | 0.004 |
| $cov(\Delta y_t \Delta y_{t+1})$ | -0.030 | -0.035 | -0.023 |
| $cov(\Delta y_{m,t} \Delta y_{m,t+1})$ | -0.010 | -0.011 | -0.010 |
| $cov(\Delta y_{f,t} \Delta y_{f,t+1})$ | -0.018 | -0.009 | -0.001 |

The groups are the terciles of the husband's age distribution, in that age groups are as follows: $\leq$ 35, $36-42$, and 43 $\geq$.

Table C.3: The autocovariance table of wage growth

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| $var(\Delta w_{m,t})$ | 0.071 | 0.067 | 0.065 |
| $var(\Delta w_{f,t})$ | 0.042 | 0.040 | 0.035 |
| $cov(\Delta w_{m,t}\Delta w_{f,t})$ | 0.006 | 0.003 | 0.004 |
| $cov(\Delta w_{m,t}\Delta w_{m,t+1})$ | -0.027 | -0.023 | -0.026 |
| $cov(\Delta w_{f,t}\Delta w_{f,t+1})$ | -0.017 | -0.013 | -0.012 |

The groups are the terciles of the husband's age distribution, in that age groups are as follows: $\leq 35$, $36-42$, and $43 \geq$.

Table C.4: The autocovariance table of consumption growth

| | Group 1 | Group 2 | Group 3 |
|---|---|---|---|
| $var(\Delta c_t)$ | 0.146 | 0.130 | 0.140 |
| $var(\Delta c_{p,t})$ | 0.199 | 0.162 | 0.163 |
| $var(\Delta c_{m,t})$ | 0.403 | 0.363 | 0.341 |
| $var(\Delta c_{f,t})$ | 0.545 | 0.470 | 0.482 |
| $cov(\Delta c_t\Delta c_{p,t})$ | 0.137 | 0.116 | 0.129 |
| $cov(\Delta c_t\Delta c_{m,t})$ | 0.076 | 0.068 | 0.067 |
| $cov(\Delta c_t\Delta c_{f,t})$ | 0.081 | 0.057 | 0.059 |
| $cov(\Delta c_{p,t}\Delta c_{m,t})$ | 0.004 | 0.010 | 0.012 |
| $cov(\Delta c_{p,t}\Delta c_{f,t})$ | 0.015 | 0.006 | 0.008 |
| $cov(\Delta c_{m,t}\Delta c_{f,t})$ | 0.158 | 0.139 | 0.134 |
| $cov(\Delta c_t\Delta c_{t+1})$ | -0.058 | -0.054 | -0.060 |
| $cov(\Delta c_{p,t}\Delta c_{p,t+1})$ | -0.077 | -0.070 | -0.069 |
| $cov(\Delta c_{m,t}\Delta c_{m,t+1})$ | -0.158 | -0.139 | -0.149 |
| $cov(\Delta c_{f,t}\Delta c_{f,t+1})$ | -0.223 | -0.171 | -0.185 |

The groups are the terciles of the husband's age distribution, in that age groups are as follows: $\leq 35$, $36-42$, and $43 \geq$.

Table C.5: Estimation of partial insurance parameters with *"After Tax"* total household earnings

| | (1) iid Transitory | (2) MA(1) Transitory | (3) Total Consumption | (4) Consumption Breakdown |
|---|---|---|---|---|
| $\sigma_v^2$ | 0.021*** | 0.028*** | 0.021*** | 0.022*** |
| | (7.38) | (8.90) | (7.34) | (7.91) |
| $\sigma_u^2$ | 0.025*** | 0.017*** | 0.025*** | 0.023*** |
| | (8.19) | (4.89) | (8.01) | (7.85) |
| $\theta$ | | 0.216 | | |
| | | (1.50) | | |
| $\phi$ | | | 0.258*** | |
| | | | (4.31) | |
| $\psi$ | | | 0.006 | |
| | | | (0.16) | |
| $\sigma_\eta^2$ | | | 0.023*** | |
| | | | (8.10) | |
| $\phi_m$ | | | | 0.346*** |
| | | | | (3.25) |
| $\psi_m$ | | | | -0.057 |
| | | | | (-0.80) |
| $\sigma_{\eta_m}^2$ | | | | 0.072*** |
| | | | | (6.76) |
| $\phi_f$ | | | | 0.152 |
| | | | | (1.36) |
| $\psi_f$ | | | | -0.029 |
| | | | | (-0.44) |
| $\sigma_{\eta_f}^2$ | | | | 0.108*** |
| | | | | (7.58) |
| $\phi_p$ | | | | 0.211*** |
| | | | | (3.28) |
| $\psi_p$ | | | | 0.038 |
| | | | | (0.79) |
| $\sigma_{\eta_p}^2$ | | | | 0.034*** |
| | | | | (9.08) |
| $\rho_{m,f}^\eta$ | | | | 0.180*** |
| | | | | (18.40) |
| $\rho_{p,m}^\eta$ | | | | 0.021*** |
| | | | | (4.35) |
| $\rho_{p,f}^\eta$ | | | | 0.023*** |
| | | | | (4.02) |
| $N$ | 13601 | 13601 | 14980 | 14877 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results estimated using GMM and standard errors clustered at the household level.

