Changes in relative wages in Japan: 1984-2003. The role of supply and demand

Ciro Baldi

Japan Institute of Labour Policy and Training - Visiting Researcher

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Comments and feedbacks are welcome.

1. Introduction[1]

The analyses of wage structure changes have developed quickly in the last 15 years. In particular a vast American literature fostered by the availability of long time series of data has measured and studied the evolution of skill related wage differentials. Most of this literature has theorized that to explain the rise in the skill premium an improvement in technology that has promoted the demand of skilled workers must be called in to compensate the quick rise in the supply of high skilled workers. The study of the wage differentials of the Japanese economy can exploit the existence of excellent data available for long time series, but the English-written literature on the subject has been inadequate in quantity.

The main scope of this paper is to contribute to enlarge the existing literature and provide a statistical portrait of the changes in the wage structure over 20 years from 1984 to 2003. To this purpose, part of the analysis is dedicated to the choice of the

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method to realize this measurement and conclude that the fixed weighted method by Katz and Murphy (1992) is an appropriate way to do it.

Although I will provide evidence on the changes of wage structures among gender and experience groups, the focus is on education related differentials.

In this sense this paper finds a place in the vast literature that has examined the evolution of skill related premium. For most of the paper I follow the methodology set up by Katz and Murphy (1992), both for the measurement of the changes in the wage structure and for the analysis of the market forces that can have contributed to drive it. Accordingly, a second scope of the work is to check to what extent a simple supply-demand framework can explain the measured changes of the university-high school wage gap. The main finding is that this wage premium has increased during the second half of the 80's, reduced during the 90's and again increased in the last years. The movement of the wage differential cannot be accounted for by changes in the pace of the relative supply of skilled workers. Relative demand changes have to be called in to fit the data. Since the employment changes have occurred to a large extent within industries, the relative demand shift implied is more consistent with the hypothesis of Skill biased technological change. The analysis concludes that a slowdown in the rise of the relative demand of skilled workers in the first half of the 90's is necessary to explain the measured dynamics. This pattern is partly consistent with evidence on indicators of technological change and unemployment.

The paper is organized as follows. Section 2 provides a summary of the evidence found by the American literature, recalls the framework used by most economists to study the change in wage differentials over time and reviews some recent studies on the Japanese side. Section 3 presents the data source and its features. Section 4 discusses some methodological options a researcher must face when measuring the change in the wage differentials. The accent is on the choice of the model to measure wages differentials and the choice of weighting. Section 5 applies the method of Katz and Murphy to measure the wage changes in Japan from 1984 to 2003. Section 6 analyzes the evolution of the labour supply of different socio demographic groups. Section 7 looks for a first evidence in the relation between relative labour supply and relative wages. Section 8 starts the analysis of demand side with a standard study of the role of shift within industries and between industries. Section 9 applies the model of Katz and Murphy to measure, in a more structured way, the size and the evolution of the relative demand shift consistent with the pattern of relative wages and relative supplies. Section 10 discusses the results at the light of related evidence on unemployment and technological change. Section 11 moves away from Katz and Murphy method and examines the extent to which a cohort based statistical model can be used to fit the data. Finally, some concluding remarks are presented.

2. Wage differentials, Technological change and the role of supply and demand

The studies about the wage structures have flourished in the last decade promoted by the availability of long time series and new techniques. In particular, the American literature has explored in quite detail the structure and evolution of the wage differentials across a long time span[2].

This section is devoted to review the results found by the American literature and briefly recall the theories that have been proposed to explain this evidence. Since the framework proposed to study the change in wage structure is common to many dimensions of the structure itself I will recall briefly all these aspects.

The changes can be neatly summarised by reviewing the article by Card and Di Nardo (2002).

[2] Another key feature of the more recent literature is the development and utilization of new techniques united to the availability of datasets of individual data to go beyond the analysis of the wage variability between groups (gender, education, experience) and study both the evolution of the within components of the wage structure and the movements over different zone of the wage distribution. The view that has arisen from these studies is greatly enhanced.

During the 80's the overall wage inequality has risen dramatically, while it has stabilized in the 90's.
The return to education and, more specifically, the return to college education has increased during this period even if the pace of the rise has strongly reduced in the 90's.
The increase in the return to college has been concentrated on the younger workers, while it has remained roughly constant for the older ones.
The return to experience has remained fairly stable over the 80's for the high school graduates while it has had a sharp rise for the college graduates (Katz, Loveman and Blanchflower 1995).
The gender wage gap has been decreasing until the mid 90's where it came to a stop
The residual wage inequality, which is the inequality within the groups, has showed a pattern similar to the overall inequality with a steady expansion during the 80's and a constant path during the 90's.

The theories that have been proposed to cope with the above-mentioned facts share the idea that two set of forces can have played a role in fostering the changes in wage differentials: labour market forces and institutional forces. Some authors refer to the overall paradigm as SDI, an acronym that stands for Supply Demand Institutions (e.g Katz and Author 1999). To focus the ideas I limit the discussion to the theories proposed to explain the rise in the return to education. Most authors agree that to explain the rise in the university-high school wage gap a rise in the demand of university graduates relative to the high school graduates must have occurred. Since in the years considered, due to factors such as the rise in the average income and the improved effectiveness of the education system, the developed countries have experienced an unprecedented rise in the supply of universities graduates and an increase in the share of the labour force with higher education, shifts in the relative demand toward more educated workers must have occurred to be able to drive the rise in the return to college education. Among the hypothesis about the determinants of the rise of the relative demand, the most widely accepted one is the Skill Biased Technological Change (SBTC) Hypothesis. This states that the recent development in technology, incorporated in new capital equipment, has fostered an increase in the relative demand of more skilled workers either because the cost of teaching the use of the new instruments is lower for this group of workers, or because the people with higher skills and education have a greater capacity of adapting to further changes in the technological environment. This capital-skill complementarities theory is well represented by the view that the computer revolution and the organizational changes that it has required (and it is still requiring) have urged the firms to change the composition of their workforce to include a larger share oh high skill workers. Some authors have further argued that, especially in some industries, the fundamental competitive advantage is becoming more and more the capacity of product and process innovation and this in turn requires the firms to have a skilled workforce able to produce new ideas.

To the extent that the skills to use new technologies, to adapt to further technological change or even to promote more innovations are provided by universities level education, the above mentioned complementarity has augmented the productivity of highly educated workers and then their demand.

A slightly different approach to the issue is the view that has been promoted by Juhn, Murphy and Pierce (1993), according to which the technological change has raised the productivity of every type of skill (both observable and unobservable) that is likely to be complementary to it, not only those provided by the formal education. According to this hypothesis the technological change has to be considered a driving force behind wage differentials beyond the education-related one. In particular, Juhn Murphy and Pierce analysis suggests that it can have raised the productivity and then the price of unobservable skills (such as some type of ability) and this can be the main cause of the rise in the variability of wage within groups.

An alternative theory advanced to explain why the relative demand of skilled labour has boosted claims that the major force behind it has been the changing pattern of the goods flows related to the liberalization of trade and the related phenomena (AKA globalization). With the new rules of the global trade, in fact, the developed countries have experienced a rise in the import of the low value added - low skill intensive products and a related decrease of the demand for the these products manufactured internally with a consequent rise in the job destruction in these sectors. Contemporaneously, they have experienced an increase in the demand, both domestic and foreign, of the high value added - high skill intensive products. The required industrial shift should have boosted the demand for high skill workers and reduced the demand for the low skilled ones. Even if these two hypotheses, the SBTC hypothesis and the Changing trade hypothesis, have the same implications as regard the aggregate relative demand for skills, they imply different movements in the skill composition of the industries. In fact while it is believed that the technological improvement and the computer revolution has affected the economy across the sectors, even if with different intensities, and thus should have promoted the upskilling of the workforce throughout all the economy, the change in the trade patterns entails that the low skilled intensive sectors would have experienced job losses while the high skill intensive sectors would have seen a rise in employment. In other words the SBTC hypothesis is consistent with a relative rise in demand for skill within the industries, while the changing trade hypothesis is consistent with a between industries movement.

Thus, the literature trying to discern between these two hypotheses has analyzed whether the labour demand shift has occurred within sectors or between sectors. Although different techniques can provide different measurement of this quantity and the hypothesis behind them can vary, the research has found that most of the change in the share of skilled labour is accounted for by changes that happen within industries, thus pointing towards technological change based hypothesis.

A framework that is commonly utilized to analyze the supply and demand forces argument to understand the movement of the skilled unskilled wage gap traces back to Katz and Murphy (1992). Synthetically (more details is given in the section 10) they derive a relative labour demand schedule from a simple production function with only two inputs (two types of labour). Under the hypothesis of exogenously driven (relative) labour supply, the other factor that drives the relative wages is a demand shift associated with changes in the productivity of the two types of workers. Since this is an unobservable factor, two approaches can be taken: either estimating the function hypothesizing a simple structure of the demand shift or simulating the demand shift under different measures of the function's parameter. Under the first approach, the work by Katz and Murphy used simply a linear time trend to approximate the demand shift. In a successive work aimed at reassessing the Katz and Murphy model over a longer time period, Autor Katz and Kearney (2005), add to the model the unemployment rate of prime age male workers, as a measure of cyclical conditions of the labour market, and a control for the real minimum wage to measure changing institutions. Their results shows that for the period 1963-1987 (that analyzed by Katz and Murphy) a model with only a time trend fits the data reasonably well and other variables add relatively little. When Autor, Katz and Kearney extend the sample period to include the 90's the model predict a too large increase of the wage gap over this decade. They have to allow for a trend break to get better results in terms of fitting. The problem with this implied reduction in the pace of the demand shift is that is inconsistent with the evidence on the pace of technological change since, as observed by the authors, there is no evidence of a slowdown in the growth of computer investment in the 90's.

What is the evidence for Japan? To the best of my knowledge, there are few recent studies in English on the evolution of the wage structure, notably on the differentials between educational groups.

However two studies are directly related to the present work both for the data used (the Basic Survey of Wage Structure data) and for the focus of the analysis (the education related wage gap). Sasaki and Sakura (2005) examine the dynamic of the skill premium from 1985 to 2003. The sample of their analysis is limited to male workers in the manufacturing sector. They find that in the period considered there has been a slight but monotonous growth of the differential between the wage of university graduated workers and high school graduated workers (and other educational groups). The technique used to estimate is a regression with only main effects that controls for length of service, size of the firm classes and detailed industry dummies. Their analysis proceeds with an analysis of the determinants of the wage bill share of universities graduates derived from a structural model of cost function. They include as regressors a variable related to the advancement in technology (the R&D expenditure) and the variables related to the effect of globalization (the import ratio from East Asia and the foreign production ratio). They find positive and significant effect on all these variables and conclude that there is evidence of a demand biased toward high educated workers driven by the forces of the technological change and by globalization.

The second study, Saito (2005b), analyzes the evolution of the university/high school wage ratio for a longer period (1976-2003) from a very different perspective. His analysis aims to demonstrate that the evolution of the ratio is due to the changing ability composition of the stock of high school graduates and universities graduates and not to changes in the return to education. His basic hypothesis, derived from the theory presented in Saito (2005a), states that if over time less and less able people pass from the lower level of education to the higher one, the university/high school wage ratio is bound to follow a u-shaped dynamic (initial decline followed by a monotonous increase). The cohort based analysis performed in Saito (2005b) is consistent with such pattern in the Japanese data. His analysis suggests that what is measured as price change is likely to be biased by a fallacy of the statistic used related to the changing composition of the two stocks of workers. Although his hypothesis and analysis certainly deserves greater attention, the framework of the present work lays instead in the literature presented above.

3. Features of data

The data come from the Basic Survey of Wage Structure (hereafter BSWS), an annual survey held in June of each year.

The survey covers all establishments with at least 10 employees belonging to the private sector of the economy plus the public segments for the Electricity, gas, heat supply and water and Transport, information and communication sectors.

The survey is limited to the regular employees that are defined as: 1) Employees hired for an indefinite period, 2) Employees hired for longer than one month, 3) Employees hired for less than one month or by the day and who were hired for 18 days or more in April and May.

The sample consists of about 71000 establishments and about 1.51 million of employees. The questionnaire contains questions on the wage received in the survey period, number of hours worked, age , education, tenure, occupation. Moreover, information on the industry, size, location of the establishment is present in the survey.

Given the unavailability of micro data the data used in this work come from aggregated tables. However these tables are very detailed and the information is rich enough to conduct an articulated analysis of the wage differentials. In particular, the data used come from two sources, a database corresponding to the table 1 published in the annual report of the survey by the Ministry of Health Labour and Welfare for the years 1984-

1988 and 2001-2003 and a special tabulation for the years 1989-2000[3]. The data from these tables refer to regular full-time workers since for part time workers the survey do not distinguish the educational attainment. Finally, I have limited the sample to workers aged between 20 to 64 years old.

The final dataset consists in over 2000 groups per year constituted by 2 gender categories, 4 education categories, 9 age categories (and/or 9 potential experience categories), 9 industries corresponding to the divisions of the Japan Standard Industrial Classification[4], 3 size classes of the establishment, 2 occupational categories. The effective number of the groups however is far smaller than the number of potential groups (2*4*10*9*3*2=4320) for two related reasons: the first is that in the population some cells are empty indicating that there are no employees in a certain age group of a certain gender, with a specific education etc. The second is that the number of occurrences surveyed in certain groups is so small that the estimate is considered unreliable and the survey compilers prefer to blank that cell. However, for the BSWS whose realized sample size is so large, this case is highly unlikely if the event is not rare in the population as well[5].

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3 The two sources of data differ slightly because the published tabulations do not distinguish within the production worker between the three upper levels of education. However in a related table there is enough information to disentangle the figures of the three levels of education. This is actually the approach I have undertaken to make the two kind of tabulations consistent with each other.

4 These are: Mining; Construction; Manufacturing; Electricity, gas, heat supply and water (private and public); Transport, information and communication (private and public); Wholesale, retail, eating and drinking places; Finance and Insurance; Real estate; Services.

5 Beside these two reasons there is a third one, less important, related to the approximation policy of the survey compiler. The number of employee is rounded to 10 units. This imply that for cells whose

4. Methodological issues: the choices of the model and of the weights

This strand of literature shares the idea that the market forces and the institutions set up the prices for a whole array of characteristics of the workers and of the jobs. More specifically, the prices to the skills of workers such as his/her educational background, his/her labour market experience and specific firm experience, or even the more specific ability that workers can have, are established by the system. Beside the skills of a worker other workers characteristics such as the gender or the ethnicity and job characteristics (the industry, the size of the firm or the establishment, the region where the establishment is located, the occupation) belongs to the overall price vector.

In a simple notation let's think to the relevant skills for the labour market as a vector of N characteristics denoted by (x_1 x_2 …. x_N). and the prices associated with this vector as the vector (p_1 p_2 …. p_N)[6].

To fix the ideas x_1 can be thought to be the level of formal knowledge, x_2 the labour market experience, x_3 the experience specific to the firm and so on.

The wage paid to a specific worker *i* is thus simply the sum of the return for his skills, that is:

$$w_i = \sum_{j=1}^{N} p_j x_{ij} \ . \qquad [4.1]$$

The entire array of the prices is referred to as the wage structure of a country in a certain period of time. When we talk about the change in the wage structure we are interested in the changes of the whole array of prices or a subset of it along a specific dimension (gender, education, industry etc..). However, the aggregate data publicly available are not apt to measure directly the wage structure because they are a mixture of prices and

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estimated number of employees is less than 5 the number is rounded to zero. Even if data are available for the other variables I preferred to avoid using these cells. However the loss of information is very small.

