Service Inventions: Article 29 of Patent Law states that an invention (and therefore the patent) obtained by an employee as part of employment belongs to the employee. The employer (firm or government) has the right to practice the patent provided employee is given "reasonable compensation".

Nakamura Shuji succeeded in developing the blue light emitting diode (LED) as employee of Nichia Kagaku Kogyo. Red and yellow LEDs had already been developed but development of blue was considered to be a decade away. LEDs low energy property had numerous applications. Nakamura was paid 20,000 yen for the invention in line with the company regulation on employee inventions. Nakamura sued for "reasonable compensation" claiming that half of the firm's net revenue of 120 billion yen can be attributed to the blue LED. The court ordered the firm to pay Nakamura 20 billion yen. The firm appealed but eventually Nakamura received 6 00 million yen in an out of court settlement. This set off a series service inventions, and firms such as Hitachi and Ajinomoto were sued.

The court rulings demonstrated that firm internal rules for rewarding inventions, patent applications and patent registrations did not suffice as "reasonable compensation". In case of Olympus, firm regulation states that the firm pays the employee 3000yen at the time of patent application, 8000 yen when patent was registered and 200,000 yen when the patent generated revenue. Olympus was sued by Tanaka Shumpei (inventor of optical pick-up device) for "reasonable compensation". In the final ruling, the Supreme Court ordered Olympus to pay Tanaka 2.5 million yen, based on revenue of about 9 million yen. The final Supreme Court ruling in 2005 also determined that revenues from abroad (based on foreign patents) should be included in calculating "reasonable compensation".

Research Funding

In 2006 total research expenditure in Japan was almost 18 million yen. Private sector accounted for 80.7% of the total while government's share was 19% percent. Of the total government (central and local) funding of 3.4 million yen, 51.2% went to universities, 40.4% to public research institutions (publicly funded facilities for experiments and surveys). Only 4.3 % sent to private research. Looking the other

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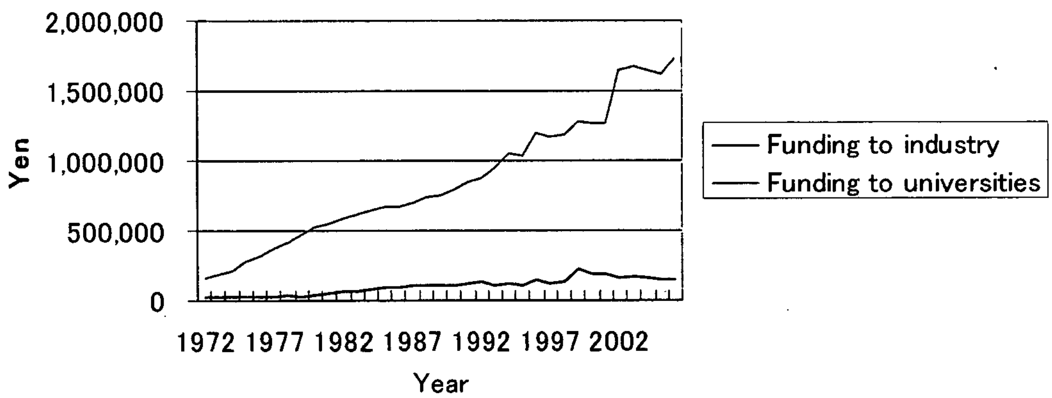
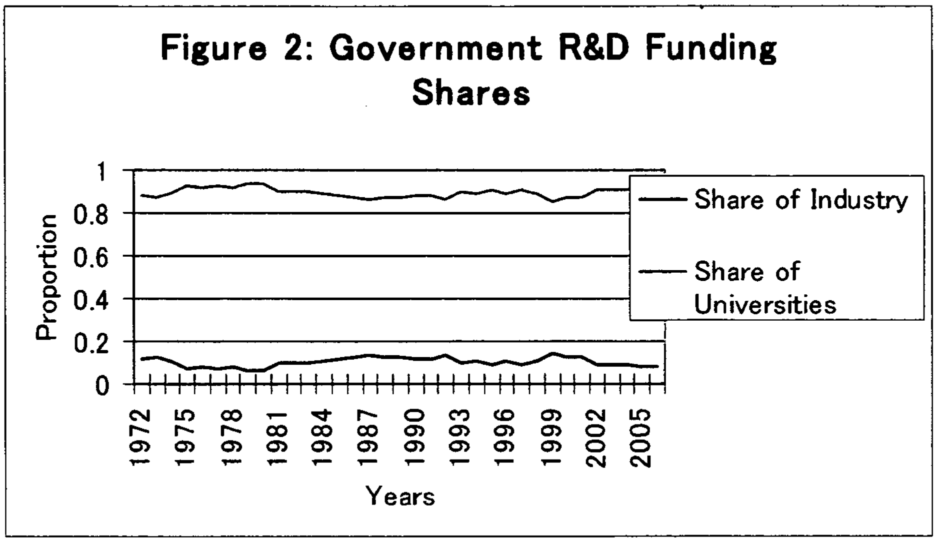
may increase probability of follow up (second generation) innovations taking place, but it may reduce over all welfare by discouraging ex-ante licensing.

