intensity of use. The fixed fee is usually a proportion of licensee's revenue which is set to reflect licensee's value of music or photographs. For instance, music would be more valuable to a radio station than a restaurant whose main business is serving food. Thus the rates for radio stations are higher than for restaurants. This pricing policy is rational because it is very difficult for CCS to know which particular music or photograph is most valuable to the licensee. Under such circumstance, it is better not to price the individual IPs separately for it may distort the choice. Blanket license is designed so that each licensee will choose whatever combination of IPs will maximize its profit. CCS will take a fixed proportion ~~of~~ that maximized profit. CCS charges the same price (actually zero) for each IP so it will not distort licensee's profit maximizing choice.

CCS distributes license revenue to members according to how much the member's music or photograph was used. Intensity of use is obtained by combination of reporting by major licensees such as major television and monitoring of other licensees.[26]

Simple model

The following model is due to Bensen, Kirby and Salop.[27] When the size of intellectual property (IP) rights is N, the value to society of the catalogue is $V(N)$. We assume $V(N)$ is increasing concave function of N. Each licensee would be paying their individual value of the catalogue and the sum of all the fees should be equal to $V(N)$. Thus, this is CCS's licensing revenue. The CCS's administration cost is $C(N) = F + cN$, where F is the fixed cost of administration and c is the cost per IP. Typically c would be the monitoring cost. The surplus is $\pi(N) = V(N) - cN - F$.

For simplicity we assume one member has one IP right and CCS surplus is divided equally among its N members. Then in order to maximize per member profit, membership size should be chosen to maximize

$$\frac{\pi(N)}{N} = \frac{V(N) - cN - F}{N}$$

The per member maximizing size, N^m satisfies,

$$\frac{d}{dN}\frac{\pi(N^m)}{N^m} = 0 \quad \Leftrightarrow \quad V'(N^m) - c = \frac{V(N^m) - cN^m - F}{N^m} \qquad (2)$$

[26] Corbet, see Chapter 10 of this volume.

[27] Bensen, Stanley M., Sheila N. Kirby and Steven C. Salop, 'An Economic Analysis of Copyright Collectives', 78 *Virginia Law Review*, 1992. 383–411.

The membership size N^m to maximize per member surplus is set so that marginal surplus equals surplus per member.

$$\pi'(N) = 0 \quad \Leftrightarrow \quad V'(N^*) = c.$$

The socially optimal membership size is to maximize total surplus, $\pi(N)$ ~~and the optimal membership N^*,~~

The socially optimal membership size, N^* is set to equate marginal surplus to marginal cost. Comparing equations (1) and (2), we observe that membership is kept too small if CCS tries to maximize surplus per member, $N^m < N^*$.

Formation and stability

One advantage of CCSs is the reduction of transaction cost for enforcing property rights. CCS saves monitoring cost by monitoring all music or photograph use on behalf of the members, making individual monitoring by each IP owner unnecessary. However, the economies of scale effect of monitoring cost is not the only reason why CCSs do not suffer from instability. First of all, there is no externality that non-members can free ride on as in the case of patent pools. Instead the blanket license practiced by CCS contributes to stability. Because licensees pay a fixed fee, there is no marginal cost of using more from the CCS IP catalogue. On the other hand, licensee must pay a separate royalty to use a non-member's IP, making it costly not to be a CCS member. Thus not only is there incentive to stay, there is an incentive to join CCS. It is not surprising that CCSs have been stable over time and memberships have grown.

23.4 Incomplete contract structures

Arrow in his seminal work[28] argued that risk was *not* the essence of innovation since this can be contracted away in a perfect capital market. The reality is that the capital market is not perfect. Both open source and CCL address the issue of uncertainty in innovation.

An outcome of innovation is uncertain and not always successful. Which idea (which may be protected by IP)[29] or molecule is most likely to succeed is often unknown a priori. Which researcher will be most

[28] Arrow, K. 'Economic Welfare and the Allocation of Resources for Inventions' in Nelson, R.(ed), *The Rate and Directions of Inventive Activity*, Princeton, Princeton University Press, 1962, 635 p.