Table C.6: Estimation of partial insurance parameters with total household earnings and direct consumption data

| | (1) iid Transitory | (2) MA(1) Transitory | (3) Total Consumption | (4) Consumption Breakdown |
|---|---|---|---|---|
| $\sigma_v^2$ | 0.025*** | 0.033*** | 0.025*** | 0.025*** |
| | (6.17) | (8.54) | (6.05) | (6.12) |
| $\sigma_u^2$ | 0.034*** | 0.026*** | 0.035*** | 0.035*** |
| | (6.91) | (4.79) | (7.01) | (7.06) |
| $\theta$ | | 0.144 | | |
| | | (1.33) | | |
| $\phi$ | | | 0.260*** | |
| | | | (4.16) | |
| $\psi$ | | | -0.013 | |
| | | | (-0.60) | |
| $\sigma_\eta^2$ | | | 0.027*** | |
| | | | (9.44) | |
| $\phi_m$ | | | | 0.276*** |
| | | | | (2.95) |
| $\psi_m$ | | | | -0.016 |
| | | | | (-0.38) |
| $\sigma_{\eta_m}^2$ | | | | 0.065*** |
| | | | | (6.46) |
| $\phi_f$ | | | | 0.109 |
| | | | | (1.10) |
| $\psi_f$ | | | | -0.036 |
| | | | | (-0.79) |
| $\sigma_{\eta_f}^2$ | | | | 0.096*** |
| | | | | (7.44) |
| $\phi_p$ | | | | 0.244*** |
| | | | | (3.51) |
| $\psi_p$ | | | | -0.008 |
| | | | | (-0.27) |
| $\sigma_{\eta_p}^2$ | | | | 0.040*** |
| | | | | (8.59) |
| $\rho_{m,f}^\eta$ | | | | 0.128*** |
| | | | | (15.64) |
| $\rho_{p,m}^\eta$ | | | | 0.000 |
| | | | | (0.08) |
| $\rho_{p,f}^\eta$ | | | | 0.004 |
| | | | | (0.83) |
| $N$ | 14737 | 14737 | 15019 | 15012 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results estimated using GMM and standard errors clustered at the household level.

Table C.7: Estimation of partial insurance parameters with total growth rates (without taking the residuals)