way around, 50.9% of university research is funded by the government and only 1.2% of private sector research comes from the government.

Share of government funds in total research expenditure was around 30% in the 1960s but had dropped to around 20% by 1980. While government expenditure grew at rate of around 20% in the 1960s and private growth remained around 15%, private expenditure growth remained above 10% in the 1980s while the government growth remained below 10%. There was almost no research funding growth in the 1990s, government expenditure growth remains close to 0 but private research funding has been growing at around 1% since the beginning of the decade. (Figures 1 and 2)

Figure 1: Government R&D Funding





Breakdown of 2006 university research expenditure[16] by field was life sciences 23.2%, information and communication 4.2%, material sciences 2.7%, environment 2.5%, nanotechnology 1.2%, energy 1.5 % , marine development 0.42% and space development 0.22%. Breakdown for non-profit sector research was life sciences 19.1%, energy 17.7 %, space development 12.4%, environment 7.3%, information and communication 5.7%, material sciences 4.6%, nanotechnology 0.99%, and marine development 0.42%. Private sector research was information and communication 21.02%, life sciences 10.1%, environment 5.6%, energy 4.3 %, material sciences 3.3%, nanotechnology 0.99%, space development 0.20%, and marine development 0.04%.

University Innovation

Japanese national universities became independent agencies in April 2005. The funding system is undergoing a change. Universities are turning to intellectual property licensing as source of funding. (Table 1). Patent applications are on the rise for all universities. In 2003 there were 32 national universities that had any revenue from patents. The number increased to 83 in 2005. Total revenue increase from 543 million yen in 2003 to 638 million yen in 2005. Nagoya University had the largest patent revenue with 409 million yen in 2003 but the blue LED related patents are beginning to expire and the university's patent revenue dropped to 199 million yen in 2005. The increase in over all revenue means other universities are increasing their patent revenue significantly. The distribution of university owned patents seem to exhibit the same skewedness mentioned in Chapter 8.

[16] 2006 Science and Technology Survey.

Table 1: Number of Inventions

	National Universities		Private Universities		Public Universities		Total	
	Ratio to Previous Year	Number Of Inventions	Ratio to Previous Year	Number Of Inventions	Ratio to Previous Year	Number Of Inventions	Ratio to Previous Year	Number Of Inventions
FY 2000	2,391		–		–		–	
FY 2001	3,040	1.27	–		–		–	
FY 2002	3,832	1.26	–		–		–	
FY 2003	6,787	1.77	1,094		197		8,078	
FY 2004	6,968	1.03	1,590	1.45	275	1.40	8,833	1.09

※「–」not surveyed

Table 2: Patent Applications

National Universities		Private Universities		Public Universities		Total	
	Ratio to		Ratio to		Ratio to		Ratio to