[29] An idea may be the subject of an IP right. (Access and) use of an idea differs according to the fact whether there is IP on the idea or not. The author is grateful to Geertrui Van Overwalle for pointing to this very important distinction.

effective may also be unknown. In addition to these uncertainties, there are informational problems. That is, the IP owner may be more informed than a researcher about quality and likely success of IP or a molecule. Similarly, a researcher may be better informed about his or her ability than the IP owner. Furthermore, the IP owner may only not be able to observe how much talent a researcher has (hidden information) but also may not be able to observe how hard she is working (hidden action).

While some uncertainties are possible to contract away, it is difficult to write contracts when there are informational asymmetries (hidden information).[30] It is also not easy to induce optimal effort with contracts when effort is not observable (hidden action) and it is usually not possible to have an efficient outcome. That is, the IP owner will have difficulty having others conduct or invest in innovation to improve or develop its IP.

Open source and CCL are functioning as a form of incomplete contracts when there are these uncertainty and informational problems. The problem is made worse by the dynamic nature of innovation. In case of software improvements, improvements are cumulative. This means rents from innovation need to be distributed between generations and these distribution rules in turn affect incentive to innovate. As Hope[31] argues, it is possible to obtain private returns from open source material through complementary goods, return from market positioning etc., meaning there are rents appropriated by each generation of cumulative innovation with open source.

An important function of ICS is to provide an environment to innovate and to realize value of IP. In this sense, The Alliance Centers of the Consultative Group on International Agricultural Research, the CGIAR,[32] has aspects that should be included in this group. It maintains germplasm from around the world that can be distributed to crop breeders upon request, a function similar to the Molecular Libraries Initiative – CCL regime. It provides opportunity to realize value.

23.5 Concluding remarks

We have categorized various clearing mechanisms and contractually constructed liability according to economic functions. **Exchanges**

[30] Bolton, P. and M. Dewatripont, *Contract Theory*, Boston, MIT Press, 2005, 724.

[31] Hope, see Chapter 12 of this volume.

[32] Henson-Apollonio, V., 'Case 10. The International Treaty on Plant Genetic Resources for Food and Agriculture: the Standard Material Transfer Agreement as Implementation of a Limited Compensatory Liability Regime', Chapter 18 of this volume.

reduce transaction costs (search and contracting costs). Any resulting contracts are bilateral and IP owners retain ownership. **Collective rights organizations** include well-established clearing mechanisms: copyright collection societies and patent pools. Their main function is to provide access to a large catalogue of IPs and collect royalties. IPs are complements in case of patent pools while existing copyright collection societies offer blanket licenses because relationships among IPs are not clear a priori.

The last group of clearing mechanisms, the **incomplete contract structures** exist to facilitate access to IP and innovation using them. By definition structures are for IP used for further research, either because they are very basic as in molecules (contractually constructed liability) or because knowledge is part of an ongoing cumulative innovation process (open source). Open source is already in existence although not very well understood. Contractually constructed liability is a new concept yet to be put into practice. Both systems are promising and surely will attract future research interest.

Last but not least, all clearing mechanisms are based on the network effect. There is danger of an equilibrium with very few participants. Coordination, by public or private or by national or international entities, is essential for successful formation. The network effect by itself is very stable, meaning it becomes self-enforcing once an organization has been established.

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On the Persistence of Low Birthrate in Japan

Reiko Aoki*and Yoko Konishi‡

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Abstract

We first present a simple model to explain why we might observe a positive relationship between birth rate and female labor participation. We verify the implications of the model with cross-sectional Japanese regional (by prefecture) for every five years 1980-2005. We show quality adjusted consumption has a negative effect with number of children. Relationship between labor participation and birthrate becomes negative once this is taken into account. We expand quality adjusted consumption approach to a general equilibrium model and show decline in population will result in higher or lower birthrate, depending on maturity of technology. Technology dictates the relationship between quality of consumption good and skilled labor.

