Family Transfers in Rural Mexico: An Application to Risk Sharing and Labor Supply Elasticity

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Abstract

This paper develops a new model of risk sharing that allows for permanent wage shocks, variable labor supply and non-separable consumption. This model predicts that high wage men work more, and consume fewer complements and more substitutes for leisure. I test this model with two new instruments for wages in rural Mexico. I find that men who receive a positive long-term wage shock work more, own fewer televisions, eat the same food and own more cars. Because my wage instruments use education shocks, they are also valuable to economists studying education in the developing world.

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Introduction

People in the developing world face a great deal of income risk. A rich economics literature studies how individuals smooth consumption in response to short-term non-labor income shocks (Townsend 1994). However, no research studies how individuals smooth consumption in response to permanent wage shocks, to my knowledge. In fact, permanent wage shocks are a common source of income risk. I will create a model of consumption smoothing when lifetime wages are random and test my model with data from rural Mexico.

I present a model of labor supply and consumption when adult children support retired parent. My model yields results similar to Becker (1981). All children receive identical marginal utility of consumption. Unlike Becker's original paper, I vary wages among the adult children. Because marginal utility of leisure is always equal to wages, high wage children have a higher marginal utility of leisure.

My model yields three testable predictions. Compared to their low wage siblings, high wage children :

(1) Work more hours;

(2) Consume fewer complements for leisure and more substitutes for leisure;

(3) Send more money to support the retired parents.

My labor supply prediction is very different from the existing literature. High wage men work approximately the same hours as everybody else in a model with random wages and no risk sharing (Kimball and Shapiro 2003). In the empirical section, I estimate that men with wages 10% higher than their brothers work 4% more hours. This

labor supply response is much larger than any existing estimate using permanent wage shocks, to my knowledge.

My consumption prediction is also very different from the existing literature. In the previous literature high income men never consume less of any normal good in a model with non-labor income shocks (Mace 1999). In the empirical section, I estimate that high income men do indeed consume less of some goods. This result is strong evidence for my model of risk sharing with random wages.

My paper also contains empirical work in addition to my theoretical model. I will show that a simple cross-sectional regression, OLS, does not estimate within family elasticity of transfers, labor supply and consumption using the Mexican census. I will use instrumental variables, IV, to estimate these parameters. Using instruments is equivalent to observing a natural experiment that exogenously raises wages for one child in the family while holding wages for the rest of the family fixed.

My paper also introduces two novel instruments for wages in rural Mexico. The first instrument uses school calendar changes. In some states the school calendar was temporarily cut from 9 months to 8 months. Children in the states with shorter school calendars were more likely to drop out, more likely to repeat grades, and earn permanently lower wages as adults. The second instrument uses weather variation. Corn grows faster in warm weather (Pahlavanian and Silk 1988), so the demand for farm labor is higher during a heat wave. When a heat wave occurs during the academic year, rural children miss school to work on the farm. I find that children who missed school because of the weather earn permanently lower wages as adult. The two instruments pass a joint over-identication test.

I use my two instruments to study families where one member receives an exogenous wage increase of 10%. Consistent with my prediction for labor supply, I find that high wage men work 4% more than their brothers. This is equivalent to a labor supply elasticity of 0.4 – much larger than the permanent labor supply elasticity observed without risk sharing (Kimball and Shapiro 2004). Consistent with my predictions for transfers, I find that the high wage children send home enough transfers to increase their parent's consumption by approximately 12%-15%.

I can also use my instruments to test my consumption prediction. However, that prediction is much more complex to test because the prediction varies across goods. Therefore, I focus on three goods with a clear relationship to leisure: televisions, animal protein, and cars. Televisions are a clear complement to leisure. Watching TV is an extremely time intensive form of leisure, and so men working long hours have no use for a television in their home. Animal protein is neither a complement nor a substitute to leisure. Eating a hamburger takes about the same amount of time as eating a tortilla, it just tastes better. Cars are a clear substitute for non-work time. Driving is much faster than walking or taking a bus, and so men with a high value of time benefit from cars the most. Therefore, I predict that high wage men own fewer television, eat the same quality of food and own more cars than their brothers.

I then use my two instruments to study families where one member receives an exogenous wage increase of 10%. I find that:

(a) High wage men own 2%-3% fewer televisions than their brothers.

(b) High wage men eat the exact same amount of animal protein as their brothers.

(c) High wage men own 2%-4% more cars than their brothers.

Taken individually, none of these three results is absolute proof for my model of risk sharing with random wages and non-separable leisure. However, explaining away each individual result requires separate assumptions. My model shows that all three are in fact part of a single coherent whole.

My paper has seven parts. Part 1 describes a model of consumption and labor supply when adult children support retired parents. Part 2 describes how instrumental variables can be used to estimate within family labor supply elasticity and within family elasticity of consumption. Part 3 describes the datasets used and Part 4 describes two novel instruments for education. Part 5 then uses the instruments I create to estimate labor supply elasticity within the family. Part 6 uses the instruments I create earlier to estimate elasticity of consumption within the family. Finally, Part 7 uses these instruments to demonstrate that high wage children do indeed give significant transfers to their parents.

1. A Model of Transfers Within Extended families

I create a model of risk sharing within the extended family in this section. In contrast to the previous literature, I assume that consumption is non-separable from leisure. Some goods may be complements to leisure and other goods may be substitutes for leisure. This freedom makes my model very general.

In my model, I assume that multiple adult children support a single retired parent[1]. Each child is altruistic towards the parent and therefore consumption by the

[1]It might seem that few parents in the developing world live long enough to worry about retirement. In fact, life expectancy for Mexicans was 76 in 2007 (CIA World Factbook 2008). Other developing countries have seen similar dramatic increases in life expectancy (Becker, Phillipson and Soares 2003)

parent is a public good shared among all of the adult children. The public good aspect creates a free-rider problem for the family as a whole. In other words, each child prefers to give nothing to support the parent and instead rely on his or her sibling's contributions instead[2].

I use a non-cooperative Cournot-Nash game to solve for transfers (Warr 1983). The solution to this game is a single Nash equilibrium: child j gives money until he[3] gets the same utility from a dollar in his own pocket and a dollar in the parent's pocket[4]. Results are qualitatively similar if I use different models of family interaction[5].

In my model, there are *n* adult children and one retired parent in a family. In my analysis, I focus on comparing two separate children in the family. I designate these two children as child j and child k. The average wage for all individuals in the family is w_f, child j receives a wage shock, ($w_j - w_f$). In total, wages for child j are $w_j = w_f + (w_j - w_f)$. Child k receives a similar wage shock and earns wages w_k. The dependent parent earns no labor income but receives a non-labor income of A.

In my model there are *m* normal consumption goods, $(c^1,...,c^m)$. Child j has three decisions to make:

a) How many hours to work, H_j;

b) How much to buy of each consumption good, $(c_j^1,...,c_j^m)$;

c) How much money to send home to support the dependent parent, t_j;.

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[2]An alternative interpretation of this model is that the group consists of n villagers and 1 village public good (Cancian 1965). Labor supply and consumption results will be identical in this interpretation.

[3] My empirical work focuses on men, so I will use the masculine pronouns.

[4] This non-cooperative equilibrium gives far too little money to the parent. Even putting the parent's utility aside, the children would be better off if they could cooperate to give more money.

[5] Theoretical analysis using the Stackelberg set-up (Varian 1994) or Becker's altruistic dictator area available on request. A cooperative model allows an infinite number of solutions (Browning and Chiappori 1998)

My model has only a single time period, and so there are no savings. Child j either spends his money or gives it to the parent. I assume that the parent's utility is a concave function of total spending, $V(\text{A}+\sum_{k=1}^{n} t_k)$.

Child j's maximization problem is:

Max $U_j = u(c_j^1,...,c_j^m, H_j) + \alpha V(\text{A}+\sum_{k=1}^{n} t_k)$, subject to:

Child j's budget constraint: $\sum_{i=1}^{m} c_j^i = w_j H_j - t_j$

Child j views $\sum_{k \neq j}^{n} t_k$, the transfers given by his brothers and A,
the parent's non-labor income (like a retirement pension) as fixed constants.
Instead, child j focuses on changing t_j, H_j and $(c_j^1,...,c_j^m)$

I then solve to get first order conditions for child j:

$$(\partial u / \partial c_j^r) = -(1/w_j)(\partial u / \partial H_j) = \lambda_j \text{ for any good r; } \lambda_j \geq \alpha V'(\text{A}+\sum_{k=1}^{n} t_k)$$

Child k has a similar maximization problem and similar first order conditions.

Appendix 1 solves for the interior solution of these maximization problems and derives comparative statics for transfers, consumption, and labor supply for child j and child k. I will focus on the interior solution[6] for the remainder of the paper.

Lemma 1 (Labor Supply Elasticity): $\partial(H_k - H_j)/\partial w_k > 0$

This lemma states that w_k always increases relative labor supply, $(H_k - H_j)$. High wage men always work more than the rest of the family.

In my model of risk sharing, marginal utility of consumption is always identical for brother j and k. An increase in w_k has no effect on relative income, and the income effect does not affect relative labor supply. Only the substitution effect determines within family labor supply elasticity. The substitution effect is always positive, so high wage brothers always work more than low wage brothers. These predictions about within family labor supply elasticity are original to my model of risk sharing with random wages. In a model with random non-labor income, high income men will never work more than their siblings. If risk sharing is complete, high income men work exactly the same number of hours; if risk sharing is incomplete, high income men will work less.

In a model without risk-sharing, permanently high wages have two simultaneous effects on labor supply: a) high wage men are richer, so they can afford to work less (income effect); b) high wage men face a higher opportunity cost of leisure, so they work more holding income fixed (substitution effect). There are no transfers between families, and therefore no risk sharing across families in my model. Raising w_f creates both an

[6] The corner solution will occur when A is large enough that the parent can live comfortably without help from their children. This scenario is common in the developed world.

income effect and a substitution effect on average family labor supply. The net impact of the two together on labor supply is theoretically ambiguous and has been empirically estimated at close to 0 (Kimball and Shapiro 2003). In my empirical work, I show that $\partial(H_k - H_j)/\partial w_k > \partial H_k / \partial w_f$. This result is strong evidence of risk sharing within families and no risk sharing across families.