[6] Since the vector of prices associated with the vector of skills is thought to be unique, at least for a group of homogenous workers, the theory behind it is one of a competitive labour market.

composition of the workforce. For instance the average wage of a particular industry compared to another (reference) industry is not directly usable for measuring the price of working in that industry, because it depends on the composition of the workforce in both sectors.

Several methods to calculate the wage differentials can be found in the relevant literature.

This paragraph compares some of the methods with special reference to two issues: the choice of the model and the choice of weights to calculate aggregates.

4.1 Model specification

The model I choose to represent the data is a Mincer-type earnings function. In its original formulation it states that the logarithm of the wage of a worker is a linear function of the number of years of education and of potential experience (in quadratic form). Several variants have been used in the literature including additions as regressors of workers characteristics such as gender or ethnicity, controls for industry, firm size, occupation, the use of age instead of the potential experience, the introduction of interaction between education and experience and so on. For a recent survey on some of these issues see Lemieux (2005).

For the present purposes I choose a specification very much in the spirit of the original one. In what follows the dependent variable is the (log of) hourly wage calculated dividing the monthly wage (contractual cash earnings plus 1/12 of the annual special cash earnings[7]) by the total number of hours worked in that month (scheduled plus

7The contractual cash earnings are defined as: “Before-tax, not after-tax, amount of cash wages paid of employees, for the surveyed month of June, based on paying conditions and calculating methods specified in advance in labour contract, labour agreement, and/or working rules of establishments”

The annual special cash earnings are defined as: Special wages including bonus and term-end allowance paid in the previous year (in principle, a year from January to December).

overtime). I include as regressors of the model only gender, education and potential experience. The variable that measures education available in the BSWS data is a categorical variable with 4 level of educational attainment: Junior High School, Senior High School, Professional school and Junior colleges, and Universities and beyond. As for the potential experience it is calculated starting from the variable age and education: the data groups workers in 5 years age groups (20-24,25-29, 30-34,35-39,40-44,45-49,50-54,55-59,60-64). I obtain a quantitative potential experience variable by subtracting the normal age at which each educational level is completed[8] from the simple average of each age bracket[9]. Beside that I group this quantitative potential experience variable in 5 years brackets (0-4,5-9,10-14,15-19,20-24,25-29,30-34,35-39,40 and more). Thus, respect to the original formulation of Mincer, the variable related to the general labour market experience is not included in continuous form. However this formulation, though induced by the data structure, is less restrictive and conforms to the indications of some authors that find that more flexible specifications fit the data better: for instance, Lemieux (2005) suggests a quartic, instead of a quadratic, polynomial in experience.

Special wages including bonus and term-end allowance include 1) wages which are paid for temporary or unexpected reasons, not based upon agreements or rules established in advance and 2) wages paid in accordance with payment conditions and calculation methods already determined in labour agreements or working rules but paid based on a calculation period exceeding three months. They also include 3) wages paid under reason which are uncertain and 4) wages in back pay under a new labour agreement.
These and other definitions of the survey can found at:
http://www.mhlw.go.jp/english/database/db-l/b-explanation.html

[8] For junior High school, 15; for Senior High school, 18; For Junior Professional School and Junior College, 20; For Universities, 24.

[9] Negative potential experience values are coded as 0 years of experience.

In order to assess the importance of interactions terms I perform an analysis of variance for only two years, 1984 and 2003, including the main effects as well as the second order and the third order interactions. This model, as the regression models that follows, is estimated through weighted least squares, using as weights the number of hours worked by the employees in each cell. The number of hours is the average number of hours worked (normal + overtime) multiplied by the number of employees in the cell. The use of weighted estimators is justified on the ground of two considerations. On one hand, cell mean regressions need weighted least squares to cope with the possible unequal variance of the units that can arise from cells of different size. While the weighting variable more commonly used for BSWS data is the number of employees (see for instance Abe 2000), the choice of the number of hours as a more comprehensive measure of labour input seems more appropriate in conjunction with an hourly measure of wage as a dependent variable. However, the results in this work are not sensible to the choice of the weighting variable. On the other hand when using a sampling weight when compiling statistics (averages, variances or regression coefficients) from a sample survey reduce the bias that can arise when the units are sampled with unequal probability of inclusion (that is the common case). Dealing with cell averages instead of individual data does not change the consideration above: in fact the cell estimate (for instance the average wage) is obtained by using the sampling weights, so that when higher aggregates are calculated, to keep the consistency with the lower aggregates, it’s necessary to weight the cell estimates by some variable that includes the sample weights (in our case the number of hours worked or the number of employees).

Table 1 shows the sum of squares and the associated F statistics of the ANOVA exercise for 1984 and 2003. The sum of squares reported are the Type I’s or sequential sum of squares and they show the increment of the SS explained by the model as we add another factor. The main indication of the table is that the inclusion of second order interactions is statistically significant for both years, while, the addition of the third order interaction is not. However one has to keep in mind that the meaning of the test is that after including for the main effect and the second order interactions, the third order interaction does not add significance to the model. Since changing the order of the factors can change the result of the test and since the relative importance of the interactions of experience and education with the gender variable I perform a second ANOVA split by gender. The figures reported in table 2 show that in this case the interaction of education and experience (that can be thought as the third order interaction in the model that pooled male and female) is statistically significant for both sexes in both years. I interpret the results of this analysis as suggesting the use of a quite flexible model to estimate the wage differentials.

To see the importance of choosing an appropriate model Figure 1 and 2 shows the evolution of the universities-high school wage gap implied by two models. The trends displayed in figure 1 are derived by a model including only the main effects on education and experience fitted separately by men and women, while the trends in figure 2 are those implied by a model that includes beyond the main effects the interaction between experience and education[10]. The two figures shows very different dynamics: while the model with only main effects predicts an overall upward trend for both men and women, the model that includes interactions predicts a roughly stable wage gap for the women and a more articulated dynamics for men (an increasing trend

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[10] The wage gap displayed in the figure is obtained by simply averaging in each year the wages predicted by the model for the universities graduates and senior high school graduates and then subtracting the average predicted (log) wage of high school graduates from the corresponding figure for the universities graduates. Since the purpose of this exercise is just to show the difference between the wage gap derived by the two models here the method chosen is a simple average and not a weighted one. In other words the differences between the two models are due only to the model specification and not to any difference in the weighting scheme to get the aggregates.

up to the beginning of the 90's, a decreasing pattern until the 1997 and since then a reversal to an upward trend).

In summary, the choice of the model to derive the wage structure is of fundamental importance: in particular the choice of introducing or not interactions between the main variables can end up in different conclusions about the wage differentials. Here I propend to use a model separated by gender with interactions for two main reasons. First, the interaction of the gender variable with experience and education is statistically significant suggesting, as is the case in this type of studies, that the return to human capital variables is quite different between men and women. Second, once split the model by gender the interaction between age and education get significant hinting at different return to education for different age groups.

4.2 Weighting Scheme

If the choice of the model is one with interactions to get a summary measure of a wage differential (to fix the ideas let us think to universities-high school wage gap) it is necessary to average over the predicted wages. Hence, here it is important to choose the appropriate weighting scheme. In principle, no scheme is preferred: it all depends on what we are trying to measure. A fixed weighting has the property to depurate from compositional effects and thus is better suited to get estimates of the "price" changes, that is to obtain measures that can be attributed to change in the wage structures vs. estimates that includes the change in the composition of the workforce.

Before comparing the results obtainable from the chosen model when different weighting schemes are applied, I investigate the extent of the compositional effects over the 20 years when the relative wages are calculated through simple unconditional means. The technique applied is due to Vaupel (for references see Canudas Romo (2003)) and, although it has been invented for decomposing demographic variables, it is general in scope and can thus been used to understand the movement of economic variables as well. The technique by Vaupel is meant to decompose the change over time of a variable that represents an average over several groups in the part due to the change of the group level variables and the part due to the changing composition of the aggregate. Given a variable:

$$\bar{w}(t) = \frac{\int_0^{\varpi} w(x,t) f(x,t) dx}{\int_0^{\varpi} f(x,t) dx} \qquad [4.2]$$

that is the weighted average of *w(x)* with weights *f(x)*, where *x* is a variable that indexes some groups, Vaupel demonstrates that

$$\dot{\bar{w}} = \bar{\dot{w}} + Cov(w, \ddot{f}) \qquad [4.3]$$

where the dot (.) over the variable represent the derivative with respect to time and the double dot (..) represent the relative derivative (that is the time derivative of the log). In words the [4.3] simply states that the change of an average is equal to the average of the changes plus the covariance between the levels and rate of change of weights. The meaning of the formula is easily grasped: the change of the average will be higher than the average change if there is a positive correlation between the level of the variables and the rate of growth of the weights. Put in a different way, if the weights of the groups with higher level of *w* are the one that have had a higher change, the change of the average will be higher than the average change.

Equation 4.3 is valid to decompose the change of an average (in continuous time jargon, the time derivative of the average). In the current situation where we are interested in the change of a ratio of averages (the ratio between the mean wage of university graduates and the mean wage of high school graduates) I use here a variant of the formula 4.3 valid for the relative change of an average (that is the time derivative of the log average). This is because the change of the log wage gap ratio can be approximated by the difference in the relative change of college educated workers and high school educated workers.

The formula that Vaupel use for the relative change of a mean is:

$$\ddot{\bar{w}} = \tilde{\ddot{w}} + [\, \tilde{\ddot{f}} - \bar{\ddot{f}} \,] \qquad [4.4]$$

Here the ~ instead of the – as cap of the variables indicate an averaging using an alternative set of weights (weights proportional to the product of *w* and *f)*.

Here, as before, the first term represent the direct effect and the second, in square brackets the indirect or compositional effect.

If we define by

$\bar{w}_s$ the average wage of the skilled workers (university graduates) and by

$\bar{w}_u$ the average wage of the unskilled workers (high school graduates), we can easily define the difference in the growth rates of the two groups as

$$\ddot{\bar{w}}_s - \ddot{\bar{w}}_u = \left(\tilde{\ddot{w}}_s - \tilde{\ddot{w}}_u \right) + \left([\, \tilde{\ddot{f}}_s - \bar{\ddot{f}}_s \,] - [\, \tilde{\ddot{f}}_u - \bar{\ddot{f}}_u \,] \right) \qquad [4.5]$$

This difference is approximatively equal to the change in (log) wage ratio and thus can be used to understand the effect of the compositional changes (again the first term in round brackets represent the direct effect and the second term the indirect or compositional effect). To estimate the [4.5] firstly one has to pass from a continuous formulation to a discrete one. As suggested by Canudas Romo (2003) one can accomplish this task assuming a linear or an exponential dynamic between the starting and the finishing time and evaluating the derivatives at the middle point of this interval. It must be said however that, while the above formulas hold exactly the discrete time formulation and the estimation yields only approximate results.

The table shows the decomposition in the difference in the growth rates of the wage of the college graduates and the wage of the high school graduates for the entire period and four sub periods. The figures are measured as yearly averages in percent points. Column (a) is the measured difference in growth rates measured on a yearly basis. Thus for the total male and female on the entire period the wage of college graduates has decreased relatively to the one of high school graduates of .2 percent points a year. The next columns show the Vaupel decomposition, with the column (b) measuring exactly the same quantity of column (a) but calculated as a sum of the two components of the decomposition. The distance between this column and the previous is a measure of the approximation error of the technique. The last two columns show the part due to the direct effect and the part due to indirect or compositional effect. Here the change due to the direct effects is 0, while the indirect effect is slightly higher at 0.1% (with an approximation error of 0.1%. Over entire period, thus, it's difficult to draw conclusions about the importance of compositional effects due to the presence of an approximation error. Things get clearer when we look at the sub periods. From 1984 to 1989 the increase of 0.7 percent point a year is due to compositional effect for 0.3 points, while in the second sub period the overall decrease (at a rate of 0.3 points per year) is composed by a direct effect of -0.6 points partly compensated by compositional effect (0.3). In the 1994-1999 period the negative effect is due in equal part to direct and to indirect effects, while in the last period there are no relevant compositional effects at works. Summarizing direct effects are masked by compositional effect especially in the first half of the time span: without considering the effects of composition the growth of the first sub period would be overestimated and the decrease of the second period would be largely underestimated. The picture is roughly the same for the male workers while for the females the importance of compositional effect is smaller, even in the first two sub periods.

The essence of the analysis conducted by the Vaupel decomposition is confirmed by the figure 2. The universities –high school wage gap there illustrated is derived by applying the model with interactions of the previous discussion and applying first a variable weighting scheme (top panel) and then a fixed weighted scheme (bottom panel) to get the higher aggregates and then the wage gap. In the first case I have applied the current number of hours worked in each cell defined by gender, education and experience. In the second, I use a fixed weighted averaging (as presented in the next paragraph). Read together the panels of figure 2 show that while the time pattern of the female wage gap is basically the same whether a variable or a fixed weighting scheme is applied, for the men it changes dramatically. When a variable weighting scheme is used it shows an upward trend throughout all the period with a faster rate of change in 80's and in the 2000's. When a fixed scheme is instead applied we note two big differences: the rate of changes of the 80's is considerably reduced and during the 90's a downward trend instead of a slightly upward one is observed.

Synthesizing this part of the analysis has shown the sensitivity of the results to the choice of the weighting scheme when aggregates are calculated. Since the scope of the work is to analyze possible changes in the wage structure, that is in the price of the skills I will use throughout the paper a fixed weighting scheme.

5. Wage structure changes

Having ascertained the measures of compositional effects and evaluated which method is better suited to measure the change in the price of skills, in this paragraph I provide a measurement of the change in the wage structure in a period of 20 years from 1984 to 2003.

The procedure followed in this paragraph is due to Katz and Murphy (1992). The basic analysis unit is the cell gender-education-experience. The average wage of this cell is calculated by averaging the wage in the initial dataset using as weights the number of hours worked in each year. To obtain higher level aggregates I use the following weighting scheme. First, the number of hours is calculated for each basic cell for each year. Second, the ratio of hours worked in each basic cell over the total number of hours worked is derived for each year. Third, by averaging the share of each cell over the entire period I obtain the fixed weight for each cell.

In other terms, a variable weighting scheme is utilized to average within the basic cell and a fixed weighting scheme is utilized between them[11].

To analyze wage differentials I start comparing the average wage of a specified group to the overall average wage in each year.

Table 4 shows wages calculated according to the procedure sketched out before for aggregated demographic groups. The figures reported are 100 times the change in the log of the relative (to the bundle of all workers) wage and I'll refer to them as percent change. The table shows the evolution of the entire period and for four sub periods: 1984-1989, 1989-1994, 1994-1999, 1999-2003. Over the entire period the women have gained ground respect to the men: in fact the female relative wage increased by about 8% while the men's decreased by about 2%: in other terms the gender wage gap decreased by almost 10%. The analysis by sub periods reveals that the change has been quite uniform over time.