*Institute of Economic Research, Hitotsubashi University aokirei@ier.hit-u.ac.jp
†Research Institute of Economy, Trade and Industrykonishi-yoko@rieti.go.jp
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1 Introduction

We start with some observations from time series and cross-country data on fertility and female labor participation. The usual relationship between female labor participation and fertility is negative (Becker (1965)) as the time series of female labor participation rate (FLPR) and total fertility rate (TFR) of selected OECD countries exhibit (Figure 1). Recently the positive relationship between FLPR and TFR cross-country data in 2005 (average of years 1985-1996 as well as year 2000, Sleebos (2003), d'Addio and d'Ercole (2005), Da Rocha and Fuster (2006)) have gained much attention. In Japan also, cross-section among prefectures show positive relationship in 1987 and 2002 (Figure 2).

We also note that countries with high per capita GDP have low birthrates (Figure 3). The usual interpretation would be based on the positive relationship between higher per capita GDP and higher wages. Higher opportunity cost when wages are high means lower fertility when per capita GDP is high. Higher per capita GDP is also associated with higher quality of consumption. We believe that the trade-off between consumption and number of children should be taken into account when understanding childbearing and working decisions.

We fill first present a model of consumer choice where children and consumption experience require both goods and time. We demonstrate how change in quality of consumption and change in wages have different effects on number of children. Since wage level and consumption quality are related, relationship between fertility and labor participation can be positive or negative. We verify the model implications with cross-sectional Japanese data for every five years 1980 – 2005. We use indicators of consumption quality as well as consumption behavior.

We verify implications of the model with Japanese cross sectional data from 8 different points in time (every five years from 1970 – 2005) in which a positive correlation between TFR and FLPR among prefectures (regions) have been observed since 1980. However, we find that FLPR has a significantly negative effect on TFR after resolving econometric problems from unobservable heterogeneity, simultaneity or endogeneity and measurement error by Fixed effect IV estimation. The results are consistent with the theoretical predictions as well as traditional economic models of the relation between TFR and FLPR. Furthermore, consumption variables are statistically significant and have negative impact on TFR.

In the second half of this chapter, we endogenize the wages and consumption quality in a general equilibrium model with heterogenous labor and vertically differentiated products. Through comparative statics, we analyze the cause and implications of low birthrate in the long run. We show that the feedback mechanism of the economy may not reverse the declining birthrate, contradicting an implication of the Easterlin Hypothesis cohort effect. This is because the labor market structure and product market adjusts to change in birthrate and thus the cohort effect never materializes.

The approach is in the spirit to papers in growth and trade that take into account the reaction of the economy in the long run (Acemoglu (1998), Flåm and Helpman (1987), Thoenig and Verdier (2003)). Acemoglu (1998) showed that while in the short run, labor input is reduced in response to scarcity of skilled labor and high wages, skilled labor supply increase in response triggers technological change that makes skilled labor even more productive, raising skilled labor wage in the long run. Our analysis suggests that a similar long term adjustment of the economy will prevent a natural feedback mechanism from working. That is, smaller population will increase marginal product of labor in the short run but consumption pattern will change in the long run reducing such an advantage.

2 Re-examination of female labor participation - birthrate relationship

Consider a situation where utility of a household depends on number of children, n, consumption of a good x. Both child rearing and consumption of a good requires time. Number of children is determined by amount of good x_c, and time devoted, ℓ_c,

$$n = f(x_c, \ell_c), \quad f_x > 0, f_\ell > 0.$$

Subscripts on functions denote partial derivatives. The utility of consumer is actually determined by amount of z, which is consumption experience that depends on amount of the good, x, and time devoted, ℓ,

$$z = g(x, \ell), \quad g_x > 0, g_\ell > 0.$$

Utility function is,

$$u(n, z), u_n > 0, u_z > 0.$$

Budget constraint depends on price of good and wage, and labor endowment, $\bar{\ell}$,

$$px + px_c + w\ell + w\ell_c = w\bar{\ell}.$$

Figure 4 demonstrates the optimization problem. The opportunity set is defined as,

$$\left\{(z, n) | n = f(x_c, \ell_c), \quad z = g(x, \ell), \quad p(x + x_c) + w(\ell + \ell_c) = w\bar{\ell}\right\}.$$

The frontier is downward sloping (see Appendix). It reflects the budget constraint as well as the technologies, g and f. We can show that