Lemma 2 (Consumption Elasticity): $\partial\left(c_k^r - c_j^r\right)/\partial w_k < 0$ if $(\partial u^2 / \partial c^r \partial H) < 0$
$\partial\left(c_k^r - c_j^r\right)/\partial w_k > 0$ if $(\partial u^2 / \partial c^r \partial H) > 0$

This lemma states that w_k has an ambiguous effect on relative consumption, $(c_k^r - c_j^r)$. High wage men consume fewer complements and more substitutes for leisure than the rest of the family.

Because of risk sharing all brothers receive the same marginal utility of consumption. If labor supply is fixed all brothers consume the exact same bundle of consumption goods. However, I vary wages and labor supply within the family. By assumption, men working long hours consume fewer complements and more substitutes to leisure. Therefore, high wage men consume fewer complements and more substitutes for leisure than their low wage brothers.

My predictions about within family elasticity of consumption are also novel and testable. High income men will never consume less than their siblings in a model with random non-labor income. If risk sharing is complete, high income men consume exactly the same; if risk sharing is incomplete, high income men will consume more.

In a model without risk sharing, permanently high wages increase consumption of all normal goods[7]. There are no transfers between families, and therefore no risk sharing across families in my model. Therefore, $\partial(c_k^r - c_j^r)/\partial w_k < \partial c_k^r / \partial w_f$ except when good r is a very strong substitute for leisure. In the empirical section I focus on three goods: televisions, animal protein and car ownership. I show that $\partial(c_k^{TV} - c_j^{TV})/\partial w_k < 0 < \partial c_k^{TV} / \partial w_f$; $0 \approx \partial(c_k^{Food} - c_j^{Food})/\partial w_k < \partial c_k^{Food} / \partial w_f$ and $\partial(c_k^{Car} - c_j^{Car})/\partial w_k \approx \partial c_k^{Car} / \partial w_f$. These diverse results cannot be explained by a model of random non-labor income with risk sharing or a model of random wages without risk sharing. The only consistent explanation is risk sharing with random wages and non-separable leisure.

Lemma 3 (Transfer Elasticity): $\partial(t_k - t_j)/\partial w_k > 0$

This lemma states that w_k always increases relative transfer sent, $(t_k - t_j)$. High wage men are primarily responsible for supporting the retired parent.

This prediction about within-family elasticity of transfers is not novel to my model of random wages and variable labor supply. A model with random non-labor income produces very similar results. I cannot use transfer data to distinguish between the two models.

[7]Assuming that labor supply remains constant.

2. Econometric Strategy to Estimate Within Family Labor Supply Elasticity

I focus on estimating within family labor supply elasticity in this section. I use the exact same empirical techniques to estimate within family elasticity of consumption and within family elasticity of transfers. To save space I will only describe the econometrics for labor supply.

Suppose that the true relationship between hours worked, *H*, and wages is determined by the equation:

$$H_j = \gamma w_f + \beta(w_j - w_f) + \varepsilon_j$$

Average wages for the family are w_f and individual j's wages are w_j. Over an entire family, $w_f = \sum_{j=1}^{n} w_j / n$. The error term, ε_j, represents individual j's unobservable taste for leisure; γ is between-family labor supply elasticity; and β is within family labor supply elasticity.

Method 1: Cross-sectional regression (OLS)

In the Mexican Census, wages for men and their household are easily observable – but there is no information on wages for brothers living outside the household.

Therefore, I cannot observe w_f (average family wages) for the general population. Suppose that I regress H_j (hours worked) on w_j (own wages) without controlling for w_f and ε_j. This is equivalent to an OLS regression of H_j on w_j. If the sample size is sufficiently large, my estimate converges to the population analogue.

$$\beta_{OLS} = \text{Cov}(H_j, w_j)/\text{Var}(w_j) = \text{Cov}\left(\gamma w_f + \beta(w_j - w_f) + \varepsilon_j, w_f + (w_j - w_f)\right)/\text{Var}(w_j)$$

Because $w_f = \sum_{j=1}^{n} w_j / n$, w_f and $(w_j - w_f)$ are uncorrelated.

We can simplify the expression above to get:

$$\beta_{\text{OLS}} = \left(\text{Cov}(\gamma w_f, w_f) + \text{Cov}\left(\beta(w_j - w_f), (w_j - w_f)\right) + \text{Cov}(\varepsilon_j, w_j)\right)/\text{Var}\left(w_j\right) \rightarrow$$

$$\beta_{\text{OLS}} = \left(\gamma \text{Var}(w_f) + \beta \text{Var}(w_j - w_f) + \text{Cov}(\varepsilon_j, w_j)\right)/\text{Var}\left(w_j\right) \neq \beta$$

This OLS estimate is unsatisfactory for two main reasons:

(a) Individual wages, w_j, may be correlated with the unobservable error term, ε_j. For example, men who earn high wages might be healthier. This would bias the labor supply elasticity upwards (chronically ill men need more leisure).

(b) Even if $\text{Cov}(\varepsilon_j, w_j) = 0$, I still cannot recover β using OLS.

Instead OLS estimates: $\beta_{\text{OLS}} = \left(\gamma \text{Var}(w_f) + \beta \text{Var}(w_j - w_f)\right)/\text{Var}\left(w_j\right) \neq \beta$. β_{OLS} is a weighted average of γ , between family labor supply elasticity, and β, within family labor supply elasticity. If $\left(\text{Var}(w_f)/\text{Var}(w_j)\right)$ is close to 1, then β_{OLS} is close to γ. If $\left(\text{Var}(w_j - w_f)/\text{Var}(w_j)\right)$ is large, then β_{OLS} is close to β. I calculate that

$\left(\mathrm{Var}(w_f)/\mathrm{Var}(w_j)\right)$ is more than .75[8] in rural Mexico. Accordingly, in the Mexican Census, β_{OLS} is heavily biased towards γ. These results are very similar to Mundlak's 1978 work with panel data.

Method 2: Instrumental Variables (IV)

Suppose I have an instrument, *Z*, such that $\mathrm{Cov}(Z_j, w_f) = 0$, $\mathrm{Cov}(Z_j, \varepsilon_j) = 0$ & $\mathrm{Cov}(Z_j, w_j - w_f) \neq 0$. In other words, *Z* is only correlated with individual wages, and not with family background or unobservable error terms. Then *Z* is an instrument for within-family wage variation, $(w_j - w_f)$, alone. If the sample size is sufficiently large, my estimate converges to the population analogue.

$$\beta_{IV} = \mathrm{Cov}(H_j, Z_j)/\mathrm{Cov}(w_j, Z_j) =$$
$$\mathrm{Cov}(\gamma w_f + \beta(w_j - w_f) + \varepsilon_j, Z_j)/\mathrm{Cov}(w_f + (w_j - w_f), Z_j) \rightarrow$$
$$\beta_{IV} = \frac{\left(\mathrm{Cov}(\gamma w_f, Z_j) + \mathrm{Cov}\left(\beta(w_j - w_f), Z_j\right) + \mathrm{Cov}(\varepsilon_j, Z_j)\right)}{\left(\mathrm{Cov}(w_f, Z_j) + \mathrm{Cov}\left((w_j - w_f), Z_j\right)\right)} = \beta$$

In other words, IV is equivalent to a natural experiment that exogenously raises wages for one child, but hold wages for the rest of the family fixed[9]. Accordingly, β_{IV} is an unbiased estimate of β.

[8]This is taken from a sample of adult brother sharing a household, and may not be representative of the general Mexican population. My calculation does not account for measurement error in wages, so the true correlation may be even higher.

The theoretical model in section 1 predicted striking differences between γ, across-family labor supply elasticity, and β, within-family labor supply elasticity. I do not test whether $\gamma = \beta$ directly. Instead, I test whether $\beta_{\text{OLS}} = \beta_{\text{IV}}$. Because β_{OLS} is a weighted average of γ and β, $\gamma \leq \beta_{\text{OLS}} \leq \beta = \beta_{\text{IV}}$ for all populations. Accordingly, the result that $\beta_{\text{OLS}} < \beta_{\text{IV}}$ is equivalent to a result that $\beta < \gamma$.

$$\gamma \leq \beta_{\text{OLS}} \leq \beta = \beta_{\text{IV}}$$

As a result, I can use $(\beta_{\text{IV}} - \beta_{\text{OLS}})$ as a lower bound for $\beta - \gamma$.

Most previous work on risk sharing assumes that wages are fixed and non-labor income is random[10]. In that model, transfers exactly offset individual income shocks. Consumption by any given individual depends only on aggregate income for the group and not on his or her own income (Mace 1991). Because the model makes such specific predictions, it is very easy to test for complete risk sharing. Previous papers studying the developing world have focused on testing whether the risk sharing observed is complete or not (Townsend 1994), (Angelucci and De Georgio 2006), (Duflo and Udry 2004), and (Townsend 1995).

In my empirical section, I do not test for complete risk sharing within the family. Instead, I only test the hypothesis 'some risk sharing' versus the null of 'no risk sharing'.

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[9] In a more complex model, β is not a fixed constant. In that case, IV will not necessarily recover $\mathrm{E}(\beta_j)$. Instead it will recover a weighted average of the various β_j's, with the weights determined by how much Z affects $(w_j - w_f)$ (Heckman, et al 2006). In this paper, I use two instruments for schooling that have the largest effect on rural children who are on the margin for dropping out of school before are 17. As a result, IV recovers within-family labor supply elasticity for this group. It is also possible that siblings who share risk as adults have a more elastic demand for schooling (Becker and Tomes 1976). As a result, IV may overestimate risk sharing in the general population.

