Horizontal stratification among university graduates in Hong Kong: A dynamic analysis using census data

(Submitted for presentation at the 2009 Annual Meeting of the Population Association of America)

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ABSTRACT. "Horizontal stratification" refers to systematic differences in labor market outcomes experienced by individuals with the same level of education based on the *type* of degrees they obtain. We analyze two aspects of horizontal educational among university graduates in Hong Kong: specialization of study and locality of institution (foreign vs. local institutions). Using micro-sample Hong Kong census data we examine trends in the choice of field and in locality of study among male and female university graduates. We estimate log-linear models that show increasing gender differences in the choice of particular fields over time. In the second stage of our analysis, we estimate earnings models with full and partial proportionality constraints on the effects of specialization and locality in order to see whether their magnitude and/or pattern have changed over time. Specialty became a more important source of earnings differentials among both male and female university graduates in Hong Kong between 1995 and 2000, which we attribute to the increase in supply of graduates.

Introduction

Research on educational stratification has recently devoted greater attention to how the labor market outcomes of individuals with university degrees vary systematically according to the different *types* of degrees they have. This 'horizontal' stratification within higher education (Charles and Bradley 2002; Gerber and Schaefer 2004; Gerber and Cheung 2008) can operate in many dimensions: types of institution (elites vs. non-elite, polytechnic vs. university), intensity of study (full or part-time), place of study (local or overseas), and field of specialization. These dimensions of horizontal stratification can not only exert direct effects on the labor market outcomes of post-secondary graduates, they can also potentially mediate the effects of gender, race/ethnicity, and origins on these outcomes (Daymont and Andrisani 1984; Fuller and Schoenberger 1991; Brown and Corcoran 1997; Joy 2003).

So far most studies of horizontal stratification in higher education have focused on the United States or other highly developed countries. Our paper expands the literature in two ways. First, we add to a new and distinctive case, Hong Kong, which holds particular interest for comparative analysis. As a former British colony and protectorate, a current part of the People's Republic of China, and a newly industrialized country (NIC) in Asia, Hong Kong may exhibit different patterns of gender imbalances in and returns to different post-secondary specializations than are typically observed the United and Western Europe.

Second, we bring a dynamic perspective to the study of horizontal stratification patterns in post-secondary education. A broader theoretical interest in whether the magnitude, pattern, and gendered basis of horizontal stratification in post-secondary are subject to change over time motivates our analyses. Hong Kong is an ideal setting for assessing such changes, because during the last three decades it has undergone a dramatic shift from a manufacturing to a service-industry based market economy. This restructuring has reshaped the occupational structure: the proportion of manufacturing workers has declined sharply, while that of service-industry workers has soared during this period. As in other NICs, the government has responded to changes in the global economy that demand a highly trained workforce by expanding higher education. Because they span the period during which these changes took place, our Hong Kong data permit us to see whether these changes shaped the pattern and/or magnitude of horizontal educational stratification.

We analyze two aspects of horizontal educational stratification in Hong Kong: specialization of study and locality of institution (foreign vs. local institutions). Using micro-sample Hong Kong census data we examine trends in the choice of field and in locality of study among university graduates, and we examine trends in gender differences in the choice of particular fields of study using log-linear models. In the second stage of our analysis, we estimate regression models for earnings among university graduates in order to identify variations by specialization and locality in Hong Kong and to see whether their magnitude and/or pattern have changed over time. Before presenting our data and analyses, we briefly describe the Hong Kong education system and economy, and we provide some theoretical considerations that inform our hypotheses and empirical analysis.

Higher education in Hong Kong: from restricted growth to rapid expansion

As a former British colony, the educational system in Hong Kong has modelled itself largely after that of Britain. Students attend six years of primary education followed by five years of lower secondary education. Most take the so-called Hong Kong Certificate of Education Examination (HKCEE) at age 16 after completing the five years of secondary schooling. Students can choose whether to continue on to the upper secondary education, which lasts for

two years widely known as the "sixth forms." At the end of the sixth forms (lower sixth and upper sixth), students take another standardised public examination: the Hong Kong Advanced Level Examination, a qualification that is equivalent to the British A-levels. This is practically a university entrance examination. Entrance to post-secondary education is heavily dependent on the results of these public examinations.

Extremely competitive in nature, higher education has been a commodity for the privileged few in Hong Kong until very recently. For a long time, there were only two universities in the former British colony. The first university, University of Hong Kong was established in 1911, which incorporated a College of Medicine created in 1887. The second university, the Chinese University of Hong Kong, was not established until 1963, when three colleges were combined to form a single institution. These two universities were for many years the only local degree-granting institutions.

Throughout the 1960s to the early 1980s, Hong Kong's economy relied heavily on labor-intensive light manufacturing industries. Therefore, the need for semi-skilled labor has been far greater than that for university graduates. Even so, the severe restriction on the growth of student numbers meant that graduates were much sought after by employers in both public and private sectors. Senior civil servants in the government, for instance, were mostly graduates from the two universities during this restricted growth phase. Non-degree tertiary education was offered in technical colleges and a small number of private colleges.

The numbers for first year first degree (FYFD) students as a percentage of the relevant age group are under 0.5% in 1911 and 2.1% in 1981 respectively (University Grants Committee, 2002).

(Figure 1 HERE)

During the eighties higher education expanded dramatically and took the form of a two-tracked development, the so-called binary system: on one hand, universities increased enrolments; on the other, new polytechnics and tertiary education colleges were established and began offering degree courses. First year first degree (FYFD) students went from just over 2% of the relevant age group in 1981 to nearly 9% in 1989.

In 1983 the Hong Kong Polytechnic offered degree courses for the first time; in that same year the Hong Kong Baptist College was incorporated as a tertiary education institution, which began to award degrees in 1987. In 1984 the City Polytechnic was founded, and it started to offer degree as well as sub-degree courses. In 1989 the decision was also made that a new science and technology university was to be built. The Hong Kong University of Science and Technology was established in 1991, and the Open Learning Institute of Hong Kong (now renamed the Open University of Hong Kong) was established in 1989.

The rationale behind the introduction of a binary system was primarily to introduce greater diversity into higher education by widening the range of institutions that offer and confer degrees and by introducing new developments such as part-time degrees and modular curricular. It was also believed that a binary system would, *ideally,* reduce the elitism of the old system, given that polytechnics and public sector institutions were considered different species altogether. Polytechnics offer flexibility in expanding higher education quickly and relatively cheaply, in order to meet labor market demands as well as to satisfy growing social mobility aspirations.

The 1990s marked the beginning of the re-definition of tertiary education. The traditional elitist model of the 'restricted growth' phase gave way to a model with greater emphasis on enlarging the proportion of the population that can enrol in some kind of post-secondary education. New priorities include the supply of non-degree tertiary places and part-time courses, in both the publicly funded and private sectors.

In October 1989 the Hong Kong government announced its plans to further expand higher education. The aim was to provide FYFD places to 18% of those in the relevant age groups by 1994-95 - this represents a nine-fold increase from the 1980s. In 2002 around 38% of 17-20 year olds in Hong Kong receive post-secondary education, including sub-degree courses and students studying overseas. A total of 14,500 FYFD places in higher education universities cater for around 18% of the 17-20 cohort; sub-degree places cater for another 15% of the cohort, with another 5% studying overseas (University Grants Committee 2002). To reach the target numbers, the two polytechnics and two higher education colleges were re-named universities in the latter half of the 1990s, and the Institute of Education began awarding degrees. It was announced in the Chief Executive's 2002 policy address that Hong Kong aims to provide 60% of those in the relevant age groups some form of higher education.