The next part of the table shows the change in relative wages by educational level. Quite surprisingly, the group that has seen the highest increase in the relative wage is the group with the lowest education title, the junior high school graduates, whose wage increased in relative terms by over 5%. This increase is almost entirely due to the second and third sub period where the wage rises respectively by 2.9% and 2.1%, while it has suffered a slight decline at the end. The junior college graduates also experienced a rise in their relative wage, though much less substantial than the one of the previous group (2.6%) with an acceleration of the increase over time. In contrast the groups of

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[11] The choice of this level of aggregation and not of more detailed one (e.g. adding to the classification the industry and/or the establishment size) depends on the scope of the analysis. Here the main interest is the change in the wage structure along characteristics of the worker such as the educational background. A reallocation of the employment along the industry dimension can change the educational related differentials if, for instance, high wage industries hire more and more educated workers. But, given the scope of the present analysis, one would like to account the changes due to these factors as change in the skill related wage premium.

senior high school graduates and university graduates have suffered a relative loss. Specifically, for the latter, the decline has been concentrated in the 90's with a change of -2.5% in the first half and of -0.9% in the second half, while for both the beginning and the end of the period they have experienced a rise in the relative wage of about 1%. The last panel of the table shows the evolution of the relative wages by potential experience group. Over the entire period the groups that have seen the major increase are the people with the longest and the shortest experience in the labour market. The relative wage of those with at least 40 years of experience rose by almost 12 percent points followed by people with 35-40 years of experience whose wage increased by over 6%. At the other extreme the least experienced, those who have been in the labour market by less than 5 years increased by 9.4%. The analysis of the timing of the rise for the "gaining" groups and of the fall for the "losing" groups does not reveal particular patterns. The study of the experience groups can be performed in a different way, by looking at the evolution along the diagonals of the (sub) table. Since I have grouped people in 5 years intervals and the sub periods are of 5 years length (except the last), analysing the table along the diagonals shows the performance of (roughly) the same cohort of people[12]. The cohort here is defined by the year of entry in the labour market. For instance, the workers with less than 5 years of experience in the 84-89 subperiod have 5 to 10 years experience in the following subperiod. Looking over the diagonals an interesting pattern emerges: the group with negative signs are in every subperiod the groups that in the first subperiod were between 5 and 25 years old in experience terms. Moreover the size of the decline of their relative wage is roughly constant through time. This hints at a cohort effect in the evolution of wages.

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[12] The way the potential experience groups are calculated is by assuming that each group of worker belonging to same age bracket was concentrated in the central point of the age bracket. A much finer and precise analysis can be conducted on individual level data when the actual age of each worker is available.

To focus on the wage premium associated to education I watch at the relative wages choosing as a reference category the group of high school workers instead of the bundle of all workers. The figure 3 shows the pattern for the total of male and female workers. As before what is plotted is the (log of the) composition adjusted wage gap. Looking specifically at the college-high school wage gap, that has been the centre of attention in the literature, the graph (panel c) makes more evident the evolution described in table 4 with three distinct phases: the end of the eighties when the wage gap has slightly increased, notwithstanding large fluctuations, from 37.4 log points in 1984 to 39 in 1990; the 90's where it has had a substantial decline up to 35 in 2000; and the beginning of 2000's where there has been a considerable recover up to 37.2 log points re-gaining the levels that characterised the start of the period. The figure also reports the pattern of Junior High school and Junior College workers wage relatively to Senior High school. They are increasing over all the period but with two notable differences. First, the increase in the relative wage of Junior college graduates has been very modest until 2000 (about 1% since the start). In contrast the rise has been very pronounced for the junior high school students. Second, while the dynamic of the junior high school wage comes to a stable phase in the last years, the wage of junior college graduates has, seemingly to the university's, a sharp increase.

Splitting the analysis by gender (figure 4) reveals that the observed decline of the university-senior high school wage gap during the 90's has been driven mainly by men: for them, in fact the relative wage of college graduates has fallen from 31.2 log points in 1990 to 27.7 in 2000, with a decline that has continued throughout the decade. In contrast, the trend of the wage gap of women during the 90's has been more stable, with a fall only at the end of the decade[13]. Instead the rise of the beginning of 2000's seems to have interested both sexes and has been more pronounced for women.

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[13] The dynamics is a little different from the one shown in figure n. 2 essentially because the operations of taking logs and averaging are performed in different order. In the Katz and Murphy framework first the

6. Relative supply of skill changes

The analysis of relative wages of the previous section has made clear that the pattern of the relative wages can be usefully divided into three phases: the rise of the relative wages of the college educated workers of the end of the eighties, the compression of the wage gap that last all along the 90's and a new increase of the differential in the 2000's. This description fits in particular men relative wages. For women, the 90's have been a period of more stable university-high school wage gap. The theory assigns a crucial role in the dynamics of relative wages to the evolution of relative supply and demand. This section examines the change of relative supply, while the study of the relative demand is assigned to the next section. If the relative demand is stable, a decrease in the relative wages of skilled workers should be accompanied by an expansion in the correspondent relative supply. To be able to explain the findings of the previous section a theory entirely based on the supply side would predict a decrease in the relative supply of skilled workers in the 80's, an increase during the 90's and again a fall during the 2000's. This prescription is at odd with the well known rise of the educational attainment in the population that has continued during the last decades. If we instead allow for a stable increase in the relative demand of skills fluctuations in relative wages can be explained by fluctuations of opposite sign in relative supply. For this reason it's useful to look at the pace of the change in the labour force during the period under examination. Here as a measure of supply I use the total amount of hours worked by the employees in the sectors covered by the BSWS. To adjust for productivity differences, following Katz and Murphy, the supply is expressed in efficiency units. To obtain the efficiency units the number of hours of each demographic group is multiplied by the average relative wage of that group. The logic behind this procedure descends from the

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aggregate wages are calculated, and then logs of the relative wages are taken. In the exercise behind figure 2 the regression is performed directly on logs and only after the aggregation is operated.

fact that in a competitive labour market the wage equals the productivity. Table 5 is the correspondent table of table 4 and expresses the changes of the relative supplies of the demographic groups against the bundle of all workers. The change in relative supply of university graduates in efficiency units has been rather stable throughout the 20 years period. More variable has been the increase in the junior college groups. In contrast, the decrease of the junior high school worker supply has accelerated from a yearly change of -5.8% in the first sub-period to a change of -9.5 in the last one. A similar pattern, although less pronounced, has been experienced by the supply of high skill workers, which has registered an accelerating decline.

Analysing male and female separately reveals important differences: first, the pace of the increase of labour supply of female universities graduates is up to three times higher than that of men witnessing the rapid catch up of the female in the accumulation of formal human capital. Second, the change in the relative supply of female college graduates has been uneven in the 4 sub periods: in the 90's it rose up to 7.6% in the first half and remained high to a considerable level in the second half, while in the 80's and in the 2000's the change was sensibly lower. As before to give a synthetic insight on the phenomenon we are evaluating, figure 5 and 6 present the evolution of the labour supply of the educational groups relative to that of senior high school graduates for the total of the workforce and divided by gender. From the figure it is possible to see that although the trends are roughly monotonously increasing for the higher level of education and monotonously decreasing for the lowest level the rate of change has not been even over all the time. Focusing the attention on panel c of figure 6 which display the supply gap between university and high school workers it's possible to see an accelerating trend throughout the period for men. For women there is a slowing down in the last years[14].

[14] The rate of changes can be calculated from the previous table subtracting the measure of high school from the measure of the educational group under study

7. Relative supply vs. relative wages

Looking together at the graphs of figure 4 and 6 makes emerge both elements in support and adverse to a supply driven mechanism in presence of a stable demand side. On the side of elements in favour of such an explanation is the evolution of wage and supply of junior high school graduates: the stable downward trend of their relative supply well matches with the almost stable rise in their relative wages[15]. Another element in support of this theory is the fall in the relative wages of universities graduates in the 90's that can be explained by the increase in their supplies.

On the other side the pace of labour supply changes for the universities graduates does not seem to fit to the explanations for the entire period if we assume a stable increase in their relative labour demand. In fact the increasing speed of labour supply does not match with the increase of relative wages in 2000's.Assuming a stable increase in the ralative demand for the universities graduates the increase in the labour supply does not explain the rise in the relative wages of the 80's and 2000's. For the junior college graduates the monotonous increase of labour supply it is at odd with the roughly constant relative wages until the end of the 90's.

In order to try a different evaluation of the relationship between wages and supply, figure 7 plots the (log) change in relative wages against the (log)change in relative supply for the 4 sub periods. Each point represents one of the 70 sex-education-experience groups. Thus this analysis looks at the relationships wage-supply across our set of basic cell. The super imposed lines represent the OLS regression between the two variables. For the entire period as a whole it's unlikely that an explanation entirely based on the supply side can hold. In fact for the first and the last sub period, the

[15] Another possible cause of the increment of the relative wage of Junior HS workers was suggested to me by Mr. Fujii. Since in the last years firms have substituted low educated workers with more educated personnel, they could have retained in the process only the most able low educated workers. This selection effect could have shifted the composition of low educated workers toward those who earn a higher salary.

relationship between the two variables, depicts a positive correlation. In other words the increase in relative wages is associated to an increase in relative supply. This finding is inconsistent with a constant labour demand. In contrast the relationships that holds for the two half of the 90's is a negative one: in this case should the schedule of (relative) labour demand have been stable the increase in the labour supply of the more skilled workers and of females would be sufficient to explain the decrease in the relative wages. Summarizing, the results of this section suggests that a theory entirely based on variation of the relative labour supply hypothesizing a stable or even a constantly increasing relative labour demand would fail to account for changes in relative wages.

8. The role of relative demand: between vs. within industrial shifts

As we have seen before, to be able to explain the pattern of relative wages we need to introduce demand side considerations. In particular, both to explain the overall pattern through demographic groups and to explain the evolution of the college high school wage premium the relative labour demand of skilled groups should have had a different pace in the 80's and in the 2000's in comparison with the 90's. One important point to get insights about the role of relative demand is the nature of the process of the demand shifts. In particular, most of the literature has found useful to analyze in which measure the demand shift is due to an increase of skilled labour within industries or to an increase in the labour input of those industries that normally employ high share of skilled workers. The traditional tool to analyze this issue is the fixed input requirements index due to Freeman (see for instance Freeman 1980).

As showed in Airola and Juhn (2005), the original index by Freeman can be built in the following way. Let's define the change in employment of the group *j* by ΔE_{jt}. This change can be decomposed as:

$$\Delta E_{jt} = \sum_i \lambda_{ij} \Delta E_{it} + \sum_i \left(\Delta \lambda_{ij}\right) E_i \qquad [8.1]$$

Where λ_{ij} represents the share of employment of the group *j* in industry *i*, ΔE_{it} is the change in employment of the industry *i*.

However, being interested in the change of relative input, following Katz, Loveman and Blanchflower (1995) I obtain a simple variant of the previous formula defining:

$e_{jt} = E_{jt} / E_t$ and $e_{it} = E_{it} / E_t$

In this way the previous formula can be written as:

$$\Delta e_{jt} = \sum_i \lambda_{ij} \Delta e_{it} + \sum_i (\Delta \lambda_{ij}) e_i \qquad [8.2]$$

The first term of equation 8.2 represents the (relative) change in group *j* due to the growth (or decline) of each industry had the input shares of group *j* in each industry been constant, and the second term is the change due to the change in the input shares for fixed employment at industry level. In other words the first term is the between industry shift that would have been observed if the production technique in each industry would have not been changed, while the second term is the within industry shift due to the change in these techniques. In the literature the between effect is commonly associated to sources of change in the structure of product demand by industry (e.g. induced by a changes in international trade pattern) or a change in the labour productivity between industries. The within effect is instead associated to a skill biased factor demand which promotes, in the current framework, a process of skill upgrading that happens in every industry[16]. I apply the method to the male workforce for 42 industries for the years 1985, 1990, 1995, 2000 and 2003. The choice of the years is conditioned by the necessity of using industrial classifications that can be made consistent to each others. Unfortunately I cannot obtain the equivalent decomposition

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[16] A note of caution should be made about the empirical applications: ideally to provide a good discrimination between theories that stress out the importance of between sectors shifts against theories that emphasize the role of changes happened within the sectors a very detailed breakdown of industries should be used. Due to data limitations, however in the literature a lot of examples are applied to a relatively small number of sectors. The above decomposition applied to less fine industrial classifications are likely to over estimate the within industry shift and to underestimate the between industry shifts.

for the female workforce since the tables used as for 1985 and 2003, broken down by two digits industries, aggregate the female universities and junior college graduates to the senior high school graduates.

The table 6 shows the decomposition into between and within shift using as measures of input both the number of hours and the wage bill.

I concentrate the attention on the decomposition for the university graduates. The total change in the share of hours of male college graduates has been almost constant in the first two sub periods at about 0.5% per year and then it has increased to about 0.7% in the last two sub periods. Throughout the entire 20 years span the within shift accounts for over the 80% of the total change showing that the large part of the change of the share of college graduates is accounted for by shift within industries. Its absolute size has increased from 0.4% in 1985-1990 up to 0.69% in 2000-2003, This finding is consistent with theories that stress out the importance of technological change. The analysis of the wage bill share, although confirming the dominant role of the within effect, provides a slightly different picture of the timing showing that both the total effect and the within effect has decreased from the first sub period to the second respectively of 0.13 percentage points and 0.06 percentage points and since then they have risen up to almost 1% yearly change (total effect) and 0.86% (within effect). The picture shown by the wage bill thus seems indicating an effect of the technological progress that has slowed down, although slightly, from the first subperiod to the second and since then considerably accelerated.

Summarizing, the analysis of the decomposition confirms that the within effects have played a dominant role in the change of the employment composition either if measured as number of hours or as wage bill. This finding is consistent with most of the literature and, for Japan, with the work on the manufacturing sector of Sasaki and Sakura (2005). A second point is that both the measures point toward an acceleration of the increase of the share of universities graduates since the mid of the nineties. They slightly disagree on the relative size of changes from 1984 to 1994: this can be an indication that the increase of relative demand of skilled due to technological change during this period has been quite stable.

9. Relative demand and relative supply to explain the education premium

This section is devoted to understand what is a plausible relative demand pattern consistent with the wage differentials by education. To do this I employ a structural model used by many authors (see for instance Katz and Murphy (1992) and Katz and Autor (1999)) in which the relative wage scheduled is derived by a production function. To keep things simple, the production function mostly used by the literature is a Constant Elasticity of Substitution (CES) function with only two types of labour input: skilled labour and unskilled labour. In deriving the schedule of labour demand I follow Katz and Autor (1999).

The CES production function can be written as:

$$Y_t = [\alpha_t (a_t N_{st})^{\rho} + (1-\alpha_t)(b_t N_{ut})^{1-\rho}]^{1/\rho} \qquad [10.1]$$

Where Y_t is the output produced by the economy at time *t*, N_{st} and N_{ut} are respectively the input of skilled and unskilled labour, ρ is a constant parameter of production that unambiguously determines the elasticity of substitution between the two inputs: $\sigma=1/(1-\rho)$. a_t,b_t are parameters of production that represents the productivity specific to the two inputs and α_t indexes the share of work activities allocated to skilled labour. A skill biased technological change implies a rise of α_t or of a_t/b_t.

Deriving the marginal product of the two types of labour and adding the additional constraint that the productivity is equal to the (real) wage in a competitive labour market, it's direct to derive the relative wages schedule:

$$\log(w_{st}/w_{ut}) = \log(\alpha_t/(1-\alpha_t)) + \rho\log(a_t/b_t) - 1/\sigma\log(N_{st}/N_{ut}) \qquad [10.2]$$

which, rewritten in an estimable form, yields:

$$\log(w_{st}/w_{ut}) = (1/\sigma)D_t - (1/\sigma)\log(N_{st}/N_{ut}) \qquad [10.3]$$

where D_t is a term that represents the shift of the relative demand toward skilled workers and is usually associated to a skill biased technological change.