[10] A model that assumed fixed labor supply and random wages produces identical results.

The reason for this choice is theoretical. My model does not predict any specific point estimates unless I use a particular utility function. For example, a small within family labor supply elasticity might suggest incomplete risk sharing, but it is also consistent with complete risk sharing and inelastic labor supply. Similarly, almost any consumption behavior can be justified under both complete risk sharing and incomplete risk sharing. I can only test for complete risk sharing if I already know the true labor supply elasticity and consumption elasticity. In contrast, I can test the null hypothesis of no risk sharing without knowing the true labor supply elasticity. That hypothesis predicts that $\beta_{\text{OLS}} = \beta_{\text{IV}}$, and so the result $\beta_{\text{OLS}} < \beta_{\text{IV}}$ shows that at least some risk sharing exists.

3. Data Sets Used

I take my main datasets from the 1970 and 2000 Mexican Census. The 1960 and 1990 Census are also used for background information. The 1980 Census is not publicly available, so I am unable to include it in my analysis.

In my analysis, I use all men 25-74 born outside of Mexico City. I restrict the sample to men to minimize the importance of selection into the labor market. I exclude men under 25[11] because younger men might be still attending school and not yet part of the labor force. I exclude men over 74 because mortality becomes important at older ages[12]. The final exclusion is of men born in Mexico City. Both of my instruments only affect education for boys in rural areas, and are not valid instruments for one of the

[11] Empirical results are very similar if I use a younger age cut-off.
[12] Many analysises of labor supply focus on prime-aged working men (25-55) in order to avoid retirement issues. I purposefully include an older age group in order to study labor supply elasticity over the complete lifecycle.

largest urban areas in the world.[13] Men who are born in a rural area and then later move to Mexico City remain in the sample. Summary statistics are given in Tables 1 and 2.

Sample selection caused by emigration to the United States does not change my results. While it is true that approximately 10% of all adults born in Mexico lived in the United States in 2000 (Lacuesta 2004) there was much less emigration before 1970. Accordingly, I can compare results from the 1970 and 2000 Census to see whether emigration changes empirical results. I find similar estimates of within-family labor supply elasticity and within-family elasticity of TV ownership for both years. These results suggest that emigration does not bias results.

I focus only on wage variation caused by education in my empirical analysis. This approach has a number of practical advantages:

a) Education is typically fixed throughout adulthood. Therefore, the wage differences created by education are permanent. I need not worry about short-term labor supply elasticity in response to temporary wage shocks;

b) Education is observed for all men in the sample, regardless of labor force participation. In contrast, wages are only observed for men with positive hours of work. If I used reported wages I would need to impute wages for men who are not working;

c) Hourly wages may be mismeasured if men report hours worked incorrectly. This measurement problem typically biases labor supply elasticity estimates downward. In my empirical work, I regress outcome variables directly on education, but still report results as if I had used education to impute wages.[14]

[13] An instrument that decreases schooling in rural Mexico slightly increases schooling in Mexico City.
[14] For simplicity, I will use a 10% return to education in 2000 and a 15% in 1970. Returns to schooling estimates are presented later in the paper, in tables 4, 8 and 9.

3. Two Novel Instruments for Education and Wages

To recap from Section 2, my empirical work needs instrumental variables to properly estimate within-family elasticity of labor supply, consumption and transfers. None of the existing instruments for education are suitable for studying behavior in rural Mexico, to my knowledge[15]. Therefore, I create two new instruments in order to test my theoretical model. These two instruments are equivalent to a natural experiment that exogenously raises wages for one child in the family while holding wages for the rest of the family fixed.

My first instrument for education uses changes in the school calendar during the 1960's. Originally, Mexico had two separate school calendars. The temperate states[16] followed calendar A, with a school year starting at the end of January and continuing until the end of November. The tropical[17] states followed calendar B, with a school year starting at the beginning of September and continuing until the end of June the next year. In 1965, the government decided to merge the two calendars by shortening the A calendars by one month for the next 5 years. This change had an immediate negative impact on education[18]: between 1965 and 1966, grade repetition in primary schools increased from 20% to 25% and rural drop-out rates increased from 20% to 25%.[19]

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[15] The Mexican government recently introduced a new program that pays rural children to stay in school (Schultz 2001). In the future, this program may be a good instrument fo education. Unfortunately, the program was first introduced in 1997 and the children affected are still in school.

[16] Chiapas, Distrito Federal, Guanajuato, Hidalgo, Mexico state, Michoacan, Morelos, Oaxaca, Puebla, Queretaro, San Luis Potosi, Tabasco, Tlaxcala, Veracruz.

[17] Aguascalientes, Baja California Norte, Baja California Sur, Campeche, Coahuila, Colima, Chihuahua, Durango, Guerrero, Jalisco, Nayarit, Nuevo Leon, Quintana Roo, Region Lagunera, Sinaloa, Sonora, Tamaulipas, Yucatan and Zacatecas

[18] These results seem are very different from Pischke (2003), who found shortening the German school year had little long-term effect on wages. However, the two results are actually consistent. Pischke also found a significantly increased grade repetition rate – but the base rate was so small the increase was economically

The calendar change had permanent negative effects on completed education and adult wages. Using a linear regression, I find that one month of missed school reduces completed education by 0.07 to 0.09 years in Table 3, I find similar results with a regression. When I use school calendar as an instrument for education I find returns to education of 10% in Table 4. In other words, a child who missed 1 month of school earns 0.7%-0.9% lower wages for the rest of his lives. The F-statistic for this instrument is above the threshhold of 10 recommended by Staiger and Stock (1997).

Even though my theoretical model requires only one instrument, I create two instruments for education in rural Mexico. Using two instruments provides two important practical benefits:

(1) Because I have two instruments I can use over-identification to jointly test their validity. My instruments easily pass that test.

(2) My calendar instrument only affects education for children in school during the late 1960's. Therefore, I cannot use it to study men in the 1970 Census. In contrast, my weather instrument works for both the 1970 and 2000 Census.

I separately estimate within-family elasticity of labor supply, consumption and transfers with both instruments in my empirical work. I find very similar point estimates with both instruments. This similarity is strong evidence that my instruments are estimating the same underlying economic parameters.

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trivial. And he did not even study the drop-out rate for primary school children (presumably because it was close to 0).

[19]This is for children in primary schools in temperate states not including Mexico City from 1965 to 1966. I was not able to obtain the equivalent dataset for type B schools. The education statistics give negative drop-out rates for urban areas in both years. The negative drop-out rates appear to be an artifact created by migration into large cities.

My second instrument for wages uses changes in the timing of farm labor. In rural Mexico children often miss school when they are needed on the farm. As a result, children attend more school if peak farm labor demand occurs during the school vacation, and less school if peak farm labor demand occurs during the academic year. Hence, random variation in the timing of demand for farm labor changes schooling received.

I use weather to exogenously change the timing of demand for farm labor. Plants grow faster in warmer temperatures (Pahlavanian and Silk 1988) (Pastenes and Horton 1996), as shown in Figure 1. Because plants grow faster in warm months more farm labor is needed to tend them. As a result, rural children are more likely to miss school when temperatures are warm. I examine the short-term effect of warm weather in Table 5. I find that boys are 1% less likely to be in school if the weather was 1° Celsius warmer last month.

By itself, weather is not a perfect instrument for education because it affects many factors others than schooling. For example, warm weather decreases mortality from cardiovascular and respiratory disease (Deschenes and Moretti 2007) and increases mortality from infectious diseases (Ballester, Corella, Perez-Hoyos, Saez and Hervas 1997). Temperature and rainfall may also be correlated with farming profits (Lang 2001)[20]. I control for these non-school factors by using only exact timing of warm weather and not mean temperature. My instrument is:

$$\Delta \text{ Temp} = \text{Mean School Temperature} - \text{Mean Vacation Temperature}$$

Δ Temp is positive if a heat wave occurs during the academic year and Δ Temp is negative if a heat wave occurs during the school vacation. Adult are unlikely to be

[20] Previous economists have found that rural families withdraw their children from school when weather shocks reduce farming income (Jacoby and Skoufias 1997), (Jensen 2000) and (Duflo and Udry 2004).

affected by the exact timing of a heat wave. In all regressions, I subtract out the average monthly temperature, so Δ Temp is not affected by changes in the school calendar[21] or by different weather patterns across states[22].

High temperatures during childhood school have a permanent effect on completed education and adult wages. I find that men get 0.4 less years of education when Δ Temp ages 6-17 is 1° Celsius larger. Results are similar in 1970[23] and 2000. If I use temperature during childhood as an instrument for education I find that one year of schooling increases wages by 15% in 1970 and 10% in 2000. Therefore, raising Δ Temp during childhood by 1° Celsius reduces adult wages by 4%-6%. Results are given in tables 5-9.

Neither of these instruments is perfect for testing my theoretical model. The ideal instrument would raise wages for exactly one child in the family and hold wages for all of his brothers fixed. In fact, both instruments are correlated within the family. Twins always receive identical education shocks and siblings close in age receive similar education shocks. This correlation will bias my estimates of within-family labor supply elasticity towards 0. Despite this bias, I can still reject the null hypothesis that within-family labor supply elasticity is equal to across-family labor supply elasticity. I can also reject the null hypothesis that within-family consumption elasticity is equal to across-family consumption elasticity for television ownership and food consumption.

5. Within family Labor Supply Elasticity

[21] For the period 1960-1980 Δ Temp is positively correlated with the number of months of school missed. This will result in point estimates for the Weather IV and the Calendar IV quite close for 2000. Results remain qualitatively similar if I control for the correlation.
[22] I also control for year of birth, so my results are not affected by global warming.
[23] Using only the first column.

To recap, the model described in section 1 makes a strong prediction about within family labor supply elasticity: Compared to their low wage brothers, men with high wages work much longer hours. In this section, I use instrumental variables to estimate within family labor supply elasticity. My instruments are equivalent to a natural experiment that exogenously raises wages for one child while holding wages for the rest of the family fixed.