Today, access to higher education still depends heavily on public exam results discussed earlier. There are now eight universities, all of which provide undergraduate degrees and are heavily funded by the government. Amongst them, the “new” universities (i.e. the two former polytechnics and two former higher education colleges) also offer a range of non-degree courses including those leading to the award of diplomas, higher diplomas, professional diplomas and associate degrees. Continuing and professional education units of the two traditional universities also offer a range of self-financing sub-degree courses. Since the two former polytechnics began increasing their supply of undergraduate degree places in the early 1990s, the Hong Kong Institute of Vocational Education, which was established by merging the two former Technical Colleges and seven former Technical Institutes, began to offer vocational courses that lead to diplomas and higher diplomas for school-leavers at third and fifth form level. Amongst the eight UGC funded degree-granting institutions there is a clear hierarchy in terms of prestige and funding received from the University Grants Committee.

A unique feature of higher education in Hong Kong is that the late and highly restricted expansion of higher education has resulted in a long tradition of middle class families sending their children to universities abroad, typically those in North America, Britain, and Australia. Educating a child overseas is a costly affair. Not only do they have to pay much higher tuition fees than at local institutions; the cost of international travel, accommodation, and maintenance all mean that most parents cannot afford this option. In 1996 there were about 130,000 full-time equivalent students studying in Hong Kong, while the corresponding number for those studying overseas is 45,000 (UGC 1996). During British rule civil servants in the middle and upper ranks were given generous subsidies to send their children to study in Britain at secondary and post-secondary levels. Many seized the opportunity to send their children to Britain to receive an ‘overseas’ education.

These ‘overseas’ qualifications are often regarded as highly desirable for a number of reasons. First, most graduates with overseas degrees have better command of the English language which is a much sought after quality in the business world as well as in senior civil

service. Second, a significant proportion of these overseas graduates had also received their secondary education abroad. Many were sent to the boarding schools in Britain, where they received a 'public school' (i.e., private sector) education. Leaving home at a young age and settling in a new environment forces one to be independent and to make decisions that may not be necessary if they were living at home. It could be that these overseas graduates had acquired a wide range of highly desirable transferable skills that are much valued in the work place. Given that access to higher education in Hong Kong remains highly competitive even after the rapid expansion that took place in the 1990s, a significant proportion of middle class youth continue to attend universities overseas. For these reasons, overseas qualifications can be expected to send a positive "signal" to employers and thus bear, on average, higher returns in the labor market than degrees from local institutions.

However, the extent to which the place where qualification is obtained affects labor market outcomes has not been systematically examined. Moreover, although we hypothesize that foreign university degrees bring higher returns than degrees from local institutions, we recognize that the effect could be the opposite. Employers may feel more familiar with the level of training and expertise imparted by local institutions, and they may be uncertain of the standards of institutions in foreign countries. Perhaps for this reason, foreign university are discounted in the US labor market relative to degrees from domestic institutions (Zeng and Xie 2004). Thus, the direction and significance of the effect of foreign vs. local degrees in the Hong Kong labor market remains an open empirical question.

From manufacturing to service industry and a knowledge economy

As in most developed post-industrialised societies, the rationale for higher education expansion has largely been articulated in terms of manpower needs, economic development, and competitive advantage in an increasingly global knowledge economy. In order to maintain economic competitiveness, a highly trained, highly specialised workforce is necessary to serve the ever changing needs of the economy.

Back in the seventies, Hong Kong's economic fortunes began in light manufacturing industry where garments and textiles, plastic and electrical and electronics goods were produced and exported mainly for consumption in the west. Capitalising on the abundant supply of cheap labor and low tax free trade regime, the former British colony's economy steadily took off during the two decades. Labor-intensive light manufacturing could not be relied upon in the face of the globalizing economy in the early eighties. Fierce competition from other Newly Industrialized Countries (NICs) in the Far East and increasingly from Mainland China put pressure on Hong Kong to diversify and switch to more capital-intensive, high technology industries. The need for qualified professionals, technologists, engineers and scientists suddenly loomed larger than ever.

Like most post-industrial economies, economic restructuring in the late 1980s and early 1990s in Hong Kong meant that there was a sharp decline in the once dominant manufacturing industries, which gave way to fast-growing service industries. Today, less than 10% of the workforce is employed in manufacturing and over 90% of employees work in the service industry. With the decline of the manufacturing sector in the late 1980s and early 1990s (or more specifically, its relocation to mainland China), Hong Kong has experienced a shift towards a service sector-led economy. One consequence of the expansion of the service sector is that more middle managerial and routine non-manual 'white-collar' jobs are now available, in which women are traditionally over-represented. Another is the rise of opportunities in high-tech industries and occupations. Does this shift mean that the certain

specializations will reap higher labor market returns because they are better suited to the "new" knowledge-based economy? For example, specializations in science and technology and computing might fare better in the labor market than their peers in other specialties. Concentrations in business administration and law might also prove more profitable than previously. Engineering fields, which are traditionally associated with the productive branches of the economy, might decline in relative standing.

A Supply Side View

A different theoretical consideration leads us to expect that independently of any change in the pattern of returns to different specialities, the overall magnitude of the effects of specialization should increase over time in Hong Kong. We derive this hypothesis from the sharp increase in the supply of highly educated workers that resulted from the expansion of higher education during the 1980s. In earlier periods when there were few university educated workers, employers who wanted or needed to hire expert labor had relatively fewer potential employees to choose from. In such conditions, they might have been less likely to distinguish applicants on the basis of field of university study, reasoning that a degree in any field acted as a signal of cognitive ability and diligence.

With the dramatic increase in the supply of university educated workers, employers could now afford to be more selective. In particular, they could be expected to seek a better match between the technical or cognitive demands of the job and the specific type of training the applicant received, which is better captured by field of specialization than by any other single measure. Thus, we anticipate that the overall magnitude of specialty differences in earnings among university educated workers in Hong Kong increased over the last decade. This would be consistent with the general principle observed by other researchers on horizontal stratification that when equalizations take place with respect to a level of education, finer distinctions within a particular level take on greater importance: horizontal stratification increases as vertical stratification diminishes (Lucas 2001; Charles and Bradley 2002).

Gender Differences?

This same reasoning leads us to expect that gender differences in the choice of specialty also increased across cohorts of graduates in Hong Kong. If it is indeed the case that specialty comes to play a greater role in shaping the earnings of university graduates, we would expect male students to increase their relative representation in the most lucrative fields and decrease their representation in the least rewarded specialties.

More generally, it is of interest to see whether we observe the traditional gender divide in the choice of specialty that typically obtains in most western societies such as the US, and Sweden (Jacobs, 1995; Jonsson, 1999; Gerber and Cheung 2008). Given the recent and compressed nature of higher education expansion in Hong Kong, a distinctive pattern of gender differences in specialty may obtain for older cohorts. As recently as 1985, only 2-3% of 17-20 year olds attended universities. This means that those who were able to do so were in many ways exceptional, and therefore traditional gender norms and biases may not have prevailed. Yet over time, as enrolments of both men and women grew, the gender bases of different specialties may well have converged with a more traditional model.