To estimate the previous equation some issues have to be addressed. The first concerns the way two labour inputs are derived from the four educational groups of the BSWS data. The standard way, also followed by Katz and Murphy, is to collapse the groups to a college equivalents group and a high school equivalent group. To get this result I transform the junior high school labour into senior high school equivalents multiplying the labour input of junior high school in efficiency units by a transformation coefficient. The transformation coefficient is obtained by regressing the relative wage of junior high school graduates to the relative wage of senior high school graduates[17]. In a similar way the junior college labour is transformed into universities equivalent. To get the total supply then I sum the transformed labour respectively to the "pure" high school labour and the "pure" university labour.

The second issue is that the relative demand shift is not directly observable. To capture the possibility of such shift, I represent it as a time trend. The third issue concerns the different nature of the two main series of the regression, the relative wages and the relative supply. While the first is characterised by short term fluctuations, the second is much smoother reflecting the relative non importance of deviations from a long run trend of shift toward higher education. To make the regression of relative wages on relative supplies and a time trend meaningful I smooth the two series by a 3 terms centered moving average filter. Finally, in order to compare the results of the present analysis with the analysis of the between-within decomposition of section 8, the analysis is conducted only on male workers.

The transformed series of relative wage and relative supply are represented in figure 8. As is suggested from the figure, the presence of a linear time trend to represent the

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[17] The relative wages are those calculated in section n. 4 and the regression is performed without intercept.. The approach is similar to that used by Katz and Murphy.

demand shift is of little help to fit the data. In fact, in the regression analysis, shown in table 7- column 1, none of the coefficients is statistically significant. A second attempt to fit the data is using instead of a linear time trend, a piecewise linear trend. This regression, reported in the second column improve the fits of the model (the R square is 77%) and all the coefficients are significant. The sign of the coefficient of the relative supply measure is negative as expected. It is also useful to note that the coefficient associated to the 90's is significant only at 10 percent and its magnitude is lower than the coefficients associated to the other periods, conveying the idea that the pace of the demand shift is diminished in the 90's. As a third and final attempt to capture the features of the data represented in figure 8 and to explore the dynamic of the demand shift, I have performed a simple semiparametric regression where to the parametric effect of the relative supply, a spline has been added for the time trend. The parameter estimates (column 3) are all significant as is the spline for the time trend. In order to compare the models of column 2 and 3, figure 9 and 10 compare the actual relative wage series to the series predicted by the models. It is possible to see that while the parametric model captures the main features of the data, the fit is not so good. In particular, the rate of decline is under-estimated for the second half of the 90's and the model do not fit the data well in the last part. In contrast, the semiparametric model does a fairly good job in fitting the data. I interpret this analysis as a sign that a variable pattern of demand shift has possibly occurred during the 90's. Figure 11 reports the estimated effect of the time trend. The upward trend is indeed not strictly monotonous during the 90's, with a deceleration at the beginning of the decade and a reprise of the pace after the mid 90's. However, the estimate of the substitution elasticity implied by this last model is about 6 which seems a too large value when compared to the range of 1 to 3 indicated by Katz and Autor as the range of estimates got for most countries (Katz and Autor 1999).

Since estimating the elasticity of substitution from a relatively short time series is not considered a sufficiently robust procedure another approach to tackle the study of the relative demand shift is simulating its pattern under different assumed values of σ. The task is easily obtained by solving the equation 10.3 for D_t. The figure 12 displays the demand shift implied by three values of σ, 0.5,1.5,4. The second value is close to the value of the elasticity estimated by Katz and Murphy (1.4) in their seminal paper, which has been used as a landmark in other studies on the topic.

To better compare the three patterns what is displayed is an index of demand shift obtained by setting the value for the first year at 0 for the three of them. Although all three implied demand shift are upward trended the rate of growth differs among them in different sub periods. An higher value of the elasticity produce a demand shift with larger fluctuation. The reason is well explained by Autor, Katz and Kearney (2005) as follows: "The greater is σ, the smaller the impact of shifts in relative supplies on relative wages and the greater must be fluctuations in demand shifts (D_t) to explain any given time series of relative wages for a given time series of relative quantities" Autor, Katz and Kearney (2005, p.11).

The index implied by the value of 4 show an increasing rate of growth in the 90's, while the pattern is less accelerating for the other two values of σ. The story told by the analysis of the implied demand shift, that in the production function framework has to be intended to represent a skill biased technological change, can be contrasted with the relative demand shift associated with the between-within decomposition of the previous section. To make the two analysis comparable I have collapsed the shift of relative wage bill of the within-between analysis to represent the two aggregated groups of this section. The results can be read in the table 8 where the figure represents yearly average changes. The between-within decomposition suggests that the pace of technological change, measured by the within shift, has been fairly stable in the first two sub-periods and then had a jump of about 30% in the later period and remained to this higher level in the last part. This pattern is more in accordance with the demand shift implied by the central estimate of the elasticity of substitution. In contrast, the lowest value indicates an accelerating shift throughout the period, while the highest value implies a strong decline in the second sub period and acceleration since then.

In summary the analysis of supply and demand while is suggestive of an increase in the speed of skill biased technological change since the second half of the nineties leaves open some uncertainty about the precise pattern throughout the period.

10. Relative demand Shifts, Technological change and Unemployment. Widening the picture.

Do the pattern of demand shifts pro and against high skill workers find supports in related evidence?

In order to see if the implied trend of demand shift is consistent with the advancement in technology it's necessary to look at the evidence on the measurement of the IT related variables. An accurate analysis of the recent literature in Japan on this issues is beyond the scope of this work. However some pieces of evidence from recent works can be recalled to confront with the previous analysis. A study of the cabinet office of the Japanese government report that the contribution of IT to labour productivity slowed down from 1985-1990 to 1990-1995 and since then it has accelerated (Cabinet Office 2001). Jorgenson and Motohashi (2005) in their comparative study of the Japanese and US economies found that the contribution of IT capital (equipment and software) to the growth of GDP has had a surge in the second half of the 90's. and almost recovered the contribution of the 1980-1990 period (See table 4 of the discussed article). Also the contribution to the TFP growth increased after 1995 due mainly to the growing contribution of computer equipment (table 5 of the article).

Figure 11 reports the estimates of R&D intensity from the Report on the Survey on Research and Development. The plot shows that the ratio between expense in Research and Development and GDP (a commonly used indicator for technological change) has increased up to the beginning of 90's when it came to a stop and then started growing again since 1994. A similar trend is shared by the ratio of R&D expense on sales in the Industry.

These studies seem to support the view that an increase in the pace of technological change and productivity has occurred in the second half of the 90's.

A final piece of evidence on the demand shifts can be looked for in the data on other quantities of the labour market. The analysis so far has implicitly assumed full employment. However, in a less constraining model, the presence of relative demand shift would probably affect the relative unemployment as well as the relative wages. To see if this is the case I have built relative unemployment rates between each educational group and the group of Senior High School people. As in the previous analysis the rates at the basis of this calculus have been adjusted for compositional changes[18]. The results are shown in figures 12 and 13. Focusing on the unemployment gap between university and high school the graph for the total (male plus female) labour force present an increase up to the beginning of the 90's. Then it has remained fairly stable up to the 1997 when it reverted the trend in favour of the high skill group. The evidence on the unemployment rates present some consistency with the overall picture of a worsening of the situation of university graduates in the first half of 90's, while since the second half this trend has been reverted.

[18] The procedure I followed is in the same spirit of the procedure of section 5. 1) I have calculated specific unemployment rate for cell defined by gender,age and education fro each year. 2) I have calculated the share of the labour force of each basic cell in each year. 3) These shares have been averaged over the period 1986-2003. 4) To build unemployment rates of more aggregated groups the weights defined in 3 have been applied to the specific rates of 1. 5) To get rid of low frequency noise I have smoothed the series with a 3 year centered moving average before calculating the relative unemployment rates. What are shown in the figures are the difference between the unemployment rate of each group respect to the unemployment rate of high school workers.

Summarizing, many pieces of evidence indicate an acceleration of demand shifts in favour of High skill workers since the mid 90’s. Furthermore, this pattern finds support in recent evidence on technological change. Substantial uncertainty remains on the precise pace of the demand shifts throughout the period.

11. A slightly alternative view: a cohort analysis of the educational wage gap

The previous analysis has shown that the relative supply plays an important role in the determination of the wage gap between high educated and low educated workers. The regression model used finds a significant negative relationship between the relative supply of universities equivalents and the universities wage premium. In performing the previous analysis however some implicit hypothesis have been made. To keep things tractable for the structural model of the labour demand the 70 groups defined by sex, potential experience and education have been aggregated in two groups: universities equivalents and high school equivalents. The operation of aggregation implies assuming that these educational groups are relatively homogenous within themselves and heterogeneous against each other. The implicit economic hypothesis is that within each group the workers of different experience (or age) are highly substitutable in production. This hypothesis is very strong because different experience levels usually correspond to different levels in the career ladder. This consideration is also valid in relative terms: even within the same homogenous production unit such as an establishment or even an occupation can be very difficult to substitute an experienced but poorly educated worker with a young more educated worker. The Japanese labour market, in particular, is recognized to be characterised by long term employment relationships and it is often argued that this feature is functional to have a consistent accumulation of firm-specific human capital. In turn this lead to larger investment in training and a lower turnover rate compared to other countries. See for instance Mincer and Higuchi (1988). In other terms, the wage gaps associated to experience can be much more important than those associated to the educational background. For this reasons in the recent literature models are found that allows for an imperfect substitutability of young and old workers, e.g. Card and Lemieux (2001). This line of reasoning leads us to think that it's unlikely that the change in the overall stock of relative labour supply of skilled workers can affect the universities premium across all age/experience groups.

To take into account at least partly these considerations in this section we look at the data in a different way by performing a cohort based analysis. It must be said that the scope of this piece of work is not to develop an economic structural model of the type of the previous section but of analysing the data by allowing some of the hints we have just discussed to be more consistent with a statistical model. In this sense this paragraph is much more in line (and in fact it is inspired by) with the work of Baraka (1999) of the Taiwanese economy than to the work of Card and Lemieux (2001) which develops and estimates an extended version of the Katz and Murphy model.

To do this I start with a dataset which, for each sex-potential experience group, report the wage gap between universities graduates and high school graduates. To be more precise the variable analysed is the log of the wage ratio between these two groups. Since the potential experience groups are defined by 5 year classes I limit the analysis to only 5 waves of BSWS data: 1984, 1989, 1994, 1999 and 2003. In this way I'm able to track groups that have entered the labour market in the same interval of years (the last year is an exception but in this context I act as the 2003 represent the 2004). I identify the cohorts by retrieving the period into which the workers have entered the labour market obtaining 12 synthetic cohorts. The analysis intends to evaluate separate cohorts and year effect once controlled for experience of the group. In other words the model we would like to estimate is of the type:

$$w_{st}/w_{ut}=f(p)+g(c)+h(e)+error \qquad [10.1]$$

where w_{st} and w_{ut} have the usual meaning, *p* stands for period, *c* stands for cohort and *e* for (potential) experience. *f()*, *g()* and *h()* represent generic functions of the argument.

The simplest way to estimate this model is to add a full set of dummy variables for each dimension. However, apart from the linear constraint of each factor that is produced once we introduce an intercept, there is an additional constraint that derives from the fact that $p=c+e$. This problem is well known in the literature on the Age, Period and Cohort modelling: it leads to the unidentifiability of the three effects and there is not a widely accepted way to overcome it (see for instance Hall Mairesse and Turner 2005). Since the scope of this analysis is purely explorative I cope with this into two ways: the first is to estimate models that contain just two out of three effects and the second is to replace the cohort dummies with a variable correlated with (possible) cohort effects. The model estimated separately for male and female specifies the experience effect with a quadratic polynomial in the central point of the experience bracket. Thus, the parameters of the experience are not allowed to interact with either the cohorts or the year. This can be considered restrictive but it's useful in an analysis whose scope is focused on distinguish year and cohort while just controlling for the experience. The choice of the functional form instead is motivated just for brevity of the regression tables. The dataset for the regression analysis is limited to those cohorts that have more than one observation. The table 9 displays the results of the three models for the male workforce (in the first three columns) and the female (columns 4, 5, 6). The analysis permits a number of considerations. First, the tree models are not equally acceptable for the men since the R square drop considerably in the model without age controls and the F statistics signals that the model is not significant. Thus the experience effect seems to be dominant among the three. Second, in the model cohort-experience the coefficients of the cohorts dummy are mostly significant at least at the 10% and show a tendency to decrease until the cohorts that entered in the market in the 1980-1984 and after that an increase. For the female things seems to stay quite differently. First, experience is no longer so important for the overall significance although the (adjusted) R-square is a bit reduced in the model without experience. However this may only mean that what we call year effect in the second model is partly capturing the aging of the workforce and thus the increase in the effect due to experience. The analysis of the previous table illustrates the complexity of the task of disentangle the effect of experience, period and cohort from the data. Given the high correlations that are present among the three variables, even two factors effect are unlikely to give appreciable results. But the greatest difficulty is to choose between the models. Focusing on the men, model 1 and 3 give very similar results in terms of F statistics and R square, so that we are left with the choice of believing in a model with experience and cohort effect or a model that claims that apart from an experience effect only the second period have a different value form the base period.

One other possible way to break the linear dependence of experience cohort and period is to replace one of the three factor with a variable that is highly correlated to it. Since we are interested into the effect of increasing educational pattern on the wage gap the immediate choice is to use a variable that measures the level of education in each cohort. To represent this variable I use the (log of) ratio of the number of hours worked by universities graduates on the number of hours worked by senior high school graduates, both calculated in efficiency units as in the previous calculations[19]. A possible choice is to measure this variable at the first available data points for each cohort. However this way hides a difficulty since the starting point of observation is different for different cohorts: for instance the first group of potential experience observed for the cohort that entered in the market in the first half of the 50's is people with an average experience of 37 years, while the first group for cohort entered in the last half of nineties is constituted by workers with 2 years of average experience. Since the composition of the workforce by education can vary within the cohort over time the ratio at the first observed point can give a biased result. To check for this I have used as an alternative measure the (log

[19] Albeit replacing this supply measure in efficiency units with one in simple units does not make much difference.

of) average ratio over time for each cohort. However, both the variables present a monotonous increasing trend over the cohorts and the result of this sensitive analysis shows very limited differences: thus for sake of brevity I report only the result with the first measures. Table 11 shows the estimates of a regression with experience, year effect and the cohort effect measured as illustrated. The male regression has all the effects significant. The level of education is negatively related to the wage ratio suggesting, as expected, that an increasing relative supply of high skilled workers causes a reduction in the relative wage. However this has been compensated by an increase associated with the time effect. I interpret this time effect as before as being related to the demand side of the labour market. The increase is not strictly monotonous: in fact the relative magnitude of the coefficients of the 1989 and 1994 are very close hinting that the difference between the two years is modest or null. The female regression, in contrast shows none of the features of the male's. Neither the cohort effects nor the period effect are significant at all. This can be due to a number of factors. One is the poor relationship between our proxy of potential experience and the real labour market experience for the female workforce. This is due, to the fact that the working experience for women is usually characterized by interruptions. Since most of the analysis of this paragraph is based on this variable the results can just depend on this measurement error. To check for this kind of measurement error I have rerun the analysis for the female substituting the age to the potential experience both as effect and as basis of the cohort identification. The results, not reported, do not change in any important point. Thus taken at face value the estimation of the model for the women indicate that apart from experience/age effect, the wage gap is not influenced by the cohort level of education nor is driven by any period effect.