My empirical results are: within family labor supply elasticity is 0.4. I find that raising individual wages by 10% increases labor supply for men in 2000 by 1.5 hours per week[24], as described in Table 10. The two separate instruments produce very similar point estimates. I find that raising wages by 10% increases labor supply for men in 1970 by 0.4[25] months per year, as described in Table 11. These coefficients are equivalent to a within-family labor supply elasticity of 0.4. Standard errors are low enough that I can reject the null hypothesis that within-family labor supply elasticity is actually 0 with $p<.01$ for both 1970 and 2000.

By itself, my point estimate 0.4 for within-family labor supply elasticity does not measure risk sharing. However, I can compare it to across-family labor supply elasticity to measure risk sharing. If families did not share risk across-family labor supply elasticity would be identical to within-family labor supply elasticity. In Tables 10 and 11, I find that across-family labor supply elasticity is only 0.07 and within-family labor supply elasticity is 0.4. Standard errors are low enough that I can reject the null

[24]Most of the increase observed is caused by men switching from non-work to full-time work. When I restrict the sample to working men labor supply is small and statistically insignicant.
[25] Taken from column 1.

hypothesis that the two are equal with p<.01 for 2000 and p<.05 for 1970. Therefore, risk sharing within the family increases labor supply elasticity of 0.33 = (0.4-0.07).

There is no existing empirical research on within-family labor supply elasticity, to my knowledge. Accordingly, I cannot compare my point estimate of 0.4 with the prior literature. The closest empirical research studies labor supply elasticity in response to short-term wage shocks. The typical estimate for short-term labor supply elasticity is around 0.5 (Oettinger 1999), (Fehr and Gotte 2002), and (Mulligan 1998). The similarity provides suggestive evidence that risk sharing within the family may be just as important as credit-markets for explaining labor supply.

I calculate that risk sharing within the family increases labor supply elasticity by at least 0.33. How do I calculate that number? Earlier in the paper, I show that $\text{labor supply elasticity without risk sharing} < \beta_{\text{OLS}} < \text{labor supply elasticity with risk sharing}$ and $\beta_{\text{IV}} = \text{labor supply elasticity with risk sharing}$. In Tables 10 and 11, I find that β_{OLS} is about .07. Therefore, risk sharing within the family increases labor supply elasticity by at least (.4-.07) = .33.

Measurement error is a possible alternative explanation for the small point estimates using OLS in Tables 10 and 11. In a population where some people report incorrect education all OLS estimates using reported education are biased towards 0 (Ashenfelter and Krueger 1994). In my sample, measurement error appears to be small. Returns to education are similar using OLS and IV, as shown in Tables 4 to 9. In fact, I cannot reject the null hypothesis that the downward bias for OLS is 0. Across-family labor supply elasticity is still less than 0.1 even after correcting for possible measurement

error. Therefoer, I can reject the null hypothesis that across-family labor supply elasticity is equal to within-family labor supply elasticity.

6. Within Family Elasticity of Consumption

To recap, I predict that men with high wages consume fewer complements to leisure and more substitutes for leisure than their low wage siblings. In this section, I study how wage shocks affect three particular consumption goods: televisions, animal protein, and automobiles. I argue that these three goods have different relationships to leisure: televisions are complements to leisure, animal protein is separable from leisure, and automobiles are substitutes for leisure. Based on these assumptions, I predict that men who receive exogenous wage shocks own fewer televisions, consume the same amount of animal protein, and own more cars.

To preview my empirical results, I find that men who receive an exogenous wage shock of 10% own 2%-3% fewer televisions, eat the same amount of animal protein and own 2%-4% more cars. Taken separately, none of these three results are sufficient proof for my model of risk-sharing with variable labor supply and non-separable consumption. For example, the decrease in television ownership might be explained in a model with incomplete risk-sharing if televisions are an inferior good. The fixed consumption of animal protein might be explained a model with complete risk-sharing and fixed labor supply. The increase in car ownership might be explained in a model of incomplete risk sharing if cars are a normal good. However, each of these explanations requires separate

individual assumptions. The consistent explanation for all three results is my model of risk-sharing with variable labor supply and non-separable leisure.

The first measure of consumption I study is television ownership. Televisions are widely owned in Mexico: about 33% of households own them in 1970 and 85% in 2000. Most standard economic models would agree that televisions are a normal good. Therefore, I predict that rich households are more likely to own televisions. This prediction is reinforced by comparing rich families and poor families using OLS. I find that a 10% rise in average family wages increases television ownership by 3% in 1970 and 2% in 2000. While it is true that correlation does not always equal causation most standard models would infer that televisions are a normal good in this circumstance. However, my model of risk-sharing with random wages predicts a very different result when one family member receives an exogenous wage shock. Televisions are a very time-intensive good which are used almost exclusively for leisure. Therefore, it is likely that televisions are a complement to leisure[26]. Accordingly, I predict that men who receive an exogenous wage shock own fewer televisions.

I test my predictions using the two instruments described earlier. I find that television ownership rates decrease 2%-3% when men receive an exogenous wage increase of 10%. Regression results are given in Table 13 in the IV rows. Point estimates are similar in both 1970 and 2000, but only in 2000 are standard errors low enough to reject that null that IV = 0. These results are consistent with the increase in labor supply observed in Tables 10 and 11. Men who receive an exogenous wage shock work many more hours, so they have less time available to watch television. The

[26]Men without televisions may still watch a small amount of TV at a bar or a friend's house.

decrease in television ownership is strong evidence for my model of risk-sharing with permanent wage shocks.

The second measure of consumption I study is animal protein. Traditionally, rural Mexicans ate a great deal of corn and beans, and very few animal products such as meat, fish, milk or eggs. Across the world, high income countries eat more animal protein than low income countries and developing countries eat more animal protein when they get richer (Yotopoulos 1985) Therefore, I predict that rich Mexican households eat more animal products than poor households. This prediction is reinforced by comparing rich families and poor families using OLS. I find that a 10% rise in average family wages increases animal protein consumption by 0.2 meals per week. However, there is no obvious connection between animal protein and value of time. Eating a hamburger takes about the same amount of time as eating a tortilla. In addition, recent research by Aguiar and Hurst (2004) shows that quality of food[27] consumed does not change after retirement, even though leisure increases dramatically. That results suggests that leisure and food quality are separable. Accordingly, I predict that exogenous wage shocks have no effect on animal protein consumed by rural Mexicans.

I test my prediction using the two instruments described earlier. I find that consumption of animal protein does not change when men receive an exogenous wage increase of 10%, as described in Table 12 using IV. Point estimates are close to 0 for all food groups. In other words, high income men from low income families eat the same food as their low income brothers. In contrast, I find that a 10% increases in average family wages increases consumption of meat, milk, and eggs by 0.2 meals per week, as

[27] They find that retired households spend less money on groceries but compensate by spending more time shopping for food.

described in Table 12 using OLS. Standard errors are low enough that I can reject the null hypothesis that OLS = IV for meat, eggs, and total food quality. These results are evidence for risk sharing within the family. However, a model of risk sharing with random non-labor income produces identical predictions for animal protein consumption to my model. By themselves, the results in Table 12 do not distinguish between those two models of risk sharing.

The third measure of consumption I study is automobile ownership. The main benefit of owning a car is speed, driving is almost always faster than walking or taking a bus. However, the value of speed to an individual man depends on his wage. A high wage man forgoes a lot of money when he walks for an hour rather than working. A low wage man forgoes much less money during the exact same walk. This variation in opportunity cost holds even if men value the exercise they get while walking to work. Therefore, I predict that high wage men are more likely to own cars. This prediction hold regardless of family income, only individual wages matter.

I test my prediction using the two instruments described earlier. I find that automobile ownership rates increase by 2%-4% when men receive an exogenous wage shock of 10%, as described in Table 14. Standard errors are low enough that I can reject the null that IV=0 at $p<.01$. By comparison, when average family wages increase by 10% average family car ownership goes up by 3.5%. I cannot reject the null hypothesis that OLS=IV at any significance level.

Taken alone, the results for car ownership might seem to be evidence against risk sharing. After all, high wage men from rich families and high wage men from poor families own the same number of cars. However, the results for car ownership results are

also consistent with my model of variable labor supply if cars are a strong substitute for leisure.

7. Within-Family Elasticity of Transfers

To recap, my model makes a clear prediction about transfers within the family: high wage children give more money to support their parents than low wage children. This prediction is the basis for all the other results in my model. I cannot test that prediction directly because the Mexican census contains data only on transfers received and nothing on transfers sent. Instead, I test the related hypothesis that elderly parents receive a larger total transfer if their adult children earn a high average wage.

The Mexican Census does not link parents to adult children. So I cannot directly regress transfers received by the elderly parents on their children's wages. Instead, I impute wages based on the children's year of birth and state of birth. Further details on my empirical technique are given following Table 15.

I test my predictions using the two instruments for children's wages described earlier. I find that elderly parents get 225-275 more pesos a month when their children's wages increase by 10%[28]. I calculate that a transfer of 225-275 pesos provides a 12% - 15% increase in consumption for the elderly parents. In order to make this calculation, I assume that retired parents do not draw down saving during retirement, elderly fathers receive 1300 pesos a month in labor and non-labor income, and elderly fathers receive

[28] Out of this total amount, 150-200 pesos comes from transfers within Mexico and only 75 pesos from transfers from abroad.

500 pesos a month in labor and non-labor income. These numbers are taken from Table 1 for adults over 65.

My calculations presented above require strong assumptions about saving behavior and income. Alternatively, I can calculate what % of a wage increase do children share with their parents. The typical elderly couple in my sample has five adult children. Average earnings for each child are 1900 pesos a month (900 for women and 2900 for men). Therefore a 10% wage increase for the children raises their earnings by 190 pesos (holding labor supply fixed). Each child then gives about 50 pesos extra to the elderly couple. Therefore, a 10% wage increase for the children raises each child's consumption by 140 pesos a month and raises each parent's consumption by 125 pesos a month[29]. I cannot reject the null hypothesis that parents and children receive an identical benefit from higher wages for children.