| | (1) iid Transitory | (2) MA(1) Transitory | (3) Total Consumption | (4) Consumption Breakdown |
|---|---|---|---|---|
| $\sigma_v^2$ | 0.025*** | 0.026*** | 0.025*** | 0.025*** |
| | (7.52) | (9.17) | (7.34) | (7.44) |
| $\sigma_u^2$ | 0.042*** | 0.041*** | 0.042*** | 0.041*** |
| | (10.07) | (9.31) | (10.05) | (9.98) |
| $\theta$ | | 0.011 | | |
| | | (0.23) | | |
| $\phi$ | | | 0.240*** | |
| | | | (4.24) | |
| $\psi$ | | | -0.001 | |
| | | | (-0.06) | |
| $\sigma_\eta^2$ | | | 0.019*** | |
| | | | (7.04) | |
| $\phi_m$ | | | | 0.309*** |
| | | | | (2.97) |
| $\psi_m$ | | | | -0.020 |
| | | | | (-0.50) |
| $\sigma_{\eta_m}^2$ | | | | 0.048*** |
| | | | | (6.02) |
| $\phi_f$ | | | | 0.118 |
| | | | | (1.13) |
| $\psi_f$ | | | | -0.021 |
| | | | | (-0.51) |
| $\sigma_{\eta_f}^2$ | | | | 0.072*** |
| | | | | (6.76) |
| $\phi_p$ | | | | 0.207*** |
| | | | | (3.45) |
| $\psi_p$ | | | | 0.019 |
| | | | | (0.71) |
| $\sigma_{\eta_p}^2$ | | | | 0.027*** |
| | | | | (7.43) |
| $\rho_{m,f}^{\eta}$ | | | | 0.134*** |
| | | | | (18.66) |
| $\rho_{p,m}^{\eta}$ | | | | 0.001 |
| | | | | (0.45) |
| $\rho_{p,f}^{\eta}$ | | | | 0.003 |
| | | | | (0.66) |
| $N$ | 20552 | 20552 | 21817 | 21757 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results estimated using GMM and standard errors clustered at the household level.

Table C.8: Estimation of partial insurance parameters with only nondurable part of consumption

| | (1) iid Transitory | (2) MA(1) Transitory | (3) Total Consumption | (4) Consumption Breakdown |
|---|---|---|---|---|
| $\sigma_v^2$ | 0.025*** | 0.033*** | 0.024*** | 0.025*** |
| | (6.01) | (8.27) | (5.83) | (6.15) |
| $\sigma_u^2$ | 0.034*** | 0.026*** | 0.033*** | 0.030*** |
| | (6.81) | (4.59) | (6.62) | (6.21) |
| $\theta$ | | 0.147 | | |
| | | (1.32) | | |
| $\phi$ | | | 0.221*** | |
| | | | (3.63) | |
| $\psi$ | | | 0.000 | |
| | | | (0.01) | |
| $\sigma_\eta^2$ | | | 0.024*** | |
| | | | (8.48) | |
| $\phi_m$ | | | | 0.309*** |
| | | | | (2.94) |
| $\psi_m$ | | | | -0.037 |
| | | | | (-0.66) |
| $\sigma_{\eta_m}^2$ | | | | 0.066*** |
| | | | | (6.01) |
| $\phi_f$ | | | | 0.119 |
| | | | | (1.13) |
| $\psi_f$ | | | | -0.026 |
| | | | | (-0.46) |
| $\sigma_{\eta_f}^2$ | | | | 0.107*** |
| | | | | (7.22) |
| $\sigma_{me,c_f}^2$ | | | | 0.268*** |
| | | | | (20.61) |
| $\phi_p$ | | | | 0.188*** |
| | | | | (3.18) |
| $\psi_p$ | | | | 0.038 |
| | | | | (1.07) |
| $\sigma_{\eta_p}^2$ | | | | 0.034*** |
| | | | | (8.72) |
| $\rho_{m,f}^\eta$ | | | | 0.190*** |
| | | | | (18.54) |
| $\rho_{p,m}^\eta$ | | | | 0.023*** |
| | | | | (4.44) |
| $\rho_{p,f}^\eta$ | | | | 0.026*** |
| | | | | (3.62) |
| $N$ | 13670 | 13670 | 13934 | 13905 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results estimated using GMM and standard errors clustered at the household level.

Table C.9: Estimation of partial insurance parameters with inclusion of the change in assets in the first stage