Returning to men the results confirm the results of the previous section that there is a trend effect behind the evolution of the wage gap. The interpretation of the supply side can be however different since these results suggest that the cohorts differ in their entry wage gap (and this can be caused by the increase in the educational level) and this gap remain constant within the cohort apart from the experience related effect. This result is more striking since it fits the data at a more disaggregated level.

11. Conclusions

The main purpose of this paper was to provide evidence on the skill wage differentials in Japan in the last 20 years according to the Basic Survey of Wage Structure. First I have showed that different measurement methods can give different results indicating opposite patterns in the education related wage gap. Since the presence of interactions in a Mincer-like earnings equation are statistically significant the model chosen include interactive terms. In addition, to measure price changes in the wage differentials I have employed a method that explicitly addresses the problem of compositional effects. Using the method of Katz and Murphy (1992), consistent with this preliminary analysis, I find that the university premium over the high school has increased over the 80's, declined during the 90's and had a surge in the last years. It has been shown that to compensate for the effect of the exponential growth in the supply of high educated workers the pattern of relative demand consistent with the above mentioned dynamic of the relative wages is one that predict a rise in the second half of the nineties. This pattern is found consistent on one side with the pattern of demand shift within industries and on the other hand with evidence on the dynamic of R&D intensity and some recent studies on the contribution of IT to the Japanese growth. These associations support the view that an important role in shaping the wage differential can be attributed to a skill biased technological change process. The relative demand shift implied by the analysis is also partly supported by the Labour force survey data that shows a pattern of relative unemployment rate shifting against high school workers since the second half of the 90's. Finally, an exploration of the relative wages by cohort suggests that one can model the data without assuming high substitutability between workers of different experience and that the increase in the relative supply of universities graduates can have played a role in shaping the wage differentials between educational groups at the beginning of their career.

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Table 1. Analysis of Variance Main effect and interactions

Source	*DF*	*SS*	*FValue*	*ProbF*
		1984		
gender	1	243317848	2488.21	<.0001
education	3	40610541	138.43	<.0001
experience	8	186951904	238.98	<.0001
gender*education	3	16255422	55.41	<.0001
gender*experience	8	38315316	48.98	<.0001
education*experience	22	10390868	4.83	<.0001
gender*education*experience	22	2190326.3	1.02	0.437
		2003		
gender	1	104714985	1456.73	<.0001
education	3	69223498	321	<.0001
experience	8	160820029	279.65	<.0001
gender*education	3	9862518.3	45.73	<.0001
gender*experience	8	12047492	20.95	<.0001
education*experience	22	8813107.6	5.57	<.0001
gender*education*experience	22	872827.3	0.55	0.9539

Table 2. Analysis of Variance by gender Main effect and interactions

gender	*Source*	*DF*	*SS*	*FValue*	*ProbF*
		1984			
Men	education	3	27797586	82.4	<.0001
	experience	8	225342553	250.51	<.0001
	education*experience	22	8747273.6	3.54	<.0001
Women	education	3	18558070	77.44	<.0001
	experience	8	10434973	16.33	<.0001
	education*experience	22	3833920.6	2.18	0.0013
		2003			
Men	education	3	54759453	180.91	<.0001
	experience	8	156035569	193.31	<.0001
	education*experience	22	6437727.9	2.9	<.0001
Women	education	3	19896584	174.11	<.0001
	experience	8	21261932	69.77	<.0001
	education*experience	22	3248207	3.88	<.0001

Table 3. Vaupel decomposition of the change of university-high school wag

Period	*Total change*	*Total effect*	*Direct Effect*	*Indirect effect*
Men and Women				
84-89	0.7	0.7	0.4	0.3
89-94	-0.3	-0.3	-0.6	0.3
94-99	-0.3	-0.3	-0.1	-0.2
99-03	0.4	0.4	0.4	0.0
84-03	0.2	0.1	0.0	0.1
Men				
84-89	0.9	0.9	0.5	0.4
89-94	-0.1	-0.1	-0.6	0.5
94-99	0.1	0.1	-0.1	0.2
99-03	0.6	0.6	0.4	0.2
84-03	0.6	0.4	0.1	0.4
Women				
84-89	0.5	0.5	0.4	0.1
89-94	0.2	0.2	0.2	0.0
94-99	-0.3	-0.3	-0.2	-0.1
99-03	1.1	1.1	0.9	0.2
84-03	0.5	0.2	0.4	-0.2

Table 4. Relative Wage changes

		100 Log Changes				
Group		*84-89*	*89-94*	*94-99*	*99-03*	*84-03*
All		0	0	0	0	0
Gender	Men	-0.58	-0.39	-0.51	-0.51	-1.98
	Women	2.39	1.59	2.01	1.95	7.94
Education	J. high school	0.79	2.86	2.14	-0.49	5.3
	S. high school	-0.81	0.54	-0.28	-0.69	-1.25
	J. college	0.05	0.63	0.79	1.14	2.62
	University	0.96	-2.49	-0.87	1.02	-1.39
Gender and education	Men - J.H.S.	-0.08	2.6	1.71	-1.53	2.7
	Men - S.H.S.	-1.46	0.33	-0.82	-1.05	-3
	Men - J.Col.	-2.32	0.57	-0.82	-0.52	-3.09
	Men - Unive.	0.77	-2.88	-1	0.74	-2.37
	Women - J.H.S.	5.04	4.07	4.1	4.09	17.3
	Women - S.H.S.	1.61	1.29	1.64	0.58	5.12
	Women - J.Col.	2.31	0.69	2.28	2.62	7.9
	Women - Unive.	3.37	2.33	0.7	4.32	10.73
Experience (years)	< 5	3.32	4.22	-0.47	2.35	9.41
	5 =<10	-0.26	2.56	1.4	-0.4	3.3
	10=<15	-2.21	-0.44	1.65	1.78	0.78
	15=<20	-1.92	-3.27	-0.21	1.73	-3.67
	20=<25	-1.97	-3.89	-2.7	0	-8.56
	25=<30	2.25	-3.89	-2.01	-2.83	-6.49
	30=<35	0.47	2.3	-2.01	-2.3	-1.54
	35=<40	0.14	3.31	3.94	-1.31	6.08
	40=<	1.36	3.94	5.34	1.16	11.8

Table 5. Relative supply (Efficiency Units) changes

		100 Log Changes/number of years				
Group		*84-89*	*89-94*	*94-99*	*99-03*	*84-03*
All		0	0	0	0	0
Gender	Men	-0.05	-0.19	0.03	0.01	-0.05
	Women	0.20	0.74	-0.14	-0.02	0.20
Education	J. high school	-5.79	-6.96	-7.86	-9.53	-7.06
	S. high school	0.87	-0.02	-0.98	-1.27	-0.29
	J. college	4.08	5.44	4.72	3.32	4.22
	University	2.25	2.34	2.62	2.46	2.29
Gender and education	Men - J.H.S.	-5.46	-6.80	-7.42	-8.96	-6.71
	Men - S.H.S.	0.90	-0.01	-0.64	-0.95	-0.13
	Men - J.Col.	3.02	5.64	5.89	3.66	4.37
	Men - Unive.	2.07	1.98	2.23	2.16	2.00
	Women - J.H.S.	-7.21	-7.73	-10.05	-12.87	-8.82
	Women - S.H.S.	0.76	-0.06	-2.21	-2.49	-0.88
	Women - J.Col.	5.03	5.25	3.64	2.99	4.08
	Women - Unive.	5.57	7.55	6.99	5.20	6.07
Experience (years)	< 5	-0.50	0.23	-3.09	-4.14	-1.67
	5 =<10	0.56	0.54	1.55	-1.08	0.45
	10=<15	-3.28	0.67	1.52	2.59	0.25
	15=<20	-0.25	-3.45	1.53	2.01	-0.14
	20=<25	0.09	-0.32	-2.39	1.91	-0.27
	25=<30	1.32	0.20	0.08	-2.11	-0.02
	30=<35	2.19	1.08	0.97	1.32	1.32
	35=<40	-0.33	1.91	0.79	-0.25	0.54
	40=<	0.84	0.11	-1.30	-3.36	-0.76

Table 6. Within Between decomposition according to the Fixed Input requirements Index - Average yearly effect (effect divided number of years). Men

	1985-1990			1990-1995			1995-2000			2000-2003		
education	**total**	**between**	**within**	**total**	**between**	**within**	**total**	**between**	**within**	**total**	**between**	**within**
	Number of Hours											
Junior High School	-1.25	-0.06	-1.19	-1.05	-0.01	-1.04	-0.9	-0.06	-0.84	-0.74	-0.03	-0.7
Senior High School	0.53	-0.05	0.58	0.17	-0.04	0.21	-0.2	-0.02	-0.18	-0.2	-0.02	-0.19
Junior College	0.24	0.02	0.21	0.38	0.03	0.35	0.42	0.05	0.37	0.23	0.02	0.21
University	0.48	0.08	0.4	0.51	0.02	0.48	0.68	0.03	0.66	0.72	0.03	0.69
	Wage Bill											
Junior High School	-1.19	-0.08	-1.11	-0.89	-0.01	-0.88	-0.79	-0.07	-0.72	-0.72	-0.06	-0.66
Senior High School	0.34	-0.06	0.4	0.04	-0.07	0.11	-0.32	-0.03	-0.29	-0.51	-0.07	-0.44
Junior College	0.17	0.02	0.15	0.3	0.03	0.27	0.37	0.05	0.32	0.27	0.03	0.24
University	0.68	0.12	0.56	0.55	0.05	0.5	0.75	0.06	0.69	0.96	0.1	0.86

Table 7. Regression analysis of log relative wages. Men

Variable	*M1*	*M2*	*M3*
Intercept	0.3796	0.0794	0.1514
	(0.1050)**	(0.0959)	(0.0260)**
relative supply	0.0801	-0.2503	-0.16756
	(0.1138)	(0.1061)*	(0.0282)**
time	-0.0044	-	-
	(0.0046)	(-)	(-)
time 84-89	-	0.0094	-
	(-)	(0.0041)*	(-)
time 90-99	-	0.0079	-
	(-)	(0.0041)~	(-)
time 00-03	-	0.0095	-
	(-)	(0.0043)*	(-)
linear(time)	-	-	0.00567
	(-)	(-)	(0.0011)**
nobs	20	20	20
fstat	5.1058	12.2860	
rsq	0.3753	0.7662	
adjrsq	0.3018	0.7038	

Standard Errors in parenthesis
~ significant at 10%, * significant at 5%, ** significant at 1%
Model 1 and 2 are estimated trhough OLS.
Model 3 is semiparametric with a spline smoother for time
The smoothing parameter is equal to 0.949, estimated with 4 degree of free
The spline is significant at 1%

Table 8. Changes In relative wages, relative supplies,and impled demand shift - Men

	Effective values		*Implied demand shifts*			*Correspondent B-W decomposition*		
period	*Relative wage*	*Relative Supply*	*D. Shift sigma=0.5*	*D. Shift sigma=1.5*	*D. Shift sigma=4*	*total*	*between*	*within*
1985-1990	0.15	3.33	3.41	3.55	3.92	0.85	0.14	0.71
1990-1995	-0.5	4.08	3.83	3.34	2.09	0.85	0.08	0.77
1995-2000	-0.07	4.78	4.74	4.68	4.51	1.12	0.11	1.01
2000-2003	0.74	3.66	4.02	4.76	6.6	1.23	0.13	1.1

Table 9. Regression analysis of wage gap. Cohort, Experience and year effects

	Men			*Women*		
Variable	*M1*	*M2*	*M3*	*M1*	*M2*	*M3*
Intercept	0.3254	0.4235	0.2104	0.1967	0.7503	0.2346
	(0.0545)**	(0.1240)**	(0.0216)**	(0.0769)*	(0.0836)**	(0.0283)**
d_coh1957	-0.0535	0.0039	-	0.0905	0.0472	-
	(0.0516)	(0.1457)	(-)	(0.0710)	(0.0995)	(-)
d_coh1962	-0.0846	0.0112	-	0.0291	-0.0740	-
	(0.0488)~	(0.1360)	(-)	(0.0668)	(0.0929)	(-)
d_coh1967	-0.0775	0.0369	-	0.0459	-0.1281	-
	(0.0483)	(0.1323)	(-)	(0.0661)	(0.0910)	(-)
d_coh1972	-0.1139	0.0255	-	-0.0037	-0.2389	-
	(0.0496)*	(0.1309)	(-)	(0.0683)	(0.0907)*	(-)
d_coh1977	-0.1303	0.0015	-	-0.0090	-0.3237	-
	(0.0513)*	(0.1314)	(-)	(0.0722)	(0.0915)**	(-)
d_coh1982	-0.1450	-0.0648	-	-0.0137	-0.4508	-
	(0.0523)*	(0.1302)	(-)	(0.0741)	(0.0880)**	(-)
d_coh1987	-0.1055	-0.0536	-	0.0428	-0.4769	-
	(0.0534)~	(0.1332)	(-)	(0.0755)	(0.0903)**	(-)
d_coh1992	-0.0888	-0.0620	-	0.0664	-0.5357	-
	(0.0547)	(0.1377)	(-)	(0.0769)	(0.0936)**	(-)
d_coh1997	-0.1015	-0.1328	-	0.0587	-0.6551	-
	(0.0572)~	(0.1446)	(-)	(0.0799)	(0.0981)**	(-)
experience	0.0322	-	0.0303	0.0322	-	0.0289
	(0.0024)**	(-)	(0.0023)**	(0.0035)**	(-)	(0.0032)**
experience sq.	-0.0008	-	-0.0007	-0.0004	-	-0.0004
	(0.0001)**	(-)	(0.0001)**	(0.0001)**	(-)	(0.0001)**
d_year1989	-	0.0423	0.0348	-	0.0738	0.0094
	(-)	(0.0532)	(0.0202)~	(-)	(0.0395)~	(0.0294)
d_year1994	-	0.0148	0.0001	-	0.1298	-0.0009
	(-)	(0.0552)	(0.0204)	(-)	(0.0412)**	(0.0297)
d_year1999	-	0.0328	-0.0026	-	0.2343	0.0128
	(-)	(0.0567)	(0.0204)	(-)	(0.0423)**	(0.0301)
d_year2004	-	0.0734	0.0029	-	0.3435	0.0281
	(-)	(0.0604)	(0.0217)	(-)	(0.0453)**	(0.0338)
nobs	37	37	37	37	37	37
fstat	21.2500	0.6502	31.2823	49.3788	20.3876	72.0398
rsq	0.8999	0.2605	0.8582	0.9543	0.9170	0.9331
adjrsq	0.8576	-0.1401	0.8308	0.9350	0.8720	0.9201