Hypotheses

We also expect that the magnitude of horizontal stratification should increase over time due to the dramatic expansion-driven increase in the number of post-secondary graduates in the labor market. We hypothesize that horizontal distinctions are less decisive when there is less

competition among post-secondary degree holders: as their supply increases, so does the level of competition and thus the impact of horizontal differences.

The link between higher education and labor market returns is complex, and theories regarding possible changes in horizontal stratification are not well developed in the literature. Thus, our a priori expectations should be viewed as guidelines for analysis more than firmly grounded hypotheses. Nonetheless, it is useful to formulate very tentative hypotheses as a way of summarizing our thinking about the dynamics we might observe in the data.

As our discussion above suggests, we expect to find change over time in the pattern of effects of field of specialization reflecting the post-industrial shift in the economy during the decades in question: fields that involve specialized knowledge work and service provision should become more lucrative over time relative to fields that involve production-based skills. If so, then student enrolment trends should reflect, if imperfectly, the changing pattern of returns.

> *Hypothesis 1:* In post-industrialised Hong Kong, the proportion of students specializing in math and science, computing, accounting, and business administration increased, while the proportion specializing in more academic fields such as humanities and social sciences and production-oriented fields like engineering and applied studies (operationalized with the category, "textiles, clothing, design") decreased.
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> *Hypothesis 2:* The pattern of labor market returns to different specialties changed in parallel fashion.

Our supply side reasoning leads us to expect that the overall strength of specialty effects grew over time in Hong Kong, irrespective of any change in the pattern of those effects. We predict, in other words, an increase in horizontal stratification in this dimension:

> *Hypothesis 3:* The magnitude of the effects of specialty increased over time, for both men and women.

If this is indeed the case, we would expect males to increasingly displace females in the better-rewarded specialties (and vice versa):

> *Hypothesis 4:* Gender differences in specialization should grow in magnitude over time.

Moreover, while we would not be surprised to see a distinctive pattern of gender specialization for earlier cohorts, given the highly selective nature of higher education for those cohorts, we would expect that as enrolments of males and females both increase there is a trend of convergence toward international patterns:

> *Hypothesis 5:* The pattern of gender differences in specialization changes over time.

Finally, because study in foreign institutions has long been the province of the wealthier classes and, anecdotally, is held in greater esteem:

> *Hypothesis 6:* University degrees obtained overseas bear higher returns than those obtained in local institutions, for both men and women.

Data, Methods and Analysis

The data we analyze come from the 1% sample of the Census and by-Census of Population Surveys of Hong Kong from 1981 to 2001[1]. Data are available for analysis at five time points: 1981, 1986, 1991, 1996 and 2001. However, due to changes in questions and coding we use only the data from 1991, 1996, and 2001. In addition to the usual basic socio-demographic data that are routinely collected in most government censuses, the Hong Kong census data are unusual in that they include information on the field and place of study of respondents, as well as information about current labor market situation. Thus, they offer a unique opportunity to analyze the dynamic stratifying effects of horizontal stratification in post-secondary education.

Our empirical analysis consists of three parts. First, we descriptively examine change over time in the distribution of fields of specialization among university-educated individuals. To do so, we compare the distribution of specialties across five different "approximate graduation cohorts." We do not know the actual year in which individuals received their university degrees, so we assume that they all did during the year when they turned 22. So, our approximate graduation cohorts correspond to decades when successive cohorts reached the age of 22.

After our descriptive analysis, we estimate a series of log-linear and log-multiplicative models analysing the association between graduation cohort (C), sex (S), locality of study (L), and major (M). We gear our analysis toward assessing whether the association between sex and major (SM) changed in pattern and/or magnitude across cohorts. To do this, we fit the three-way SLC marginals and the three two-way marginals involving M. Then we test a variety of constrained interactions between SM and C.

In the third step we estimate a series of regression models for logged earnings from main job on the sample of currently employed university degree holders. Here we measure the effects of specialization and locality of study and assess whether they change in magnitude and/or pattern over time. Our initial analyses revealed minimal changes from 1991 to 1995, so we combine those two years of data and contrast them with 2001. Rather than interact all specialty dummies with period, we take a more parsimonious approach, constraining their effects to be proportional during each period and specifying change over time using a single scale factor. This specification is akin to a "unidiff" model in log-linear analysis (Xie 1992; Erikson and Goldthorpe 1992) or a stereotype ordered regression (DiPrete 1990), or a logistic response model with proportionality constraints (Hauser and Andrew 2006; see also Hout, Brooks, and Manza 1995), except that our dependent variable is continuous (logged earnings). If the multiplicative interaction parameter is significant and the full set of proportionality constraints provides an optimal fit to the data, it implies that the pattern of specialization effects remained constant over time but the magnitude of those effects changed. If, however, we can improve the fit of the model by relaxing all the proportionality constraints, it implies that the pattern of effects varied over time. Finally, we might find that a subset of effects varied in a proportional fashion, while others varied independently – in this case, a partially constrained interaction would provide the best model fit.

We use maximum likelihood to estimate the regression models, because standard software packages do not readily permit the application of non-linear constraints. In the interest of

[1] We have recently obtained the 5% sample and we are replicating all our analyses with it. We will update the paper with the results based on the larger sample.

model parsimony, we assess the fit of competing specifications of change over time using the BIC statistic. But given our large sample size, differences in BIC of fewer than 5 points are not sufficient to adjudicate between models (Wong 1994). In such cases, when the models are nested we rely on the standard likelihood ratio test. Control variables in our regressions include age, age squared, and dummy variables denoting immigrants from China and from elsewhere. Our preliminary analyses revealed substantial differences in the patterns of earnings determinants for men and women, so we estimate separate earnings models by sex.

Results

Trends in specialization

Figures 2 and 3 display the trends across approximate graduation cohorts in the distribution of male and female university graduates by the specialty categories available in the data. As we hypothesized, business administration surged in prominence as a major for both sexes, particularly during the 1970s. Computing grew sharply in popularity in the 1980s, but much more for men than for women. At the same time, accounting and clerical/secretarial fields drew ever larger proportions of women.

[Figures 2 and 3 about here]

Contrary to hypothesis 1, math and science declined for women. But this is consistent with hypothesis 5, as males typically predominate in these fields in other countries. Medical specialties, more the province of women in Hong Kong, fell in popularity for both sexes. But humanities and social sciences – where for older cohorts we observe something closer to gender parity than is typical – fell in popularity among men while remaining fairly stable among women. This is another example of convergence over time toward a typical international pattern, as women typically predominate in humanities and social science fields, which are often poorly remunerated compared to pre-professional and engineering specialities. As for engineering, despite a modest decline for men in the most recent decades, it has been an overwhelmingly male major throughout the post-war era in Hong Kong.