| | (1)<br>iid Transitory | (2)<br>MA(1) Transitory | (3)<br>Total Consumption | (4)<br>Consumption Breakdown |
|---|---|---|---|---|
| $\sigma_v^2$ | 0.025*** | 0.033*** | 0.024*** | 0.025*** |
| | (6.17) | (8.54) | (6.00) | (6.24) |
| $\sigma_u^2$ | 0.034*** | 0.026*** | 0.034*** | 0.032*** |
| | (6.91) | (4.79) | (6.82) | (6.54) |
| $\theta$ | | 0.144 | | |
| | | (1.33) | | |
| $\phi$ | | | 0.243*** | |
| | | | (4.09) | |
| $\psi$ | | | -0.002 | |
| | | | (-0.06) | |
| $\sigma_\eta^2$ | | | 0.024*** | |
| | | | (8.08) | |
| $\phi_m$ | | | | 0.310*** |
| | | | | (2.96) |
| $\psi_m$ | | | | -0.026 |
| | | | | (-0.50) |
| $\sigma_{\eta_m}^2$ | | | | 0.072*** |
| | | | | (6.73) |
| $\phi_f$ | | | | 0.130 |
| | | | | (1.24) |
| $\psi_f$ | | | | -0.027 |
| | | | | (-0.52) |
| $\sigma_{\eta_f}^2$ | | | | 0.109*** |
| | | | | (7.59) |
| $\phi_p$ | | | | 0.198*** |
| | | | | (3.37) |
| $\psi_p$ | | | | 0.029 |
| | | | | (0.84) |
| $\sigma_{\eta_p}^2$ | | | | 0.034*** |
| | | | | (9.08) |
| $\rho_{m,f}^\eta$ | | | | 0.179*** |
| | | | | (18.34) |
| $\rho_{p,m}^\eta$ | | | | 0.021*** |
| | | | | (4.25) |
| $\rho_{p,f}^\eta$ | | | | 0.023*** |
| | | | | (4.04) |
| $N$ | 14737 | 14737 | 15029 | 14999 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results estimated using GMM and standard errors clustered at the household level.

Table C.10: The matched moments in the SMM estimation

| | Data Moments | Model Moments |
|---|---|---|
| $\Delta c_{m,t}^2$ | 0.4684 | 0.4375 |
| $\Delta c_{m,t}\Delta c_{p,t}$ | 0.6354 | 0.5822 |
| $\Delta c_{m,t}\Delta y_t$ | 0.1913 | 0.1838 |
| $\Delta c_{m,t}\Delta c_{m,t-1}$ | 0.0213 | 0.0239 |
| $\Delta c_{p,t}^2$ | 0.0231 | 0.0214 |
| $\Delta c_{p,t}\Delta y_t$ | 0.0061 | 0.0064 |
| $\Delta c_{p,t}\Delta c_{p,t-1}$ | 0.0003 | 0.0004 |
| $\Delta c_{f,t}^2$ | 0.0066 | 0.0064 |
| $\Delta c_{f,t}\Delta c_{p,t}$ | -0.1967 | -0.2073 |
| $\Delta c_{f,t}\Delta y_t$ | -0.2619 | -0.2801 |
| $\Delta c_{f,t}\Delta c_{f,t-1}$ | -0.0782 | -0.0805 |

The moments that matched in the simulated method of moments estimates.

Table C.11: Comparing the magnitude of the risk-aversion heterogeneity and the threat of divorce mechanism in explaining the gap in passthroughs including both directions

| (1) Mechanism | (2) Predictor | (3) Direction | (4) Estimates of The Gap in Passthroughs | (5) Difference from Full Sample |
|---|---|---|---|---|
| Risk Aversion Heterogeneity | Human Wealth Ratio | High | 0.250* <br> (0.079) | 0.048 <br> (0.334) <br> [ 23%] |
| Risk Aversion Heterogeneity | Human Wealth Ratio | Low | 0.121 <br> (0.203) | -0.082 <br> (0.285) <br> [ -40%] |
| Threat of Divorce | Marital Happiness | Unhappy | 0.287* <br> (0.057) | 0.084 <br> (0.270) <br> [ 41%] |
| Threat of Divorce | Marital Happiness | Happy | 0.135 <br> (0.184) | - 0.068 <br> (0.294) <br> [-33 %] |
| Threat of Divorce | Number of Children | Low | 0.484** <br> (0.040) | 0.281 <br> (0.127) <br> [138 %] |
| Threat of Divorce | Number of Children | High | 0.049 <br> (0.339) | -0.154* <br> (0.049) <br> [ -76%] |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To compare the relative magnitude of the effect of the mechanisms, the table collects the estimates of the gap in passthroughs that can be attributed to each one of the proposed mechanisms. The first column specifies the mechanism. The second column reports the predictor according to which we divide the sample in order to obtain the subsample for which the presence of a certain mechanism is strengthened or weakened. The fourth column reports the estimates of the gap in passthroughs in the specified subsample. The fifth column reports the difference of the gap in the passthrough estimate between the second column and the full sample estimate. This difference is an indication of the strength of the mechanism in widening or narrowing the gap in passthroughs. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.12: The effect of the threat of divorce mechanism after controlling for the risk-aversion heterogeneity mechanism with the number of children as the predictor of divorce