Claim 1. *When wage increases, the opportunity set expand. (Dotted line in Figure 5.) Under regularity conditions, hours worked increases and number of children increase or consumption increases or both when wage increases. That is, denoting equilibrium quantities as ℓ_c^*, x_c^*, ℓ^*, and x^*, if $u(n, z)$, $f(x, l)$ and $g(x, c)$ are concave, then*

$$\frac{\partial \ell_c^*}{\partial dw} < 0, \frac{\partial \ell^*}{\partial w} < 0, \text{ and } \frac{df(x_c^*, \ell_c^*)}{dw} > 0 \text{ or } \frac{dg(x^*, \ell^*)}{dw} > 0 \text{ or both.}$$

Proof is in the Appendix. The result is intuitive. When wage increases, there is substitution away from labor to goods, which increases hours worked. Higher wage expands the budget set and will increase x_c. This may off set the decline in ℓ_c which increases number of children despite lower ℓ_c, i.e., more hours worked. A positive relationship between labor participation and child birth is observed.

We further index consumption (consumption experience) by quality, Q. Utility function is

$$u(Qz, n)$$

where z measures quantity of consumption. First-order condition for utility maximization are,

$$\frac{f_x}{f_\ell} = \frac{g_x}{g_\ell} = \frac{p}{w}, \tag{1}$$

$$\frac{u_n}{u_z} = Q\frac{g_x}{f_x}. \tag{2}$$

Equation (1) implies less labor intensive consumption and child rearing method will be used when wage increase. The time series of female wage has been rising in Japan would lead to less labor intensive methods which means greater labor participation. Equation (2) implies better quality of consumption leads to more consumption and less children.

Higher wage but not significantly higher quality means positive relationship. However with the same higher relative wage and higher quality consumption means negative relationship between labor participation and fertility. Availability of consumption goods, such as entertainment and restaurants, is much greater in larger cities. This means higher Q, meaning less children and more consumption in cities.

2.1 Empirical Evidence with Japanese Regional Data

In this section we examine the empirical evidence to support the theoretical implications of the previous sections. In Section 2.2,we present the data with descriptive statistics and confirm the positive relationship between total fertility rate (TFR) and female labor participation rate (FLPR) among regions (prefectures) in Japan, as seen in other OECD countries. We present the estimation results in Section 2.3. We estimate the equations that assume that regional TFR is affected by regional variables that reflect quality of consumption goods. Specifically we consider household leisure and entertainment expenditures, automobile ownership, and number of department stores as explanatory variables, in addition to the traditional marriage and other family variables. Child bearing and female labor market participation are determined simultaneously which implies there is a simultaneous or endogeneous relationship between TFR and consumption behavior variables. Furthermore, because the quality of consumption goods are the latent variables, we employ some proxy variables. To address the simultaneity, endogeneity and measurement error problems, we apply the fixed effects instrumental variables(FE-IV) method to our panel data. The unobserved heterogeneity among regions is also taken into account by this approach.

2.2 Data and Descriptive Statistics

We use data from 47 prefectures for years 1970, 75, 80, 85, 90, 95, 2000, and 2005 (Okinawa prefecture is not included in 1970). Figure 4 plots correlation coefficients between regional TFR and FLRP for every five years from 1970 to 2005. The coefficient is negative for 1970 but is positive thereafter. For the last few years, the correlation is not only positive but close to 0.5, a very clear positive relationship between TFR and FLRP. The positive relationship has also been observed in cross=section of other OECD countries in recent years. We will be controlling for consumption variables implied by the proceeding theoretical model to understand the relationship.

The labels and sources of the variables for the regression in the next section are summarized in Table 1. We introduce some new variables as determinants of TFR in addition to the traditional marriage and household variables. Specifically we consider household leisure and entertainment expenditures and automobile ownership as the consumer behavior variables that capture optimal choice, i.e., consumer behavior. In order to reflect quality of consumption, we use the number of department stores, which specialize in high end or high quality products. Leisure and Automobile Ownership can be considered to be high quality goods and Department Store to be a proxy variable for high quality of consumption goods. They both should have negative impacts on TFR.