In sum, the descriptive patterns we observe in the Hong Kong census data are broadly consistent with hypotheses 1 and 5, despite some patterns that do not conform to one or the other. Of course, it is difficult to evaluate these hypotheses on the basis of descriptive trends alone. Not only is it hard to assess whether any apparent change in patterns of gender differentials are significant, it is not evident how to assess trends in the magnitude of gender differences in choice of specialty. Moreover, the descriptive patterns may be masking joint associations of gender, period, and specialty with locality of study. We therefore turn now to our log-linear analysis of these associations, which permit us to systematically test for changes over time in the pattern and magnitude of the SM association and to control for the possible joint association of S and M with locality of study.

Trends in association between sex and major

Because our theoretical interests do not cover the associations between sex, locality, and cohort, we fit that three way marginal (and all its constituent lower marginals) completely in all our models. We start with a model (1) positing that major is independent of the other three variables. Not surprisingly, the independence model fits the data quite poorly, as evinced by the positive BIC statistic and high index of dissimilarity (δ) (Table 2). The model (2) containing the three two-way associations involving M dramatically improves in fit according to both BIC and δ. Model 3 permits a distinctive pattern and magnitude of association between S and M to obtain within each category of C. Although this "full

interaction" model of the SMC association improves upon model 2 based on the likelihood ratio statistic, it is not very parsimonious: it uses an additional 40 degrees of freedom as it in effect requires estimation of five separate sets of 10 parameters defining the (2 x 11) SM association (one for each cohort) rather than a single set. Accordingly, the BIC statistic prefers model 2 by far.

[Table 2 about here]

We follow the standard practice in such situations by using log-multiplicative scaling factors (ϕ_c) to specify change in the magnitude but not the pattern of SM association (Xie 1992; Erikson and Goldthorpe 1992). First (model 4) we estimate a separate ϕ_c for each cohort (with the standard identifying constraint that $\phi_1 = 1$). This yields a better fitting model than model 3, but the improvement of fit relative to model 2 is not sufficient relative to the sacrifice of four degrees of freedom to produce a superior BIC. Models 5-7 apply three different sets of constraints to the ϕ_c in order to conserve degrees of freedom, viz.: $\phi_1 = \phi_2 = 1$, $\phi_3 = \phi_4$ (model 5); $\phi_1 = \phi_2 = 1$, $\phi_3 = \phi_4 = \phi_5$ (model 6); and $\phi_c = c*\phi$, with integer scored cohorts (model 7). Models 6 and 7 each use only a single degree of freedom: both fit equivalently to model 2 based on the BIC statistic (their BIC values are more negative, but the difference is less than 5 BIC points). But both fit better than (2) using the likelihood ratio criterion. Thus, we prefer either one degree of freedom specification.

Models 6 and 7 both specify that the pattern of gender differences in specialty choice (net of the associations that are perfectly fit by the model) is constant across cohorts, but the magnitude of gender differences changes – either after the 1960s (model 6) or in a linear fashion with each decade (model 7). Accordingly, these models contradict hypothesis 5 (changes in patterns of gender differentials that converge toward patterns typical in other countries), but they support hypothesis 4 (so long as estimates of ϕ are greater than 1.00, which in fact they are.

But before we rule out changes in the pattern of SM association over time on the basis of the vastly superior fit of models 6 and 7 compared to model 3, we should see if we can improve upon 6 and 7 by allowing a subset of individual SM parameters to depart from the proportional variation specified by the unidiff model. Inspection of the unconditional male/female odds ratios pointed to two likely candidates: math and science start out as a predominantly female major but shift over time into a predominantly male major, while the opposite obtains for business administration. This reversal in the direction of the SM association over time cannot possibly be captured by a log-multiplicative scaling factor, as a change in the sign of the (local) logged odds ratios must violate the proportionality of the SM parameters.

Thus, the next set of models specifies that a subset of SM associations vary across cohort in proportional fashion, while two specific parameters (pertaining to math/science and business administration) vary freely across cohorts. These "partial undiff" models imply that a basic pattern of gender association obtains for 9 of the 11 majors for all cohorts, but the strength of the association can vary multiplicatively, and, moreover, the gender balance within math/science and business administration changes for each cohort in a manner independent of the pattern relating to other nine specialties. Models 8 through 12 apply various constraints to the ϕ parameters that govern changes in the magnitude of the association within the dominant pattern, including a time invariant version (model 11, with all ϕ constrained to equal 1). None of these models fit the data better than their corresponding "full unidiff"

variants, as the degrees of freedom consumed by the freely varying SM parameters do not yield a sufficient improvement in chi-square to prevent less negative BIC values.

Our next tactic is to impose constraints on the two sets of "free" SM parameters, which we do in models 13-15. We constrain each of the these sets of SM parameters to vary linearly across cohorts, which conserves eight degrees of freedom relative to the corresponding models which allow both to vary freely. All three provide superior fit relative to their "full unidiff" counterparts. The BIC statistic offers no guidance for choosing among the three. However, both models 13 and 14 are superior to model 15 (which is nested within them) based on the likelihood ratio test. Since models 13 and 14 are not nested, we choose model 14 as our preferred model based on its (slightly) more negative BIC statistic. In any case, they are substantively very similar.

Our preferred model (14) indicates that for the most part, the pattern of gender differences remained constant across cohorts, but the magnitude of those differences increased (since the estimated ϕs, given the manner in which the linear constraint was applied are .87 for the first two cohorts, 1.00 for the next two, and 1.13 for the youngest cohort.) These two statements apply to nine of the eleven specialties. Gender differences with respect to math/science and business administration changed over time in such a way as to reverse their signs: the former went from a predominantly female major to a predominantly male major, the latter changed in the opposite manner.

To illustrate these patterns and trends in a more intuitive manner, we present the local logged male/female odds ratios pertaining to each specialty by each cohort implied by our preferred model (Table 3). Negative values indicate female predominance in a major, positive values indicate male predominance. Note the symmetric and mirror patterns of change over time for math/science and for business administration. In addition, note that the magnitude of sex differences in representation within the remaining majors increases in the 1970s and again in the 1990s. As this table shows, our analysis supports our hypothesis that the magnitude of sex differences in university specializations increased over time in Hong Kong. With two exceptions, though, the pattern of sex differences remained constant. One of those two exceptions is clearly consistent with Hypothesis 5: in a departure from standard international patterns, math/science was initially a "female" major in Hong Kong, but over time it shifted to become a male major, converging with the more typical pattern. At the same time, the other exception to the consistency in the pattern of association over time represents a divergence away from a typical pattern, as business administration went from a mainly male to a mainly female major. Finally, with the possible exception of business administration, the gendered pattern of university in Hong Kong for the youngest cohorts is quite similar to the global pattern (e.g. Bradley 2000): men predominate in engineering, computing, and math/science; women in education, humanities/social science, and health fields.

[Table 3 about here]

Horizontal stratification and earnings

Table 4 provides fit statistics for a series of alternative specifications of the dynamics of horizontal stratification in the earnings of university graduates. As noted, we estimated separate models for men and women, because (as will become evident) the preferred specifications differ substantially by gender: employing gender-interaction terms would add unnecessary additional complication to an already complex set of models.

[Table 4 about here]

Starting with the models estimated on the male sample, we included only a constant in the first model to produce a baseline log-likelihood. The second model includes only the main effects of the dummy variables for specialty, local university, and the other covariates intended to serve as controls (age, age-squared, immigrant from China, immigrant from elsewhere, and dummy variables for 1991 and 1996 data files.