Table 3: Patent Application by National Universities

	Life Sciences		Information and Communication		Environment		Nanotechnology Material Sciences		Other		Total
FY 2004	1,226	29.5%	670	16.1%	296	7.1%	960	23.1%	1,000	24.1%	4,152

Table 4: Practiced Patents and Royalty Payments FY 2005 (FY 2004)

	Number of Practiced Patents		Royalty Revenue (1000 yen)	
	(185)	Ratio to Previous Year	(543,224)	Ratio to Previous Year
Total	477	2.58	542,509	1.00
National Universities	(79) 223	2.82	(427,655) 415,997	0.97
Private Universities	(106) 247	2.33	(115,569) 124,893	1.08
Public Universities	(0) 7	–	(0) 1,619	–

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研究成果の刊行に関する一覧表レイアウト

雑誌・ワーキングペーパー

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
青木玲子	On the Persistence of Low Birth Rate in Japan	CIS Discussion Paper	347	23	2007

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資　料　1

PIE/CIS Discussion Paper No.347

Project on Intergenerational Equity (PIE)
Center for Intergenerational Studies (CIS)
Institute of Economic Research, Hitotsubashi University

On the Persistence of Low Birthrate in Japan

Aoki, R.

February 2008

On the Persistence of Low Birthrate in Japan

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"Fertility and Public Policy: How to Reverse the Trend of Declining Birth Rates"
CIS-CESifo, Munich, 1-2 February 2008†

Abstract

We first show that quality of consumption is an important determinant of fertility and labor supply. Taking this observation into account and using a general equilibrium model with vertical quality differentiation and heterogeneous labor, we show how low fertility may persist. This occurs because product quality and skilled labor supply adjust, never realizing the change in labor productivity necessary to reverse declining fertility.

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†This version 31 January 2008

1 Introduction

This paper consists of two parts. First, we present a model of consumer choice where children and consumption experience require both goods and time. We demonstrate how change in marginal utility of consumption and change in wages generate different relationship between fertility and labor participation, i.e., possible source of the difference between cross section and time series. In the second half, we embed a simplified version of this consumer into 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.

This paper 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), Flam 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 more productive 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

Large Time series among many OECD countries show negative relationship between female labor participation and TFR (Figure 1) , while cross country 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)) show a positive relationship. In Japan, although time series relationship has been negative for 1980 - 2000 (Figure 1) , cross section among prefectures show positive relationship in 1987 and 2002 (Figure 2). Obviously conditions that differ across regions in Japan are different from difference between two points in time. We also note that countries with high per capita GDP have low birthrates (Figure 3), suggesting low fertility may be correlated with high consumption. In this section we introduce a consumer optimization model to capture differences in income difference and quality of consumption.

We assume that a 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 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.[1]

[1]For instance, there are 191 Tokyo restaurants listed in the Michelin restaurant guide, compared to 64 in Paris and 42 in New York (Robinson (2007)). Same hours spend at a Tokyo restaurant yields higher Qz on the average compared to other locations in Japan.

3 General Equilibrium with high quality product and heterogenous labor

In this section we analyze a general equilibrium 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.

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,

$$U_\rho(n,x) = (Qx^\rho + n^\rho)^{\frac{1}{\rho}}, \quad 0 < \rho < 1. \tag{3}$$

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 (3) 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,

$$x^*_\sigma(p,w;Q) = \frac{Q^\sigma \bar{\ell}}{(\frac{p}{w})^\sigma \left(Q^\sigma (\frac{p}{w})^{1-\sigma} + 1\right)}, \quad n^*_\sigma(p,w;Q) = \frac{\bar{\ell}}{Q^\sigma (\frac{p}{w})^{1-\sigma} + 1}, \tag{4}$$
$$\text{where } \sigma \equiv \frac{1}{1-\rho} > 1.$$

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,

$$\sigma < \hat{\sigma} \equiv \frac{\ln \frac{p_H}{p_L}}{\ln \frac{p_H}{p_L} - \ln Q}. \tag{5}$$