| | (Smaller Gap) High Human Wealth High Number of Children | High Human Wealth | (Larger Gap) High Human Wealth Low Number of Children |
|---|---|---|---|
| Subsamples | 0.080 | 0.250* | 0.792 |
| | (0.494) | (0.079) | (0.429) |
| | | | |
| Differences | - 0.171 | | 0.541 |
| | (0.488) | | (0.451) |
| | [- 68%] | | [216 %] |
| Observations | 4091 | 7501 | 2245 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the level of heterogeneity in risk aversion. In particular, we focus on the sample in which the heterogeneity is higher than the full sample. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on the households with a higher ratio of human wealth to physical wealth for the male, namely the below-median observations. The table uses the number of children as the predictor of divorce. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have differential propensity to divorce. The first column is the group with a smaller propensity to divorce and the third column is the group with a larger propensity to divorce. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third column from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.13: The effect of the risk-aversion heterogeneity mechanism after controlling for the thereat of divorce mechanism with the number of children as the predictor of divorce

| | (Smaller Gap)<br>Low Number of Children<br>Low Human Wealth | Low Number of Children | (Larger Gap)<br>Low Number of Children<br>High Human Wealth |
|---|---|---|---|
| Subsamples | 0.162 | 0.484** | 0.792 |
| | (0.245) | (0.040) | (0.429) |
| Differences | - 0.322 | | 0.308 |
| | (0.133) | | (0.473) |
| | [- 66%] | | [64 %] |
| Observations | 1896 | 4141 | 2245 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the intensity of the threat to divorce by the female. In particular, we focus on the sample in which the propensity to divorce is higher and subsequently the threat of divorce is more substantial. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on households with lower numbers of children. Specifically, the households with no children or at most one child. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have differential levels of risk-aversion heterogeneity. The table uses the male's ratio of human wealth to physical wealth as the predictor of risk-aversion heterogeneity. The first column is the group with a smaller ratio of human wealth to physical wealth and the third column is the group with a larger ratio of human wealth to physical wealth. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third columns from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.14: The effect of the threat of divorce mechanism after controlling for the risk-aversion heterogeneity mechanism with marital relationship quality as a predictor of divorce: controlling at lower levels of risk-aversion heterogeneity

| | (Smaller Gap) Low Human Wealth Happy Marriage | Low Human Wealth | (Larger Gap) Low Human Wealth Unhappy Marriage |
|---|---|---|---|
| Subsamples | 0.038 | 0.121 | 0.253 |
| | (0.456) | (0.203) | (0.141) |
| | | | |
| Differences | - 0.083 | | 0.132 |
| | (0.400) | | (0.228) |
| | [- 69 %] | | [109 %] |
| Observations | 3125 | 7500 | 2174 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the level of heterogeneity in risk aversion. In particular we focus on the sample in which the heterogeneity is higher than the full sample. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on households with a lower ratio of human wealth to physical wealth for the male, namely the below-median observations. The table uses self-reported happiness about the marital relationship as the predictor of divorce. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have a differential propensity to divorce. The first column is the group with a smaller propensity to divorce and the third column is the group with a larger propensity to divorce. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third column from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.15: The effect of the risk-aversion heterogeneity mechanism after controlling for the thereat of divorce mechanism with marital relationship quality as predictor of divorce: controlling at less substantial levels of thereat of divorce

| | (Smaller Gap) Happy Marriage Low Human Wealth | Happy Marriage | (Larger Gap) Happy Marriage High Human Wealth |
|---|---|---|---|
| Subsamples | 0.038 | 0.135 | 0.187 |
| | (0.456) | (0.184) | (0.216) |
| Differences | - 0.096 | | 0.053 |
| | (0.381) | | (0.376) |
| | [- 71%] | | [39 %] |
| Observations | 3125 | 9405 | 3376 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the intensity of the threat to divorce by the female. In particular we focus on the sample in which the propensity to divorce is higher and subsequently the threat of divorce is more substantial. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on households with higher levels of satisfaction in their marital relationship. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have differential levels of risk-aversion heterogeneity. The table uses the male's ratio of human wealth to physical wealth as the predictor of risk-aversion heterogeneity. The first column is the group with a smaller ratio of human wealth to physical wealth and the third column is the group with a larger ratio of human wealth to physical wealth. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third column from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.16: The effect of the threat of divorce mechanism after controlling for the risk-aversion heterogeneity mechanism with the number of children as the predictor of divorce: controlling at lower levels of risk-aversion heterogeneity