Model 3 incorporates a scalar parameter that serves as a multiplier effect for the set of dummy variables corresponding to specialty. This is our proportionally constrained temporal interaction model. Using only one degree of freedom, it reduces –2 log likelihood by 8.0. With our large sample size, BIC cannot adjudicate between models 2 and 3, but the likelihood ratio test clearly prefers the latter, in which the former is nested. Model 4 adds the full set of interactions between the dummy variables for major and period to model 2. This model produces a clearly inferior BIC, indicating that the proportionally constrained change over time (implying constant pattern but varying magnitude of association) is to be preferred over a model with free variation in parameters over time.

We next add interactions involving the other covariates (including locality) and period, in order to make sure our significant interaction involving major is not an artefact of suppressed interactions involving other variables. Net of the full set of interactions involving other covariates, the addition of the proportionally constrained interaction of major with period produces an equivalent BIC and a superior –2 log likelihood (models 5 and 6), while the addition of the full set of period by major interactions produces a clearly inferior BIC (compare 5 and 7).

In a parallel fashion to our approach in the analysis of the SLCM association, we then see whether we can improve our model fit by permitting a subset of majors to depart from the larger (proportionally constrained) pattern. It turns out that the best fit is obtained by freeing a single major (education) to depart from proportionality: this single additional parameter (an interaction between the dummy for "education" and the dummy for "pre-2001") yields an improved BIC (compare model 8 to model 6). Removing the proportionally-constrained interaction term subsequently yields an equivalent BIC but an inferior –2 log likelihood (model 9). Finally, by removing two non-significant interactions involving covariates – locality of university and the dummy for non-Chinese immigrants – we produce our preferred model (10). In turn, removing the proportionally constrained interaction term again generates an equivalent BIC but a poorer-fitting model based on –2 log likelihood (model 11).

We employ the same basic modelling strategy to arrive a preferred earnings model for women that also includes both a proportionally constrained set of temporal interactions and some freely varying parameters. There is one wrinkle for the female models: we found that only a limited set of majors differed significantly from the omitted (baseline category.) We dealt with this by repeating our modelling procedure for a restricted specification of the major effects for women that included only those majors that differ statistically from the baseline category. The resulting preferred model is the same in all but specification of the dummy variables for major.

The parameter estimates for the preferred male and female models are reported in Table 5. For both men and women, our results contradict our hypothesis 6 in that the earnings payoff accruing to local degrees is higher than the payoff to degrees obtained from foreign

institutions. Contrary to our expectations, Hong Kong more closely resembles the United States in this respect: local degrees are valued more than foreign degrees (Zeng and Xie 2004). We suspect that this effect may pertain more to immigrants than to native born residents of Hong Kong. In the next phase of our research on this project, we will this explanation using suitable interactions.

[Table 5 about here]

Before turning to specialty differentials we note that university graduates who are Chinese immigrants earn less than native born Hong Kong university graduates, but this differential declined between 1996 and 2001. We can only speculate that this decline is somehow related to the accession of Hong Kong to the PRC in 1997, but it seems plausible that it would play a role. Also, note the different signs for the male and female effects of being an immigrant from a country other than China.

Table 6 reports the specialty differentials for 1991/1996 and 2001 that are implied by our preferred model. The partial proportionality constraints and significant scalar interaction terms both are consistent with increases in the magnitude of the effects of specialization but broad stability in the patterns of those effects. Thus, we find support for hypothesis 3: as the proportion of the population with higher diplomas increases, the magnitude of horizontal distinctions tends to increase as well. The departures from proportionality that we identify do not, however, confirm hypothesis 2. Only one "free" interaction term – textiles etc. for women – is consistent with a systematic change in the pattern driven by structural change in the economy. On the other hand, when we employ a summary measure of the magnitude of speciality differentials – κ (the standard deviation of the set of coefficients, initially proposed by Hout et al. 1995) – we find still more evidence of an increase, for both men and women. In sum, our findings provide considerable support for our expectation that the degree or strength of horizontal stratification grew in Hong Kong along with the supply of highly educated workers, but they do not point to systematic changes in the pattern of returns that can be meaningfully related to the new, post-industrial economy.

[Table 6 about here]

Discussion and Conclusion

The main findings from our initial analyses of the dynamics of horizontal stratification of post-secondary education in Hong Kong are as follows:

1) Over time, gender differences in specialization have increased in Hong Kong. This is in contrast to the global trend, whereby women begin to enter traditionally male fields as their university enrolments rise (Ramirez and Wotipka 2001). The departure of the Hong Kong pattern could reflect the low starting point in terms of overall enrolment rates. For the early post-war graduation cohorts, competition for slots was so intense that those who made it into universities were highly select. In such a group, gender norms plausibly played a lesser role in shaping educational choices than in the larger group of matriculants during the era of expansion.

2) Despite some exceptions, however, the pattern of gender differences by and large corresponds to patterns observed elsewhere. One exception – disproportionate female representation in math/science – reversed itself over time.

3) Specialty became a more important source of earnings differentials among both male and female university graduates in Hong Kong between 1995 and 2000.

4) We do not detect changes in the pattern of returns to different specialties that correspond systematically to changes in the economy associated with globalisation and post-industrialism. Therefore, we conclude that the increase in the magnitude of speciality effects results from the increase in the supply of university graduates in the labor market due to expansion of higher education: as job applicants with university diplomas become less scarce, employers become more discerning with respect to specialty (and, presumably, other markers related to horizontal stratification in higher education).

5) Contrary to our expectations, degrees earned in Hong Kong are worth more in terms of earnings than degrees earned abroad, other things being equal. This suggests that employers are less uncertain about standards and quality in foreign institutions. However, we suspect that this differential applies mainly to immigrants; the effect of a foreign degree might still be positive for Hong Kong natives. We will test this in the next phase of our analysis.

We will also conduct a parallel set of analyses for non-university forms of post-secondary education. In addition, we plan to examine the linkages between specialization, occupation, and sector of employment, to determine whether those linkages help explain the variations in earnings returns to different specializations.

We conclude with a caveat. Although we have been describing earnings differentials by speciality and locality of degree as "returns," we recognize that the choice of both specialty and location of study may well be endogenous to expected earnings that result from those choices. We would therefore caution against interpreting the coefficients we estimate as generalizable effects that would obtain for individuals randomly assigned to specializations and localities of study. However, our findings are nonetheless highly informative in a descriptive sense, and they do suggest that horizontal distinctions can and do increase within a relatively narrow time frame, perhaps in response to sudden changes in the supply of graduates with a particular level of education. We might expect to observe similar changes in other countries that have undergone rapid expansion of post-secondary education. We hope that the tentative theoretical ideas and analytical design we implemented here might prove useful to researchers studying the dynamics of horizontal educational stratification in other national settings.

References

Bradley, Karen. 2000. "The Incorporation of Women into Higher Education: Paradoxical Outcomes?" *Sociology of Education.* 73: 1-18.

Brown, Charles and Mary Corcoran. 1997. "Sex-Based Differences in School Content and the Male-Female Wage Gap." *Journal of Labor Economics*. 15: 431-65.

Chan, Hau-nung Annie. 2006. "The Effects of Full-Time Domestic Workers on Married Women's Economic Activity Status in Hong Kong, 1981–2001" International Sociology, 21:133-159.