Conclusion

In this paper, I developed a novel model of risk sharing within the family. In my model, labor supply is variable and consumption is non-separable from leisure. This model is general enough to analyze a wide range of income shocks. In my paper, I focused on individuals that receive permanent wage shocks. Despite their frequency, these wage shocks have been ignored in the existing literature. My paper fills that gap and provides the tools to more accurately test for risk-sharing.

[29] My estimate of 25% is larger than Bureau of Economic Analysis's estimates of the average remittance rate by US immigrants to their families back home. However, Table 15 estimates the marginal remittance rate and not the average remittance rate. Therefore, the two numbers cannot be compared directly.

My model yielded three testable predictions. Compared to their low wage siblings, high wage children :

(1) Work more hours;

(2) Consume fewer complements for leisure and more substitutes for leisure;

(3) Send more money to support the retired parents.

In the empirical sections, I tested all three predictions with data from the Mexican Census. I compared two brothers where the high wage brother earns an hourly wage 10% higher. Consistent with my predictions, I find that:

(1) High wage men work 4% more than their brothers.

(2) High wage men own 2%-3% fewer televisions (complement to leisure), eat the same amount of animal protein (separable from leisure), and own 2%-4% more cars (substitute for leisure) than their brothers.

(3) High wage children send home enough transfers to increase their parent's consumption by approximately 12%-15%.

In this paper, I also developed two novel instruments for wages in rural Mexico. These instrumers were school calendar during childhood and weather during childhood. Both of these instruments reduced completed schooling and adult wages for men in my sample. I used these instruments to create a natural experiment: one family member receives an exogenous wage shock while wages for the rest of the family are held fixed. Because my instruments for wages used education shocks they are valuable to economists studying education in the developing world.

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Table 1: Summary Statistics for the 2000 Mexican Census

	Adults 25-45	Adults 45-64	Adults 65+
Average Age	33.55	53.13	73.65
% Female	52.7%	51.9%	53.4%
Mean Years Education	8.00	5.17	3.02
% Men Married	80.17%	87.35%	73.63%
% Women Married	77.34%	70.16%	38.76%
% Men Working	90.59%	81.17%	42.30%
% Women Working	39.25%	28.16%	10.18%
Men's Earnings Last Month	3,075.00 Ps.	2,555.24 Ps	649.55 Ps
Men's Non-Labor Income Last Month	43.92 Ps.	235.01 Ps	564.58 Ps
Men's Transfers from Family	14.79 Ps.	54.54 Ps	118.33 Ps
Women's Earnings Last Month	1,020.06 Ps.	610.94 Ps.	101.83 Ps.

Women's Non-Labor Income Last Month	42.44 Ps.	158.18 Ps.	270.41 Ps.
Women's Transfers from Family	63.24 Ps.	108.85 Ps.	154.53 Ps.
% Disabled	2.2%	5.1%	18.3%
Number People	2,366,939	1,171,313	511,169

These statistics are for all adults in the Mexican Census not born in Mexico City. Observations are weighted by the sample weight given in the Census. Individual with invalid data for one question are removed for that summary statistic, but used for other observations. The official exchange rate in February 2000 was approximately 9.4 Pesos to one American dollar.

Table 2: Summary Statistics for the 1970 Mexican Census

	Adults 25-45	Adults 45-64	Adults 65+
Average Age	33.30	52.83	72.24
% Female	51.7%	50.9%	51.6%
Mean Years Education	2.32	1.79	1.24
% Men Married	82.50%	87.89%	76.0%
% Women Married	82.2%	71.06%	44.0%
% Men Working	92.7%	91.1%	71.8%
% Women Working	15.0%	14.9%	10.9%
Men's Income Last Month	945.86 Ps.	1003.40 Ps.	540.87 Ps.
Women's Income Last Month	131.81 Ps.	126.72 Ps.	72.98 Ps.
Number People	94,716	44,987	16,794

These statistics are for all adults in the Mexican Census not born in Mexico City. Individual with invalid data for one question are removed for that summary statistic, but used for other observations. In 1970, the Mexican peso was fixed at 12.5 pesos for 1 American dollar.

Figure 1: Growth Rate of Corn At Different Temperatures

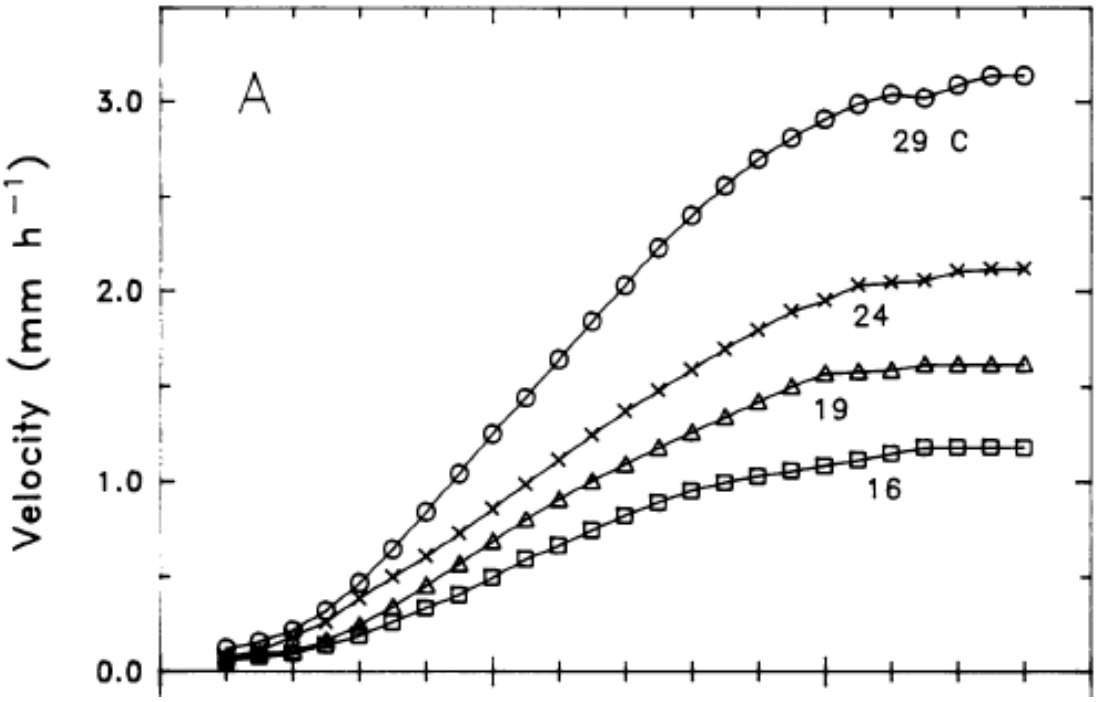

Table 3: First Stage Regression of Education on Months School Missed for Men 25-74 in 2000 Census

$$\text{Education}_j = b*X_j + d*(\text{Months of School Missed 6-17})_j + e_j$$

	Dependent variable: Years Education		
Months of School Missed ages 6-17 (d)	-0.090	-0.085	-0.073
	(0.008)	(0.007)	(0.007)
Control for Birth State & Age?	Y	Y	Y
Control for Birth State Trends?	N	Y	Y
Restrict Sample to Men with Valid Wages?	N	N	Y

Observations are weighted by the sampling weight given in the census, and standard errors are clustered by cohort. Men with invalid data are excluded.

This table provides additional evidence the short school year hurt men in temperate states. Depending on the specification, one month less of school reduces completed education by .07 to .09 years.

Table 4: Regression of Wages on Years Education for Men 25-74 in 2000 Census

$$\text{Ln(wages)}_j = f*X_j + \rho*\text{Education}_j + \sigma_j$$

	Calendar IV

Return to Education (ρ)	9.67%	10.11%	9.94%
	(1.00%)	(.99%)	(1.13%)
		OLS	
Return to Education (ρ)	9.32%	9.27%	9.27%
	(.05%)	(.05%)	(.05%)
Control for Birth State & Age?	Y	Y	Y
Control for State of Residence?	N	Y	Y
Control for Birth State Trends?	N	N	Y

Controls used are identical to Table 3. Men with invalid data are excluded from the sample.

This table compares OLS and IV regression of wages on education. Both estimates find returns to education of about 10%. In other words, one year of education increases wages by 10%.

Table 5: Regression of School Attendance on Temperature Last Month for Boys 6-17

$$\%Enrollment_j = b*X_j + d*(\text{Mean Temperature Last Month})_j + e_j$$

	Dependent Variable: %In School Now	
Mean Temperature Last Month (d)	-1.31%	-.74%
	(.49%)	(.39%)
Control for State Fixed Effects?	Y	Y
Control for State Trends?	N	Y

In all specifications, I control for age and year by including a dummy for each age-year cell. Observations are weighted by the sampling weight given in the census, and standard errors are clustered by state-year cell.

Table 6: First Stage Regression of Education on ΔTemp 6-17 for Men in 1970 Census

$$Education_j = b*X_j + d*(\Delta \text{ Temp ages 6-17})_j + e_j$$

	Dependent variable: Years Education		
ΔTemp ages 6-17 (d)	-.471	-.096	-.194
	(.102)	(.104)	(.112)
Control for Birth State & Age?	Y	Y	Y
Control for Birth State Trends?	N	Y	Y
Restrict Sample to Men with Valid Wages?	N	N	Y

Controls identical to Table 3

Table 7: First Stage Regression of Education on ΔTemp 6-17 for Men in 2000 Census

$$\text{Education}_j = b*X_j + d*(\Delta \text{ Temp ages 6-17})_j + e_j$$

	Dependent variable: Years Education		
ΔTemp ages 6-17 (d)	-.445	-.444	-.357
	(.065)	(.055)	(.058)
Control for Birth State & Age?	Y	Y	Y
Control for Birth State Trends?	N	Y	Y
Restrict Sample to Men with Valid Wages?	N	N	Y

Controls identical to Table 3

Tables 5, 6 and 7 demonstrate that high temperatures during childhood result in a short-term decrease in school attendance, and a permanent reduction in completed education. Therefore, random temperature variation can be used as an instrument for education.

