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HUMAN CAPITAL CREATION IN AN ECONOMIC PERSPECTIVE

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FOREWORD

The Research Institute of the Finnish Economy ETLA arranged a Nordic seminar on *Human Capital Creation in an Economic Perspective* in May of this year.

This topic is of the utmost importance, not least in times of deep economic recession. Periods of economic slowdown and rapidly increasing unemployment tend to increase the demand especially for longer education and training. This brings up, in turn, questions regarding overeducation and satisfying both private and social returns on investments in human capital.

The ongoing recession in combination with falling tax revenues has forced economies with large public sectors to decide on cutbacks and reallocations of educational expenses. But at the same time it may be questioned whether it is reasonable to undertake far-reaching measures in order to improve the efficiency in education without having reliable information on the real-world macro- and microeconomic effects of the vast resources annually expended on education and training.

The main purpose of the seminar was to shed as much light as possible on the economic role of investment in human capital at the individual, firm and macroeconomic level. Researchers, mainly from the Nordic countires, were therefore invited to present theoretical and empirical results from their ongoing research projects in these fields. Two "keynote speakers" were also invited, viz. Prof. Lisa Lynch from M.I.T. and Prof. John Bishop from Cornell University.

The speeches given at the seminar spurred lively discussions and have, hopefully, also stimulated the research on the important topic of human capital both within and across the Nordic countries. We therefore consider it worthwhile to make the speeches available to a broader audience by publishing them in this seminar report along with the seminar program and the list of participants. The speech by Karl-Gustaf Löfgren will be published later on as a separate discussion paper in this same series.

Helsinki, 7 October 1992

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HUMAN CAPITAL CREATION IN AN ECONOMIC PERSPECTIVE*

Helsinki, 14-15. May, 1992

SEMINAR PROGRAM

Thursday 14 May 1992

Session 1: **Human Capital and Individual Earnings**

John H. Bishop (Cornell University):

Schooling, Learning and Worker Productivity

Rita Asplund (ETLA), Erling Barth (ISF, Oslo), Carl le Grand (Stockholm University), Arne Mastekaasa (ISF, Oslo), Niels Westergård-Nielsen (Aarhus School of Business):

Wage Differentials in the Nordic Countries

Anders Björklund (Stockholm University):

The Impact of Family Background on the Returns to and Length of Schooling in Sweden

Kristin Dale (SNF, Bergen):

Regional and Occupational Wage Differences in Norway

*Financial support from the Ministry of Education and the Yrjö

Friday 15 May 1992

Session 2: **Competence Building in the Labour Market**

Lisa Lynch (M.I.T.):

Workplace Skill Accumulation and its Impact on Earnings and Labor Mobility

Leenamaija Otala (Educational Consultant, Oberursel):

Trends in European Lifelong Learning

Karl-Gustaf Löfgren (Umeå University):

Cost-benefit Analysis of Manpower Training in Sweden

Hege Torp (ISF, Oslo):

Back to Work? Employment Effects of Labour Market Training Programmes

Session 3: **Human Capital and Economic Performance**

Gérard Ballot (E.R.M.E.S., Paris):

Continuing Education and Schumpeterian Competition: Elements for a Theorethical Framework

Gunnar Eliasson (IUI, Stockholm):

Education, Competence Development and Economic Growth - A Micro Explanation to Macro Economic Growth

Kim Huynh & Marie-Pierre Merlateau (E.R.M.E.S., Paris):

Human Capital, Specialization and Growth

Draft

SCHOOLING, LEARNING AND WORKER PRODUCTIVITY

John Bishop
Cornell University
Working Paper #

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SCHOOLING, LEARNING AND WORKER PRODUCTIVITY

"Knowledge and Human Power are Synonymous"
--Francis Bacon

Concern about slackening productivity growth and deteriorating competitiveness has in many countries resulted in a new focus on the skills and education of frontline workers. The introduction of Lean Production and Total-Quality-Management is apparently raising the cognitive demands placed on blue collar workers (Womack, Jones and Roos, 1991). Increasingly they are working in production cells in which every member of the team is expected to learn every job and to take on responsibilities formerly the sole province of supervisors, specialized technicians and industrial engineers. Higher order thinking and problem solving skills are believed to be in particularly short supply so much attention has been given to mathematics and science education because it is thought that these subjects are particularly relevant to their development (Secretary's Commission on Achieving Necessary Skills 1991).

The debate has been enlivened by the availability of comparative data on mathematics and science achievement of representative samples of secondary school students from many industrialized nations. At age 13 the mathematical achievement of Finnish students (48.4 percent correct on the SIMS test) is roughly equal to England and Scotland, slightly ahead of the New Zealand and the United States (46.2 percent) and substantially below France (53.6 percent), Belgium (52.8 percent), Netherlands (58 percent), and Japan (63.6 percent). Swedish students got only 43.4 percent of the questions correct and rank below all of the industrialized nations with the exception of Luxembourg.

By the end of secondary school, however, the Finnish and Swedish students who are taking advanced mathematics courses intended to prepare for university education were substantially ahead of university bound students in Scotland, Belgium, and Canada and the United States. This group represented 13 percent of the age cohort in the US, 12 percent in Japan and Sweden, 15 percent in Finland and the 50 percent in Hungary. Figure 1 plots the percent correct on the Algebra section of the Second International Mathematics Study against proportion of the 18-year old population in the types of courses to which the international test was administered. Finnish students achieved the second highest mean score: 69 percent correct. Sweden's 60 percent correct was in the middle of the pack; half way between the Japanese mean of 78 percent correct and the US mean of 43 percent correct (McKnight et al 1987).

The findings of the Second International Science Study place Finland, Norway and Sweden in the middle of the pack and the US at the bottom. For 15 year olds, the percent correct on the general science test was 72 for Hungary, 67 for Japan, 62 for Finland, 61 for Sweden, 60 for Norway and 55 for the US. Only a small share of an age cohort typically takes advanced science courses in the final year of secondary school. The IAEEA data suggests that the Finnish percentages--14 percent in physics, 16 percent in chemistry and 42 percent in biology--are higher than most other countries. Swedish percentages were 5 percent in biology and 13 percent in chemistry and physics. Norwegian percentages were 10 percent in physics, 6 percent in chemistry and 4 percent in biology. Clearly, large numbers of Scandinavian students take rigorous science courses in secondary school.

Normally, countries with large proportions of the age cohort in advanced courses have lower mean scores. Finnish and Swedish scores are below the grand mean primarily for this reason. The exceptions to this generalization are the standout performance of Finland in biology and of Hong Kong in chemistry and physics and the dismal performance of the very select samples (1 to 2 percent of the age cohort in chemistry and physics) in America. The 6 percent of American 17-18 year olds who were taking their second biology course knew considerably less than much less selective groups of students in Europe, Canada and Asia (Postlethwaite and Wiley 1992).

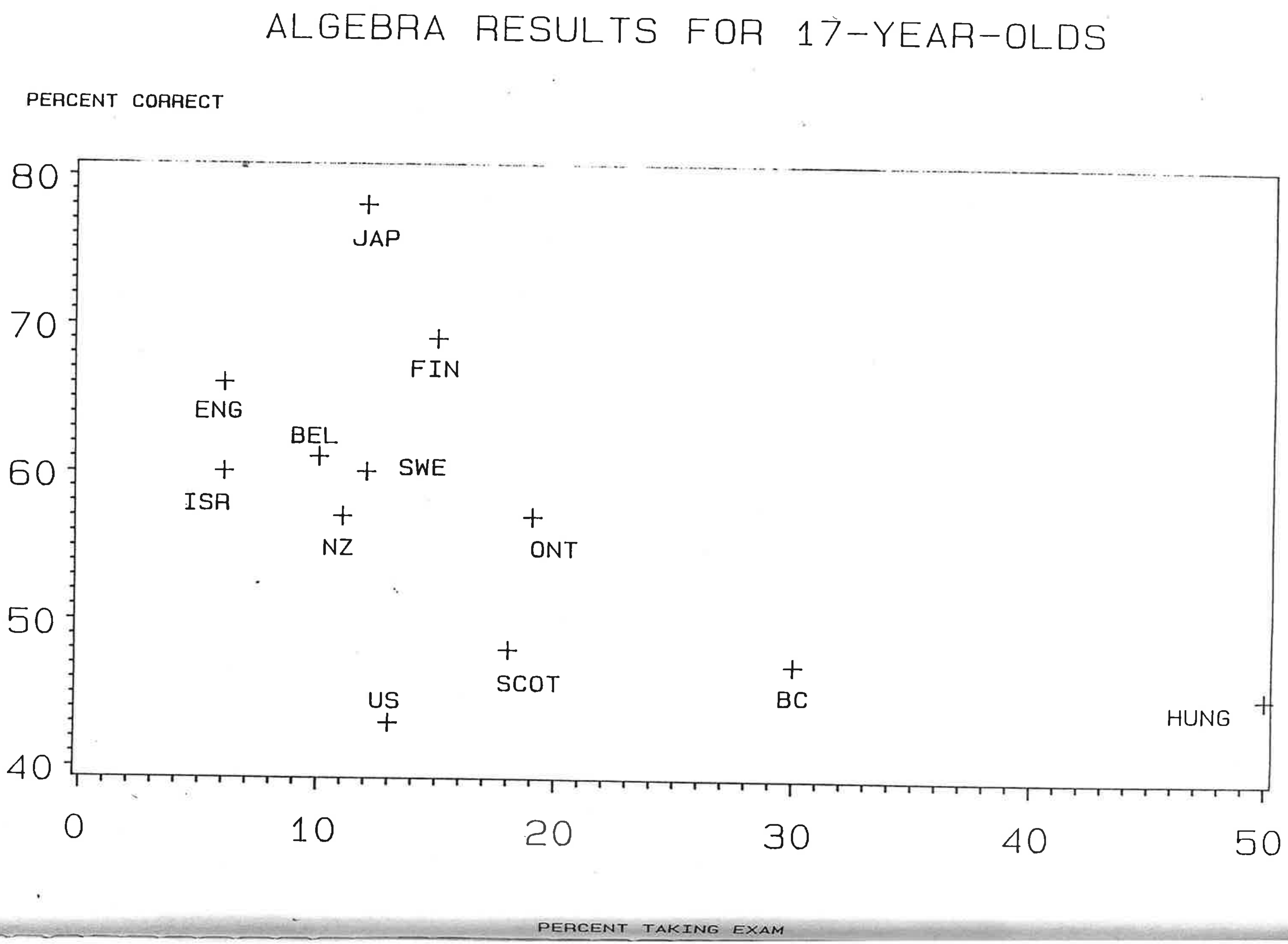
Clearly, there are large gaps between the science and math competence of young people from different nations. Do such gaps have major consequences for a nation's standard of living? In the view of many, it does:

> Learning is the indispensable investment required for success in the "information age" we are entering. (National Commission on Excellence in Education, 1983, p. 7).

Behind their call for higher standards and more class time devoted to math and science is an assumption that most jobs require significant competency in these fields. There is, however, some controversy about these claims. Morris Shamos, an emeritus professor of physics at New York University, argues, for example, that "widespread scientific literacy is <u>not</u> essential to... prepare people for an increasingly technological society"(Education Week, Nov. 23 1988. p. 28). Other commentators have questioned the relevance of algebra and geometry to the great majority of jobs that do not require technical training. It has been argued, for example, that since the great majority of employers do not currently use the new management techniques that are supposed to require a high skill work force, preparing young people for working in high performance work systems will make them unfitted for the boring and repetitive jobs that are assumed to predominate in the labor market. This paper examines whether evidence from the labor market supports the claims that schooling and academic achievement improve worker productivity and that the impacts of schooling and achievement have increased during the 1980s. It attempts to answer two questions:

* What would be the benefits of a front line work force that was much better

FIGURE 1


ALGEBRA RESULTS FOR 17-YEAR-OLDS
PERCENT CORRECT
80
70
60
50
40
JAP
FIN
ENG
BEL
SWE
ISR
NZ
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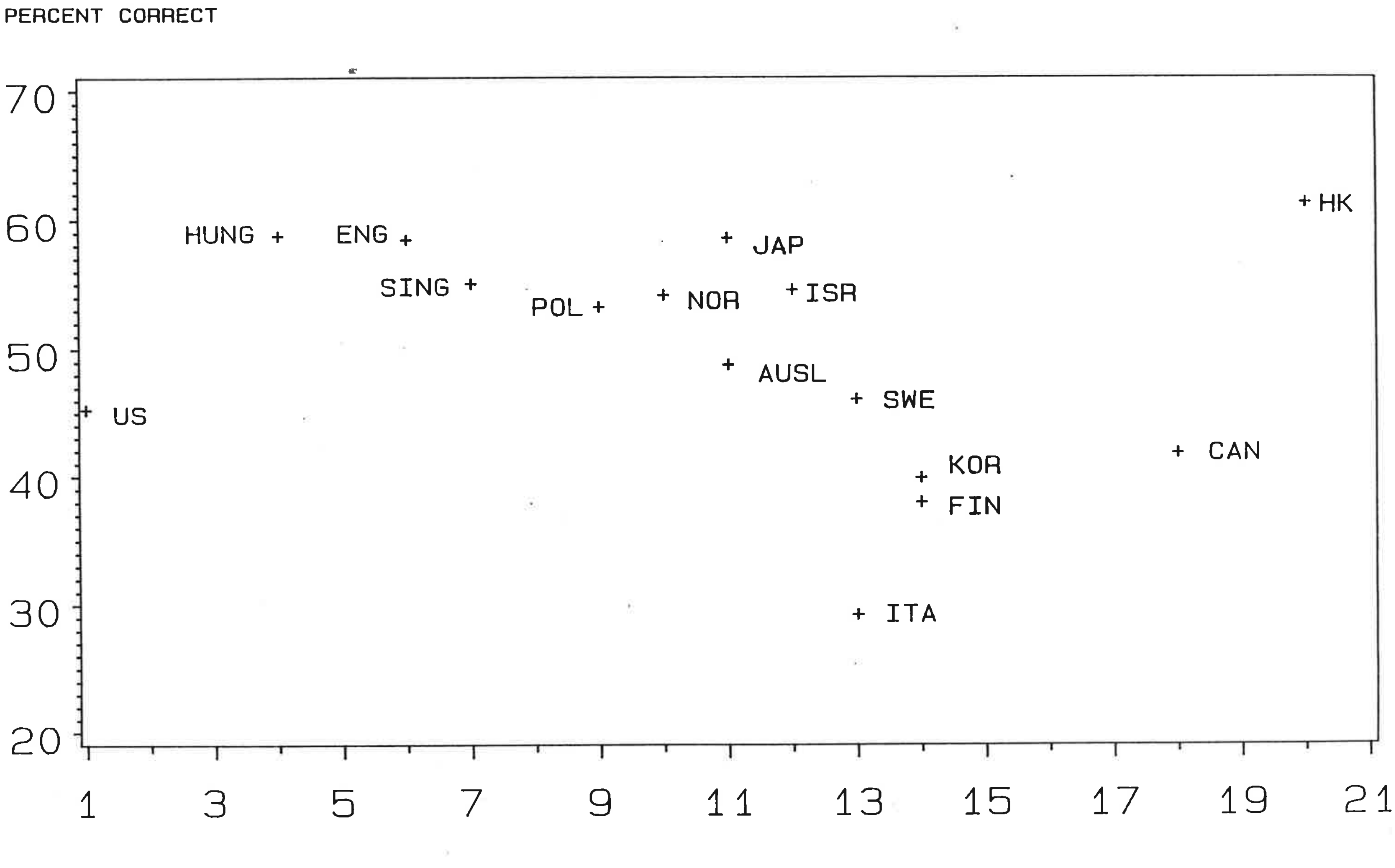
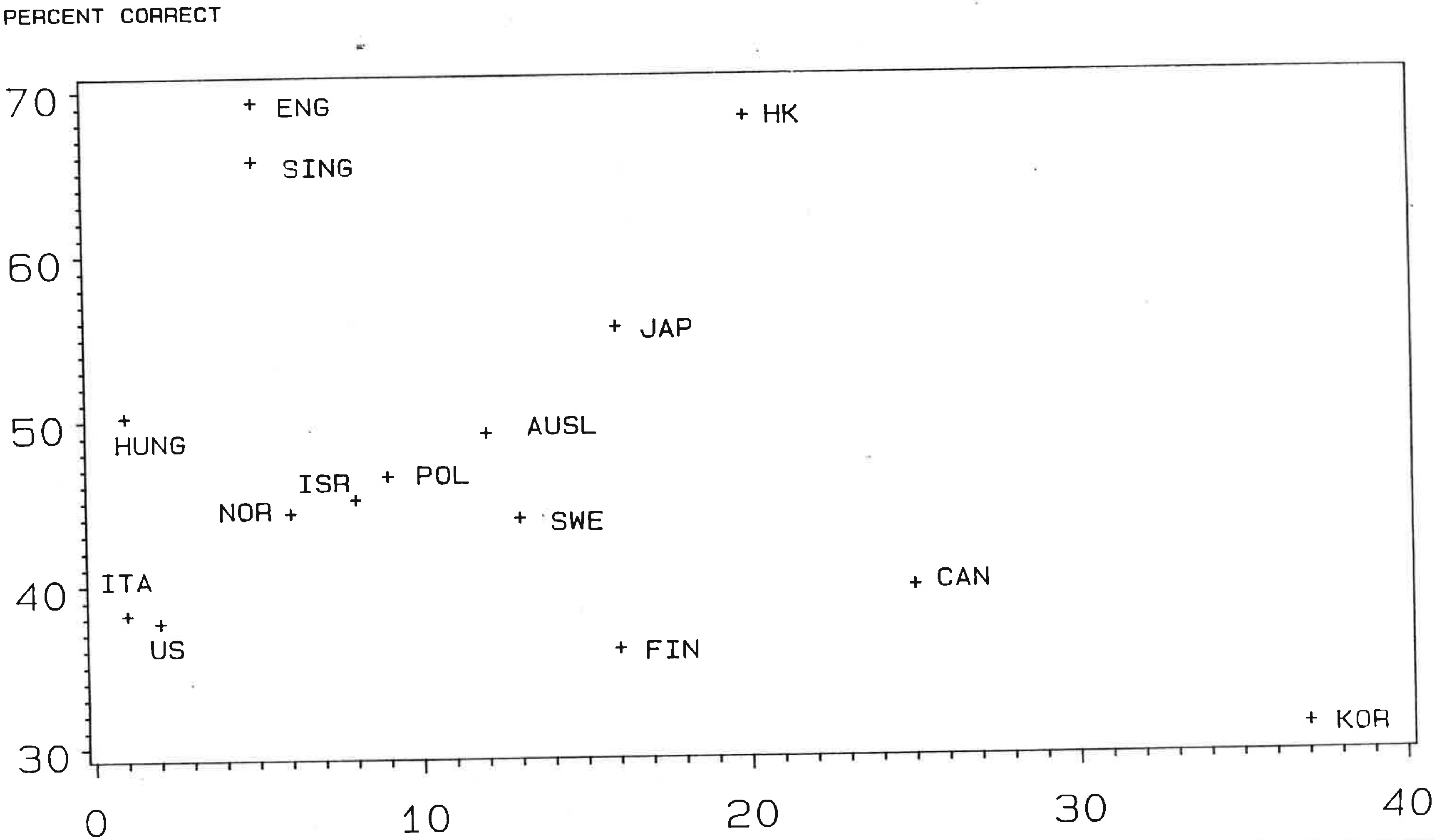
PERCENT TAKING EXAM