Charles, Maria and Karen Bradley. 2002. "Equal but Separate? A Cross-National Study of Sex Segregation in Higher Education." *American Sociological Review*. 67:573-99.

Daymont, Thomas and Paul Andrisani. 1984. "Job Preference, College Major, and the Gender Gap in Earnings." *Journal of Human Resources.* 19: 408-28.

DiPrete, Thomas A. 1990. "Adding Covariates to Loglinear Models for the Study of Social Mobility." *American Sociological Review.* 55: 757-73.

Erikson, Robert and John H. Goldthorpe. 1992. *The Constant Flux: A Study of Class Mobility in Industrial Societies.* Oxford: Clarendon.

Fuller, Rex and Richard Schoenberger. 1991. "The Gender Salary Gap: Do Academic Achievement, Internship Experience, and College Major Make a Difference?" *Social Science Quarterly.* 72: 715-26.

Gerber, Theodore P. and Sin Yi Cheung. 2008. "Horizontal Stratification in Post-Secondary Education: Forms, Explanations, and Implications." *Annual Review of Sociology.* 34: 299-318.

Gerber, Theodore P. and David R. Schaefer. 2004. "Horizontal Stratification of Higher Education in Russia: Trends, Gender Differences, and Labor Market Outcomes." *Sociology of Education.* 77: 32-59.

Hauser, Robert M. and Megan Andrew. 2006. "Another Look at the Stratification of Educational Transitions: The Logistic Response Model with Partial Proportionality Constraints." *Sociological Methodology.* 36: 1-27.

Hout, Michael, Clem Brooks, and Jeff Manza. 1995. "The Democratic Class Struggle in the United Sates, 1948-1992." *American Sociological Review.* 60: 805-28.

Jacobs, J. A. 1995. 'Gender and Academic Specialties: Trends among Recipients of College Degrees in the 1980s' *Sociology of Education*, 68:81-98.

Jonsson, J.O. 1999. 'Explaining Sex Differences in Educational Choice: An Empirical Assessment of a Rational Choice Model', *European Sociological Review* 15: 391-404.

Joy, Lois. 2003. "Salaries of Recent Male and Female College Graduates: Educational and Labor Market Effects." *Industrial and Labor Relations Review.* 56:600-21.

Lucas, Samuel R. 2001. "Effectively Maintained Inequality: Education Transitions, Track Mobility, and Social Background Effects." *American Journal of Sociology.* 106: 1642-90.

Ramirez, Fancisco O. and Christine M. Wotipka. 2001. "Slowly but Surely? The Global Expansion of Women's Participation in Science and Engineering Fields of Study, 1972-1992." *Sociology of Education.* 10: 45-59.

Roksa, Josipa. 2005. "Double Disadvantage or Blessing in Disguise? Understanding the Relationship Between College Major and Employment Sector." *Sociology of Education.* 78: 207-32.

University Grants Committee. 2002. *Higher Education in Hong Kong, Report of the University Grants Committee.*

Wong, Raymond Sin-Kwok. 1994. "Model Selection Strategies and the Use of Association Models to Detect Group Differences." *Sociological Methods and Research.* 22: 460-91.

Wong, Timothy Man-kong. 2004. "From Expansion to Repositioning: Recent Changes in Higher Education in Hong Kong." *China: An International Journal*. 2: 150-166.

Xie, Yu. 1992. "The Log-Multiplicative Layer Effect Model for Comparing Mobility Tables." *American Sociological Review.* 57: 380-95.

Yu, Tony Fu-Lai. 1997. *Entrepreneurship and Economic Development of Hong Kong*. London: Routledge.

Zeng, Zhen and Yu Xie. 2004. "Asian-Americans' Earnings Disadvantage Reexamined: The Role of Place of Education." *American Journal of Sociology.* 109: 1075-1108.

Figure 1: Percentage of mean population of 17-20 age group provided with First Year First Degree places (FYFD) of UGC-funded Programs: Hong Kong 1965-2005

(Source: University Grants Committee, 2002, 2005)

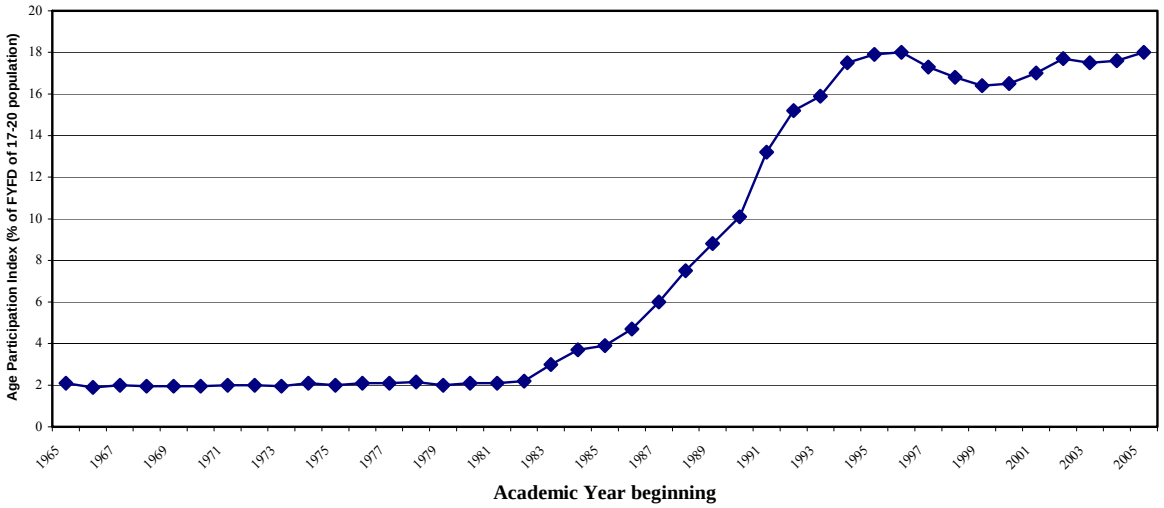

FIGURE 2. Trends in specialty, UNIVERSITY degrees, approximate graduation cohorts, WOMEN