Standard Errors in parenthesis

~ significant at 10%, * significant at 5%, ** significant at 1%

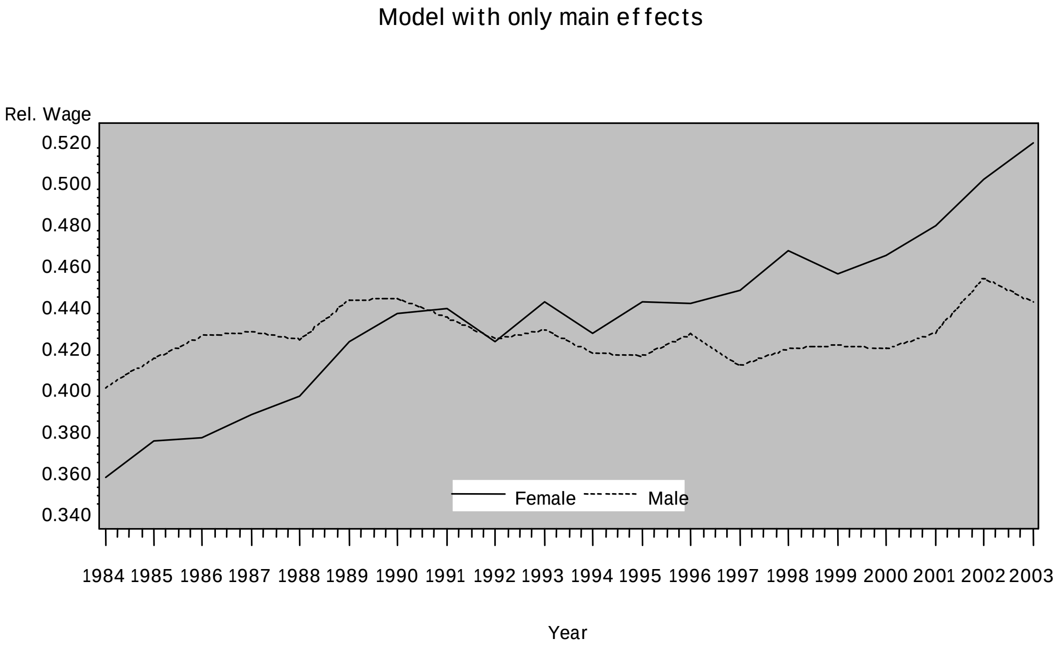
Table 10. Regression analysis of wage gap. Cohort supply gap, Experience and year

Variable	*M1*	*M2*
Intercept	0.2410	0.2991
	(0.0187)**	(0.0648)**
Relative supply	-0.1538	0.0515
	(0.0358)**	(0.0466)
d_year1989	0.0714	-0.0093
	(0.0183)**	(0.0339)
d_year1994	0.0686	-0.0389
	(0.0229)**	(0.0453)
d_year1999	0.1001	-0.0506
	(0.0290)**	(0.0647)
d_year2004	0.1421	-0.0538
	(0.0368)**	(0.0813)
experience	0.0247	0.0344
	(0.0023)**	(0.0060)**
experience sq.	-0.0008	-0.0004
	(0.0001)**	(0.0001)**
nobs	37	37
fstat	44.4956	62.3639
rsq	0.9121	0.9357
adjrsq	0.8916	0.9207

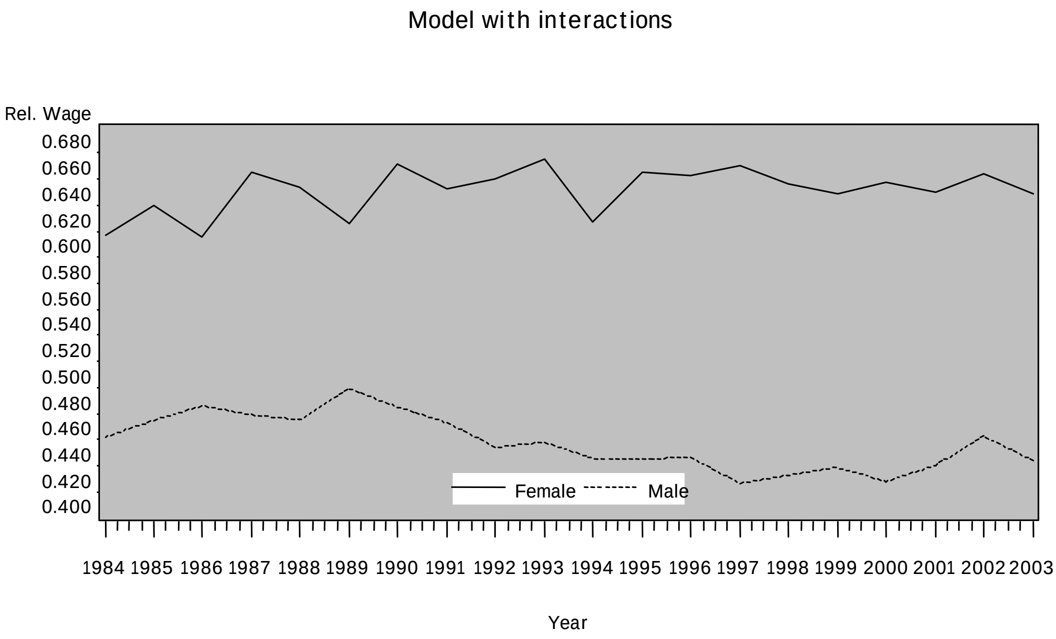
Standard Errors in parenthesis

~ significant at 10%, * significant at 5%, ** significant at 1%

Figure 1. College/high school gap by gender. Model comparison



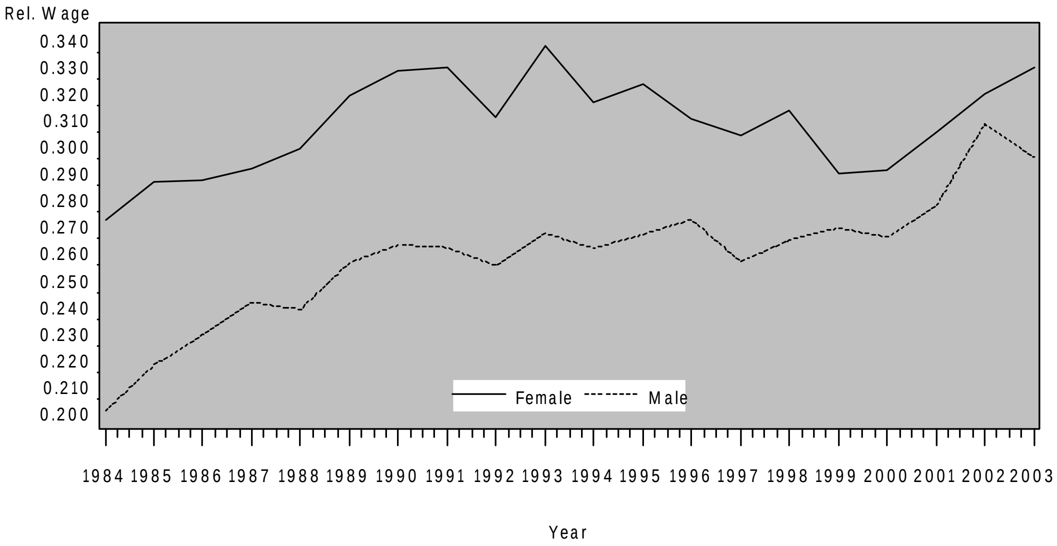
a



b

Figure 2. College/high school gap by gender. Weights comparison

Variable weights



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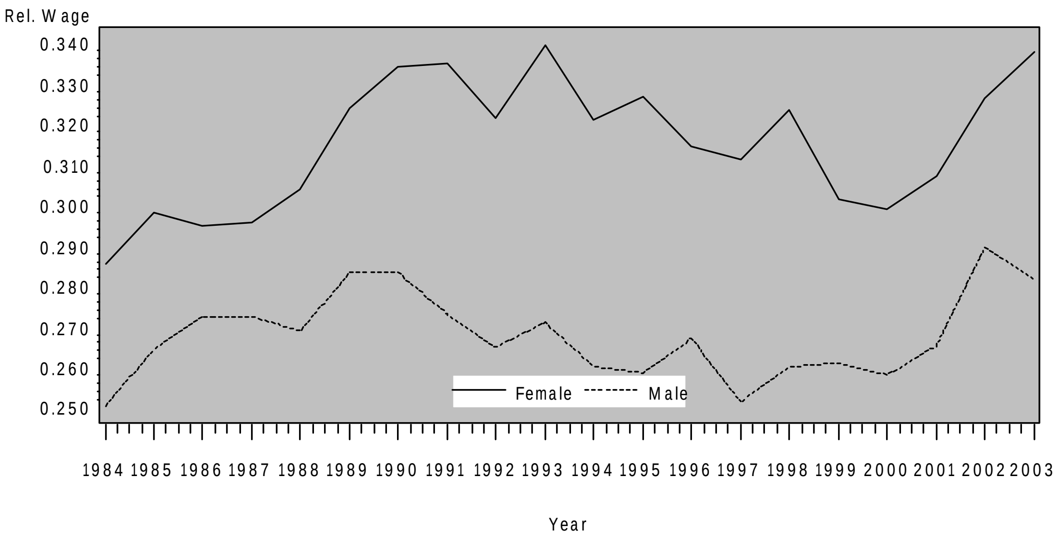
Fixed weights