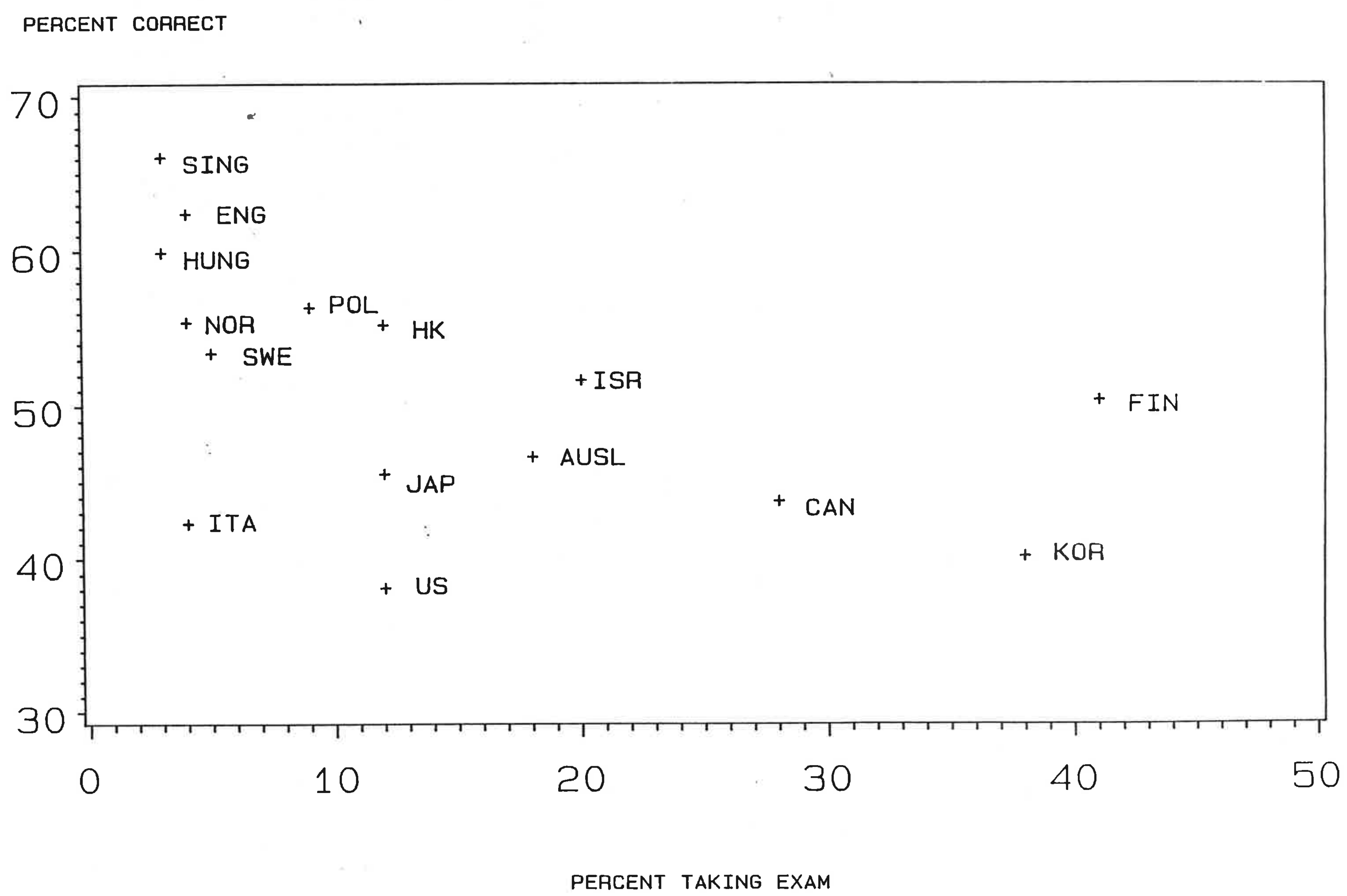
PHYSICS RESULTS FOR 18-YEAR-OLDS



CHEMISTRY RESULTS FOR 18-YEAR-OLDS



BIOLOGY RESULTS FOR 18-YEAR-OLDS



prepared in mathematics and science if current jobs remained essentially unchanged?

* Is the occupational distribution of jobs changing in ways that increase the need for rigorous study of math and science in secondary school?

The paper has two parts. Part I examines the effects of academic competencies on productivity in traditional mass production settings. The jobs studied are not located in high involvement/lean production work systems and are occupied almost entirely by workers who have not graduated from college. Part II analyzes trends in occupational composition of employment, in supplies of highly skilled workers and in the payoff to skill.

I. THE IMPACT OF ACADEMIC COMPETENCIES ON WORKER PRODUCTIVITY IN CURRENT JOBS

The standard way of assessing the impact of a worker trait on productivity is to infer its effect by studying its effect on wage rates. That is what is attempted in section 1.1, 1.2 and 1.3.

Section 1.1 and 1.2 presents evidence that the effect of generalized academic competence on the wage rates of adults is substantial and reflects a causal relationship.

Section 1.3 examines the impact of the specific academic competencies on the wage rates and earnings of young workers in the United States. The surprising finding, here, is that competence in mathematical reasoning, science and language arts has almost no effect on wage rates during the first 8 years after graduating from high school. These results suggest an immediate explanation for the poor performance of American students in science and higher level mathematics--the absence of significant rewards for the competencies. They appear, however, to provide only very weak support for the Excellence Commission's recommendations.

The reports recommending educational reform, however, make claims about the **productivity** effects not the **wage rate** effects of science, mathematics and language arts competency. Are these effects necessarily the same? This question is addressed in section 1.4. It is concluded that, when the specific competencies of students are not signaled to the labor market by a credential (as is the case for math and science achievement in US high schools), there is very little reason to expect the wage rate effects of specific competencies which are highly correlated with each other to be the same as their productivity effects.

Sections 1.5 and 1.6 of the paper, therefore, tackle the productivity effects question more directly by analyzing data sets in which worker competencies have been correlated with their relative job performance in specific jobs. These analyses provide support for recommendations for better preparation in math and science, but they also reinforce the findings from the analysis of wage rates, earnings and unemployment regarding the important role of technical competence in blue collar, craft and technician jobs.

1.1 The Effect of General Academic Achievement on Wages of Adults

We will examine the effect of overall academic achievement on wage rates by predicting adult wage rates as a function of a contemporaneous measure of general academic achievement while controlling for schooling and other worker characteristics such as work experience. It is essential that the sample be representative of the nation and that academic achievement be measured long after the completion of schooling and as close as possible to the date of the wage rate observation. The difficulty, however, is that reliable academic achievement tests are time consuming and costly to administer. Consequently, data sets which measure both adult academic achievement and earnings for national probability samples are rare. There is only one American data set with these characteristics, the Panel Study of Income Dynamics. Unfortunately, the measure of academic achievement available in the survey is a short form IQ test with 13 sentence completion questions (taken from the Lorge-Thorndike intelligence test) which has a KR-20 reliability of only .652. If not corrected for, measurement error will seriously attenuate estimated relationships between wage rates and such a short form IQ test.

Consequently, the true impact of general academic achievement (GAA) and years of schooling on wage rates must be estimated as part of a system of equations that includes a measurement model for academic achievement, years of schooling (SCH) and family background.[1] When such a model is estimated, the true effect of general academic achievement is calculated to be a 20.9 percent increase in earnings per population standard deviation change/difference in achievement. These results suggest that if the GAA of people with given levels of schooling either changes over historical time or differs across societies, these differences need to be explicitly included in any accounting of differences in labor quality across space or time.

1.2 Are Regression Estimates of The Economic Payoff to Knowledge and Skill Biased?

Will, however, improvements in performance on such tests resulting from a more rigorous, higher quality education have a similar effect on productivity? The absence of controls for the individual's genetic endowment in the above analysis might mean that the 20.9 percent effect is an upward biased estimate of the true causal impact of test score gains generated by higher quality education. There are a number of reasons for believing that if such bias exists, it is small. First, while genetic endowment has probably influenced schooling and academic achievement as an adult, it appears to have no direct effect on wages in this data set, for adding the three background variables--father's education, father's occupation and number of siblings--with the highest correlation with genetic endowment did not decrease the coefficient on academic achievement. It was the addition of Born on a Farm and Father Foreign Born which lowered the coefficient on academic achievement. Secondly, controlling for family background and genetic endowment by estimating within family models comparing brothers actually increases the effect of academic ability relative to cross section regressions of earnings on education and childhood IQ in Michael Olneck's (1977) Kalamazoo data.

The test used to characterize general academic achievement in this analysis purports to be an "aptitude" test. But, verbal and mathematical aptitude tests correlate almost as highly with broad spectrum achievement tests as alternate forms of the same test correlate with each other.[2] Numerous studies have found that school attendance raises scores on these aptitude tests (Lorge 1945; Husen 1951; Department of Labor 1970), and that taking a rigorous college prep curriculum increases the gains on these tests between sophomore and senior years of high school (Bishop 1985; Hotchkiss 1984). In recognition of the fact that aptitude test scores are significantly influenced by educational background, the College Board describes the SAT as a measure of "developed verbal and mathematical reasoning abilities (1987; p. 3)."

Adult vs Childhood GAA Tests: The final piece of evidence on this issue comes from examining the results of estimations where adult GAA tests compete with childhood IQ tests in predicting adult labor market success. It is sometimes argued that aptitude tests like the Lorge-Thorndike test really measure a stable "ability to learn" which is not substantially effected by educational experiences after the age of 10, and that it is this "ability to learn" not the content of the courses taken in secondary and tertiary education which helps workers who score well on these tests to get better, higher paying jobs. If this were true, we would expect childhood IQ tests to predict adult labor market success just as well as GAA tests taken as a young adult. In fact, however, when the two tests are simultaneously entered into a model, it is the adult test not the childhood test which has by far the biggest effect on labor market success (Husen, 1969). Evidence for this statement can be found in Tables 1 to 3. American data from the National Longitudinal Study of Youth (NLSY) was analyzed to determine whether 1985 wages and earnings were more influenced by a test taken in 1980 (the Armed Services Vocational Aptitude Battery) or by aptitude tests taken in the early 1970s. The results reported in Table 1 clearly imply that the later test had by far the most significant effect, implying that the learning that occurred during the interval between test administrations had a substantial impact on subsequent labor market outcomes.

Tuijnman's (1989) analysis of occupational attainment in the Malmo

Longitudinal Study is reproduced in Table 2. The path coefficients on the test taken at age 20 has significant positive effects on occupational status, while the childhood test often has a negative effects when the adult test is included in the model. Table 3 reports the results from a similar model predicting earnings rather than occupation.[3] The estimated effect of the IQ tests on earnings in the Malmo data is much smaller than the effects obtained in NLSY data. This might reflect the general compression of wage differentials in Sweden, the inclusion of technical competence and speed of numerical computation in the ASVAB test battery, or possibly a shift over time in the relative importance of the competencies assessed by these tests. But, here again, the adult test has much stronger effects on earnings than the childhood test.

These findings suggest that the associations between scores on employment aptitude and IQ tests, on the one hand, and productivity and labor market success, on the other, arise because the tests measure developed abilities that contribute to productivity. This suggests that an increase in the incidence of these developed abilities in the working population will increase national output. Left unresolved, however, is the relative importance of different types of developed abilities. It is to this issue I now turn.

1.3 Which Competencies are Rewarded in the American Labor Market ?

Which of the various subjects typically taught in secondary schools yield the largest economic return? This issue will be first addressed by estimating models predicting wage rates and earnings of young adults in the U.S. as a function of competence in the academic fields of mathematics, science and language arts and in the trade/technical arena while controlling for years of schooling, school attendance, ethnicity, age, work experience, marital status and characteristics of the local labor market.

The Data

The Youth Cohort of National Longitudinal Survey (NLSY) is a good data base for analyzing this issue because it contains subtest scores on the Armed Services Vocational Aptitude Battery (ASVAB), a three hour battery of tests used by the armed forces for selecting recruits and assigning them to occupational specialties. The primary purpose of the ASVAB is to predict the success of new recruits in training and their subsequent performance in their occupational specialty.[4] Even though the ASVAB was developed as an "aptitude" test, the current view of testing professionals is that:

> Achievement and aptitude tests are not fundamentally different....Tests at one end of the aptitude-achievement continuum

can be distinguished from tests at the other end primarily in terms of purpose. For example, a test for mechanical aptitude would be included in a battery of tests for selecting among applicants for pilot training since knowledge of mechanical principles has been found to be related to success in flying. A similar test would be given at the end of a course in mechanics as an achievement test intended to measure what was learned in the course (National Academy of Sciences Committee on Ability Testing 1982 p.27)."

The ASVAB test battery is made up of 10 subtests: Mechanical Comprehension, Auto and Shop Knowledge, Electronics Knowledge, Clerical Checking (Coding Speed), Numerical Operations (a speeded test of simple arithmetic), Arithmetic Reasoning, Mathematics Knowledge (covering the high school math curriculum), General Science, Word Knowledge and Paragraph Comprehension. (See Bishop 1990 for sample questions.)

Two dimensions of mathematical achievement are measured: the speed of doing simple mathematical computations is measured by a three minute 50 problem arithmetic computation subtest which will be referred to as computational speed. Mathematical reasoning ability is measured by a composite of the mathematics knowledge and arithmetic reasoning subtests. Science achievement is indexed by the ASVAB's General Science subtest. This test focuses on science definitions and has minimal coverage of higher level scientific reasoning. Verbal achievement is measured by a composite made up of the word knowledge and paragraph comprehension subtests.