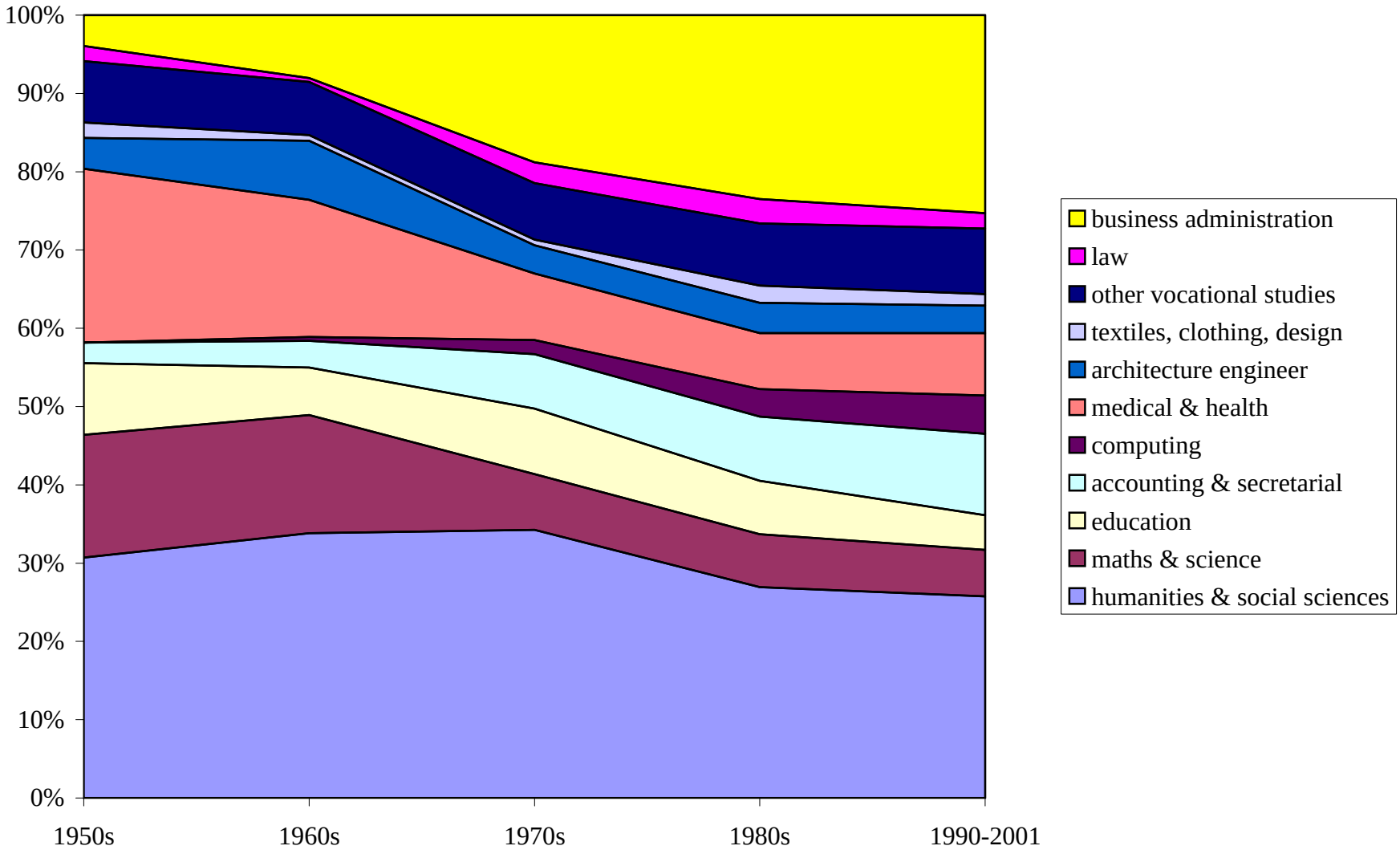

FIGURE 3Trends in specialty, UNIVERSITY degrees, approximate graduation cohorts, MEN

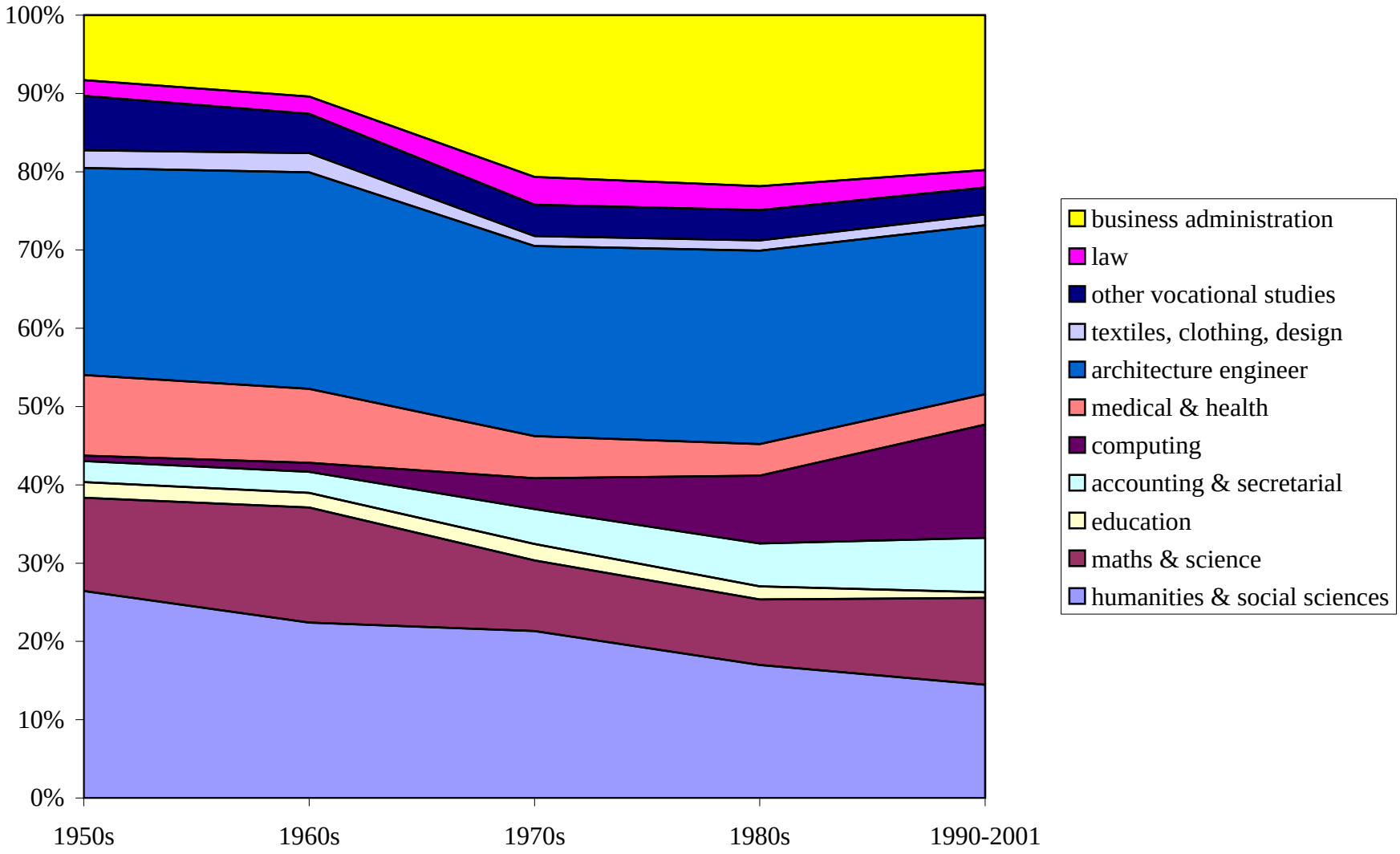

TABLE 2. Fit Statistics, Selected Log-Linear and Log-Multiplicative Models for Sex-Locality-Cohort-Major Association*

		DF	BIC	δ
1	{SLC}{M}	190	728.1	.179
2	{SLC}{SM}{LM}{CM}	130	-959.5	.049
3	{SLC}{SMC}{LM}	90	-653.4	.041
4	+ SM, full unidiff, four phis	126	-936.9	.047
5	+ SM, two phis	128	-954.8	.047
6	+ SM, one phi	129	-961.2	.048
7	+ SM, linearly constrained phis	129	-963.3	.047
8	+ partial unidiff (four phis), with two freely varying SM parameters	117	-878.7	.044
9	+ partial unidiff (two phis), with two freely varying SM parameters	119	-895.9	.044
10	+ partial unidiff (one phi), with two freely varying SM parameters	120	-903.8	.044
11	+ no phis, with two freely varying SM parameters	121	-906.8	.045
12	+ partial unidiff (linearly constrained), with two freely varying SM parameters	120	-904.5	.044
13	+ partial unidiff (one phi), with two linearly varying SM parameters	128	-975.7	.045
14	**+ partial unidiff (linearly constrained), with two linearly varying SM parameters**	**128**	**-977.0**	**.045**
15	+ no phis, with two linearly varying SM parameters	129	-979.4	.046

*See text for more detailed explication of different models.