| | (Smaller Gap) Low Human Wealth High Number of Children | Low Human Wealth | (Larger Gap) Low Human Wealth Low Number of Children |
|---|---|---|---|
| Subsamples | 0.003 | 0.121 | 0.162 |
| | (0.493) | (0.203) | (0.245) |
| | | | |
| Differences | - 0.117 | | 0.041 |
| | (0.237) | | (0.431) |
| | [- 96%] | | [34 %] |
| Observations | 3330 | 7500 | 1896 |

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In all three columns of the table, we control for the level of heterogeneity in risk aversion. In particular, we focus on the sample in which the heterogeneity is higher than the full sample. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on the households with a lower ratio of human wealth to physical wealth for the male, namely the below-median observations. The table uses the number of children as the predictor of divorce. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have differential propensity to divorce. The first column is the group with a smaller propensity to divorce and the third column is the group with a larger propensity to divorce. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third column from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.17: The correlation of hours within gender

| | Levels | | Changes | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| ***Unconditional*** | | | | |
| Labor Supply- Leisure | -0.733 | -0.109 | -0.751 | -0.249 |
| Labor Supply- Household Production | -0.159 | -0.616 | -0.209 | -0.436 |
| Leisure- Household Production | -0.514 | -0.604 | -0.447 | -0.746 |
| ***Conditional on female's employment*** | | | | |
| Labor Supply- Leisure | -0.743 | -0.284 | -0.783 | -0.364 |
| Labor Supply- Household Production | -0.166 | -0.449 | -0.220 | -0.449 |
| Leisure- Household Production | -0.494 | -0.692 | -0.395 | -0.650 |

The evidence suggests that there is complementarity between the male's and female's labor supply, leisure, and household production.

Table C.18: The correlation of hours across gender - Levels

| | Female Labor Supply | Female Leisure | Female Household Production |
|---|---|---|---|
| ***Unconditional*** | | | |
| Male Labor Supply | -0.003 | -0.090 | 0.081 |
| Male Leisure | 0.041 | 0.314 | -0.275 |
| Male Household Production | -0.072 | -0.321 | 0.326 |
| ***Conditional on female's employment*** | | | |
| Male Labor Supply | 0.091 | -0.102 | 0.032 |
| Male Leisure | -0.123 | 0.347 | -0.218 |
| Male Household Production | 0.030 | -0.358 | 0.318 |

The evidence suggests that there is complementarity between the male's and female's labor supply, leisure, and household production.

Table C.19: The correlation of hours across gender - Changes

| | Female Labor Supply | Female Leisure | Female Household Production |
|---|---|---|---|
| ***Unconditional*** | | | |
| Male Labor Supply | 0.026 | -0.081 | 0.057 |
| Male Leisure | -0.019 | 0.221 | -0.175 |
| Male Household Production | -0.002 | -0.204 | 0.194 |
| ***Conditional on female's employment*** | | | |
| Male Labor Supply | 0.042 | -0.089 | 0.050 |
| Male Leisure | -0.069 | 0.207 | -0.122 |
| Male Household Production | 0.058 | -0.175 | 0.125 |

The evidence suggests that there is complementarity between the male's and female's labor supply, leisure, and household production.