The universe of skills and knowledge sampled by the mechanical comprehension, auto and shop information and electronics subtests of the ASVAB roughly corresponds to the vocational fields of trades and industry and technical so these subtests are aggregated into a single composite which is interpreted as an indicator of competence in the "technical" arena.[5]

Competencies that are unique to clerical and retail sales jobs do not appear to be measured by the ASVAB. The ASVAB does contain a seven minute 84 item clerical checking subtest which was intended to predict performance in clerical jobs but validity studies of clerical jobs in the military have found that it does not add to the validity of composites based on verbal, arithmetic reasoning and mathematics knowledge subtests (Wise, McHenry, Rossmeissl and Oppler, 1987). The clerical checking subtest is included in the analysis but it should not be viewed as a valid predictor of clerical competency. These seven test composites have all been normalized to have zero mean and unit variance.[6]

All of these competencies are highly correlated with years of schooling. When these composites are regressed on age, ethnicity, proportion of 1980 spent in school, region, work experience, occupation of parents and schooling, the coefficients on years of high school range between .19 for math and .28 for verbal for males and range from .12 for technical and .24 for verbal and clerical speed for females. Greater work experience significantly increased the clerical speed of women but did not have positive effects on any of the other competencies.

Results

Two measures of labor market success were studied: the log of the hourly wage rate in the current or most recent job taken from the 1983 through 1986 interviews and the log was limited to those who were not in the military in 1979. At the time of the 1986 interview the NLS Youth ranged from 21 to 28 years of age. An extensive set of controls was included in the estimating equations.[7]

The labor market consequences of the competencies that a young person develops early in life were examined by regressing log wage rates and log earnings on ASVAB subtest scores, years of schooling, and the background variables listed above. Holding academic competencies in 1980 constant, female high school dropouts with 10 years of schooling earned 10 percent less than high school graduates and college graduates earned 42 percent more. Male high school drop outs earned 21 percent less than high school graduates and college graduates earned 35 percent more. The effects of our measures of academic and technical achievement are summarized in Figures 5 and 6 (see Bishop 1988 for a more complete description of the results).

The results for young men were as follows--high level academic competencies do not have positive effects on wage rates and earnings. The mathematics reasoning, verbal and science composites all had negative effects on wage rates and earnings. Speed in arithmetic computation has substantial positive effects on labor market success of young men. This competency, however, is a lower order skill that is not (and should not be) a focus of high school mathematics (National Council of Teachers of Mathematics 1980).

For young women, speed in arithmetic computation and mathematical reasoning ability both have substantial effects on wage rates and earnings. Verbal competence had somewhat more modest positive effects on wages and earnings. Science test scores had no effect on wage rates and earnings.

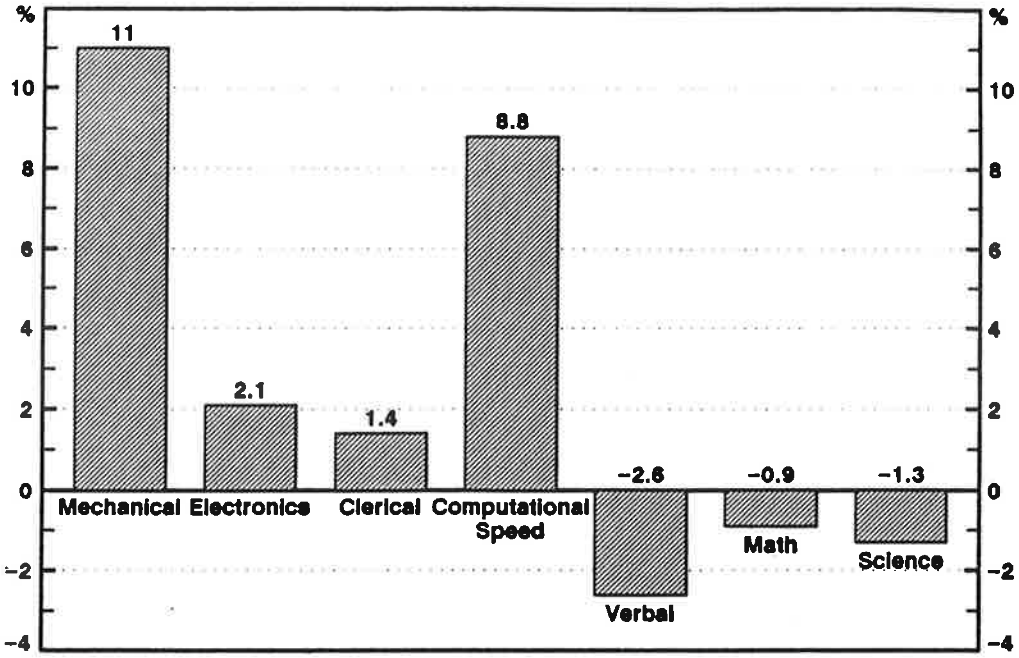
For young men, the ASVAB technical subtests measuring electronics knowledge and mechanical, auto and shop information had large and significant positive effects on wage rates and earnings. These subtests had essentially no effect on the labor market success of young women.

The clerical checking subtest had weak positive effects on wage rates of young women and large significant effects on their earnings. For young men, doing well on the clerical checking subtest appears to increase earnings very modestly but it has no effect on wage rates.

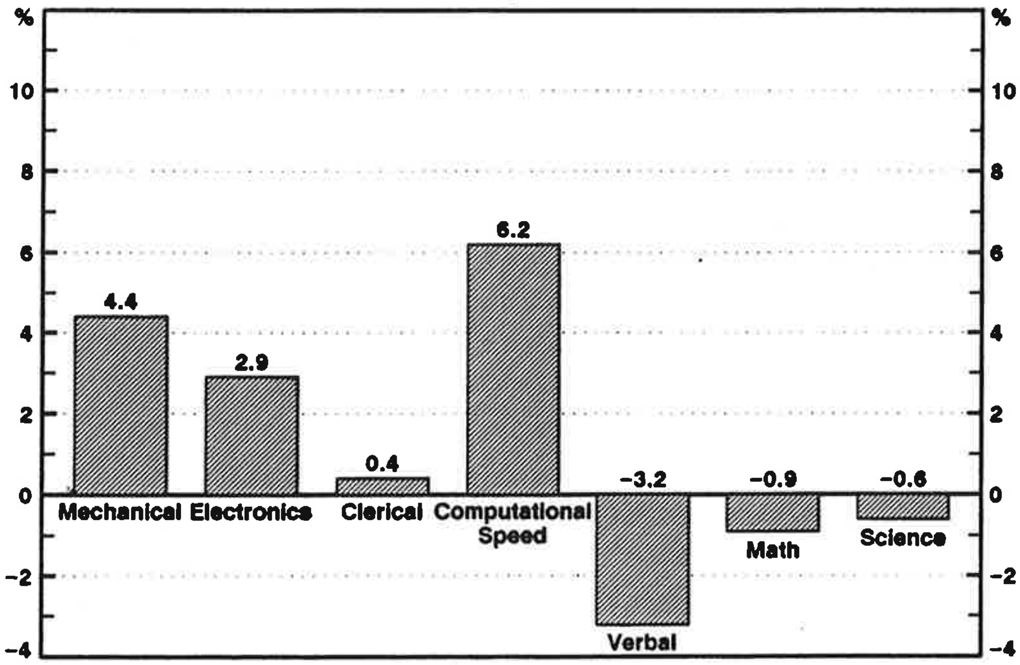
This pattern of results is not unique to this data set. Similar results were obtained in Willis and Rosen's (1979) analysis of the earnings of those who chose not to attend college in the NBER-Thorndike data, Kang and Bishop's (1986)

Figure 5

Effect of Competencies
on Earnings, 1984-1985
Young Men

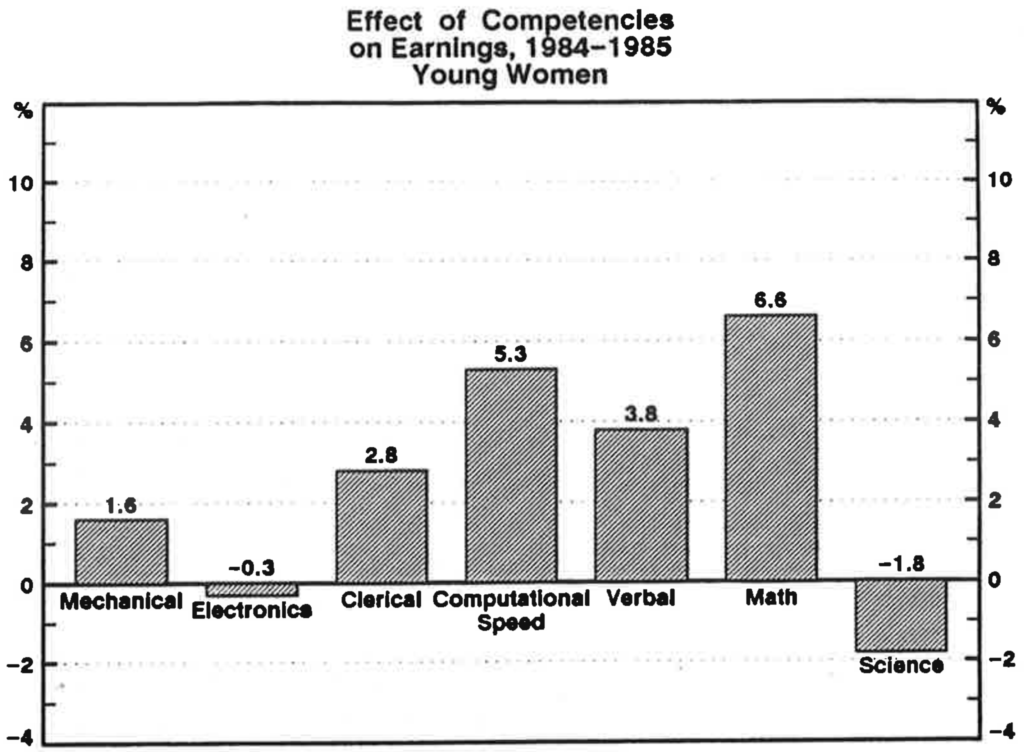


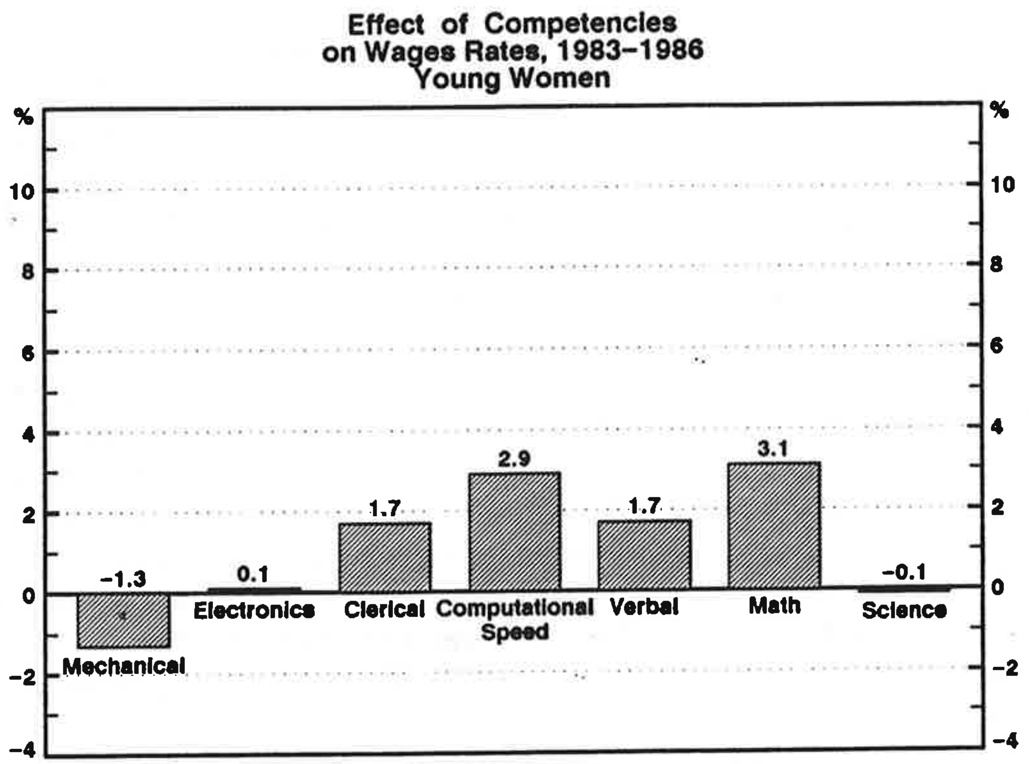
Effect of Competencies
on Wages Rates, 1983-1986
Young Men



Source: Analysis of NLS Youth data. The figure reports the effect of a one population standard deviation increase in Armed Services Vocational Aptitude Battery subtest while controlling for schooling, school attendance, age, work experience, region, SMSA residence and ethnicity.

Figure 6





Source: Analysis of NLS Youth data. The figure reports the effect of a one population standard deviation increase in Armed Services Vocational Aptitude Battery subtest while controlling for schooling, school attendance, age, work experience, region, SMSA residence and ethnicity.

analysis of High School and Beyond seniors and Bishop, Blakemore and Low's (1985) analysis of both Class of 1972 and High School and Beyond data.[8]

In summary, in the United States, when years of schooling are held constant, achievement in science has no effect on wage rates, earnings or unemployment of young men and women. Achievement in mathematical reasoning has no effect on the wage rates and earnings of young men and only very modest effects on the wage rates of young women. Verbal competency has no effect on the wage rates on young men and women and no effect on the earnings of young men. These results suggest an immediate explanation for the poor performance of American students in science and higher level mathematics. For the 80 percent of youth who are not planning to pursue a career in medicine, science or engineering, there are no immediate labor market rewards for developing these competencies. For the great bulk of students, therefore, the incentives to devote time and energy to the often difficult task of learning these subjects are very weak.

Do these findings also imply that if a way could be found to recruit a high quality engineering and scientific elite (possibly by recruiting scientists and engineers from abroad or early identification of mathematically and scientifically talented youth), there would be little need to worry about the poor math and science preparation of most American youth. It is to this question I now turn.

1.4 Is There Reason to Expect Wage Effects of Specific Competencies to be the Same as Their Productivity Effects?

Are the productivity effects of achievement in science, mathematical reasoning and English essentially zero in the types of jobs occupied by most young workers? Speed in simple arithmetic computations has large effects on the wage rates of both sexes and technical competence has large effects on wage rates of young men. Do these competencies have comparable effects on productivity?

One approach to these questions is to ask employers directly about the nature of the tasks performed by entry level workers. When the owners of small and medium sized business in the United States were asked how frequently the employee most recently hired by their firm needed to "use knowledge gained of chemistry, physics or biology" in their job, 74 percent reported that such knowledge was never required and only 12 percent reported such knowledge was used at least once a week.[9] Asked how frequently the new employee had to "use algebra, trigonometry or calculus", 68 percent reported that such skills were never required by the job and only 12 percent reported they were used at least once a week.

The skills used by entry level workers at small and medium sized firms, however, are not decisive evidence regarding employer needs for three reasons.

CURRICULUM VITAE

Name ;
Address ;
Date of Birth ;
Place of Birth ;
Nationality ;
Marital Status ;
Occupation ;
Father's name ;
Occupation ;

EDUCATION :

August 1980 – June 1985.
(All five years were spent learning through Irish.)

U.C.D.

QUALIFICATIONS :

Subject:	Intermediate Cert. (June 1983)	Leaving Cert. (June 1985)
Irish	C (H)	C (H)
English	D (H)	C (H)
Mathematics	B (H)	A (P)
French	D	C (P)
German	D	–
Science	A	–
Chemistry	–	C (H)
Physics	–	C (H)
History	B	C (H)
Geography	B	–

Reproduction of an Irish Secondary School Graduate's Resume Submitted for a Clerical Position

APPLICATION FOR APPOINTMENT

Appointment applied for Distribution Projects Manager (B+Q) Ref.No. ....

PERSONAL DETAILS: (block capitals)

Surname .... Title Mr. Forenames Mervyn John

Address ....

.... Postal Code .... Tel.No.Home .... Work ....

Marital Status M Children/Dependants (with ages) 1 x 4yrs., 1 x 1yr

Age 33 Date of Birth 5-8-55 Nationality British Place of Birth ....