TABLE 3. Implied Log-linear parameters for Gender/Specialty Interaction, Five Estimated Graduation Cohorts

	1950s	*1960s*	*1970s*	*1980s*	*1990s*
Humanities & social sciences	-.493	-.493	-.566	-.566	-.638
Maths & science	-.483	-.241	.000	.241	.483
Education	-1.327	-1.327	-1.522	-1.522	-1.717
Accounting & secretarial	-.387	-.387	-.444	-.444	-.501
Computing	.782	.782	.897	.897	1.012
Medical & health	-.622	-.622	-.713	-.713	-.805
Architecture & engineering	1.427	1.427	1.636	1.636	1.846
Textiles, clothing, design	-.163	-.163	-.188	-.188	-.212
Other vocational studies	-.671	-.671	-.769	-.769	-.868
Law	.075	.075	.086	.086	.097
Business administration	.302	.151	.000	-.151	-.302

Note: These are local male/female logged odds ratios implied by the preferred model.

TABLE 4
Fit statistics, selected regression models for earnings, estimated using maximum likelihood

MEN

Model	Description	LL	-2*LL	DF	Contrast model	Chi vs. contrast	BIC
1	Constant only	-7094.32	14188.6	0			
2	Additive effects only	-5902.29	11804.6	17	1	.000	-2237
3	S_pc*Pre-01	-5898.31	11796.6	18	2	.005	-2236
4	S*Pre-01	-5874.19	11748.4	27	2	.000	-2207
5	Cov*Pre-01	-5884.6	11769.2	21	2	.000	-2238
6	Cov*Pre-01, S_pc*Pre-01	-5880.3	11760.6	22	5	.003	-2238
7	S*Pre-01, Cov*Pre-01	-5857.88	11715.8	31	5	.000	-2205
8	Cov*Pre-01, S_pc*Pre-01, S3*P	-5872.47	11744.9	23	6	.000	-2245
9	Cov*Pre-01, S3*Pre-01	-5877.91	11755.8	22	8	.001	-2243
10	**8 - Pre-01*(local+immoth)**	**-5873.01**	**11746**	**21**	**8**	**.580**	**-2261**
11	10 without S_pc*Pre-01	-5878.41	11756.8	20	10	.001	-2259

WOMEN

Full set of specialty dummies

Model	Description	LL	-2*LL	DF	Contrast model	Chi vs. contrast	BIC
1	Constant only	-5014.82	10029.6	0			
2	Additive effects only	-4183.86	8367.72	17	1	.000	-1522
3	S_pc*Pre-01	-4183.65	8367.29	18	2	.516	-1514
4	S*Pre-01	-4174.79	8349.58	27	2	.053	-1457
5	Cov*Pre-01	-4163.16	8326.33	21	2	.000	-1530
6	Cov*Pre-01, S_pc*Pre-01	-4162.97	8325.93	22	5	.531	-1522
7	S*Pre-01, Cov*Pre-01	-4154.57	8309.15	31	5	.071	-1465
8	5 + S2*Pre-01, S8*Pre-01	-4157.8	8315.6	23	5	.001	-1524
9	**8 without two nsf cov**	**-4159.98**	**8319.96**	**21**	**5**	**.113**	**-1537**

Limited set of specialty dummies

Model	Description	LL	-2*LL	DF	Contrast model	Chi vs. contrast	BIC
1	Constant only	-5014.82	10029.6	0			
2	Additive effects only	-4185	8370	12	1	.000	-1561
3	S_pc*Pre-01	-4184.88	8369.76	13	2	.624	-1553
4	S*Pre-01	-4179.76	8359.52	17	2	.063	-1530
5	Cov*Pre-01	-4164.54	8329.09	16	2	.000	-1569
6	Cov*Pre-01, S_pc*Pre-01	-4164.43	8328.85	17	5	.628	-1561
7	S*Pre-01, Cov*Pre-01	-4159.17	8318.35	21	5	.057	-1538
8	5 + S2*Pre-01, S8*Pre-01	-4159.27	8318.54	18	5	.005	-1563
9	**8 without two nsf cov**	**-4161.34**	**8322.69**	**16**	**5**	**.126**	**-1575**

TABLE 5
Maximum Likelihood Parameter Estimates, Preferred Regression Models for Logged Earnings

	Men		*Women*	
	B	**SE**	**B**	**SE**
Constant	9.139 **	.047	9.328 **	.043
Year=1991	.044	.044	.052	.049
Year=1996	.116 **	.041	.080 *	.041
Age(-22)	.120 **	.003	.082 **	.004
Age(-22) squared	-.003 **	.000	-.002 **	.000
Immigrant from China	-.312 **	.037	-.186 **	.049
Immigrant from elsewhere	.248 **	.028	-.971 **	.033
Local university degree	.071 **	.021	.186 **	.029
Specialty (Humanities/Social Sciences)				
maths & science	.073	.046	-.230 **	.070
education	.286 **	.104		
accounting & secretarial	.163 **	.055	-.125 **	.042
computing	.130 **	.048		
medical & health	.678 **	.076		
architecture & engineering	.161 **	.036		
textiles, clothing, design	-.184 *	.100	-.392 **	.146
other vocational studies	-.016	.063	-.096 **	.044
law	.644 **	.076	.891 **	.079
business administration	.209 **	.038		
Specialty multiplier for Pre-2001	-.388 **	.094		
Standard interaction terms:				
Age(-22)*Pre-2001	-.008 **	.002	-.009 **	.003
Chinese immigrant*Pre-2001	-.118 **	.048	-.287 **	.069
Education*Pre-2001	-.491 **	.124		
Math&science*pre-2001			.221 **	.094
Textiles, etc.*pre-2001			.439 **	.191
Log-likelihood	-5873		-4161	
DF	21		16	
N	5673		3809	

TABLE 6
Implied Specialty Coefficients by Gender and Year, Preferred Regression Models

	MEN		*WOMEN*	
	1991	**2001**	**1991**	**2001**
Humanities & social sciences	.000	.000	.000	.000
Maths & science	.045	.073	-.009	-.230
Education	-.316	.286	.000	.000
Accounting & secretarial	.100	.163	-.125	-.125
Computing	.080	.130	.000	.000
Medical & health	.415	.678	.000	.000
Architecture & engineering	.099	.161	.000	.000
Textiles, clothing, design	-.113	-.184	.047	-.392
Other vocational studies	-.010	-.016	-.096	-.096
Law	.395	.644	.891	.891
Business administration	.128	.209	.000	.000
Kappa	.206	.263	.278	.320