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,

$$\ell_\sigma(p, w; Q) = \bar{\ell} - n^*_\sigma(p, w; Q) = \frac{Q^\sigma}{Q^\sigma + (\frac{p}{w})^{\sigma-1}}. \tag{6}$$

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 (4),

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

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 1. *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,

$$L_s^D(\xi) = \theta N X_s^H(\xi) + (1-\theta) N X_u^H(\xi), \tag{7}$$
$$L_u^D(\xi) = \theta N X_s^L(\xi) + (1-\theta) N X_u^L(\xi). \tag{8}$$

Labor supply is constructed in a similar manner from individual supplies. Individual labor supply as function of relative wage is , using (6) ,

$$\ell_s^H(\xi) = \ell_\sigma^*(w_s, w_s; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + 1}, \quad \sigma < \hat{\sigma},$$
$$\ell_s^L(\xi) = \ell_\sigma^*(w_u, w_s; 1) = \frac{\bar{\ell}}{\xi^{1-\sigma} + 1}, \quad \sigma > \hat{\sigma}$$
$$\ell_u^H(\xi) = \ell_\sigma^*(w_s, w_u; Q) = \frac{Q^\sigma \bar{\ell}}{Q^\sigma + \xi^{\sigma-1}}, \quad \sigma < \hat{\sigma},$$
$$\ell_u^L(\xi) = \ell_\sigma^*(w_u, w_u; 1) = \frac{\bar{\ell}}{2}, \quad \sigma > \hat{\sigma}.$$

Aggregation yields the total labor supply of each type,

$$L_s^S = N\bar{\ell} \int_1^{\hat{\sigma}} \left\{ \theta \frac{Q^\sigma}{Q^\sigma + 1} + (1-\theta) \frac{Q^\sigma}{Q^\sigma + \xi^{\sigma-1}} \right\} d\sigma, \tag{9}$$
$$L_u^S = N\bar{\ell} \int_{\hat{\sigma}}^{\infty} \left\{ \theta \frac{Q^\sigma}{Q^\sigma + \xi^{1-\sigma}} + (1-\theta)\frac{1}{2} \right\} d\sigma. \tag{10}$$

It is easy to show, from (5), 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 clearing condition,

$$L_s^D(\xi) = L_s^S(\xi).$$

The unskilled labor market has cleared by Walrus Law.

Comparative statics

We first see how the equilibrium labor supply and relative wage change with quality.

Claim 2. *(i)* L_s^S, L_u^S *and* L_s^D *are increasing and* L_u^D *are decreasing in* Q.

(ii) Equilibrium relative wages and level of skilled labor are increasing in quality. That is, $\partial\xi^*(Q)/\partial Q > 0$ *and* $\partial L_s^*(Q)/\partial Q > 0$.

(See Figures 5 and 6. Proof is in the Appendix.) Higher quality makes consumption attractive for skilled workers and also increase proportion of all workers that consumer the high quality product. Thus both demand and supply of skilled labor is increasing in quality. The same effect increases the supply of unskilled workers and reduces demand for low quality good. The latter effect implies demand for unskilled workers decreases when quality improves.

Skilled labor supply is increasing in population, $\partial L_s^S/\partial N > 0$, from (9) and demand is also increasing in population, $\partial L_s^D/\partial N > 0$, from (7). (See proof of Claim 2 in the Appendix.) This implies

Claim 3. *Both equilibrium skilled and unskilled labor will increase when population increases,* $\partial L_s^*/\partial N > 0$ *and* $\partial L_u^*/\partial N > 0$.

Again, using the proof of Claim 2 in the Appendix, both demand and supply of skilled labor is also increasing in proportion of skilled consumers, $\partial L_s^S/\partial\theta > 0$, from (9) and $\partial L_s^D/\partial\theta > 0$, from (7).

Claim 4. *Equilibrium skilled labor and equilibrium relative wage are increasing in the proportion of skilled consumers,*$\partial L_s^*/\partial\theta > 0$ *and* $\partial\xi^*/\partial\theta > 0$.