State of health OK Height 6' Weight 13st 12lbs

Any disabilities/recurrent medical problems? None Regd.disabled —

Driving Licenses Car Car Owner ✓ Company Car —

Endorsements, convictions, accidents, etc. None

Leisure activities and offices held in clubs and societies Cycling/Walking

EDUCATION:

Secondary Education

From	To	School	Exams Taken (inc. grades)	Other achievements
1966	1972	Barnstaple Grammar	'O' Level: Eng. Lang (2), Maths (3), French (3), Geog. (3), Statistics (3), Chemistry (3), Addl. Maths (6), Hist. (6), Physics (6); 'A' Level: Chem. (E), Physics (E), Maths (O)	Middle Sch. Games Captain

Further Education

From	To	College/Univ.	Course & results (inc.class/grades)	Other achievements
1972	1973	Univ. of Bradford	Applied Chemistry – left after 1 year – domestic reasons	

Other training and qualifications (inc. in-company and external courses, etc.)

From	To	Establishment	Training/Qualifications
1979		Farnley College, Leeds	Cert. of Prof. Competence (transport ops.)
1983	1984	Bradford College	Inst. of Industrial Management Cert.
1984	1989	In-Company	Numerous Management Classes

Membership of professional bodies

Date	Association/Institute	Grade of membership	Offices held

Application Form Completed by an Older University Dropout for a Managerial Position in the Private Sector in the United Kingdom

First, the low levels of scientific and mathematical competence in the work force available to small and medium sized firms may have forced them to put off technological innovations such as statistical process control that require such skills and to simplify the functions that are performed by workers who lack technical training. If better educated workers were available, entry level workers might be given greater responsibility and become more productive. Second, the study just quoted does not tell us what is happening at large firms or in the jobs occupied by long tenure employees at small firms. The CEOs of many large technologically progressive companies such as Motorola and Xerox are insisting that their factory jobs now require workers who are much better prepared in math and science than ever before. Third, employers may not realize how the knowledge and skills developed in high school science and mathematics classes contribute to productivity in their jobs. Not knowing which employee possesses which academic skill, they would have no way of learning from experience which scientific and mathematical skills are helpful in doing a particular job. Science and mathematics are thought to teach thinking, reasoning and learning skills applicable outside the classroom and the laboratory. If these skills are indeed successfully developed by these courses, productivity might benefit even when there are no visible connections between job tasks and course content.

A second approach to estimating the effect of a trait on productivity, one favored by economists, has been to infer its effect by studying its effect on wage rates. Such an approach is not justified in this case. In the United States academic achievements in high school-- particularly the fine details of achievement in a particular domain like science, mathematical reasoning or reading ability--are not well signaled to the labor market. When competencies which are highly correlated with each other are poorly signaled to the labor market, American employers have a difficult time figuring out which competencies they need and an even more difficult time finding high school graduates with the particular constellations of academic abilities they may believe they need. As a result, the relationship between their wage offers and the imperfect signals of worker competencies available to them is unlikely to reflect the true relationship between productivity and these competencies.

The Signaling Failure in the United States

In Canada*, Australia, Japan, and Europe, educational systems administer achievement exams which are closely tied to the secondary school curriculum. Students generally take between 3 and 9 different examinations. These are not pass/fail minimum competency exams. On the Baccalaureate, for example, there are four different levels of pass: Tre's Bien, Bien, Assez Bien and a regular pass (Noah and Eckstein 1988). In Europe, grades on these exams are requested on job applications and typically included on one's resume. Exhibit 1 reproduces a resume used by an Irish secondary school graduate applying for a clerical job. Exhibit 2 is the first page of an application filed by a 28 year old university graduate seeking a managerial job. While employers report they pay less attention to exam grades when hiring workers who have been out of school many years, it is nevertheless significant that the information remains on one's resume long after graduation from secondary school.

In Japan, clerical, service and blue collar jobs at the best firms are available only to those who are recommended by their high school. The most prestigious firms have long term arrangements with particular high schools to which they delegate the responsibility of selecting the new hire(s) for the firm. The criteria by which the high school is to make its selection is, by mutual agreement, grades and exam results. In addition, most employers administer their own battery of selection tests prior to hiring. The number of graduates that a high school is able to place in this way depends on its reputation and the company's past experience with graduates from the school. Schools know that they must be forthright in their recommendations because if they fail just once to make an honest recommendation, the relationship will be lost and their students will no longer be able to get jobs at that firm (Rosenbaum and Kariya 1987).

The hiring environment for clerical, service and blue collar jobs is very different in the US. American employers generally lack objective information on applicant accomplishments, skills, and productivity. Tests are available for measuring competencies, but EEOC guidelines resulted in a drastic reduction in their use after 1971. A 1987 survey of 2014 small-and medium-sized employers who were members of the National Federation of Independent Business found that aptitude test scores had been obtained in only 2.9 % of the hiring decisions studied (Bishop and Griffin, forthcoming).

Other potential sources of information on effort and achievement in American high school are transcripts and referrals from teachers who know the applicant. Both are under-used. In the NFIB survey, when someone with 12 or fewer years of schooling was hired, the new hire had been referred or recommended by vocational teachers only in 5.2 % of the cases and referred by someone else in the high school in only 2.7 %. Transcripts had been obtained prior to the selection decision for only 14.2 % of the hires of people with 12 or fewer years of schooling. Transcripts are not obtained because differing grading standards in different schools and courses make them difficult to interpret, because many high schools are not responding to requests for the information and because there are generally long delays before the transcripts arrive.

The only information about school experiences requested by most American employers is years of schooling, diplomas and certificates obtained, and area of specialization. Hiring decisions are based on easily observable characteristics which are imperfect signals of the competencies the employer cannot observe directly. As a result, hiring selections and starting wage rates are often not influenced by even very gross indicators of academic achievement such as GPA, AFQT or SAT scores (Bishop 1987b). Given the limited information available to American employers prior to hiring, it is not realistic to expect their decisions to reflect in a refined manner the specific combinations of academic competencies that students bring to the market.

But after a worker has been at a firm a while, the employer presumably learns more about the individual's capabilities and is able to observe performance on the job. Workers assigned to the same job often produce very different levels of output (Hunter, Schmidt and Judiesch 1988). Why, one might ask, are the most productive workers (those with just the right mix of specific competencies) not given large wage increases reflecting their higher productivity? The reason appears to be that workers and employers prefer employment contracts which offer only modest adjustments of relative wages in response to perceived differences in relative productivity. There are a number of good reasons for this preference: the unreliability of the feasible measures of individual productivity (Hashimoto and Yu, 1980), The unwillingness of workers to risk that their wage may be reduced if their supervisor decides they are not doing a good job (Stiglitz, 1974), the absence of any real danger that one's best employees will be raided because the skills of these top performers can be fully used only within the firm (Bishop, 1987a), the desire to encourage cooperation among coworkers (Lazear 1986) and union preferences for pay structures which limit the power of supervisors. In addition, compensation for better than average job performance may be non-pecuniary -- praise from one's supervisor, more relaxed supervision, or a high rank in the firm's social hierarchy (R. Frank, 1984).

A study of how individual wage rates varied with initial job performance found that when people hired for the same or very similar jobs are compared, someone who is 20 % more productive than average is typically paid only 1.6 % more. After a year at a firm, better producers received only a 4% higher wage at nonunion firms with about 20 employees, and they had no wage advantage at unionized establishments with more than 100 employees or at nonunion establishments with more than 400 employees (Bishop, 1987a). Over time there is some tendency for those with high test scores to be promoted more rapidly and to be employed more continuously (Wise 1975, Bishop 1991). Since, however, worker productivity cannot be measured accurately and cannot be signaled reliably to other employers, this sorting process is slow and only partially effective. Consequently, when men and women under the age of 30 are studied, the wage rate effects of specific competencies may not correspond to their true effects on productivity and, therefore, direct evidence on productivity effects of specific competencies is required before conclusions may be drawn. We turn now to an examination of direct evidence on the effects of academic and technical competencies on the job performance. Research on the determinants of job performance in the US military is examined in section 1.5. Research on the determinants of job performance in the civilian sector is examined in section 1.6.

1.5 The Impact of Academic and Generic Technical Competencies on the Job Performance in the American Military

The theoretical arguments of the previous section will now be put to an empirical test. Direct estimates of the relative importance of different competencies are obtained by estimating models in which measures of job performance in the military are regressed on all 9 subtest scores of the ASVAB battery. These direct measures of the productivity effects of the competencies measured by the ASVAB, will then be compared to the wage and earnings effects of ASVAB subtests presented in section 1.2. Is technical competence an important determinant of job performance as well as wages? Do verbal skills and scientific competencies which have no effects on wage rates, nevertheless, have significant positive effects on job performance? The wages and earnings of young men were influenced by computational speed not mathematical reasoning ability. Is this the case for job performance as well?

The ASVAB is one of the most thoroughly researched selection and classification batteries in existence, so there is a wealth of evidence on how its subtests effect job performance in a great variety of jobs. The test battery was developed by the US armed forces for use within the military, so military recruits have been the subject of almost all of this research. Eighty percent of the jobs held by enlisted personnel in the military have civilian counterparts (US Department of Defense, 1984). The civilian occupations that are not represented in the ASVAB research are professional, manager, farmer, sales representative, and sales clerk. Since most of the soldiers studied were young and male, generalizing to other populations must be done with care. This is not a problem in this study, however, for the desired comparisons are with other young males, those in the NLS.

Studies of Training Success

Most of the validity research has involved correlating scores on ASVAB tests taken prior to induction with final grades in occupationally specific training courses (generally measured at least 4 months after induction). Since recruits are selected into the army and into the various specialties by a which are imperfect signals of the competencies the employer cannot observe directly. As a result, hiring selections and starting wage rates are often not influenced by even very gross indicators of academic achievement such as GPA, AFQT or SAT scores (Bishop 1987b). Given the limited information available to American employers prior to hiring, it is not realistic to expect their decisions to reflect in a refined manner the specific combinations of academic competencies that students bring to the market.

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The theoretical arguments of the previous section will now be put to an empirical test. Direct estimates of the relative importance of different competencies are obtained by estimating models in which measures of job performance in the military are regressed on all 9 subtest scores of the ASVAB battery. These direct measures of the productivity effects of the competencies measured by the ASVAB, will then be compared to the wage and earnings effects of ASVAB subtests presented in section 1.2. Is technical competence an important determinant of job performance as well as wages? Do verbal skills and scientific competencies which have no effects on wage rates, nevertheless, have significant positive effects on job performance? The wages and earnings of young men were influenced by computational speed not mathematical reasoning ability. Is this the case for job performance as well?

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Studies of Training Success

Most of the validity research has involved correlating scores on ASVAB tests taken prior to induction with final grades in occupationally specific training courses (generally measured at least 4 months after induction). Since recruits are selected into the army and into the various specialties by a nonrandom process, mechanisms have been developed to correct for selection effects--what I/O psychologists call restriction of range (Thorndike 1949; Lord and Novick 1968; Dunbar and Linn 1986). These selection models assume that selection into a particular MOS is based on ASVAB subtest scores (and in some cases measures of the recruit's occupational interests). For the military environment, this appears to be a reasonable specification of the selection process for attrition is low and selection is indeed explicitly on observable test scores. This ability to model the selection process is an advantage that validity research in the military has over research in the civilian sector.[4]

A reanalysis was conducted of data from two large scale studies of Marine recruits (Sims and Hiatt 1981 reprinted in Hunter, Crossen and Friedman 1985; Maier and Truss 1985). These studies were selected because they used versions of the ASVAB that were quite similar to the one administered to the NLS Youth Cohort. Correlation matrices which had been corrected (for restriction of range and selection effects) were obtained from the appendices of these studies and LISREL was employed to estimate models in which training grades were regressed on the full set of ASVAB subtests. The standardized regression coefficients from this analysis are reported in table 4.

The results were similar to the wage and earnings regressions in only one respect: technical competency as indexed by the mechanical, auto-shop and electronics subtests had major effects on success in training for occupations involving the maintenance or use of complicated equipment. In all other respects, however, the results contrast sharply with the wage rate regressions for young males. The math knowledge and arithmetic reasoning subtests have much larger effects on training success than the computational speed test. Both the science and verbal subtests have strong positive impacts on success in training. It appears that the higher level academic competencies measured by the ASVAB have much larger positive effects on success in training programs than on wage rates of young men in the civilian sector.

Reanalysis of Maier and Grafton's Data on Job Performance

In the reanalysis we reported above, training success was measured by a paper and pencil test. There is a danger that validity coefficients may be biased by common methods bias. It would be desirable to check these findings in a data set in which ASVAB subtest scores predict a hands-on measure of job performance. Maier and Grafton's (1981) study of ASVAB 6/7's ability to predict the hands-on Skill Qualification Test (SQTs) provides such a data set. Maier and Grafton described the hands-on SQTs they used in their study as follows:

> SQTs are designed to assess performance of critical job tasks. They are criterion referenced in the sense that test content is based explicitly on job requirements and the meaning of the test scores is established by expert judgment prior to administration of the test rather than on the

> basis of score distributions obtained from administration. The content of SQTs is a carefully selected sample from the domain of critical tasks in a specialty. Tasks are selected because they are especially critical, such as a particular weapon system, or because there is a known training deficiency. The focus on training deficiencies means that relatively few on the job can perform the tasks, and the pass rate for these tasks therefore is expected to be low. Since only critical tasks in a specialty are included in SQTs, and then only the more difficult tasks tend to be selected for testing, a reasonable inference is that performance on the SQTs should be a useful indicator of proficiency on the entire domain of critical tasks in the specialty; that is, workers who are proficient on tasks included in an SQT are also proficient on other tasks in the specialty. The list of tasks in the SQT and the measure themselves are carefully reviewed by job experts and tried out on samples of representative job incumbents prior to operational administration (pp. 4-5).

A more extensive discussion of the procedures for developing SQTs is available in a handbook (Osborn et al, 1977). A thorough discussion of their rationale is provided in Maier and Hirshfeld (1978).

Regressions were estimated using LISREL for nine major categories of Military Occupational Specialties (MOS): Skilled Technical, Skilled Electronic, General Maintenance, Mechanical Maintenance, Clerical, Missile Battery and Food Service Operators, Unskilled Electronic, Combat and Field Artillery. Except for combat and field artillery, these MOSs have close counterparts in the civilian sector. The independent variables were the 10 ASVAB 6/7 subtest scores which had counterparts in the ASVAB 8A battery used in the analysis of NLS Youth. The standardized regression coefficients from this analysis are reported in Table 5. These coefficients are an estimate of the effect of a one population standard deviation improvement in a test score on the hands-on job performance criterion measured in standard deviation units. Since the ASVAB subtests measure competencies with error and this error has not been corrected for, these results provide lower bound estimates of the effects of the true competencies on true job performance.

The effects of the four "technical" subtests--mechanical comprehension, auto information, shop information and electronics information--are presented in the first four columns of the table. As one might anticipate, these subtests had no effect on job performance in clerical jobs. However, they had very substantial effects on job performance in all the other occupations. The impact of a one population standard deviation increase in all four of these subtests is an increase in the SQT of .415 SD in skilled technical jobs, of .475 SD in skilled electronics jobs, of .316 SD in general maintenance jobs, of .473 SD in mechanical maintenance jobs, of .450 SD for missile battery operators and food service workers, of .170 SD in unskilled electronics jobs, of .345 SD in combat occupations and .270 SD in field artillery. The technical subtests appear to have larger effects on hands-on job performance than on training grades suggesting a common methods bias in validation studies which employ training grades as the criterion. The proportionate change in productivity that results is somewhere between 25 and 40 percent of these numbers.[10] If we assume the SD of true productivity averages 30 percent of the mean wage in these jobs, the impact of a simultaneous one SD increase in all four technical subtests is 11.5 percent of the wage (or about $2875 per year) averaging across the six non-clerical non-combat occupations. The present discounted value of such a learning gain is about $50,000 (using a 5 percent real rate of discount). This is consistent with the wage rate findings presented earlier. These results imply that broad **technical literacy** is essential for workers who use and/or maintain equipment that is similar in complexity to that employed in the military.

The attention to detail subtest (which is similar to the clerical checking subtest in ASVAB 8A) has no effect on performance in clerical jobs and small effects on performance in skilled electronic, general maintenance, combat arms and field artillery.