Table 8: Regression of Log Wages (Imputed) on Education for Men 25-74 in 1970

$$\text{Ln(imputed wages)}_j = f^*X_j + \rho^*\text{Education}_j + \sigma_j$$

		Weather IV	
Return to Education (ρ)	13.66%	15.34%	19.20%
	(3.66%)	(3.26%)	(11.20%)
		OLS	
Return to Education (ρ)	11.87%	10.52%	10.50%
	(.09%)	(.09%)	(.09%)
Control for Birth State & Age?	Y	Y	Y
Control for Current State of Residence?	N	Y	Y
Control for Birth State Trends?	N	N	Y

Controls used are identical to Table 3.

Table 9: Regression of Wages on Years Education for Men 25-74 in 2000 Census

$$\text{Ln(imputed wages)}_j = f^*X_j + \rho^*\text{Education}_j + \sigma_j$$

		Temperature IV	
Return to Education (ρ)	10.61%	9.71%	10.82%
	(1.77%)	(1.77%)	(1.99%)
		OLS	
Return to Education (ρ)	9.32%	9.27%	9.27%
	(.05%)	(.05%)	(.05%)

Control for Birth State & Age?	Y	Y	Y
Control for State of Residence?	N	Y	Y
Control for Birth State Trends?	N	N	Y

Controls used are identical to Table 3. Men with invalid data are excluded from the sample.

Tables 8 and 9 compare OLS and IV regression of wages on education.

Table 10: Regression of Labor Supply on Imputed Wages in 2000

$$\text{Hours Worked}_j = g*X_j + \gamma*w_f + \beta*(w_j - w_f) + \varepsilon_j$$

Dependent Variables: Hours Worked and Wages Earned			
		Weather IV	
10% Wage Increase (β)	1.54	1.39	1.87
	(.58)	(.58)	(.48)
		Calendar IV	
10% Wage Increase (β)	1.42	1.39	1.48
	(.30)	(.29)	(.28)
		OLS estimate	
10% Wage Increase (γ)	.27	.25	.25
	(.01)	(.01)	(.01)
Control for Birth State & Age?	Y	Y	Y
Control for Current State of Residence	N	Y	Y
Control for Birth State Trends?	N	N	Y

Controls identical to Table 3. The results presented are **not** a regression of labor supply on actual wages. Instead, I regress labor supply on wages imputed from education.

Table 11: Regression of Labor Supply on Imputed Wages in 1970

$$\text{Months Worked}_j = g*X_j + \gamma*w_f + \beta*(w_j - w_f) + \varepsilon_j$$

Dependent Variable: Mean Months Worked Last Year			
		Weather IV	
10% Wage Increase (β)	.386	0.363	-.641

	(.150)	(.134)	(.851)
		OLS estimate	
10% Wage Increase (γ)	.077	.071	.070
	(.003)	(.003)	(.003)
Control for Birth State & Age?	Y	Y	Y
Control for Current State of Residence	N	Y	Y
Control for Birth State Trends?	N	N	Y

Controls and procedure identical to Table 10.

In Tables 10 and 11, I use IV variables to create a natural experiment: wages for one child increase, but wages for the rest of the family are held fixed. I find that raising wages by 10% increases labor supply by 4%.

In contrast, OLS measures the effect of raising children's wages, but not holding family wages fixed. Because wages for children and parents are highly correlated, OLS is closest to a natural experiment that raises wages for everybody in a family together. I find that raising average family wages by 10% increases labor supply by only .7%.

Table 12: Food Consumption$_j$ = h*X$_j$ + δ*w_f + τ*(w_j- w_f) +ε$_j$

	10% Increase in Individual Wages (τ)			10% Increase in Family Wages (δ)		
Meat Consumption	-0.065	-0.013	-0.001	0.217	0.197	0.194
	(0.102)	(0.083)	(0.081)	(0.002)	(0.003)	(0.002)
Fish Consumption	0.019	0.022	0.025	0.028	0.027	0.027
	(0.047)	(0.043)	(0.043)	(0.001)	(0.001)	(0.001)
Bread Consumption	0.016	0.085	0.112	0.189	0.159	0.159
	(0.121)	(0.099)	(0.097)	(0.003)	(0.003)	(0.003)
Eggs Consumed	-0.05	.000	0.009	0.196	0.176	0.173
	(0.110)	(0.089)	(0.088)	(0.003)	(0.003)	(0.003)
Dairy Consumption	-0.034	0.043	0.053	0.245	0.214	0.213
	(0.137)	(0.109)	(0.109)	(0.003)	(0.003)	(0.003)
Total Food Quality Index	-0.014	0.005	0.009	0.068	0.06	0.059
	(0.030)	(0.023)	(0.022)	(0.001)	(0.001)	(0.001)
Controls for Birth State & Age?	Y	Y	Y	Y	Y	Y
Control for State of Residence?	N	Y	Y	N	Y	Y
Control for Household Composition?	N	N	Y	N	N	Y

In all specifications, I restrict the sample to men 25-74 with valid education and state of birth. I control for age and state of birth with dummy variables. Observations are weighted by the sampling weight given in the census, and standard errors are clustered by cohort.

In the last row, I used the complete information on food consumption to create a food quality index. I created the index by regressing ln(monthly income) on 8 dummy variables for eating meat 0-7 days, 8 dummy variables for eating fish 0-7, etc. In other words, my food quality index is equivalent to monthly income predicted from food consumption

In Table 12, I use instrumental variables to create a natural experiment: raise wages for one child while holding wages for the rest of the family fixed. I find that increasing wages by 10% has no effect on food quality consumed in 1970.

In contrast to the IV natural experiment, OLS measures the effect of raising wages for the complete family. I find that increasing average family wages by 10% increases food quality consumed significantly. This is consistent with standard demand theory – food is a normal good.

Table 13: Regression of Television Ownership on Imputed Wages

$$(\%\text{Own television})_j = h*X_j + \delta*w_f + \tau*(w_j - w_f) + \varepsilon_j$$

Dependent Variable: % Population that Lives in Household With A Television in 2000				
		Weather IV		
10% Wage Increase (τ)	-2.1%	-1.7%	-2.7%	-2.7%
	(.8%)	(.8%)	(.9%)	(.9%)
		Calendar IV		
10% Wage Increase (τ)	-1.9%	-1.5%	-2.4%	-2.0%
	(.6%)	(.5%)	(.6%)	(.6%)
		OLS		
10% Wage Increase (δ)	1.9%	1.8%	1.8%	1.9%
	(.0%)	(.0%)	(.0%)	(.0%)

Dependent Variable: % Population that Lives in Household With A Television in 1970				
		Weather IV		
10% Wage Increase (τ)	-2.7%	-1.7%	-2.1%	-14.7%
	(2.1%)	(1.7%)	(2.0%)	(22.2%)
		OLS		
10% Wage Increase (δ)	3.3%	2.8%	3.3%	3.3%
	(.0%)	(.0%)	(.0%)	(.0%)
Control for Birth State & Age?	Y	Y	Y	Y
Control for Current State of Residence	N	Y	N	N

Control for Household Composition	N	N	Y	N
Control for Birth State Trends?	N	N	N	Y

Controls are identical to Table 12 except for the last column. In the last column, I include separate trends for each birth state.

In Table 13, I use instrumental variables to create a natural experiment: raise wages for one child while holding wages for the rest of the family fixed. I find that increasing wages by 10% decreases television ownership by 2%-3% in 1970 and 2000.

In contrast to the IV natural experiment, OLS measures the effect of raising wages for the complete family. I find that increasing average family wages by 10% increases television ownership by 3% in 1970 and 2% in 2000. This is consistent with standard demand theory (assuming televisions are a normal good)

Table 14: Regression of Automobile Ownership on Imputed Wages

$$(\%\text{Own car})_j = h*X_j + \delta*w_f + \tau*(w_j - w_f) + \varepsilon_j$$

Dependent Variable: % Population that Lives in Household With A Car				
		Weather IV		
10% Wage Increase (τ)	3.73%	3.93%	3.58%	4.46%
	(.92%)	(.94%)	(.97%)	(.85%)
		Calendar IV		
10% Wage Increase (τ)	2.36%	2.69%	2.14%	2.64%
	(.55%)	(.53%)	(.60%)	(.55%)
		OLS		
10% Wage Increase (δ)	3.62%	3.63%	3.56%	3.63%
	(.02%)	(.02%)	(.02%)	(.02%)
Control for Birth State & Age?	Y	Y	Y	Y
Control for State of Residence	N	Y	N	N
Control for Household Composition	N	N	Y	N
Control for Birth State Trends?	N	N	N	Y

Controls are identical to Table 13

.

In Tables 13, I use instrumental variables to create a natural experiment: wages for one child increase, but wages for the rest of the family are held fixed. I find that increasing wages by 10% increases automobile ownership by 2%-4%. This is similar to

the OLS estimates. The most likely explanation for the similarity that automobiles are a good substitute for leisure time since driving is much faster than taking a bus or walking. Accordingly, cars are more useful to people who face a high opportunity cost for leisure, regardless of their income level.