Table C.20: The effect of the risk-aversion heterogeneity mechanism after controlling for the thereat of divorce mechanism with the number of children as the predictor of divorce: controlling at less substantial levels of thereat of divorce

| | (Smaller Gap) High Number of Children Low Human Wealth | High Number of Children | (Larger Gap) High Number of Children High Human Wealth |
|---|---|---|---|
| Subsamples | 0.003 | 0.049 | 0.080 |
| | (0.493) | (0.339) | (0.494) |
| Differences | - 0.045 | | 0.031 |
| | (0.400) | | (0.498) |
| | [- 91%] | | [63 %] |
| Observations | 3330 | 7521 | 4091 |

$^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

In all three columns of the table, we control for the intensity of the threat to divorce by the female. In particular, we focus on the sample in which the propensity to divorce is lower and subsequently the threat of divorce is less substantial. The second column reports the gap in passthrough coefficients in this controlling subsample. The controlling subsample conditions on households with a higher number of children, namely two or more. The first and third columns report the gap in passthrough between the two groups within the controlling subsample that have differential levels of risk-aversion heterogeneity. The table uses the male's ratio of human wealth to physical wealth as the predictor of risk-aversion heterogeneity. The first column is the group with a smaller ratio of human wealth to physical wealth and the third column is the group with a larger ratio of human wealth to physical wealth. One expects the overall gap in passthrough coefficients to be increasing from the first column to the third column. The differences row reports the difference of the gap in the passthrough between the first and third columns from the baseline conditioning subgroup in the second column. The p-values are reported in parentheses and are calculated by block bootstrap. The numbers in brackets report the relative differences in terms of percentage points.

Table C.21: The correlation of hours and different kind of consumption - Levels

| | Male Private | Female Private | Children Private | Pure Public |
|---|---|---|---|---|
| Male Labor Supply | 0.098 | 0.031 | 0.053 | 0.073 |
| Male Leisure | -0.002 | -0.016 | 0.027 | -0.012 |
| Male Household Production | -0.122 | -0.021 | -0.099 | -0.070 |
| Female Labor Supply | 0.046 | 0.198 | 0.142 | 0.048 |
| Female Leisure | 0.026 | -0.000 | 0.030 | 0.029 |
| Female Household Production | -0.062 | -0.163 | -0.129 | -0.056 |

There is strong correlation between between the male's and female's labor supply and their respective private consumption. The female's labor supply is also strongly correlated with spending on children. Also, there is strong negative association between the male's and female's household production and spending on children, suggesting substitutability between time and money in terms of investment in children.



Table C.22: The correlation of hours and different kind of consumption - Changes

| | Male Private | Female Private | Children Private | Pure Public |
|---|---|---|---|---|
| Male Labor Supply | 0.018 | 0.003 | 0.004 | 0.007 |
| Male Leisure | -0.005 | -0.014 | -0.010 | -0.001 |
| Male Household Production | -0.017 | 0.018 | 0.006 | -0.008 |
| Female Labor Supply | 0.020 | 0.063 | 0.028 | 0.017 |
| Female Leisure | 0.003 | -0.012 | -0.017 | 0.003 |
| Female Household Production | -0.017 | -0.032 | -0.001 | -0.014 |

The correlation in changes are much weaker. However, there is still some evidence suffusing complementarity between private consumption and labor supply for both genders. The complementarity between female's labor supply and spending on children also survives.

## REFERENCES


Alvarez, J., M. Browning, and M. Ejrnaes (2010). Modelling income processes with lots of heterogeneity. *Review of Economic Studies 77*(4), 1353–1381.

Arellano, M., R. Blundell, and S. Bonhomme (2018). Earnings and consumption dynamics: A nonlinear panel data framework. *Econometrica*.

Arellano, M. and S. Bonhomme (2016). Nonlinear panel data estimation via quantile regressions. *Econometrics Journa 19*(3), 1342–1371.

Arellano, M. and S. Bonhomme (2017). Quantile selection models. *Econometrica 85*(1), 1–28.

Attanasio, O., H. Low, and V. Sanchez-Marcos (2008). Explaining changes in female labor supply in a life-cycle model. *American Economic Review 98*(4), 1517–1552.

Blundell, R., L. Pistaferri, and I. Preston (2008). Consumption inequality and partial insurance. *American Economic Review 98*(5), 1887–1921.

Blundell, R., L. Pistaferri, and I. Saporta-Eksten (2015, October). Consumption inequality and family labor supply. Working Paper 18445, National Bureau of Economic Research.

Blundell, R. and I. Preston (2004). Consumption inequality and income uncertainty: The case with endogenous family labor supply. *Working Paper*.