The results for the academic subtests, however, contrast sharply with the wage rate regressions for young males. With the sole exception of the mechanical maintenance MOS cluster, the two mathematical reasoning subtests have much larger effects on SQTs than on wage rates. **The Math Knowledge subtest assessing algebra and geometry is responsible for most of this effect.** A one standard deviation increase in competence in algebra and geometry raises predicted job performance by .121 SD in skilled technical jobs, .261 SD in skilled electronic jobs, .44 SD in general maintenance jobs, .206 SD in clerical jobs, .106 SD for missile battery operators and food service jobs, .139 in combat arms and .230 in artillery. The arithmetic reasoning test was significant in 7 of the MOS clusters and had large positive effects on performance in clerical (.24 SD), missile battery and food service (.11 SD), and field artillery (.186 SD) jobs. Assuming that the standard deviation of true productivity is 30 percent of the wage, the impact of a simultaneous one SD increase in both mathematics reasoning subtests is 6.4 percent averaging across all seven non-combat occupations. The effects of the two tests of mathematical reasoning on job performance are substantial and unlike the wage rate findings much larger than the effects of computational speed. Nevertheless, they are somewhat smaller than those obtained in the models predicting training success suggesting again the possibility of methods bias.

Science knowledge which had small negative effects on wage rates, now has positive effects on hands-on measures of job performance in eight of the MOS clusters, significantly so in 4 clusters and in pooled data. A one standard deviation (SD) increase in science knowledge raises job performance by .057 SD in skilled technical jobs, .072 SD in skilled electronics jobs, .134 SD in general maintenance and construction jobs, .096 SD in mechanical maintenance jobs, .064 SD in clerical jobs, .076 SD in missile battery operator and food service jobs and .070 in combat arms. Word knowledge has significant effects on job performance in the skilled technical, general maintenance and clerical jobs and in combat arms. While statistically significant, the effects of these two competencies appear to be rather modest. Assuming that the standard deviation of true productivity is 30 percent of the wage, the effect of a one SD increase in test scores is 2 percent of the wage for science and 1.9 percent for word knowledge averaged across the seven noncombat occupations.

Differences in science or verbal competency of one population SD are quite large. In these subjects, one population SD is about the magnitude of the difference between young people with 14 years of schooling and those who left school after the 9th grade. Consequently, a productivity increase of about 2 percent per population SD on the test may appear to be only a modest return. This may be due to the inadequacies of the 11 minute long ASVAB subtests used to assess these competencies. General Science had only 24 items and Word knowledge only 35. This biases down the estimated effects of science and word knowledge on job performance. Clearly, there is a need for new research to determine whether broader and more reliable measures of verbal capacity, scientific knowledge and understanding and the ability to solve problems have more substantial effects on job performance in non-technical jobs than these ASVAB subtests.

On the other hand, however, a 2 percent increase in productivity should not be dismissed as unimportant. It is about $500 per worker per year and has a present discounted value of about $8700. (using a 5 percent real rate of interest and a 40 year working life).

Analysis of Project A Data on Core Technical Proficiency

Still more evidence on what truly determines job performance comes from Project A, a massive study (total costs of more than $100,000,000) that is developing improved methods for selecting and classifying army personnel. Wise, McHenry, Rossmeissl and Oppler (1987) have estimated ASVAB validities for 19 very diverse jobs using Core Technical Proficiency, a MOS specific job performance measures, as the criterion. These ratings are about 50 percent based on hands-on work sample tests (the hands-on SQT) and 50 percent based on paper and pencil job knowledge exams. The ratings were obtained after the recruit had been in the army for 2 to 3 years. The study was designed to select the three or four ASVAB subtests which could be used as the aptitude composite for that MOS cluster.

Table 6 reports the names of the three or four subtests which in combination did the best job of predicting Core Technical Proficiency. As before, the technical subtests are important predictors of Core Technical Proficiency in all the nonclerical occupations. For the academic subtests the results are very different from the wage rate regressions but similar to the results of the reanalysis of Maier and Grafton's validity data for hands-on work samples. Computational speed is only a weak determinant of job performance. Competence in science, language arts and mathematical reasoning has very large effects on job performance.

Analysis of Project A Data on Other Performance Measures

Most of the ASVAB validity studies have studied MOS specific measures of performance which reflect the soldier's ability to do the job not their willingness to do it on a regular basis or under adverse conditions. Do the results change when other dimensions of job performance are studied? The Project A data set again provides an opportunity to address this issue. Besides the Core Technical Proficiency construct already analyzed, Project A offers three other performance constructs which have some applicability to civilian jobs: General Soldiering Proficiency, Effort and Leadership and Maintaining Personal Discipline. General Soldiering Proficiency assesses skills that all soldiers must have (eg. use of basic weapons, first aid, map reading, use of a gas mask) and is measured much the same way as Core Technical Proficiency by a combination of job knowledge tests and hands-on performance tests. These two constructs are designed to measure the <u>can do</u> element of job performance.

The other two constructs attempt to measure the <u>will do</u> element of job performance. John P. Campbell (1986) described the constructs and their measurement as follows:

> <u>Peer Leadership, Effort, and Self Development</u>: Reflects the degree to which the individual exerts effort over the full range of job tasks, perseveres under adverse or dangerous conditions, and demonstrates leadership and support of peers. That is, can the individual be counted on to carry out assigned tasks, even under adverse conditions, to exercise good judgement, and to be generally dependable and proficient? Five scales from the Army-wide BARS rating form (Technical Knowledge/Skill, Leadership, Effort, Self-development, and Maintaining Assigned Equipment), the expected combat performance rating, and the total number of commendations and awards received by the individual were summed for this factor.
>
> <u>Maintaining Personal Discipline</u>: Reflects the degree to which the individual adheres to Army regulations and traditions, exercises personal self-control, demonstrates responsibility in day-to-day behavior, and does not create disciplinary problems. Scores on this factor are composed of three Army-wide Bars scales (Following regulations, Self-Control, and Integrity) and two indices from the administrative records (number of disciplinary actions and promotion rate). (p. 150)

It had been planned to obtain information on commendations, awards, promotions, and disciplinary actions from administrative records. However, the cost of this approach was extremely high so "everyone crossed their fingers and we collected eight archival performance indicators via a self report questionnaire....Field tests on a sample of 500 people showed considerable agreement between self-report and archival records"(Campbell, 1986, p 144).

These two constructs are related to each other (they correlate .59) but are clearly quite distinct from the two "can do" constructs. Correlations with Core Technical Proficiency are only .28 for Effort and Leadership and .19 for Personal Discipline. The "can do" constructs are based on ratings made by the same person, so they share some common measurement error. Campbell, consequently, constructs residualized "can do" performance constructs by subtracting a ratings method factor from the raw score. With the ratings methods effect removed, Core Technical Proficiency (raw) has a correlation of .465 with Effort and Leadership (residual) and .225 with Personal Discipline (residual). In the view of the Project A team, soldiers must have both qualities--the technical competence to do their job and the willingness to do it under stressful circumstances.

Table 7 presents the results of using ASVAB test scores to predict General Soldiering Proficiency (raw), Effort and Leadership (both raw and residualized) and Personal Discipline (raw) (Campbell, 1986, Table 10). The correlation matrices were corrected for range restriction as described by Dunbar and Linn (1986). In this analysis the 9 ASVAB subtests have been reduced to four composites: Technical, Speed (Numerical Operations and Clerical Checking), Quantitative (Arithmetic Reasoning and Mathematics Knowledge) and Verbal/Science. For General Soldiering Proficiency, the results are quite similar to the results obtained predicting Hands-on SQTs and Core Technical Proficiency. The technical and quantitative composites have the largest effects, and the verbal/science composite has a substantial effect. Speed has almost no effect. As before, the pattern of coefficients is very different from the wage regression for young men.

The pattern is different for the "will do" performance constructs. The technical composite had large positive effects on both measures of Effort and Leadership. The quantitative composite had a modest positive effect on Maintaining Personal Discipline and the residualized Effort and Leadership. Speed had a modest positive effect on Effort and Leadership. The verbal/science composite had no effect on the residualized Effort and Leadership and a small negative effect on raw score measures of both constructs. The coefficient pattern for the raw score "will do" performance constructs looks rather similar to the male wage and earnings regressions. This is an interesting result that needs to be investigated in other data sets. It should be treated with caution, however, for four reasons: the information on commendations, awards, promotions and disciplinary actions was self reported, a ratings method effect was clearly visible in the data, other researchers have expressed skepticism about the validity of military ratings (Vineberg and Joyner 1982), and there appears to be major differences between the civilian and military sectors in the effect of academic achievement tests on supervisory ratings (with the effects much larger in the civilian sector)(Hunter 1986).

In any case, even if one adopts the Project A position that ratings are a valid measure of the "will do" component of job performance, this in no way implies that the "can do" elements are subsidiary or unimportant. Consequently, the findings reviewed above that science, verbal and mathematical reasoning capability predict hands-on SQTs, Core Technical Proficiency and General Soldiering Proficiency in the military appear to provide some support the claim that improved math, science and language arts education will add to the productivity of the work force.

Since 80 percent of the jobs held by enlisted personnel in the military have civilian counterparts, the research on the validity of the ASVAB in military settings just presented should generalize to major segments of the civilian economy (US Department of Defense, 1984). Nevertheless, it would be useful to examine civilian data on the effect of technical competence on job performance. It is to the analysis of civilian data we now turn.

1.6 The Impact of Academic and Technical Competence on Job Performance in the Civilian Sector

Ghiselli's Review of Validation Research Prior to 1973

Over the last 50 years, industrial psychologists have conducted hundreds of studies, involving many hundreds of thousands of workers, on the relationship between supervisory assessments of job performance and various predictors of performance. In 1973 Edwin Ghiselli published a compilation of the results of this research organized by type of test and occupation. Table 8 presents a summary of the raw validity coefficients (correlation coefficients uncorrected for measurement error and restriction of range) for six types of tests: mechanical comprehension tests, "intelligence" tests, arithmetic tests, spatial relations tests, perceptual accuracy tests and psychomotor ability tests. As pointed out earlier, mechanical comprehension tests assess material that is covered in physics courses and applied technology courses such as auto mechanics and carpentry. The intelligence tests used in this research were paper and pencil tests assessing verbal and mathematical competency.

Intelligence tests were the best predictors of the performance of foreman. For craft occupations and semi-skilled industrial jobs, the mechanical comprehension tests are more valid predictors of job performance than any other test category. For protective occupations, mechanical comprehension tests and intelligence tests had equal validity. For clerical jobs, the best predictors of job performance were tests of intelligence, arithmetic and perceptual accuracy. These results are consistent with the analysis of job performance in the military data reported in Table 5.

It would appear that measures of mathematical, verbal and generic technical competence all have substantial effects on performance in technical and blue collar jobs. What about paper and pencil occupational competency tests for specific occupations? How well do they correlate with job performance.

The Relationship between Occupational Competency Tests and Job Performance

Meta-analyses of the hundreds of studies of the validity of occupational competency tests have found that content valid occupational competency tests are highly valid predictors of job performance. Dunnette's (1972) meta-analysis of 262 studies of occupational competency tests found that their average correlation with supervisory ratings was .51. This correlation was higher than the correlation of any other predictor studied including cognitive ability tests (.45), psychomotor tests (.35), interviews (.16) and biographical inventories (.34). Vineberg and Joyner's (1982) meta-analysis of military studies found that grades in training school (which were based on paper and pencil tests of occupational competency) had a higher correlation (.27) with global performance ratings by immediate supervisors than any other predictor. The correlations for the other predictors were .21 for ASVAB ability composites, .14 for years of schooling, .20 for biographical inventory and .13 for interest. Hunter's (1982) meta-analysis found that content valid job knowledge tests had a correlation of .48 with supervisory ratings and an even higher correlation of .78 with a work sample measure of job performance, the Skill Qualification Test. Consequently, for training program graduates who are employed in the occupation for which their competency was assessed, scores on these competency exams are highly valid predictors of job performance and promotion probabilities.

Analysis of GATB Validation Studies

More recent data on what predicts job performance is available from the US Employment Service's program for revalidating the General Aptitude Test Battery (GATB). This data set contains data on job performance, the 9 GATB "aptitudes" and background data on 36,614 individuals in 159 different occupations. Professional, managerial and high level sales occupations were not studied but the sample is quite representative of the 71,132,000 workers in the rest of the occupational distribution. It ranges from drafters and laboratory testers to hotel clerks and knitting-machine operators.

Since a major purpose of these validation studies was to examine the effects of race and ethnicity on the validity of the GATB, the firms that were selected tended to have an integrated workforce in that occupation. Firms that used aptitude tests similar to the GATB for selecting new hires for the job being studied were excluded. The employment service officials who conducted these studies report that this last requirement did not result in the exclusion of many firms. A total of 3052 employers participated.

The workers in the study were given the GATB test battery and asked to supply information on their age, education, plant experience and total experience. Plant experience was defined as years working in that occupation for the current employer. Total experience was defined as years working in the occupation for all employers. The dependent variable was an average of two ratings (generally two weeks apart) supplied by the worker's immediate supervisor. The Standard Descriptive Rating Scale obtains supervisory ratings of 5 aspects of job performance (quantity, quality, accuracy, job knowledge and job versatility) as well as an "all around" performance rating (See Appendix A). Some studies employed rating scales specifically designed for that occupation and in one case a work sample was one of the job performance measures. None of the studies used ticket earnings from a piece rate pay system as the criterion. Studies which used course grades or tests of job knowledge as a criterion were excluded. Firms with only one employee in the job classification were excluded, as were individuals whose reported work experience was inconsistent with their age.

The mathematical achievement index (N) was an average of normalized scores on the same arithmetic reasoning test and on a numerical computations test. These two Verbal ability was assessed by a vocabulary test. Perceptual Speed was the sum of the P and Q aptitudes of the GATB divided by 36.72 to put it in a population SD metric. Psychomotor Ability was the sum of the K, F and M aptitudes of the GATB divided by 51.54 to put it in a population SD metric. The GATB does not contain tests assessing knowledge of electronics, mechanical comprehension, auto mechanics or shop knowledge.

Because wage rates, average productivity levels and the standards used to rate employees vary from plant to plant, mean differences in ratings across establishments have no real meaning. Therefore, normalized ratings deviations were predicted by deviations from the job/establishment's mean for gender, race, Hispanic, age, age squared, plant experience, plant experience squared, total occupational experience, total occupational experience squared, schooling and test composites.[11]

It should be recognized that the validity literature in general and this model in particular do not yield unbiased estimates of the true structural relationships prevailing in the full population (Brown 1978; Mueser and Maloney 1987). Validity studies based on examining which job incumbents are most productive are subject to bias for three reasons: omitted variables, the selection process that determines which new hires were retained by the firm and the selection process by which members of the population were hired for the job.

While the model used in this study is a more complete specification of the background determinants of job performance than is typically found in the validity literature, it lacks controls for important characteristics of the worker which effect worker productivity. Examples of things left out of the model are occupationally specific schooling, grades in relevant subjects in school, reputation of the school, the amount and quality of on-the-job training, performance in previous jobs, character traits like reliability and need to achieve, physical strength and a desire to work in the occupation. Exclusion of these variables from the model causes bias in the coefficients of included variables.

The second problem arises from the fact that job performance outcomes have been used to select the sample used in the analyses. Since incompetent workers were fired or induced to quit and high performing workers were probably promoted to jobs of a higher classification, the job incumbents used in this study were a restricted sample of the people originally hired for a job. The systematic nature of attrition from the job substantially reduces the variance of job performance and biases coefficients of estimated job performance models toward zero.[12]

The third source of problems is selection effects introduced by the selection that precedes the hiring decision. If hiring selections were based entirely on X variables included in the model, unstandardized coefficients such as ß^ would be unbiased and correction formulas would be available for calculating standardized coefficients and validities. Unfortunately, however, incidental selection based on unobservables such as interview performance and recommendations is very probable (Thorndike 1949; Olson and Becker 1983; Mueser and Maloney 1987). In a selected sample like accepted job applicants, one cannot argue that these omitted unobservable variables are uncorrelated with the included variables that were used to make initial hiring decisions and, therefore, that coefficients on included variables are unbiased. When someone with 10 years of formal schooling is hired for a job that normally requires 12 years of schooling, there is probably a reason for that decision. The employer saw something positive in that job applicant (maybe the applicant received a particularly strong recommendation from previous employers) that led to the decision to make an exception to the rule that new hires should have 12 years of schooling. The analyst is unaware of the positive recommendations, does not include them in the job performance model and, as a result, the coefficient on schooling is biased toward zero. This phenomenon also causes the estimated effects of other worker traits used to select workers for the job such as previous relevant work experience to be biased toward zero. Consequently, the results presented below should not be viewed as estimates of the structural effect of schooling and previous work experience on worker productivity.

The test score results are not similarly biased, however, because **very few firms use cognitive tests to select workers and those that do were not included**

in the sample of firms studied specifically to avoid this source of bias.[13]

Results: The results of estimating the model are presented in Table 9. Mathematical achievement was clearly the most important determinant of job performance for all occupational categories except operatives. The effect of mathematical achievement on the performance of operatives was highly significant but only about one-half to two-thirds of the size of the other occupations. Verbal ability had no effect on job performance in craft and operative jobs and in clerical and service jobs its impact is roughly 40 percent of the mathematical achievement's effect.