Table 2 summarizes the changes through time by depicting mean, standard deviation, minimum and maximum values for each variable for each year. The steady decline of TFR is striking and TFR in 2005 has decreased to almost one-half of that in 1970. The number of married couples has been declining as well. FLPR declines slightly in the period, but the standard deviation has changed from 6.313 (in 1975) to 2.467 (in 2005), implying that prefectures have become more homogeneous as far as FLPR is concerned. There is a similar phenomenon in Marriage standard deviation. On the other hand, we also observe that some variables have had rising means (proportion of one-person households, proportion of leisure and entertainment expenditure, automobile ownership rate and number of department stores), and in particular the means of Automobile Ownership and the number of department store have risen substantially. And their standard deviations have increased, suggesting they could be better explanatory variables for heterogeneity of prefectures. In Section 2.3 we regress TFR on FLPR and other variables, and apply the fixed effect instrumental variable model to our panel data to address the econometric problems and unobservable heterogeneity among prefectures.

Table 2: Descriptive Statistics

Variables	**Year**	**Mean**	**S.D.**	**Min.**	**Max.**
TFR	1970	2.092	0.115	1.88	2.35
	1975	2.006	0.165	1.63	2.88
	1980	1.829	0.135	1.44	2.38
	1985	1.825	0.125	1.44	2.31
	1990	1.616	0.125	1.23	1.95
	1995	1.525	0.134	1.11	1.87
	2000	1.473	0.133	1.07	1.82
	2005	1.307	0.122	0.98	1.71
FLPR	1970	54.483	6.313	40.2	65.5

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Variables	Year	Mean	S.D.	Min.	Max.
	1975	48.545	5.73	35.7	58.8
	1980	49.057	5.26	36.3	59.4
	1985	49.264	4.398	37.6	57.5
	1990	49.385	3.744	38.7	56.3
	1995	49.868	3.178	40.7	56.1
	2000	48.909	2.849	40.8	54.0
	2005	48.572	2.467	41.9	53.1
Marriages	1970	8.980	1.458	6.4	12.5
	1975	7.987	0.695	6.5	9.6
	1980	6.383	0.497	5.3	7.7
	1985	5.853	0.430	5.1	7.3
	1990	5.453	0.570	4.5	7.0
	1995	5.885	0.658	4.8	7.6
	2000	5.936	0.590	4.8	7.4
	2005	5.272	0.554	4.3	6.9
One-person Household	1970	N/A	N/A	N/A	N/A
	1975	0.113	0.033	0.068	0.256
	1980	0.13	0.033	0.083	0.267
	1985	0.18	0.039	0.121	0.339
	1990	0.201	0.039	0.143	0.359
	1995	0.229	0.039	0.176	0.381
	2000	0.249	0.04	0.191	0.409
	2005	0.267	0.04	0.209	0.425
Automobile Ownership	1970	0.12	0.027	0.068	0.184
	1975	0.238	0.038	0.164	0.333
	1980	0.319	0.048	0.212	0.443
	1985	0.354	0.051	0.246	0.478
	1990	0.428	0.057	0.304	0.560
	1995	0.561	0.078	0.342	0.718
	2000	0.681	0.105	0.358	0.852

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Variables	Year	Mean	S.D.	Min.	Max.
	2005	0.773	0.127	0.365	0.957
Leisure & Entertainment	1970	N/A	N/A	N/A	N/A
	1975	0.083	0.008	0.063	0.106
	1980	0.085	0.009	0.068	0.111
	1985	0.088	0.009	0.07	0.115
	1990	0.095	0.008	0.08	0.113
	1995	0.096	0.01	0.076	0.121
	2000	0.101	0.009	0.08	0.12
	2005	0.102	0.01	0.076	0.127
Department Store	1969	17.196	20.722	3	123
	1975	29.213	37.56	4	203
	1978	35.532	41.937	2	231
	1981	51.617	59.258	7	300
	1986	57.106	59.045	5	242
	1991	44.596	45.377	3	235
	1996	65.085	63.898	11	322
	2001	63.447	60.699	12	295

2.3 Estimation Results

Table 3 is from cross section regression of TFR on all variables in Table 2. The regression equation is,

$$\begin{aligned} TFR_i &= c + \beta_1 FLPR_i + \beta_2 Marriage_i + \beta_3 Oneperson_i \\ &+\beta_4 Leisure_i + \beta_5 Automobile_i + \beta_6 Dpt.Store_i + \epsilon_i, \end{aligned} \tag{3}$$

where $i = 1, \ldots, 47$, c is the constant term, $\beta_j, j = 1, \ldots, 6$ are unknown parameters and ϵ is the error term.