Table 15: IV Regression of Transfers Received By Parents on a 10% Wage Increase for Their Children

$$\text{Pesos Received}_p = m*X_j + \xi*w_f + \theta*(w_j - w_f) + \varepsilon_p$$

	Calendar IV (θ)			Weather IV (θ)		
Pesos Received by Mother from Family in Mexico	90.06 Ps.	89.59 Ps.	112.93 Ps.	52.34 Ps.	53.01 Ps.	49.21 Ps.
	(18.08)	(18.03)	(17.57)	(18.67)	(18.58)	(18.67)
Pesos Received by Father from Family in Mexico	110.30 Ps.	110.11 Ps.	110.40 Ps.	97.32 Ps.	98.25 Ps.	93.86 Ps.
	(23.18)	(23.14)	(23.07)	(30.94)	(30.75)	(30.77)
Pesos Received Received by Mother from Family Abroad	26.81 Ps.	27.50 Ps.	26.21 Ps.	24.65 Ps.	26.18 Ps.	26.21 Ps.
	(14.55)	(13.83)	(14.10)	(19.18)	(19.12)	(19.14)
Pesos Received by Mother from Family in Mexico	45.45 Ps.	46.99 Ps.	45.71 Ps.	47.43 Ps.	48.72 Ps.	46.84 Ps.
	(19.86)	(20.02)	(19.69)	(25.21)	(25.39)	(25.18)

Control for Birth State, # Children and Mean Age Children?	Y	Y	Y	Y	Y	Y
Control for State of Residence?	N	Y	N	N	Y	N
Control for Mother's Age?	N	N	Y	N	N	Y

In all specifications, I control for the mean age of children over 25 with a dummy for each year of average age, control for the number of children over 25. I calculate average ages by assuming that children are spaced exactly two years apart. For example, if a woman has 10 children, and her youngest child is 16, then 5 children over 25, with an average age of 31. Couples who do not report valid data on transfers or family size, or who have more than 15 children are excluded. Observations are weighted by the sample weights given in the census, and clustered by state-age cells.

In Table 15, I use instrumental variables to create a natural experiment: wages for adult children increase while holding parents' wages are held fixed. Overall, I find that parents get about 225- 275 pesos a month if their children have 10% higher wages. Most of these transfers come from family living in Mexico. This transfer is sufficient to raise parents' consumption by 7%.

Further Explanation of Econometric Techniques Used in Table 15

I avoid the problem of missing data on children's wages by imputing wages. The 2000 Census asks women how many children they have and how old their youngest child is. I assume that children are spaced an average of two years apart,[30] and that children are always born in their mother's birth state and then calculate age and state of birth for each child. I then impute wages for each adult child by assuming that a child earns the mean wage for their age and state or birth. For example, 30-year-old men born in Mexico State have an average wage of 10.6 pesos per hour and 40-year-old men born in Zacatecas have an average wage of 11.2 pesos per hour. I can then regress transfers received by the parents on their child's imputed wage. In all regressions, I control for child's age and state of birth and use the remaining wage variation to identify results.

I avoid the problem of endogeneity by using IV. The two instruments used are school calendar during childhood and temperature during childhood. By assumption, my instruments are uncorrelated with family background. Therefore, my instruments correspond to a natural experiment that exogenously raises children's wages while holding parent's wages fixed. In addition, my instruments are uncorrelated with measurement error for wages. Accordingly, my results are not biased when imputed wages rather than actual wages are used in the regression.

[30] This typically leads to the oldest children born after a woman is 16, except for very large families. I exclude families where the age at first birth is under 16.

In the Mexican Census, parents are only asked about the total transfers they receive, not which child sent the money.[31] I cannot estimate $(\partial t_j / \partial w_j)$, how much child j sends to the parent when his wages go up 10%. Instead, I will estimate $(\partial \sum_{j=1}^{n} t_j)/(\partial \sum_{j=1}^{n} w_j)$, how much do parents receive when mean wage for their children goes up 10%. I use mean school calendar and mean weather during childhood to instrument for mean wages. In all regressions, I control for state of birth and age of children[32] and identify coefficients using state-age variation in average wages. Differences in average wages across states have no effect on my point estimates.

[31] My model assumes that all transfers are received from children, and not other family. Relaxing that assumption does not change the interpretation of empirical results.

[32] In the empirical regressions, I focus only on children older than 25. Younger children are assumed to be in school, and dropped from the sample completely. For example, suppose a woman has three children and the youngest is 23. I regress the transfers she receives on average wages for the 25 and 27-year-old only.

Appendix 1

Interior Solution For Transfers, Consumption and Labor Supply

Assume a general utility function with m consumption goods and one leisure good. $u(c_j^1,....c_j^m,L_j)$. The utility function is continuous, smooth, and concave everywhere. For analytical simplicity I will not study the leisure good directly – instead I will study hours of work, $H = (1-L)$. For simplicity, I assume that the price of the consumptions goods are all fixed at 1, and they are all normal and separable. However, I do not assume that consumption and leisure are separable. Some goods may be complements to leisure, and other goods may be substitutes. I will also assume that the wage differences within the family are small and all children have identical utility functions. Finally, I will assume that the parents utility is a concave function of their total spending, $V(A+\sum_{k=1}^{n} t_k)$.

Suppose that there are n children in a family. Child j receives a wage of w_j and 1 unit of time to allocate between consumption and leisure. Child j gives a transfer $t_j(w_1...w_n)$ to his parent. Children are altruistic towards their parent, so that $U_j = u(c_j^1,....c_j^m, H_j) + \alpha V(A+\sum_{k=1}^{n} t_k)$. I assume that the family is at an interior solution, so that every children gives a positive transfer to his or her parent. I also assume that

children choose transfers simultaneously – so that they cannot change their behavior in response to sibling's behavior.

Lemma 1: $\left(\partial(H_k - H_j)/\partial w_k\right) > 0$

Child j's problem can be written as:

(1.1)

Max u$(c_j^1,...c_j^m, H_j) + \alpha V(A + \sum_{k=1}^{n} t_k)$ subject to:

Child j's budget constraint: $c_j^1 + .. + c_j^m = w_j H_j - t_j$

Child j picks $(c_j^1,...c_j^m, H_j)$ and t_j and views A+$\sum_{k \neq j}^{n} t_k$ as a fixed constant

We can solve child j's utility problem to get first order conditions

(1.2) $$w_j(\partial \mathrm{u}_j/\partial c_j^r) = -(\partial \mathrm{u}_j/\partial H_j) = \lambda_j \quad \& \ \lambda_j = \alpha * V'$$

Because all children in the family are at the interior solution, I can rewrite (1.2) as:

(1.3)

$(\partial \mathrm{u}_j/\partial c_j^r) = \lambda = (\partial \mathrm{u}_k/\partial c_k^s)$ for any r and s

$(\partial \mathrm{u}_j/\partial H_j)/w_j = \lambda = (\partial \mathrm{u}_k/\partial H_k)/w_k$

I can then differentiate (1.3) with respect to w_j to get second order conditions:

(1.4) $(\partial \mathrm{u}_{\mathrm{j}}^2/\partial c_j^r \partial w_j)=(\partial\lambda/\partial w_j)$ & $(\partial \mathrm{u}_{\mathrm{j}}^2/\partial H_j \partial w_j)=-\lambda - w_j(\partial\lambda/\partial w_j)$

Similarly, I can differentiate (1.3) with respect to w_k to get second order conditions:

(1.5) $(\partial \mathrm{u}_{\mathrm{j}}^2/\partial c_j^r \partial w_k)=(\partial\lambda/\partial w_k)$ & $(\partial \mathrm{u}_{\mathrm{j}}^2/\partial H_j \partial w_k)=-w_j(\partial\lambda/\partial w_k)$

For smooth functions, $(\partial f/\partial x\partial y) = (\partial f/\partial y\partial x)$, so I can differentiate in reverse to get more information.

(1.6) $(\partial u_j/\partial w_k) = \sum_{r=1}^{m}(\partial \mathrm{u}_{\mathrm{j}}/\partial c_j^r)(\partial c_j^r/\partial w_k) + (\partial \mathrm{u}_{\mathrm{j}}/\partial H_j)(\partial H_j/\partial w_k)$ $\forall$ siblings j & k

(1.7) $(\partial u_j^2/\partial w_k \partial H_j) = \sum_{r=1}^{m}(\partial \mathrm{u}_{\mathrm{j}}/\partial c_j^r \partial H_j)(\partial c_j^r/\partial w_k) + (\partial \mathrm{u}_{\mathrm{j}}^2/\partial H_j{}^2)(\partial H_j/\partial w_k)$ $\forall$ siblings j & k

(1.8) $(\partial u_j^2/\partial w_k \partial c_j^s) = \sum_{r=1}^{m}(\partial \mathrm{u}_{\mathrm{j}}/\partial c_j^r \partial c_j^s)(\partial c_j^r/\partial w_k) + (\partial \mathrm{u}_{\mathrm{j}}^2/\partial H_j \partial c_j^s)(\partial H_j/\partial w_k)$ $\forall$ good s

By assumption, the utility from different consumption goods is separable. I can simplify (1.8) to get:

(1.9) $(\partial u_j^2/\partial w_k \partial c_j^s) = (\partial \mathrm{u}_{\mathrm{j}}^2/\partial^2 c_j^s)(\partial c_j^s/\partial w_k) + (\partial \mathrm{u}_{\mathrm{j}}^2/\partial H_j \partial c_j^s)(\partial H_j/\partial w_k)$ $\forall$ good s

Combining (1.9) and (1.5), I get:

$$(1.10)\quad \begin{aligned}&(\partial\lambda/\partial w_k) = (\partial \mathrm{u}_\mathrm{j}^2/\partial^2 c_j^s)(\partial c_j^s/\partial w_k) + (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j \partial c_j^s)(\partial H_j/\partial w_k) \rightarrow \\ &(\partial c_j^s/\partial w_k) = \Big((\partial\lambda/\partial w_k) - (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j \partial c_j^s)(\partial H_j/\partial w_k)\Big)/(\partial \mathrm{u}_\mathrm{j}^2/\partial^2 c_j^s)\end{aligned}$$