Spatial ability had significant positive effects on performance only for craft occupations. Perceptual speed had small effects on job performance, but the coefficients are nevertheless significant in all but technical occupations (where the sample is quite small). Psychomotor skills were significantly related to performance in all occupations but in the better paid and more complex jobs the magnitude of the effect was only about one-third of that of verbal and mathematical achievement together.

The effect of psychomotor skills was larger in the two least skilled occupations--operatives and service except police and fire. For operatives the impact of psychomotor skills was roughly comparable to the impacts of mathematical and verbal achievement. These results are consistent with previous studies of these and other data sets (Hunter 1983). Models were estimated containing squared terms for academic achievement and psychomotor skills but these additions did not produce significant reductions in the residual variance. When test scores are controlled, years of schooling had very small and sometimes negative effects on job performance.[14]

The effects of occupational experience and tenure are also quite substantial for all occupations. The negative coefficients on the square terms for occupational experience and tenure imply they are subject to diminishing returns. For workers who have no previous experience in the field, the expected gain in job performance is about 12-13 percent of a standard deviation in the first year and about 8-9 percent of an SD in the fifth year. The effect of tenure on job performance stops rising and starts to decline somewhere between 16 and 24 years of tenure. Increases in occupational experience lose their positive effect on performance even later--at 37 years for operatives, at over 55 years for craft workers and high skill clerical workers and at 19-31 years for other occupations. Except for technicians, age has large curvilinear effects on job performance as well. Holding tenure and occupational experience constant, age had a significant positive effect on job performance in all except technical occupations. In these occupations, twenty year olds with no experience at all in the field were 7.2 to 10.3 percent of an SD more productive than 18 year olds with no experience in the field. Thirty year olds with no occupational experience were 4.7 to 7.4 percent more of an SD more productive than 28 year olds with no experience in the field.

The substantial effects of age and previous occupational experience on job performance are consistent with current hiring practices which give great weight to these job qualifications. These results suggest that a job applicant who has age and relevant work experience in his favor but low test scores may nevertheless be preferable to a young applicant who has high test scores but no relevant work experience. This is particularly likely to be the case if turnover rates are high for the productivity benefits of age and previous relevant work experience are large initially but diminish with time on the job.

1.7 Policy Implications

Many believe that high involvement work systems raise the productivity payoff of the problem solving abilities taught in mathematics and science classes. This is probably the case.[15] But the need for better mathematics and science preparation does not rest on this proposition being true.

The evidence just reviewed implies that mathematical and scientific competence contributes significantly to productivity in jobs that are structured in traditional Tayloristic-Fordist style and that do not have college level training in science and mathematics as a selection requirement. The case for higher standards in education, thus, does not depend on the rate at which employers switch from traditional mass production systems to the new lean production/high performance work systems.

II. TRENDS IN THE DEMAND FOR SKILL AND THE PAYOFF TO ACADEMIC COMPETENCE

The second rationale for improving the quality of math and science education is the need to expand the supply of engineers, scientists, computer specialists and managers with advanced training in business and economics. Those who lack a solid background in math and science find university programs in these fields very tough going and typically drop out of college altogether or are forced to transfer out of the field. Similar arguments are made for improving the general quality of secondary education. Overall college completion rates depend on communication skills as well as competence in mathematics and science, so improvements in secondary school preparation in language arts and other fields will increase the future supply of college trained workers. Analysis of cross section and time series data on enrollment and completion of college supports the view that a strong preparation in secondary school improves chances of success in university (Bishop 1992).

This rationale for higher standards in and channeling students into secondary school programs oriented toward further education at a university assumes, however, that high priority needs to be given to expanding the supply of university educated workers. This assumption rests on two crucial judgements about the labor market for university trained workers:

1) The social payoff to university education is high.
2) The social payoff to university education is not likely to diminish in the near future as rising numbers of university graduates enter the labor market.

Are these judgements justified? A conclusion on this matter requires answers to the following questions. How rapidly have the jobs that typically recruit university graduates been growing? How rapidly has the supply of university educated workers been growing? What is the balance between demand and supply of university educated workers? What is the economic payoff to obtaining a university education? And how does that payoff vary with the field of study in college?

2.1 Trends in Demand for and Supply of University Graduates

Trends in Demand: The share of jobs requiring advanced education and training has been rising all over the world. Occupations at the top of the skill continuum like professionals, technicians and managers (PT&M) jobs have been growing much more rapidly than manual (service, craft, operative, laborer and farm occupations) jobs. The difference between the growth rates of these two groups of occupations is presented in columns 1 and 2 of Table 10. In the United States PT&M grew 2.78 percent per year more rapidly than manual jobs during the 1970s and 2.46 percent per year more rapidly in the 1980s. While the U.S. rate of occupational upskilling is impressive, most countries had even higher rates. Japan's rate was 4.27 percent per year in the 1970s and 3.26 percent per year in the 1980s. Germany's rate was 3.67 percent in the 1970s and 2.53 percent per year in the 1980s. Scandinavian rates of occupational upskilling were higher still. During the 1970s the annual rate of occupational upskilling was 2.95 percent for Sweden, 6.0 percent for Denmark, 5.48 percent for Norway and 6.4 percent for Finland. During the 1980s the upskilling proceeded at a 2.5 percent per annum rate in Denmark, a 3.85 percent per annum rate in Norway and a 5.23 percent per annum rate in Finland. As a result, the professional, technical and managerial share of employment is now 28 percent in Denmark and Finland and 30 percent in Norway. Only three other countries have as high a ratio: Netherlands, United Kingdom and the United States (see column 3 of Table 10).

Trends in Supply: The supply of college educated workers has also been increasing rapidly all over the world. During the 1970s and 80s the university graduate share of the population of working age grew at an annual rate of 3.34 percent in the United States, 3.55 percent in Japan, 5.6 percent in Sweden, 5.8

percent in Norway, 3.07 percent in Belgium and 3.97 percent in Canada. The university graduate share of the working age population grew at an annual rate of 3.32 percent from 1983 to 1988 in Australia, 12.3 percent from 1981 to 1987 in Austria and 2.75 percent from 1978 to 1987 in Germany (OECD 1989). How does this growth in the supply of college graduates compare with the growth of the jobs which college graduates typically occupy?

2.2 The Supply and Demand Balance

Ronald Kutscher, Associate Commissioner of the U.S. Bureau of Labor Statistics, argues that there existed in the United Sates "an oversupply of college graduates during the 1980's (Kutscher 1991)." He sights as evidence for this view recent increases in the number of people with 16+ years of schooling who are coded by the Current Population Survey as having jobs which are not "traditional" for holders of a bachelors degree. He reports that between 1983 and 1988 workers claiming to have completed 16 years of schooling increased by 41,000 in secretarial and typist jobs, by 59,000 in factory operative jobs, and by 6,000 in bartender, waiter and waitress jobs.

But what about the opposite kind of mismatch: workers who have substantially fewer years of schooling than are "required" by the job. This kind of mismatch also increased between 1983 and 1988. The number of workers claiming to have **fewer than 16 years of schooling** increased by 23,000 among physicians, by 18,800 among lawyers and judges, by 14,500 among college teachers, by 125,000 among other teachers and by 99,000 among mathematical and computer scientists (U. S. Bureau of Labor Statistics 1990). Don't these statistics imply a growing shortage of qualified college graduate workers?

One should not, however, give much credence to any of these estimates of mismatches between schooling and occupation. The reporting and coding of occupation is quite unreliable. Those coded as a professional, a technician or manager by a Census interviewer have a 15 to 21 percent chance of being coded in a lower level occupation by a second interviewer a few months later (U.S. Bureau of the Census 1972). Ten percent of those who report completing 16+ years of schooling also claim not to have received a bachelors degree. Errors in measuring education are also quite common and the incidence of such errors appears to have risen during the 1980s (Bishop and Carter 1991). Many of the discrepancies between an individual's schooling and occupation found in CPS data are caused by reporting and coding errors. How else can one explain the 9.6 percent of college teachers and the 5.4 to 6.5 percent of lawyers, physicians and secondary school teachers who claim not to have completed 16 years of schooling (U.S. Bureau of Labor Statistics 1990, Table F-3). The unreliability of individual measures of occupation and education means that counts of mismatches between schooling and occupation derived from micro data have almost no validity at all. True mismatches between education and occupation are a lot less common than these statistics suggest.

This is not to deny that mismatches occur. College graduates are incredibly diverse and seek work in very distinct labor markets. College graduates who major in subjects which have little value in the labor market, who get C's and D's in undemanding courses, who are not geographically mobile, who have a substance abuse problem or who make a poor impression in interviews, will sometimes have to accept jobs which do not appear to "require" a college degree. These graduates are included in the averages and despite the drag they represent on the mean, the average college graduate is doing very well and compared to those who did not go to college she is doing extremely well.

The fact that the BLS keeps track of only one kind of mismatch--instances where education seems to exceed job requirements-- and ignores instances where individuals appear to be under qualified for their job makes matters worse. By ruling out the possibility of undereducation, the conceptual framework makes a conclusion that there are too many university graduates inevitable.

If something useful is to be said about the balance between supply and demand, one must put both price and quantity data to work and give up on the idea of measuring how many people are "underemployed."

A Framework for Interpreting Data on the Supply/Demand Balance

A much better approach to examining the supply/demand balance for highly educated workers is simply to compare percentage changes in supply of graduates and the number of people working in professional-technical and managerial occupations and interpret these changes in the light of contemporaneous shifts in the wage premium for college. Changes in the employment of college graduates can be decomposed into two components: (1) shifts that can be explained by changes in the occupational composition of employment and (2) changes in college graduate share of individual occupations. The growth of the engineering profession from 0.13 percent of the workforce in 1900 to 1.6 percent of the workforce in 1988 is an example of the first source of change. Historical rates of growth of professional technical and managerial jobs relative to manual jobs are given in the first two columns of Table 10.

For the United States, the normal state of affairs has been for college graduate supply to increase more rapidly than an index driven by shifts in occupational employment shares and for the difference to be made up by increases in skill and educational requirements of specific jobs (Rumberger 1981).

Engineers work at a knowledge frontier that has been shifting out at an extraordinary pace during the twentieth century. Consequently, the skills and training required to perform satisfactorily in engineering jobs have increased. At the beginning of the century most engineers did not have a bachelors degree;

now a bachelors degree is required of just about all new entrants and 20 percent of engineers have a masters degree. This demand driven escalation of the educational requirements for being an engineer illustrates the primary reason why college graduate shares of many occupations have increased over time. More recently the advent of the personal computer has shifted out the demand for managers, technicians, sales and other workers who can keep pace with this fast changing technology (Kruger 1991).

This is not, however, the only reason why the share of college graduates in an occupation might increase. During a period when college graduates are in abundant supply, some college graduates may find themselves forced into lower paying occupations which are thought to not require the skills developed in college. The signal that this is happening is declining wage premiums for recent college graduates. If, on the other hand, wage premiums for college graduates and professional occupations are stable or growing at the same time as the share of college graduates in specific occupations is rising, it is reasonable to infer that an outward shift of demand within occupations not an increase in supply caused the increase. Shifts in unemployment rates of workers classified by occupation or education can also be used as signals of changes in the balance between supply and demand.

2.3--Trends in the Payoff to University Education

In free labor markets, shortages of a particular type of labor cause it's relative wage to rise; surpluses cause it's relative wage to decline. During the 1970s the rapid growth of professional, technical and managerial occupations was accompanied by declines in the relative wage rates of these occupations in most countries (OECD 1987) suggesting that supply was growing more rapidly than demand.

Data on the 1980s for the United States and the United Kingdom indicate, however, growing relative wages for professional, technical and managerial workers, suggesting that demand for these workers was growing more rapidly than supply.

The wage premium for attaining a bachelors degree in the United States fell during the 1970s--a period of surplus for college graduate labor. During the 1980s the wage premium rose again. In May/June Current Population Survey data, real hourly wage rates of workers with 16 years of schooling and 1 to 10 years of experience rose 14.7 (12.2) percent for males (females) between 1980 and 1988 while real wage rates of workers with 12 years of schooling and similar levels of experience fell 16 (5.4) percent for males (females) (Kosters 1989). Blackburn, Bloom and Freeman (1989) report that between 1979 and 1987 the real full time earnings of 25 to 34 year old white male college graduates rose 9.2 percent while the earnings of their high school graduate counterparts fell 9.4

percent. Katz and Murphy's (1990) study of March CPS data found that between 1980 and 1987 real weekly earnings of college graduates with 1 to 5 years of work experience rose 10.6 (12.9) percent for females (males) while the real earnings of high school graduates with similar levels of experience fell 3.2 and 15 percent respectively. They conclude that "changes in education differentials ...reflect changes in 'skill prices' rather than changes in group composition. We find that rapid secular growth in the relative demand for 'more skilled' workers is a key component of any consistent explanation..." of these changes in wage structure.

Comparative data on changes in the payoff to college in other OECD countries is presented in Table 11. During the 1980s the relative wage of college graduates was stable in Japan, fell in the Netherlands but grew in all other countries for which the calculations could be made: Germany, Canada, Australia and the United Kingdom (Davis 1992). While the tendency of demand for university graduates in the 1980s to outstrip supply appears to be strongest in the United States, the phenomenon appears not to be limited to the U.S.

Unemployment Rate Differentials: An additional way of assessing the balance between supply and demand for workers categorized by education is to compare their unemployment rates. The first two columns of Table 11 report the ratio of unemployment rates for workers with less than 12 years of schooling to the unemployment rate of workers with a bachelor's degree or more. These data suggest that the balance between supply and demand for university graduates varied greatly across countries. By this ratio criterion the demand/supply balance in 1988 was extremely favorable for both male and female university graduates in Finland (7.5 & 8.0) and the United States (5.9 & 4.6) and highly favorable for male graduates in Australia (3.7), Austria (6.9), Canada (3.6), Germany (4.8), Norway (5.5) and the United Kingdom (4.0). In 1988 university graduate unemployment rates were higher than the rates of less educated workers in only three OECD countries--Greece for both men and women and Spain and Switzerland for women. It appears that in most countries the demand/supply balance was more favorable for male university graduates than for female graduates. The strong relative demand for engineering, computer, scientific and business specialties in which male college graduates predominate might be able to account for the modest gender differential in the United States. Other explanations are probably necessary for countries such as Australia, Austria, Germany and Norway with very large gender differentials.

Freeman (1991) has examined trends in relative unemployment rates in the United States. He reports that unemployment rates for college graduates were unchanged at very low levels (1.5 percent for 25-64 year olds) in both 1980 and 1988, but rates rose from 4.7 to 5.4 percent for high school graduates and from

7.4 to 9.2 percent for those who had not completed high school. He concluded that "rising educational pay differentials thus understate the growing mismatch between demand and supply for labour skills in the United States (p.361)."

Projecting the Future: The wage premium for attaining a college degree in the United States is higher now than ever before. Despite the increase in college attendance rates stimulated by the high wage premium, the supply of college graduate workers in the United States is fated to grow more slowly in the 1990s than in the 1980s. The cause of the slowdown in supply is the small size of the college age cohort during the 1990s and the growing number of retirements by workers who obtained degrees during the 1950s under the GI bill. The U.S. Bureau of Labor Statistics predicts that the rate of growth of demand for college graduate skills will slow as well (Silvestri and Lukasiewicz 1991). If their prediction is correct, the current balance between the growth of supply and demand will be maintained.

However, the BLS projection methodology is unable to anticipate the within industry shifts in occupational employment demand that are driving the explosion of college level occupations. The BLS grossly underpredicted the growth of professional, technical and managerial occupations during the 1980s. Projected to account for 28 percent of employment growth, these occupations actually accounted for 52 percent of growth between 1978 and 1990. Their projections of growth for high level occupations during the 1990s are probably biased as well. Using an econometric methodology of projecting occupational shares, Bishop and Carter (1991) predict that the growth of professional, technical and managerial employment will not diminish during the 1990s. If their prediction is correct, the labor market for college graduates, is fated to become even tighter than it is now.

2.4--Which College Specialties Generate the Largest Economic Payoff?