Table 3 only shows the estimated coefficient($\hat{\beta}_1$) of FLRP and $**$ indicates the null hypothesis $\beta_1 = 0$ can be rejected at 5% significance level. Although we observed a positive correlation between FRP and FLRP by the Pearson's Correlation Coefficient (See Figure 4), after adding to the consumption variables, the FLPR coefficient is no longer significant at the 5% level. However, the coefficient is significantly positive when cross sections are pooled for 1975 – 2005 with $\beta_{FLRP} = 0.066$.

We believe that the variables we employ do not completely explain the heterogeneity of TFR. We suspect that there must be a correlation with the error term, which causes a bias in the OLS estimators, as is often the case. To address this problem, we assume the heterogeneity among the prefectures is time invariant and apply the fixed effect model to our panel data. This will guarantee a consistent estimation even with unobservable heterogeneity. We show the estimation results in Table 4, Column 1 of Table 4 is the pooled OLS regression result of equation 3, where $t = 1975, \ldots, 2005$ and c is the constant term. We show the same result in Table 3, the FLPR coefficient is significantly positive with 0.066. Column 2 is result of equation 4 where α is the constant term and $t = 1970, \ldots, 2005$. This is a fixed effects model that takes into account of heterogeneity(α) and FLRP and Marriages are the only dependent variables, as in the previous studies. The FLPR coefficient is not significant at the 5% level, even the sign is negative.

$$TFR_{i,t} = \alpha_i + \beta_1 FLPR_{i,t} + \beta_2 Marriages_{i,t} + \epsilon_{i,t} \tag{4}$$

Column 3 shows a regression results of equation 5, where $t = 1975, \ldots, 2005$ and we obtain the negative coefficient of FLPR and it is significant.

$$\begin{aligned} TFR_{i,t} &= \alpha_i + \beta_1 FLPR_{i,t} + \beta_2 Marriage_{i,t} + \beta_3 Oneperson_{i,t} \\ &+ \beta_4 Leisure_{i,t} + \beta_5 Automobile_{i,t} + \beta_6 Dpt.Store_{i,t} + \epsilon_{i,t} \end{aligned} \quad (5)$$

Comparison of Column 2-4 allows us to understand the effects of consumption variables more clearly. As we pointed out previously, we must address the simultaneity and endogeneity between TFR, FLPR, and consumer behavior variables as well as the latency of proxy variables for the quality of consumption goods. To this end, we employ the fixed effects instrumental variables model (FE-IV model), which will guarantee a consistent estimator even unobservable heterogeneity, simultaneous problem or measurement error problem. We employ the lagged variables of FLPR, Marriages, and the other consumption expenditures (e.g. expenses for food, lighting and heating, furniture, transportation expenses and so on) as instrumental variables, and Marriages is the exogenous variable. Column 4 shows a Fixed effect IV estimation results of equation 5. We conclude that this result is our final result in the analysis.

We focus the analyze on the impact of FLPR on TFR, the coefficient of FLPR is significantly negative after controlling the effect of consumption and dealing with the econometric problems. We emphasize that the magnitude of FLPR's coefficient is larger than Column 3 in absolute value, it suggests that OLS estimator has a downward bias. The coefficient of Marriages is significantly positive, the region which has large number of married couples rather than other region achieve at higher TFR. There is a same phenomenon in the proportion of one-person households. We observe the significantly negative effects of Automobile Ownership and Leisure and Entertainment on TFR. Department Store is not significant in this estimation. Isolating the the effect of high-quality goods on TFR is left for future research.