Bonhomme, S. and J.-M. Robin (2010). Generalized nonparametric deconvolution with an application to earnings dynamics. *Review of Economic Studies 77*(2), 491–533.

Borghans, L., B. H. Golsteyn, J. J. Heckman, and H. Meijers (2009, April). Gender differences in risk aversion and ambiguity aversion. *Journal of the European Economic Association 7*(2–3), 649–658.

Bound, J., C. Brown, G. J. Duncan, and W. L. Rodgers (1994, July). Evidence on the validity of cross-sectional and longitudinal labor market data. *Journal of Labor Economics 12*(3), 345–368.

Chiappori, P.-A. and M. Mazzocco (2014). Static and intertemporal household decisions. Working paper.

Cunha, F., J. J. Heckman, and S. M. Schennach (2010, May). Estimating the technology of cognitive and noncognitive skill formation. *Econometrica 78*(3), 883–931.

Eckel, C. C. and P. J. Grossman (2008). Men, women and risk-aversion: Experimental evidence. *Handbook of Experimental Economics Results 1*, 1061–1073.

Goussé, M., N. Jacquemet, and J.-M. Robin (2017). Marriage, labor supply, and home production. *Econometrica 85*(6), 1873–1919.

Harbaugh, W.T., K. K. V. L. (2002). Risk attitudes of children and adults: Choices over small and large probability gains and losses. *Experimental Economics 1*(5), 53–84.

Heathcote, Jonathan, K. S. and G. L. Violante (2014). Consumption and labor supply with partial insurance: An analytical framework. *American Economic Review 104*(7), 2075–2126.

Hryshko, D., M. J. Luengo-Prado, and B. E. Sørensen (2011). Childhood determinants of risk aversion: The long shadow of compulsory education. *Quantitative Economics 2*, 37–72.

Hu, Y. and S. M. Schennach (2008, January). Instrumental variable treatment of nonclassical measurement error models. *Econometrica 76*(1), 195–216.

Hu, Y. and M. Shum (2012). Nonparametric identification of dynamic models with unobserved state variables. *Journal of Econometrics 171*, 32–44.

Hyslop, D. R. (2001, Sep). Rising u.s. earnings inequality and family labor supply: The covariance structure of intrafamily earnings. *American Economic Review 91*(4), 755–777.

Juhn, C. and S. Potter (2007). Is there still an added worker effect? Working paper, Federal Reserve Bank of New York. Staff Report no. 310, New York, NY.

Krueger, D. and F. Perri (2006). Does income inequality lead to consumption inequality? evidence and theory. *The Review of Economic Studies 73*(1), pp. 163–193.

Lise, J. and K. Yamada (2014). Household sharing and commitment: Evidence from panel data on individual expenditures and time use. Working paper, IFS Working Paper W14/05, London, UK.

Mazzocco, M., C. Ruiz, and S. Yamaguchi (2013). Labor supply, wealth dynamics, and marriage decisions. Working paper, UCLA Manuscript.

Mazzocco, M. and S. Saini (2012, February). Testing efficient risk sharing with heterogeneous risk preferences. *American Economic Review 102*(1), 428–468.

Meghir, C. and L. Pistaferri (2004, January). Income variance dynamics and heterogeneity. *Econometrica 72*(1), 1–32.

Olea, J. L. M. and M. Plagborg-Møller (2018, March). Simultaneous confidence bands: Theory, implementation, and an application to svars. *Working Paper*.

Otani, M. (2012, Nov 15). Splitting up: 50-50 is default when dividing assets at divorce. *Japantimes*.

Paola Sapienzaa, L. Z. and D. Maestripieri (2009, September). Gender differences in financial risk aversion and career choices are affected by testosterone. *Proceedings of National Academy of Science 106*(36), 15268–15273.

Shimer, R. and L. Smith (2000). Assortative matching and search. *Econometrica 68*(2), 343–369.

Suzuki, M. (2012, May 15). Name on deeds shouldnt affect divorce asset split. *Japantimes*.

Voena, A. (2015, April). Yours, Mine and Ours:Do Divorce Laws Affect the Intertemporal Behavior of Married Couples? pp. 1–54.

Wachter, J. A. and M. Yogo (2010, September). Why do household portfolio shares rise in wealth? *The Review of Financial Studies 23*(11), 3929–3965.