In the United States, college graduates who have majored in physical science, engineering and business earn substantially more than graduates who have majored in education, humanities or social sciences other than economics. The first four columns of Table 12 present data from the College Placement Council on how field of study effected the starting salaries received by college graduates whose placement outcomes were reported to the school's placement office for 1963, for 1969-70, for 1979-80 and for 1989 (College Placement Council 1985; 1991). The differences across field are sometimes as large as the wage gains accruing to those obtaining higher level degrees. Relative to majors in humanities and social sciences other than economics, engineers received 45-70 percent higher starting salaries in 1991, computer scientists received a 38 percent premium, physical science majors received a 24 percent premium and business majors received a 10 percent premium. Studies of the earnings of adults indicate that the salaries of business majors tend to catch up with the engineers, but education and liberal arts majors remain far behind those with engineering, physical science and business degrees (see column 5 and 6).

Largely because of these large wage differentials, there has been a dramatic growth in the relative supply of graduates in engineering, computer science and business administration. For males degrees in engineering, computer science and business which accounted for 33.2 percent of all BA's in 1973 rose to 50.8 percent of all bachelors degrees in 1986. For women degrees in engineering, computer science and business grew from 3.5 percent to 26.6 percent of degrees awarded. In 1973 degrees in education, humanities and social science accounted for 50.5 percent of bachelors degrees awarded to men and 83.5 percent of the bachelors degrees awarded to women. By 1986 these percentages had dropped to 35.1 percent and 54.7 percent respectively. As a result, the ratio of degrees awarded in engineering and computer science to degrees awarded in humanities, social science or education grew 5.2 percent per year in the 1970s and 10.7 percent per year between 1980 and 1986. The ratio of business degrees to humanities, social science, and education degrees grew 5.8 percent per year in the 1970s and 5.1 percent in the 1980s.

The very rapid growth during the last 20 years of the relative supply of college graduates trained in business and engineering fields has surprisingly not significantly diminished the wage premiums these fields command. Trends in starting wage premiums for business and technical degrees can be followed by comparing the first four columns of Table 5. Relative to humanities majors, wage premiums for engineering degrees grew dramatically during the 1970s and then dropped slightly by 1991, but remained significantly above the levels that had prevailed in the 1960s. Wage premiums for chemistry and mathematics majors over humanities majors rose from 17 percent in the 1960s to 36 percent in 1979-80 and then fell to 24 percent in 1991. Starting wage premiums for business majors rose from essentially zero in the 1960s to 10-11 percent during the late 1970s and 1980s.

Trends in the effect of college major on salaries of college graduates who have been working for many years can be examined by comparing columns 5 and 6. In 1967 male college graduates 21-70 years old who had majored in business earned 28 percent more and engineers 52 percent more than those who had majored in humanities (U.S Bureau of the Census, 1972). In 1964 college graduates who had majored in physical science earned 93 percent more, engineers earned 114 percent more and business majors 103 percent more than humanities majors (U.S. Bureau of the Census, 1987). Clearly, the economic payoff to business and technical education is considerably greater than the payoff to majors in the humanities and social sciences other than economics and the advantage of these fields of study has not diminished appreciably in the face of the massive increase in the number of students choosing these fields of study. Clearly, there has been a substantial shift in market demand in the United States favoring graduates with business and technical degrees over graduates with liberal arts and education degrees. Research is needed on how the field of study in university effects the payoff to college in Japan and Europe and how the balance between supply and demand varies with field of study.

Final Thoughts: Part 1's review of the evidence on the wage and productivity payoff to various skills generated very similar conclusions. **American studies indicate that mathematical and technical skills of average workers generate much greater wage and productivity benefits than verbal and scientific skills.** The effect of the mathematics reasoning tests is quite large (a one population SD increase appears to cause an improvement in productivity of 6.4 percent or about $1600 per year). This result suggests that the educational reformers are indeed correct in urging major improvements in mathematics education for the great mass of high school students. The policy implications of these findings, at least for the U.S., are that mathematics particularly algebra, geometry and statistics should receive much greater emphasis in the secondary school curriculum.

Tests assessing technical competence had very large impacts on both supervisory assessment and hands-on SQT measures of job performance in nonclerical jobs in the military and on the wages and earnings of young males. A one population SD increase in these competencies appeared to raise productivity in these jobs by 11.5 percent or about $2875 per year. These results imply that broad **technical literacy** is essential for workers who use and/or maintain equipment that is similar in complexity to that employed in the military. Consequently, students need to receive greater exposure to computers and other technologies.

There is no data on the productivity consequences of greater knowledge of history, geography and foreign languages. The economic case for greater emphasis on English and science in high school rests largely on the pipeline argument--these competencies are necessary for success in college. ***These conclusions must for now be tentative for much more research is required on the contribution of particular skills and competencies to productivity of individuals and competitiveness of nations.***

Evidence was also presented that the effect of general academic achievement on wage rates and productivity of adults is quite large. This, in turn, implies that the 1.25 grade level equivalent decline in the test scores of American secondary school graduates between 1967 and 1980 signalled a significant deterioration in the quality of young entrants into the American work force. The decline of student test scores was unprecedented for prior to 1967, student test scores had been rising steadily for more than 50 years. Bishop (1989) has developed an index of the quality of the US work force which incorporates the effects of improvements in academic achievement at given levels of schooling as well as increases in years of schooling. Jorgenson, Gollop and Fraumeni estimate that increases in years of schooling raised labor quality in the US by .725 percent per year between 1948 and 1973. Bishop's estimates imply that improvements in academic achievement at given amounts of schooling contributed an additional .212 percent per year to the growth of the quality of labor during this period. The test score decline reduced this contribution to .16 percent per year between 1973 and 1980, and .085 percent per year in the 1980s. If the test scores of high school graduates had continued to grow at the rate that prevailed between 1942 and 1967, labor quality would now be 2.9 percent higher. The social cost in terms of foregone GNP is now 86 billion dollars annually. Even with rapid improvements in the quality of elementary and secondary education, the labor quality shortfall grows to 5.5 percent in 2000 and 6.7 percent in 2010.[16] If academic learning creates externalities, as argued above, the social costs of deteriorating school quality are even greater.

It would appear that the education enterprise has historically been an important source of economic growth. When the academic achievement of students completing their schooling declines substantially, the economic costs are large and last for generations. Consequently, the potential benefits of major improvements in the academic achievement of students would also appear to be substantial.

Unfortunately, less than a quarter of 10th graders in the United States believe that geometry, trigonometry, biology, chemistry and physics are needed to qualify for their first choice occupation (Longitudinal Survey of American Youth 1988). The analysis of NLS Youth data presented in section 1 shows that this perception is not in error. During the first 8 years after leaving high school, young men who do not go to college receive no rewards from the labor market for developing competence in science, language arts and mathematical reasoning. It would appear the the United States needs to improve its signalling of academic competencies to employers if incentives to study mathematics and science during secondary school are ever to become as strong as they currently are in Europe and Japan.

ENDNOTES

1. The model estimated was:

$$\underline{ln}WEARN = a_0 + a_1GAA + a_2SCH + a_3AGE + a_4NOWHITE + \underline{a_5}\underline{TRUEBG} + u_1$$

$$TEST = GAA + u_2$$

$$YRED = SCH + u_3$$

$$\underline{MEASBG} = \underline{c}*\underline{TRUEBG} + \underline{u_4}$$

MEASBG is a vector of imperfectly measured characteristics of the individual's true family background: TRUEBG = [fathers education, father's occupation (Duncan index), number of siblings, father foreign born, born on a farm, born in the South]. GAA, SCH and the elements of TRUEBG are latent variables with measurement errors (u_2, u_3 and $\underline{u_4}$) which are uncorrelated with each other and with equation error (u_1). Var(GAA) is normalized to 1, Var(GAA)/Var(TEST) = .652 and Var(SCH)/Var(YRED) = .915. For the three dummy variables (Father foreign born, Born on a farm, and Born in the South), reliability is assumed to be .903 and c_i is assumed equal to be .95. For the other three background variables, c_i is assumed to be 1 and the reliabilities are assumed to be .702 for father's education, .735 for father's occupation and .927 for number of siblings (Christopher Jencks et. al., 1979, table A2.14). The results of estimating such a model predicting the log of weekly earnings in 1971 PSID data on male household heads 25 to 64 years old are:

$$(1)\ \mathit{ln}WEARN = \underset{(6.26)}{.190GAA} + \underset{(6.24)}{.0576SCH} + \underset{(2.92)}{.004AGE} - \underset{(1.25)}{.06NOWHITE} + \underset{(.45)}{.005FAED} - \underset{(1.44)}{.0028FAOCC}$$

$$- \underset{(.03)}{.0002SIBS} + \underset{(1.74)}{.076FAFOR} - \underset{(3.58)}{.152BORNFARM} - \underset{(.25)}{.009BORNSOUTH} + a_0 \qquad R^2 = .268,\ N = 1774$$

T statistics are in parenthesis below the coefficient. Except for BORNFARM, none of the indicators of family background have a significant direct effect on weekly earnings. The addition of these variables to the model causes a small (7 percent) reduction in the coefficient on academic achievement. If there is no correction for errors in measurement the coefficient on academic achievement (GAA) is .109 and the coefficient on schooling is .0596. Thus, correcting for measurement error increases the estimated effect of academic achievement by 74 percent and reduces the direct effect of years of schooling very slightly (Bishop 1989).

2. For example, reliabilities for the College Board's afternoon Scholastic Achievement Tests are .90 for English Literature and .87 for Math I and for the morning Scholastic Aptitude Tests are .91-.92. The correlation between Math I and the Math SAT is .83 and the correlation between English Literature and the Verbal SAT is .84 (College Board 1984, 1987). In contrast, the correlation between math and verbal SATs is .66. There are good reasons for high correlations between past achievement in a subject and scores on aptitude tests designed to predict future achievement in the subject. Past achievement aids learning because the tools (e.g. reading and mathematics) and concepts taught early in the curriculum are often essential for learning the material that comes later. Furthermore,

3. Tuijnman's estimated "true" correlations were used to estimate a model in which log earnings is a function of schooling, home background and the two tests.

4. Its ability to accomplish these objectives has been thoroughly researched and the battery has been periodically modified to incorporate the findings of this research. The test is highly correlated with the cognitive subtests of the General Aptitude Test Battery, a personnel selection test battery used by the US Employment Service, the validity of which has been established by studies of over 500 occupations. A validity generalization study funded by the armed forces concluded "that ASVAB is a highly valid predictor of performance in civilian occupations" (Hunter Crossen and Friedman, 1985, p. ix). During the summer of 1980 all members of the NLS Youth sample were asked to take this test and offered a $50 honorarium as an inducement. The tests were successfully administered to 94 percent of the sample. Testing was generally conducted in groups of 5 to 10 persons. The 1980 version of the ASVAB (Form 8A) was administered by staff of the National Opinion Research Corporation according to strict guidelines conforming to standard ASVAB procedures. At the time of the testing the NLS youth were between 15 and 23 years of age.

5. These subtests have some similarities with the occupational competency examinations developed to assess high school vocational students. However, the ASVAB technical subtests assess knowledge in a much broader domain and the individual items are, consequently, more generic and less detailed. The ASVAB technical composite is interpreted as a measure of knowledge and trainability for a large family of jobs involving the operation, maintenance and repair of complicated machinery and other technically oriented jobs.

6. The alternate form reliabilities of these composites are approximately .92-.93 for Technical, .93 for Math, .93-.94 for Verbal, .80 for General Science, .72 for Numerical Operations and .77 for Clerical Checking (US Military Entrance Processing Command 1984; Palmer et al, 1988).

7. Reports of weeks spent in civilian employment were available all the way back through 1975. For each individual, these weeks worked reports were aggregated across time and an estimate of cumulated civilian work experience was derived for January 1 of each year in the longitudinal file. This variable and its square was included in every model as was age, age squared and current and past military experience. School attendance was controlled by four separate variables: a dummy for respondent is in school at the time of the interview; a dummy for respondent has been in school since the last interview; a dummy for part time attendance and the share of the calendar year that the youth reported attending school derived from the NLS's monthly time log. Years of schooling was controlled by four variables: years of schooling, a dummy for high school graduation, years of college education completed, and years of schooling completed since the ASVAB tests were taken. The individual's family situation was controlled by dummy variables for being married and for having at least one child. Minority status was controlled by a dummy variable for Hispanic and two dummy variables for race. Characteristics of the local labor market were held constant by entering the following variables: dummy variables for the four Census regions, a dummy variable for rural residence and for residence outside an SMSA and measures of the unemployment rate in the local labor market during that year.

child. Minority status was controlled by a dummy variable for Hispanic and two dummy variables for race. Characteristics of the local labor market were held constant by entering the following variables: dummy variables for the four Census regions, a dummy variable for rural residence and for residence outside an SMSA and measures of the unemployment rate in the local labor market during that year.

8. Bishop, Blakemore and Low's (1985) studied the effect of math, reading and vocabulary test scores on the wage rates and earnings of high school graduates for both 1972 and 1980 in a model that contained controls for grade point average and the number of credit hours of academic and vocational courses. In both these years, none of the variables representing academic performance--the three test scores, GPA and the number of academic courses--had a significant (at the ten percent level) effect on the wage rate of the first post high school job. Only one variable (the vocabulary test for female members of the class of 1972) had a significant effect on the wage 18 months after graduation.

9. The survey was of a stratified random sample of the National Federation of Independent Business membership. Larger firms had a significantly higher probability of being selected for the study. The response rate to the mail survey was 20 percent and the number of usable responses was 2014 (Bishop and Griffin, forthcoming).

10. Studies that measure output for different workers in the same job at the same firm, using physical output as a criterion, can be manipulated to produce estimates of the standard deviation of non-transitory output variation across individuals. It averages about .14 in operative jobs, .28 in craft jobs, .34 in technician jobs, .164 in routine clerical jobs and .278 in clerical jobs with decision making responsibilities (Hunter, Schmidt & Judiesch 1988). Because there are fixed costs to employing an individual (facilities, equipment, light, heat and overhead functions such as hiring), the coefficient of variation of marginal products of individuals is assumed to be 1.5 times the coefficient of variation of productivity. Because about 2/3rds of clerical jobs can be classified as routine, the coefficient of variation of marginal productivity for clerical jobs is 30 % [1.5*(.33*.278+.67*.164)]. Averaging operative jobs in with craft and technical jobs produces a similar 30% figure for blue collar jobs. The details and rationale of these calculations are explained in Bishop 1988b and in Appendix B.

11. Only deviations of rated performance ($R^m_{ij}-R^m_j$) from the mean for the establishment (R^m_j) were analyzed. The variance of the job performance distribution was also standardized across establishments by dividing ($R^m_{ij}-R^m_j$) by the standard deviation of rated performance, ($SD_j(R^m_{ij})$), calculated for that firm (or 3 if the sample SD is less than 3). Separate models were estimated for each major occupation. They were specified as follows:

$$\frac{R^m_{ij}-R^m_j}{SD_j(R^m_{ij})} = \beta_o + \beta_1(\underline{T}_{ij}-\underline{T}_j) + \beta_2(S_{ij}-S_j) + \beta_3(\underline{X}_{ij}-\underline{X}_j) + \beta_4(\underline{D}_{ij}-\underline{D}_j) + v_2$$

where R_{ij} = ratings standardized to have a zero mean and SD of 1.

$\underline{T}_{ij}$ = a vector of the five GATB aptitude composites

S_{ij} is the schooling of the i^{th} individual.

$\underline{X}_{ij}$ = a vector of age and experience variables--age, age^2, total occupational experience, total occupational $experience^2$, plant experience and plant $experience^2$.

$\underline{D}_{ij}$ = a vector of dummy variables for black, Hispanic and female.

$\underline{T}_j$, S_j, $\underline{X}_j$ and $\underline{D}_j$ are the means of test composites, schooling, experience variables and race and gender dummies for the j^{th} job/establishment combination.

12. When all variables are multivariate normal, the ratio of the coefficients estimated in the selected sample to the true coefficient estimated in an unselected population is equal to:

$$\beta^*/\beta = VR/(1-R^2(1-VR)) = VR + R^{*2}(1-VR)$$

where VR is the ratio of the variance of y in the selected sample to its variance in the full population, R^2 is the multiple coefficient of determination of y on $\underline{x}$ in the full population and R^{*2} is the multiple coefficient of determination of y on $\underline{x}$ in the selected population (Goldberger 1981). Estimates of VR, the ratio of incumbent job performance variance to new hire job performance variance can be derived from the NCRVE employer survey analyzed in Bishop (1987a, 1990b). Data on the reported productivity in the 3^{rd} through 13^{th} week after being hired of two different workers was employed to calculate a variance ratio by dividing job performance variance of incumbents (pairs of workers both of whom were still at the firm at the time of the interview a year or so after being hired) by the job performance variance of a group of very recent hires (pairs of workers both of whom stayed at least 13 weeks but who may or may not have remained at the firm through the interview). The resulting estimate of VR was .486. Assuming multivariate normality and noting that the R^2 of the models in table 8 averages about .16, our estimate of β/β^*, the multiplier for transforming the coefficients estimated in the selected sample into estimates of population parameters, is 1.76.