3 General Equilibrium with high quality product and heterogenous labor

In this section we analyze a general equilibrium model in which consumers have a utility function that reflect the previous analysis, although somewhat simplified. Consumers differ by two attributes, their preference and quality of labor. Consumers choose either to consumer high quality product or standard (low quality) product. Child bearing choice differ according to which product they choose, as well as if they are skilled or not. Skilled workers produce the high quality product and the labor supply level determine the level of quality.

3.1 Approach

Consumers

We simplify the consumer's problem so that she chooses between consumption (x) and childbearing (n). Her preference is represented by the following utility function which also depends on the quality of the good consumed, Q,

$$U_\rho(n,x) = (Qx^\rho + n^\rho)^{\frac{1}{\rho}}, \quad 0 < \rho < 1. \tag{6}$$

Consumers preference, ρ, is distributed uniformly over [0,1]. Consumption good is either the standard (low quality) $Q = 1$ or high quality $Q > 1$. Consumer's labor endowment is $\bar{\ell}$ and wage is w which is also the opportunity cost of children. Denoting price of the good by p, consumer chooses consumption and number of children to maximize (6) with respect to the budget constraint,

$$px + wn = w\bar{\ell}.$$

Each consumer's consumption and number of children given quality Q is determined by the utility maximization given the budget constraint,

$$x_\sigma^*(p,w;Q)=\frac{Q^\sigma\bar{\ell}}{(\frac{p}{w})^\sigma\left(Q^\sigma(\frac{p}{w})^{1-\sigma}+1\right)},\quad n_\sigma^*(p,w;Q)=\frac{\bar{\ell}}{Q^\sigma(\frac{p}{w})^{1-\sigma}+1},\tag{7}$$

$$\text{where } \sigma\equiv\frac{1}{1-\rho}>1.$$

Consumption is increasing and number of children is decreasing in quality, as in the previous section. The indirect utility is,

$$v_\sigma(p,w;Q)=\bar{\ell}\left(Q^\sigma(\frac{w}{p})^{\sigma-1}+1\right)^{\frac{1}{\sigma-1}}.$$

The consumer must choose which quality to consume. If her marginal utility from more consumption is relatively large, she devotes less resources to children and has fewer children. If the quality is low and not as beneficial, she derives utility by having many children. She compares the utility levels from consuming each quality and buys whichever yields higher utility. We denote the prices of the goods with different qualities by p_H and p_L. Consumer will buy the high quality good when

$$v_\sigma(p_H,w;Q)>v_\sigma(p_L,w;1).$$

This condition is equivalent to,

$$\sigma<\hat{\sigma}\equiv\frac{\ln\frac{p_H}{p_L}}{\ln\frac{p_H}{p_L}-\ln Q}.\tag{8}$$

Since $\sigma>1$, there will be no demand for the low quality good if $\ln\frac{p_H}{p_L}<\ln Q$. This occurs if low quality product is more expensive ($p_L\geq p_H$) since $Q>1$ and $p_H>p_L$ but the price premium for the high quality is small relative to difference in quality. It does not depend on the level of income.

Consumer's labor supply is the hours not devoted to raising children,

$$\ell_\sigma(p,w;Q)=\bar{\ell}-n_\sigma^*(p,w;Q)=\frac{Q^\sigma}{Q^\sigma+(\frac{p}{w})^{\sigma-1}}.\tag{9}$$

Markets

The labor each consumer supplies is either skilled (s) or unskilled (u). There are total of N consumers, and $\theta \in (0,1)$ of the consumers are skilled. Labor endowment, $\bar{\ell}$, is the same for both types. We denote wages for skilled and unskilled by w_s and w_u. Production technology is constant returns to scale in labor: one unit of skilled labor produces one unit of high quality product and one unit of unskilled labor produces one unit of the standard product. Furthermore we assume both products are supplied competitively. Thus we have $p_H = w_s$ and $p_L = w_u$.