b

Figure 3. Wage gap to high school

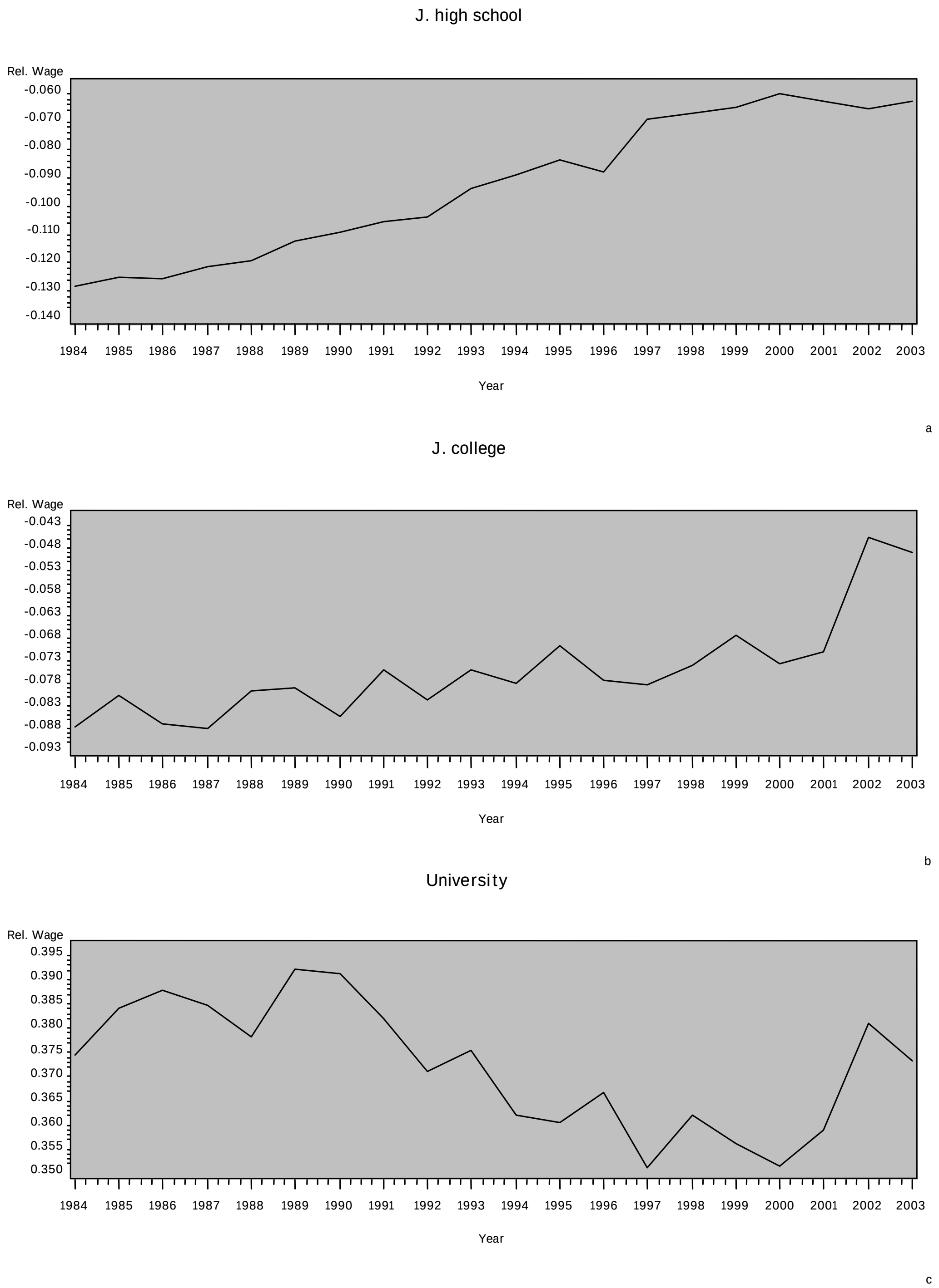


Figure 4. Wage gap to high school by sex

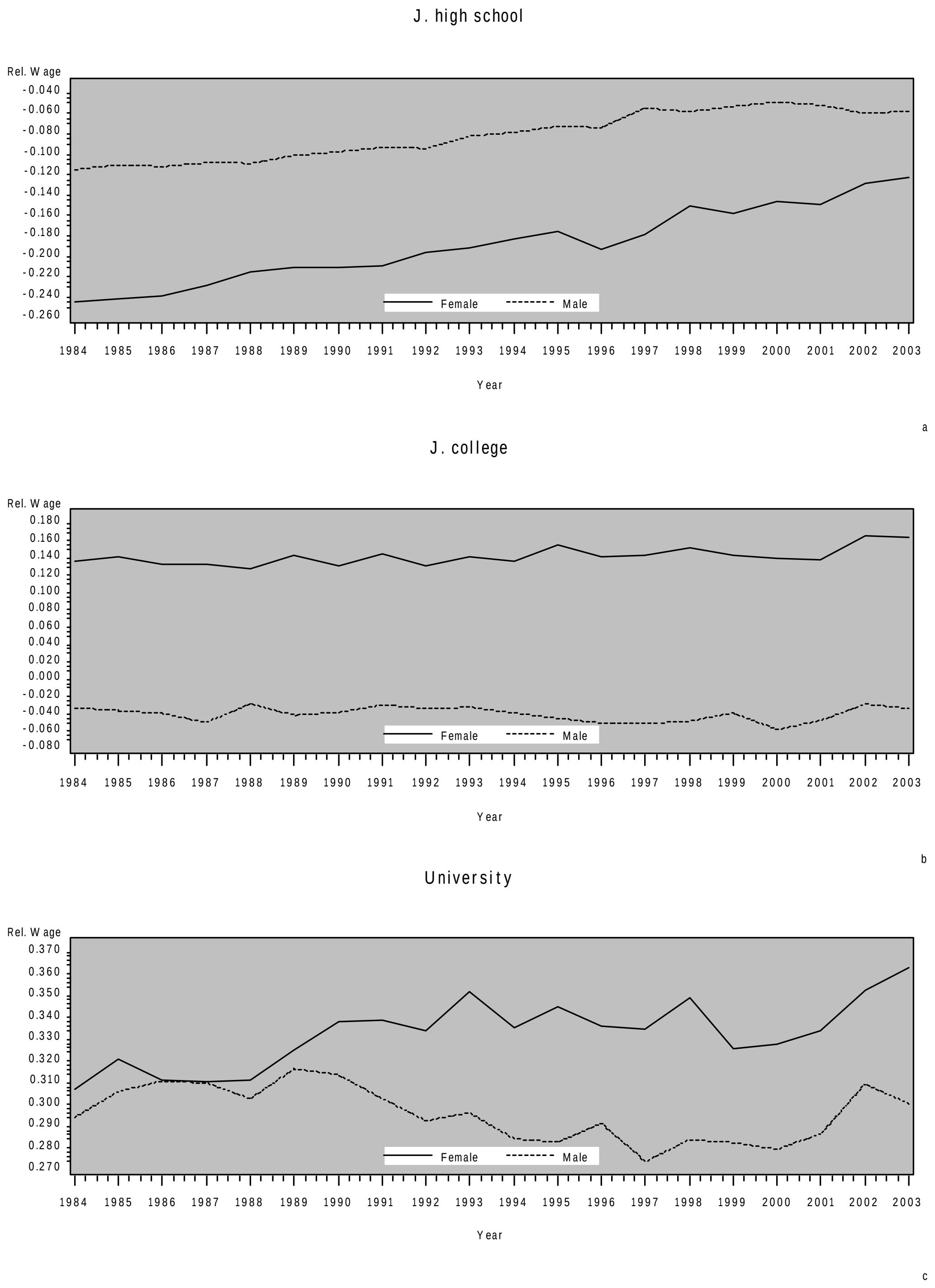


Figure 5. Supply gap in eff. units to high school

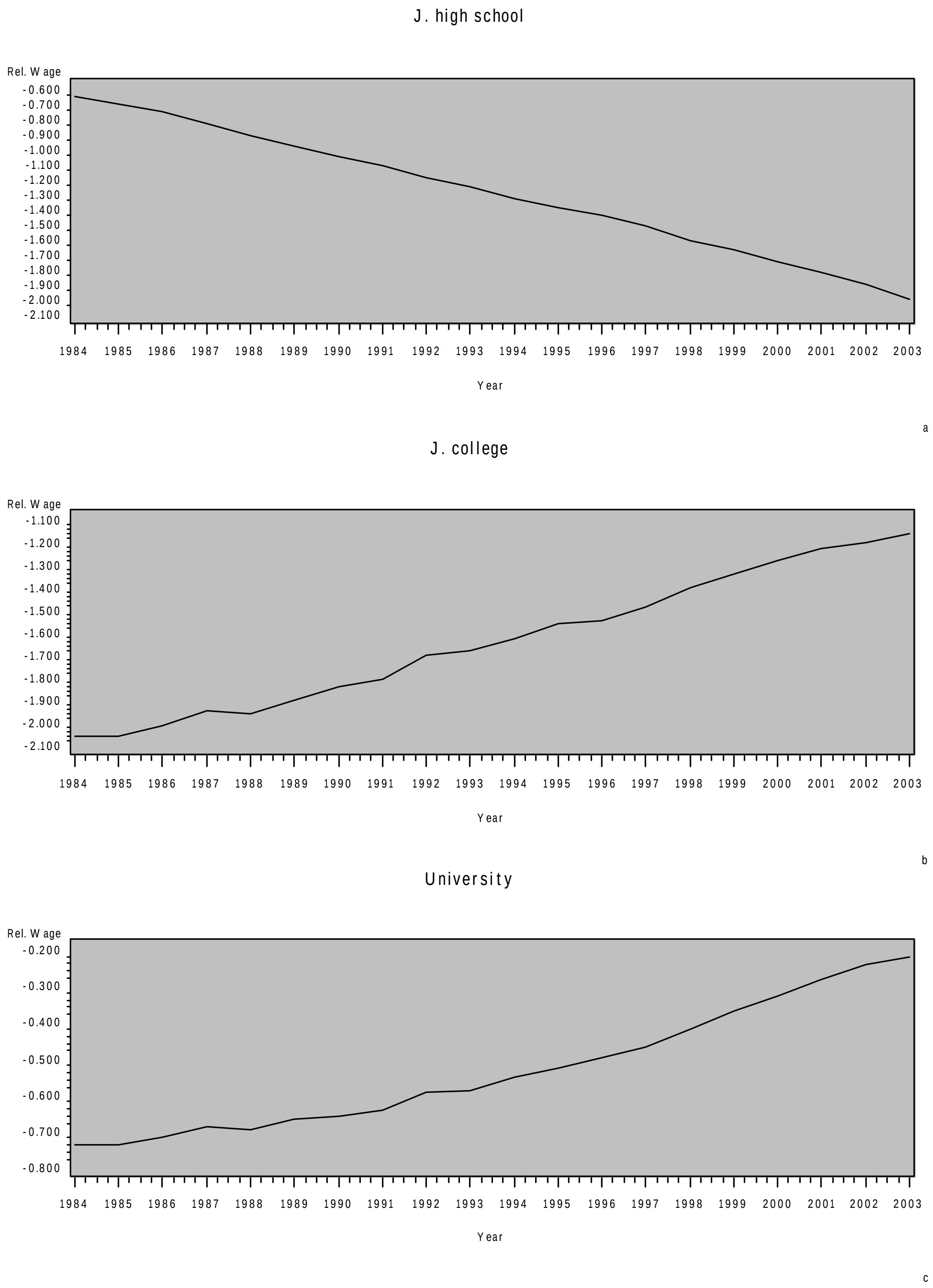


Figure 6. Supply gap in eff. units to high school by sex

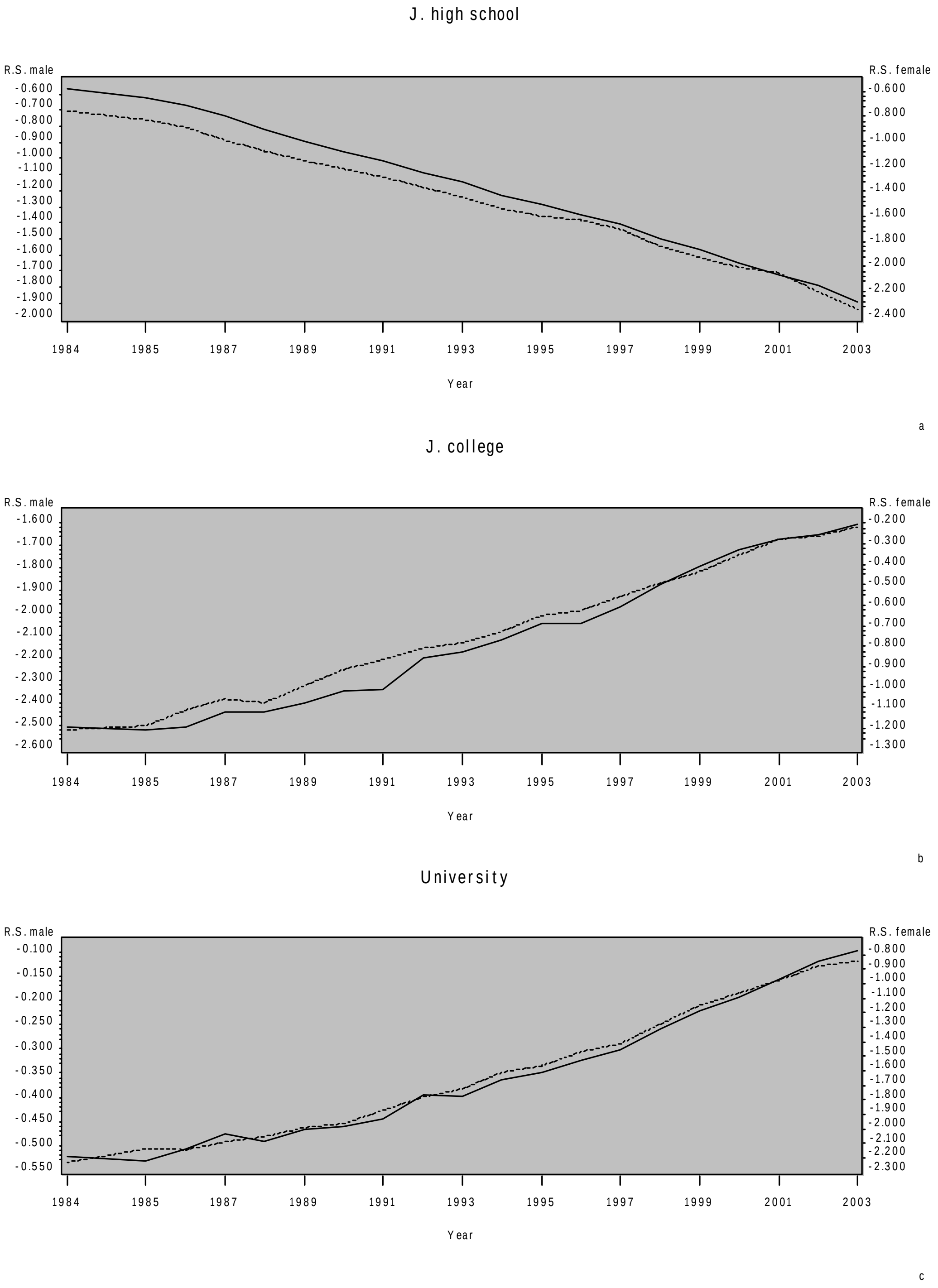


Figure 7. Change in log relative wage vs log relative supply

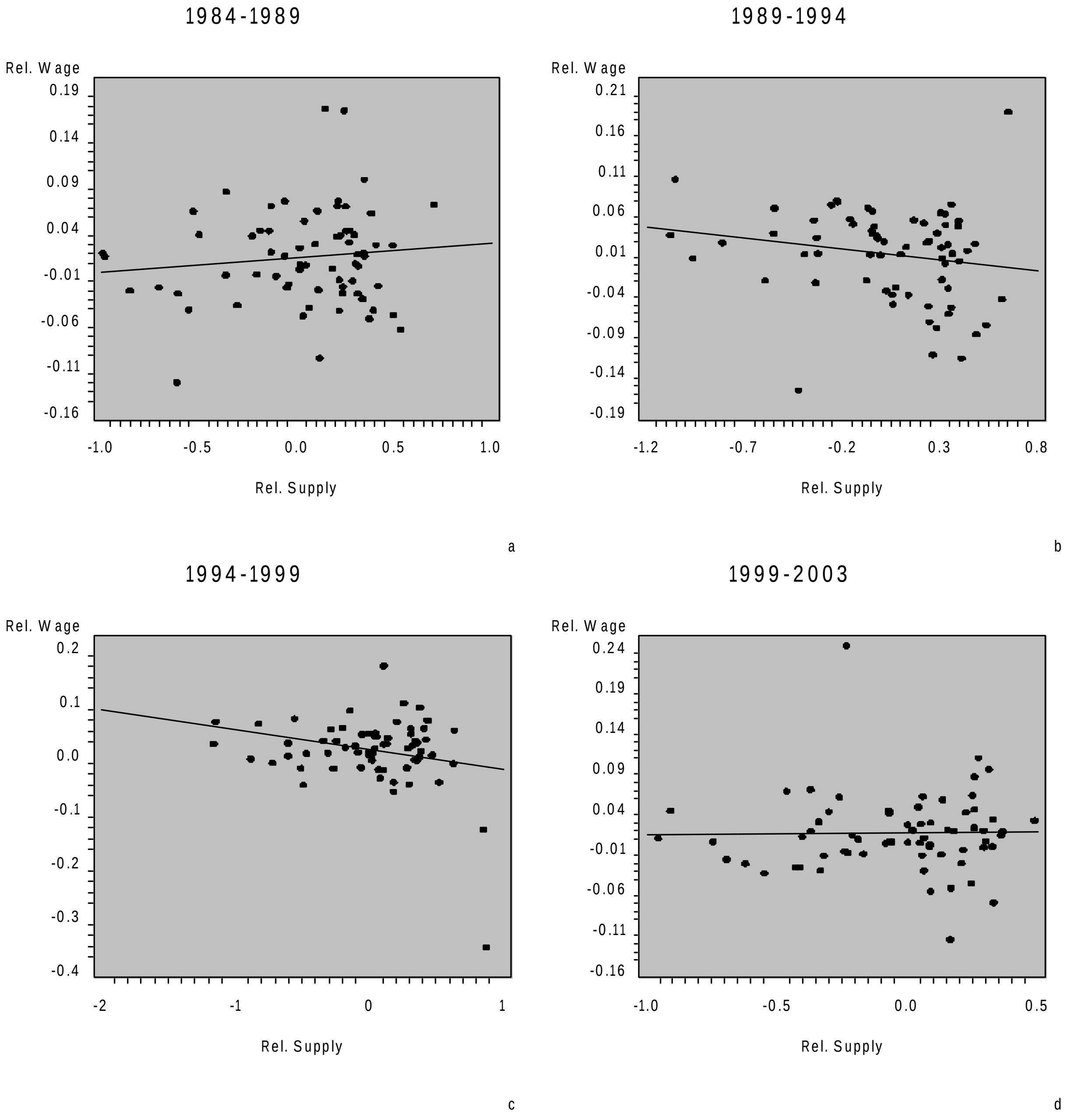


Figure 8. Relative wages and supply. Moving average

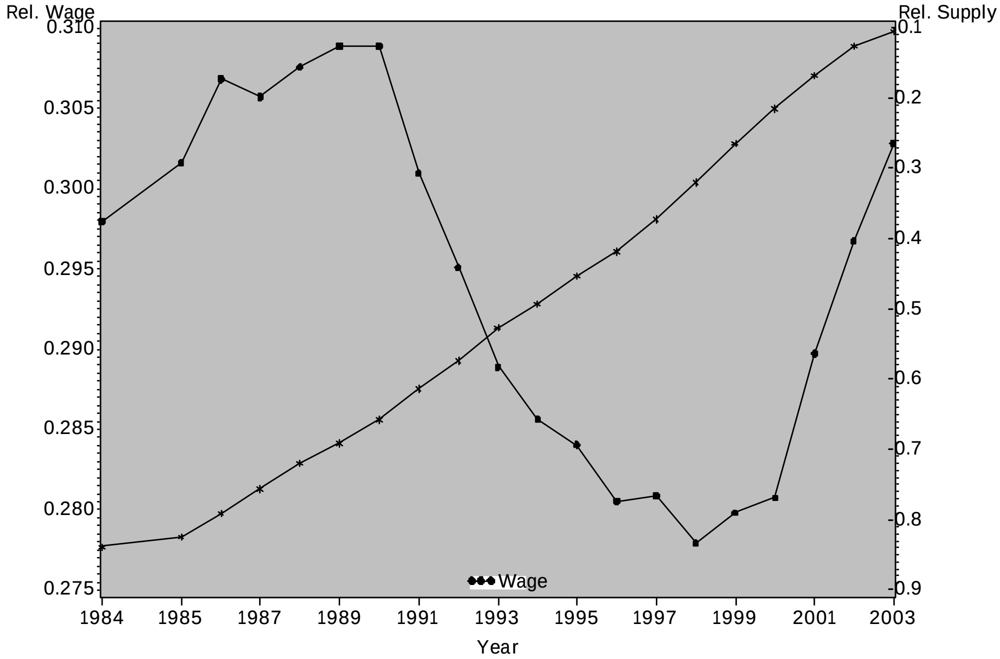


Figure 9. Relative wages: actual vs. predicted -piecewise linear trend