I can rewrite (1.10) as:

$$(1.11)\quad (\partial c_j^s/\partial w_j) - (\partial c_j^s/\partial w_k) = -\Big((\partial \mathrm{u}_\mathrm{j}^2/\partial H_j \partial c_j^s)/(\partial \mathrm{u}_\mathrm{j}^2/\partial^2 c_j^s)\Big)\Big((\partial H_j/\partial w_j) - (\partial H_j/\partial w_k)\Big)$$

Similarly, I combine (1.7), (1.3) and (1.4) to get:

$$(1.12)\quad \begin{aligned}&w_j(\partial\lambda/\partial w_k) = \sum_{r=1}^{m} -(\partial \mathrm{u}_\mathrm{j}/\partial c_j^r \partial H_j)(\partial c_j^r/\partial w_k) + (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j^2)(\partial H_j/\partial w_k) \text{ for } \mathrm{j} \neq \mathrm{k} \\ &w_j(\partial\lambda/\partial w_j) + \lambda = \sum_{r=1}^{m} -(\partial \mathrm{u}_\mathrm{j}/\partial c_j^r \partial H_j)(\partial c_j^r/\partial w_j) + (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j^2)(\partial H_j/\partial w_j)\end{aligned}$$

If I combine (1.10) and (1.12) I get:

$$(1.13)\quad \begin{aligned}&w_j(\partial\lambda/\partial w_k) = (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j^2)(\partial H_j/\partial w_k) - \\ &\sum_{r=1}^{m}\Big((\partial\lambda/\partial w_k)(\partial \mathrm{u}_\mathrm{j}/\partial c_j^r \partial H_j) + (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j \partial c_j^r)^2(\partial H_j/\partial w_k)\Big)/(\partial \mathrm{u}_\mathrm{j}^2/\partial^2 c_j^s) \text{ for } \mathrm{j} \neq \mathrm{k}\end{aligned}$$

$$(1.14)\quad \begin{aligned}&w_j(\partial\lambda/\partial w_j) = (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j^2)(\partial H_j/\partial w_j) - \lambda - \\ &\sum_{r=1}^{m}\Big((\partial\lambda/\partial w_j)(\partial \mathrm{u}_\mathrm{j}/\partial c_j^r \partial H_j) + (\partial \mathrm{u}_\mathrm{j}^2/\partial H_j \partial c_j^r)^2(\partial H_j/\partial w_j)\Big)/(\partial \mathrm{u}_\mathrm{j}^2/\partial^2 c_j^s) \text{ for } \mathrm{j} \neq \mathrm{k}\end{aligned}$$

By assumption, the family is symmetrical: every child in the family has identical utility functions, and wage shocks are small. Therefore, $(\partial\lambda / \partial w_k) = (\partial\lambda / \partial w_j)$ and I can combine (1.13) and (1.14) to get:

$$(1.15)\quad \begin{aligned} &\left((\partial H_j / \partial w_j) - (\partial H_j / \partial w_k)\right)\left(\sum_{r=1}^{m}\left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^r)^2 / (\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^s)\right) + (\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j^2)\right) = \lambda \rightarrow \\ &\left((\partial H_j / \partial w_j) - (\partial H_j / \partial w_k)\right) = \lambda / \left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j^2) - \sum_{r=1}^{m}\left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^r)^2 / (\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^s)\right)\right) \end{aligned}$$

Because leisure is a normal good, $(\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j^2) > \sum_{r=1}^{m}\left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^r)^2 / (\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^s)\right)$, and the utility function is monotonically increasing such that λ>0. Therefore,

$$(1.16)\quad (\partial H_j / \partial w_j) - (\partial H_j / \partial w_k) = (+)/(+) = (+) \rightarrow (\partial H_j / \partial w_j) > (\partial H_j / \partial w_k)$$

And because the family is symmetrical $(\partial H_j / \partial w_j) = (\partial H_k / \partial w_k)$. Therefore, $\left(\partial (H_k - H_j) / \partial w_k\right) > 0$ always

Lemma 2: $\left((\partial c_j^r / \partial w_j) - (\partial c_j^r / \partial w_k)\right)$ is ambiguous

According to (1.11):

$$(2.1)\quad (\partial c_j^s / \partial w_j) - (\partial c_j^s / \partial w_k) = -\left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^s) / (\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^s)\right)\left((\partial H_j / \partial w_j) - (\partial H_j / \partial w_k)\right)$$

Because the family is symmetrical $(\partial c_j^s / \partial w_j) = (\partial c_k^s / \partial w_k)$. I can rewrite (2.1) as:

(2.2) $(\partial c_k^s / \partial w_k) - (\partial c_j^s / \partial w_k) = -\left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^s) / (\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^s)\right)\left(\partial (H_k - H_j) / \partial w_k\right)$

Equation (2.2) is inherently ambiguous. $(\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^s) < 0$ for all concave utility functions and in Lemma 1 I showed that $\left(\partial (H_k - H_j) / \partial w_k\right) > 0$. But the cross-partial, $(\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^s)$, can be either positive or negative.

If $(\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^s)$ <0, then good s is a complement to leisure. In that case:

$(\partial c_j^s / \partial w_j) - (\partial c_j^s / \partial w_k) = (-)(-)/(-)*(+) = (-)$.

If $(\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^s)$ >0, then good s is a substitute for leisure. In that case:

$(\partial c_j^s / \partial w_j) - (\partial c_j^s / \partial w_k) = (-)(+)/(-)*(+) = (+)$

Lemma 3: $\left((\partial t_k / \partial w_k) - (\partial t_j / \partial w_k)\right) > 0$

According to the budget constraint for child j:

(3.1) $c_j^1 + .. + c_j^m = w_j H_j - t_j \rightarrow t_j = w_j H_j - \sum_{r=1}^{m} c_j^r$

We can then differentiate with regard to $\mathrm{w_k}$ to get:

(3.2) $\partial t_j / \partial \mathrm{w_k} = (\partial H_j / \partial \mathrm{w_k}) w_j - \sum_{r=1}^{m} \partial c_j^r / \partial w_k$

Similarly, the budget constraint for child k is:

$$(3.3)\; c_k^1 + .. + c_k^m = w_k H_k - t_k \rightarrow t_k = w_k H_k - \sum_{r=1}^{m} c_k^r$$

We can then differentiate with regard to w_k to get:

$$(3.4)\;\; \partial t_k / \partial \mathrm{w_k} = H_k + (\partial H_k / \partial \mathrm{w_k}) w_k - \sum_{r=1}^{m} \partial c_k^r / \partial w_k$$

Subtracting (3.2) from (3.4) gives us the combined expression:

$$(3.4)\quad \begin{aligned} &\partial (t_k \text{-} t_j) / \partial \mathrm{w_k} = H_k + (\partial H_k / \partial \mathrm{w_k}) w_k - (\partial H_j / \partial \mathrm{w_k}) w_j - \sum_{r=1}^{m} \partial (c_k^r - c_j^r) / \partial w_k = \\ &H_k - (\partial H_k / \partial \mathrm{w_k})(w_k - w_j) + \left(\partial (H_k \text{-} \mathrm{H}_j) / \partial \mathrm{w_k} \right) w_j - \sum_{r=1}^{m} \partial (c_k^r - c_j^r) / \partial w_k \end{aligned}$$

According to line (1.11) in Lemma 1:

$$(3.5)\;\; (\partial c_j^s / \partial w_j) - (\partial c_j^s / \partial w_k) = -\left((\partial \mathrm{u_j^2} / \partial H_j \partial c_j^s) / (\partial \mathrm{u_j^2} / \partial^2 c_j^s) \right) \left((\partial H_j / \partial w_j) - (\partial H_j / \partial w_k) \right)$$

Therefore, I can rewrite (3.4) as:

$$(3.6)\quad \begin{aligned} &\left((\partial t_j / \partial \mathrm{w_j}) \text{ - } (\partial t_j / \partial \mathrm{w_k}) \right) = H_j + w_j \left((\partial H_j / \partial \mathrm{w_j}) - (\partial H_j / \partial \mathrm{w_k}) \right) \\ &- \sum_{r=1}^{m} \left((\partial \mathrm{u_j^2} / \partial H_j \partial c_j^r) / (\partial \mathrm{u_j^2} / \partial^2 c_j^r) \right) \left((\partial H_j / \partial w_j) - (\partial H_j / \partial w_k) \right) = \\ &H_j + \left((\partial H_j / \partial \mathrm{w_j}) - (\partial H_j / \partial \mathrm{w_k}) \right) \left(w_j - \sum_{r=1}^{m} \left((\partial \mathrm{u_j^2} / \partial H_j \partial c_j^r) / (\partial \mathrm{u_j^2} / \partial^2 c_j^r) \right) \right) \end{aligned}$$

The first term H_j is simply child j's labor supply. This is always positive (or at least non-negative. And $\left(w_j - \sum_{r=1}^{m} \left((\partial \mathrm{u}_\mathrm{j}^2 / \partial H_j \partial c_j^r) / (\partial \mathrm{u}_\mathrm{j}^2 / \partial^2 c_j^r) \right) \right)$ is always positive when the utility function is concave and child j is at the optimal point. Finally, I showed in Lemma 1 that $\left((\partial H_j / \partial \mathrm{w}_\mathrm{j}) - (\partial H_j / \partial \mathrm{w}_\mathrm{k}) \right)$ is positive. I can simplify (3.6) as;

(3.7) $\left((\partial t_j / \partial \mathrm{w}_\mathrm{j}) - (\partial t_j / \partial \mathrm{w}_\mathrm{k}) \right) = (+) + (+)(+) = (+)$

And by symmetry I can substitute $(\partial t_k / \partial \mathrm{w}_\mathrm{k})$ for $(\partial t_j / \partial \mathrm{w}_\mathrm{j})$ to get:

(3.8) $\left((\partial t_k / \partial \mathrm{w}_\mathrm{k}) - (\partial t_j / \partial \mathrm{w}_\mathrm{k}) \right) = (+) + (+)(+) = (+)$