One skilled worker's demand for high quality product is , denoting relative wage by $\xi = \frac{w_s}{w_u} > 1$ and using (7),

$$x_s^H(\xi) = x_\sigma^*(w_s, w_s; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + 1}, \quad \sigma < \hat{\sigma} = \frac{\ln \xi}{\ln \xi - \ln Q},$$

and demand for low quality is,

$$x_s^L(\xi) = x_\sigma^*(w_u, w_s; Q) = \frac{\bar{\ell}}{\xi^{-\sigma}(\xi^{\sigma-1} + 1)}, \quad \sigma > \hat{\sigma}.$$

There will be positive demand for the low quality only if $\xi > 1$ since $\xi = \frac{p_H}{p_L}$. We make the following observation

Claim 2. *High skilled consumers consume more of both quality, $x_s^H(\xi) > x_u^H(\xi)$ and $x_s^L(\xi) > x_u^L(\xi)$.*

Total demands from all the skilled workers for high quality product and low quality product are ,

$$X_s^H(\xi) = \theta N \int_1^{\hat{\sigma}} x_s^H(\xi) d\sigma, \quad X_s^L(\xi) = \theta N \int_{\hat{\sigma}} x_s^L d\sigma.$$

Similarly for unskilled workers, we have the individual demands for high quality good,

$$x_u^H(\xi) = x_\sigma^*(w_s, w_u; Q) = \frac{Q^\sigma \bar{\ell}}{\xi^\sigma (Q^\sigma \xi^{1-\sigma} + 1)}, \quad \sigma < \hat{\sigma} = \frac{\ln \xi}{\ln \xi - \ln Q},$$

and demand for low quality good,

$$x_u^L(\xi) = x_\sigma^*(w_u, w_u; Q) = \frac{\bar{\ell}}{2}, \quad \sigma > \hat{\sigma}.$$

Total demands for each quality from all unskilled workers are,

$$X_u^H(\xi) = \int_1^{\hat{\sigma}} x_u^H(\xi) d\sigma, \quad X_u^L(\xi) = \int_{\hat{\sigma}} x_u^L(\xi) d\sigma.$$

Since production of one unit of good requires one unit of labor, demand for skilled and unskilled labor, L_s^D and L_u^D are,

$$L_s^D(\xi) = \theta N X_s^H(\xi) + (1-\theta) N X_u^H(\xi), \tag{10}$$

$$L_u^D(\xi) = \theta N X_s^L(\xi) + (1-\theta) N X_u^L(\xi). \tag{11}$$

Labor supply is constructed in a similar manner from individual supplies. Individual labor supply as function of relative wage is , using (9) ,

$$\ell_s^H(\xi) = \ell_\sigma^*(w_s, w_s; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + 1}, \quad \sigma < \hat{\sigma},$$

$$\ell_s^L(\xi) = \ell_\sigma^*(w_u, w_s; 1) = \frac{\bar{\ell}}{\xi^{1-\sigma} + 1}, \quad \sigma > \hat{\sigma}$$

$$\ell_u^H(\xi) = \ell_\sigma^*(w_s, w_u; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + \xi^{\sigma-1}}, \quad \sigma < \hat{\sigma},$$

$$\ell_u^L(\xi) = \ell_\sigma^*(w_u, w_u; 1) = \frac{\bar{\ell}}{2}, \quad \sigma > \hat{\sigma}.$$

Aggregation yields the total labor supply of each type,

$$L_s^S = N\bar{\ell} \int_1^{\hat{\sigma}} \left\{ \theta \frac{Q^\sigma}{Q^\sigma + 1} + (1-\theta) \frac{Q^\sigma}{Q^\sigma + \xi^{\sigma-1}} \right\} d\sigma, \tag{12}$$

$$L_u^S = N\bar{\ell} \int_{\hat{\sigma}}^{\infty} \left\{ \theta \frac{Q^\sigma}{Q^\sigma + \xi^{1-\sigma}} + (1-\theta) \frac{1}{2} \right\} d\sigma. \tag{13}$$

It is easy to show, from (8), that $\hat{\sigma}$ is decreasing in ξ that L_s^D and L_u^S is decreasing in $\xi = \frac{w_s}{w_u}$ and L_s^S and L_u^D are increasing in ξ. Equilibrium relative wage for a given quality level, $\xi^*(Q)$, is determined by the skilled labor market