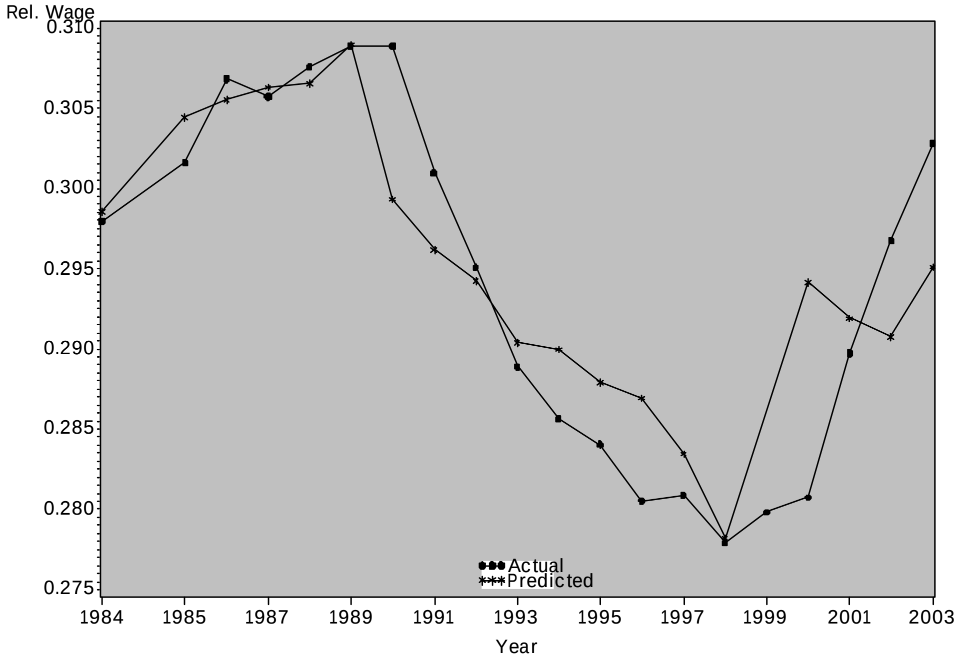


Figure 10. Relative wages: actual vs. predicted -smoothing spline trend

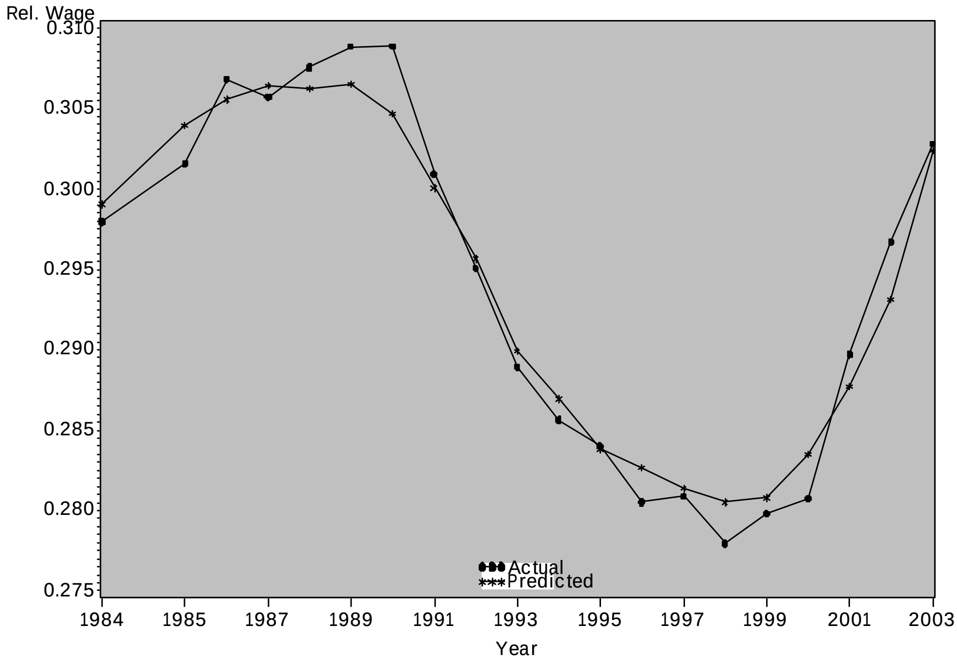


Figure 11. Est. demand shift from the semiparametric regression

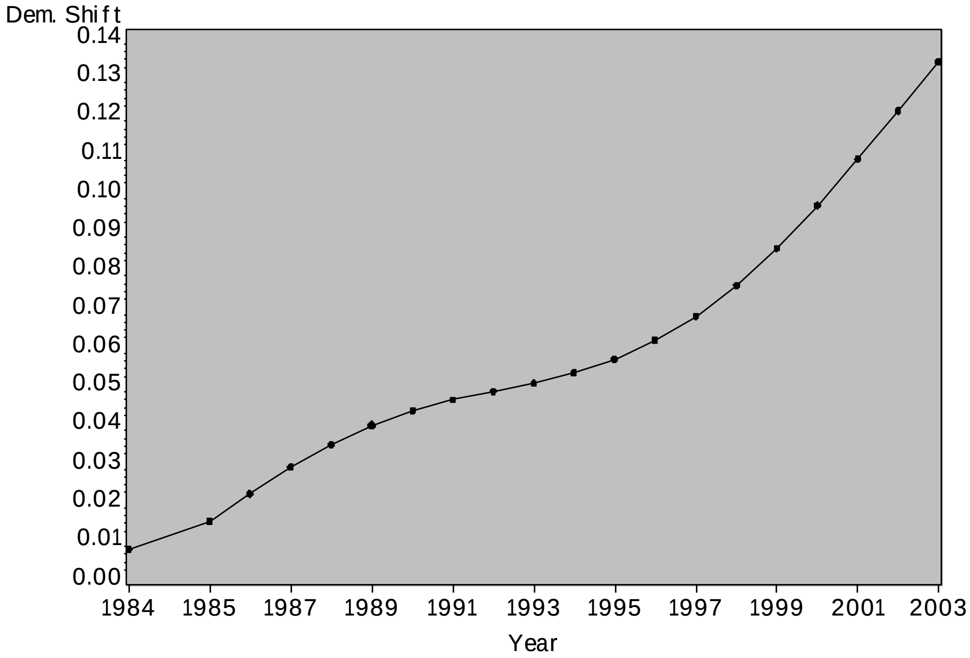


Figure 12. Implied demand shifts. Various sigma

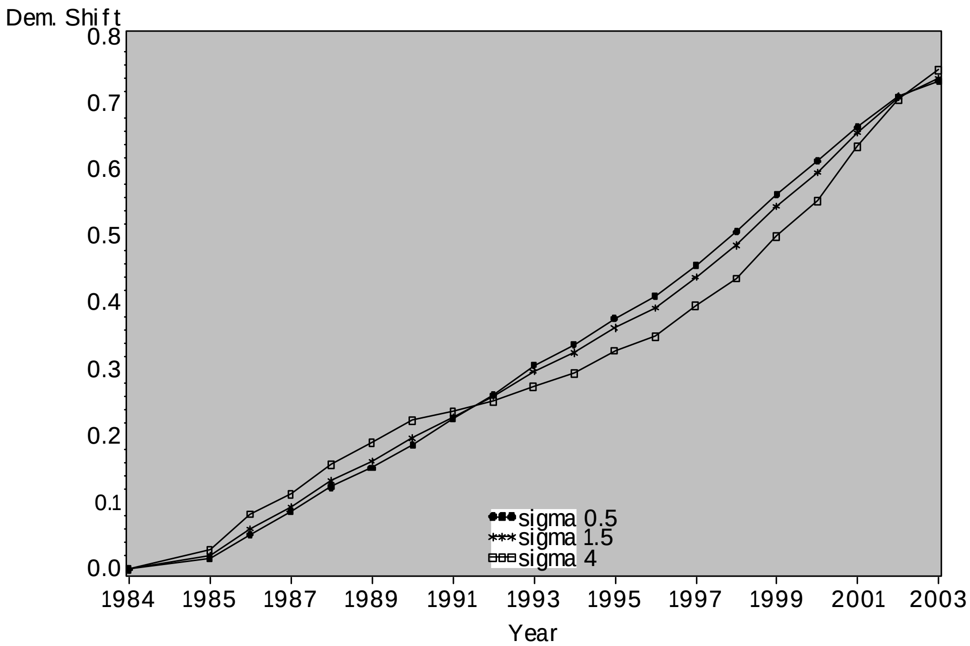


Figure 13. R&D intensity in the Japanese economy and Industry

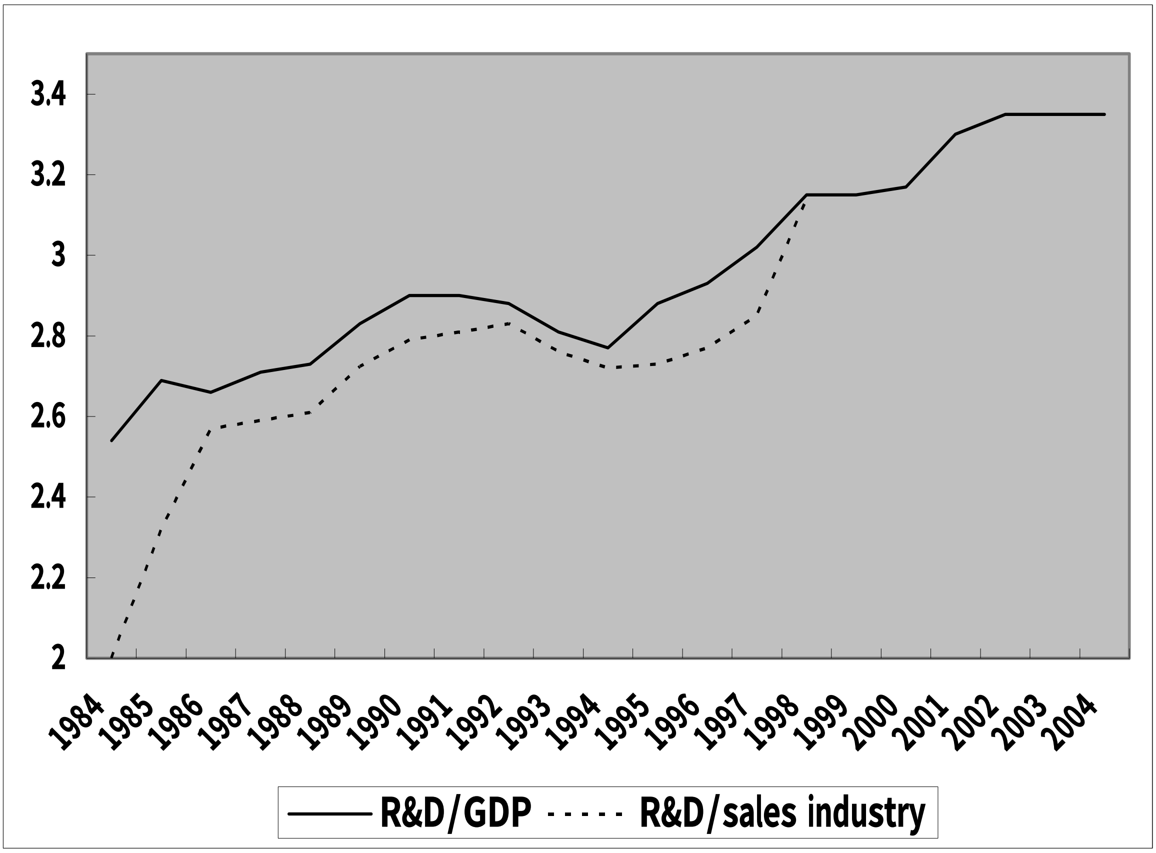


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Figure 14. Relative unemployment rate to high school

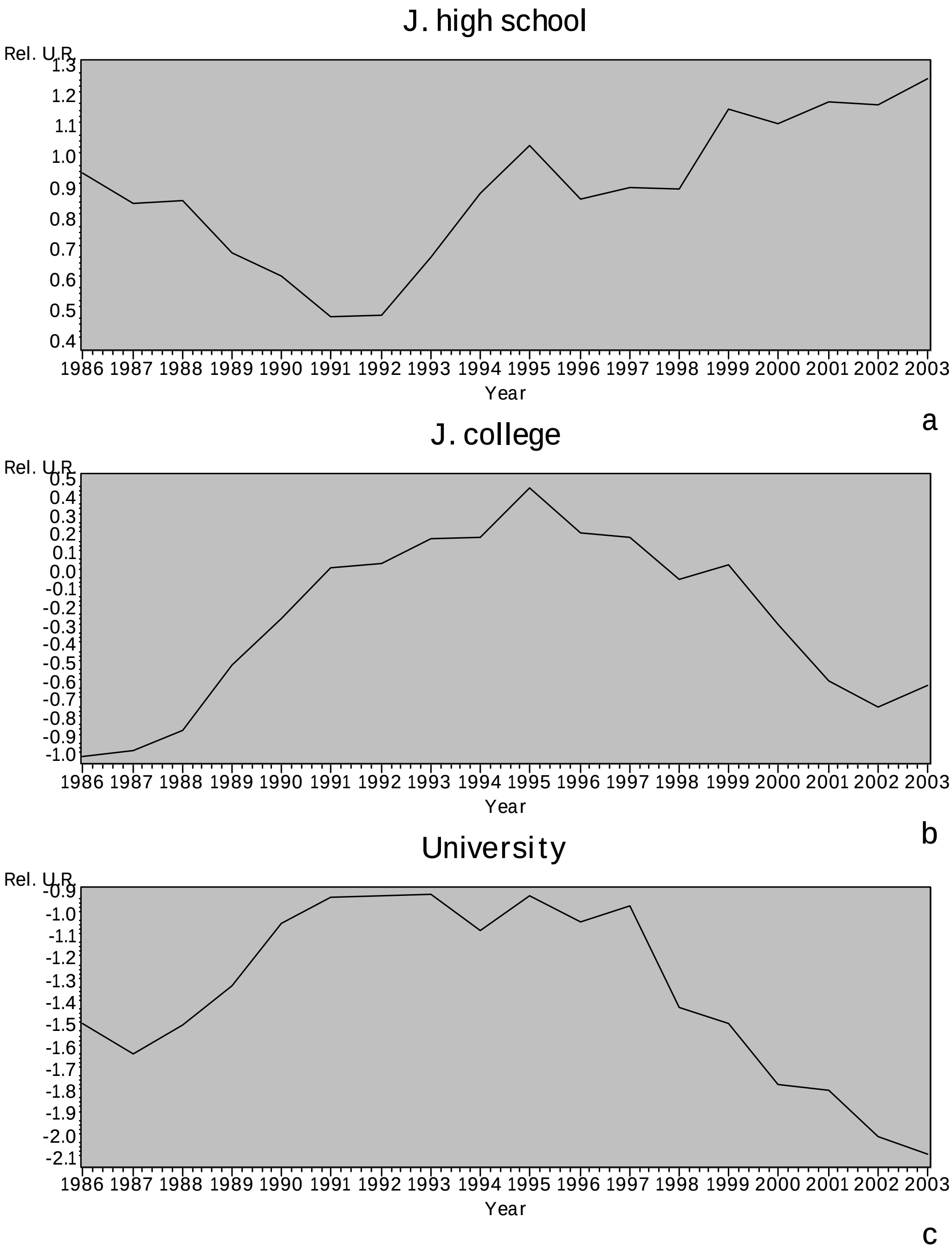

Figure 15. Relative unemployment rate to high school by sex