13. Variables which were not used to select new hires such as the GATB test scores may have a positive correlation with unobservable characteristics of the individual which are used in selection. If the unobservable has its own independent effect on job performance (ie. it is not serving solely as a proxy for test scores), test score coefficients may be positively biased. Mueser and Maloney (1987) experimented with some plausible assumptions regarding this selection process and concluded that coefficients on education were severely biased but that coefficients on test scores were not substantially changed when these incidental selection effects were taken into account.

14. Mueser and Maloney (1987) argue persuasively that since schooling is a very important factor in the selection process, the coefficients on schooling in estimations like these are negatively biased estimates of true population relationships. This argument probably applies as well to the coefficients on work experience in the occupation but not at the firm.

15. Unfortunately, there is only limited hard scientific evidence on this issue. Projecting the future skill demands of particular occupations is a good deal more difficult than describing past changes and yet there is controversy about even such simple matters as whether word processors have raised or lowered the skills required of secretaries.

16. The only way to prevent these forecasts from being realized is to change the relationship between GIA at age 17 and GIA as an adult. This might be accomplished by attracting massive numbers of adults back into school, by expanding educational offerings on television and/or by inducing employers to provide general education to long term employees.

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Table 1
Effect of ASVAB and Early School Tests on Wage Rates and Earnings in 1985

	ASVAB	School Test	Controls For Educ. & Background	R^2	N	FTest of Equality of Coef.
<u>Males</u>						
Log Wage Rate	.119 (4.91)	-.049 (2.53)	X	.243	1244	18.7***
Log Earnings	.207 (5.54)	-.067 (2.27)	X	.396	1330	21.2***
<u>Females</u>						
Log Wage Rate	.092 (3.03)	.016 (.73)	X	.274	1211	
Log Earnings	.100 (1.87)	-.016 (.43)	X	.315	1199	2.0

Source: Analysis of NLS Youth Data. The ASVAB test score was an average of all 9 subtests. The school test was the Z score relative to national norms on a test taken early in the youth's school career were included in the models. A full set of controls for years of schooling, school attendance, actual cumulated work experience, gender, race, Hispanic and characteristics of the local labor market. The sample was limited to youth for whom an early test score was available.

Table 2
Determinants of Occupation
Swedish Malmo Data

	Test Age 20	Test Age 10	Youth Educ.	Home Back Ground	Adult Educ.
Occ 25	.45	-.24	.39	.08	-
	(3.0)	(1.8)	(7.2)	(1.9)	-
Occ 30	.41	-.21	.46	.04	-
	(3.0)	(1.6)	(9.0)	(1.1)	-
Occ 35	.35	-.16	.45	.10	.13
	(2.6)	(1.3)	(9.0)	(2.6)	3.1
Occ 40	.39	-.20	.38	.14	.20
	(2.8)	(1.6)	(7.5)	(3.6)	4.7
Occ 43	.38	-.23	.34	.14	.31
	(2.8)	(1.9)	(6.7)	(3.7)	(6.1)
Occ 52	.31	-.20	.33	.09	.42
	(2.4)	(1.7)	(7.0)	(2.6)	(9.0)
Occ 56	.36	-.22	.31	.09	.43
	(2.8)	(1.9)	(6.5)	(2.5)	(9.3)

Source: Standardized regression coefficients (with T statistics in parenthesis) for models predicting occupational attainment are from Tuijnman, 1989, Supplementary Tables A 9.2 to A 9.8.

Table 3
Determinants of Earnings
Swedish Malmo Data

	Test Age 20	Test Age 10	Youth Educ.	Home Back	R^2
Earn 25	.036 (1.23)	-.002 (.09)	.056 (3.13)	.015 (1.16)	.104
Earn 30	.029 (1.05)	.008 (.36)	.129 (7.60)	.022 (1.77)	.302
Earn 35	.061 (1.89)	.018 (.66)	.161 (8.00)	.071 (4.79)	.434
Earn 40	.063 (1.69)	-.017 (-.56)	.247 (10.68)	.037 (2.15)	.431
Earn 43	.066 (1.65)	-.009 (.28)	.222 (9.01)	.048 (2.64)	.385
Earn 52	.032 (.79)	.020 (.60)	.165 (6.69)	.034 (1.86)	.261
Earn 56	.059 (1.35)	.005 (.15)	.151 (5.58)	.032 (1.60)	.223

Source: For log earnings models unstandardized regressions coefficients are reported so the test score coefficients provide an estimate of the percentage change in earnings that results from a one population standard deviation change in the test score. They were fitted using Tuijnman's estimated "true" correlations reported in Tables 9.2, 9.8 and Appendix C.

Table 4
Cognitive Determinants of Success
in Marine Training Programs

	Mechanical Comprehension	Auto & Shop Knowledge	Electronics	Clerical Speed	Computational Speed	Math Reasoning	Math Knowledge	Verbal	Science	Spatial	R^2
Sims & Hiatt ASVAB 6/7 (23061)											
All Occupations	.043*** (5.20)	.098*** (12.46)	.047*** (5.78)	.013** (2.29)	.060*** (8.96)	.116*** (14.44)	.205*** (25.26)	.086*** (11.68)	.089*** (10.68)	.037 (5.89)	.345
Maier & Truss ASVAB 8/9/10											
Electronics Repair (4103)	.055*** (2.73)	.027 (1.40)	.102*** (4.81)	.009 (.69)	.062*** (3.44)	.151*** (6.41)	.256*** (11.91)	.031 (1.40)	.130*** (5.73)	---	.492
Mechanical Maintenance (5841)	.058*** (3.29)	.253*** (15.02)	.094*** (5.02)	.063*** (4.44)	.014 (.87)	.086*** (4.16)	.135*** (7.14)	.120*** (6.27)	.005 (.27)	---	.444
Operators, Food (1897)	.079*** (2.72)	.063** (2.27)	.018 (.57)	.086*** (3.66)	.022 (.82)	.137*** (4.02)	.199*** (6.41)	.164*** (5.20)	.093*** (2.84)	---	.490
Clerical (5231)	.014 (.74)	-.022 (1.22)	.026 (1.33)	.136*** (9.03)	.037** (2.26)	.125*** (5.70)	.259*** (13.02)	.206*** (10.14)	-.101 (.47)	---	.443
Combat (8191)	.087*** (4.98)	.078*** (4.68)	.020 (1.09)	.027* (1.95)	.056*** (3.62)	.069** (3.40)	.143*** (7.71)	.073*** (3.88)	.061*** (3.12)	---	.251
Field Artillery (1062)	.055 (1.34)	.237*** (6.01)	-.009 (.21)	.178*** (5.36)	.060 (1.64)	.148*** (3.07)	.138*** (3.13)	-.011 (.24)	.065 (1.41)	---	.448

Table 5 Effect of Competencies on Job Performance (SQT).

	Mechanical Comprehension	Auto Info.	Shop Info.	Electr. Info.	Attention to Detail	Comp. Speed	Word Knowl.	Arith. Reasoning	Math Knowl.	Science	R^2
Skilled technical	0.092***	0.017	0.132***	0.174***	0.024	0.031	0.215***	0.062**	0.121***	0.057*	0.548
(1324)	(3.07)	(0.58)	(4.28)	(5.09)	(1.12)	(1.17)	(6.77)	(1.96)	(3.76)	(1.83)	
Skilled electronic	0.086	0.098	0.246***	0.045	0.084	-0.013	-0.004	-0.021	0.26***	0.072	0.436
(349)	(1.30)	(1.49)	(3.64)	(0.60)	(1.81)	(0.22)	(0.06)	(0.30)	(3.67)	(1.05)	
General (const.) maintenance	-0.004	0.082**	0.117***	0.121***	0.043*	0.068***	0.066*	-0.101***	0.441***	0.134***	0.592
(879)	(0.11)	(2.34)	(3.25)	(3.05)	(1.76)	(2.19)	(1.80)	(2.73)	(11.70)	(3.67)	
Mechanical maintenance	0.042	0.314***	0.206*	-0.089	0.055	0.235**	-0.004	-0.068	0.061	0.096	0.412
(131)	(0.38)	(2.88)	1.84)	(0.71)	(0.72)	(2.43)	(0.03)	(0.59)	(0.52)	(0.85)	
Clerical	-0.068	0.087***	-0.030	0.065	0.015	0.085**	0.118***	0.241***	0.206***	0.064	0.425
(830)	-(1.59)	(2.05)	(-0.69)	(1.33)	(0.50)	(2.24)	(2.61)	(5.33)	(4.46)	(1.44)	
Operators and food	0.109*	0.179***	0.062	0.100**	0.050	-0.037	0.061	0.114*	0.106**	0.076*	0.414
(814)	(2.50)	(4.11)	(1.39)	(2.02)	(1.62)	(0.96)	(1.33)	(2.47)	(2.25)	(1.66)	
Unskilled electronic	0.004	0.027	0.062*	0.077**	0.036	0.053*	-0.010	0.058*	0.018	-0.025	0.062
(2545)	(0.14)	(0.87)	(1.93)	(2.15)	(1.65)	(1.92)	(0.31)	(1.75)	(0.55)	(0.76)	
Combat	0.147***	0.060***	0.080***	0.058***	0.048***	0.035**	0.069***	0.070***	0.139***	0.070***	0.358
(5403)	(8.28)	(3.38)	(4.42)	(2.86)	(3.82)	(2.23)	(3.71)	(3.74)	(7.29)	(3.82)	
Field artillery	0.059	0.047	0.030	0.134**	0.088**	-0.009	0.000	0.186***	0.230***	0.061	0.422
(534)	(1.10)	(0.89)	(0.56)	(2.21)	(2.33)	(0.19)	(0.01)	(3.28)	(3.99)	(1.10)	

Source: Reanalysis of Maier and Grafton's (1981) data on the ability of ASVAB 6/7 to predict Skill Qualification Test (SQT) scores. The correlation matrix was corrected for restriction of range by Maier and Grafton.

* $p < .05$ on a one tail test
** $p < .025$ on a one tail test
*** $p < .005$ on a one tail test
T statistics are in parentheses under the coefficient

Table 6
ASVAB SUBTESTS WHICH ARE THE BEST PREDICTORS OF CORE TECHNICAL PROFICIENCY
by Military Occupational Specialty Cluster

Subtest	Technical	Speed	Quantitative	Verbal/Science
Electronics Repair (123)	Electronics	Compute-Speed		Science
Skilled Tech. (1329)	Mechanical Comp.		Math Knowledge	Science Verbal
Mechanical Maintenance (716)	Auto-Shop Know. Mechanical Comp. Electronics			Science
General Maintenance (272)	Auto-Shop Know.		Math Knowledge	Science Verbal
Operators/Food (1215)	Auto-Shop Know.		Arith Reasoning Math Knowledge	Verbal
Surveillance & Communication (289)	Auto-Shop Know.	Compute-Speed	Math Knowledge or Arith Reason.	Verbal
Clerical (1210)			Arith Reasoning Math Knowledge	Verbal
Combat (1429)	Auto-Shop Know. Mechanical Comp.		Math Knowledge	Science
Field Artillery (464)	Auto-Shop Know. Mechanical Comp.	Compute-Speed		Science

Source: Summarized from Table 2 of Wise, McHenry, Rossmeissl and Oppler, 1987. Based on an analysis of the ability of ASVAB subtests to predict Core Technical Proficiency ratings after the recruit has been in the US Army for 2 or 3 years. Core Technical Proficiency ratings are about 50 percent based on hands-on work sample tests and 50 percent based on paper and pencil job knowledge exams. The subtests listed in the table are the 3 or 4 subtests which in combination maximized the R^2 of the model predicting Core Technical Proficiency.

Table 7

Effect of ASVAB Composite
on other Dimensions of Job Performance

	Technical	Speed	Quantitative	Verbal	R^2
General Soldering Proficiency	.26	.03	.20	.10	.461
Effort and Leadership (resid)	.21	.07	.08	.03	.280
Effort and Leadership (raw)	.21	.09	.03	-.07	.206
Personal Discipline	.06	.04	.07	-.03	.10

Source from John Campbell, 1986, Table 10. Standardized Coefficients from an Analysis of Project A Data on Performance in the Military.

Table 8

Raw Validity Coefficients

	Mechanical Comprehension	Intelligence	Arithmetic	Spatial Relations	Perceptual Accuracy	Psychomotor Abilities
Foreman	23[c]	28[e]	20[d]	21[d]	27[d]	15[b]
Craftworkers	26[d]	25[f]	25[f]	23[f]	24[e]	19[f]
Industrial Workers	24[d]	20[f]	21[f]	21[f]	20[f]	22[f]
Vehicle Operators	22[d]	15[d]	25[c]	16[c]	17[b]	25[d]
Service Occupations	——	26[d]	28[d]	13[d]	10[d]	15[d]
Protective Occupations	23[b]	23[d]	18[c]	17[d]	21[c]	14[d]
Clerical	23[d]	30[f]	26[f]	16[e]	29[f]	16[f]

Source: Ghiselli (1973) compilation of published and unpublished validity studies for job performance. The raw validity coefficients have not been corrected for restriction of range or measurement error in the performance rating. The Perceptual Accuracy category include number comparison, name comparison, cancellation and perceptual speed tests. They assess the ability to perceive detail quickly. Psychomotor tests measure the ability to perceive spatial patterns and to manipulate objects quickly and accurately. This category of tests includes tracing, tapping, dotting, finger dexterity, hand dexterity and arm dexterity tests.

[a] Less than 100 cases.
[b] 100 to 499 cases.
[c] 500 to 999 cases.
[d] 1,000 to 4,999 cases.
[e] 5,000 to 9,999 cases.
[f] 10,000 or more cases

Table 9
Determinants of Job Performance

	Technician	High Skill Clerical	Low Skill Clerical	Craft Workers	Operatives	Ser
Mathematics	.198*** (.035)	.161*** (.033)	.207*** (.026)	.168*** .017	.107*** (.018)	.2 (.0
Verbal	.051 (.038)	.073** (.035)	.070** (.030)	-.018 (.020)	.012 (.023)	.0 (.0
Spatial Perception	.025 (.029)	-.068*** (.026)	-.002 (.021)	.075*** (.014)	.022 (.016)	.0 (.0
Perceptual Ability	.026 (.036)	.106*** (.031)	.103*** (.025)	.048*** (.018)	.082*** (.019)	.0 (.0
Psychomotor Ability	.113*** (.027)	.094*** (.026)	.091*** (.021)	.083*** (.013)	.145*** (.015)	.1 (.0
Yrs. of Schooling	.031* (.016)	.026 (.016)	-.014 (.013)	-.009 (.007)	-.036*** (.008)	-.0 (.0
Relevant Experience	.041*** (.014)	.019 (.015)	.042*** (.012)	.040*** (.005)	.036*** (.010)	.0 (.0
(Relevant Experience)²	-.00094** (.00046)	-.00012 (.00046)	-.0009** (.0004)	-.00025* (.00015)	-.0005 (.0003)	-.0 (.0
Tenure	.085*** (.015)	.113*** (.016)	-.0925*** (.014)	.0620*** (.0056)	.079*** (.011)	.0 (.0
Tenure²	-.0024*** (.0006)	-.0031*** (.0006)	-.0026*** (.0006)	-.00156*** (.00018)	-.0017*** (.0004)	-.0 (.0
Age	-.0024 (.0163)	.040*** (.015)	.037*** (.010)	.052*** (.0078)	.053*** (.007)	.0 (.0
(Age-18)²	-.00012 (.00021)	-.00064*** (.00020)	-.00062*** (.00013)	-.00071*** (.00010)	-.00072*** (.00009)	-.0 (.0
Female	.057 (.056)	.063 (.072)	-.024 (.063)	-.396*** (.066)	-.194*** (.043)	.1 (.0
Black	-.138** (.060)	-.390*** (.054)	-.146*** (.042)	-.247*** (.032)	-.216*** (.029)	-.0 (.0
Hispanic	.046 (.099)	-.286*** (.086)	.053 (.069)	-.109*** (.042)	-.053 (.049)	-.0 (.1
R. Square	.114	.167	.139	.150	.145	.1
Number of Obs.	2384	2570	4123	10016	8167	1

Source: Analysis of GATB revalidation data in the US Employment Services Individual Data File. Deviations of j performance ratings from the mean for the job/establishment are modeled as a function of deviations of worker characteristics from the mean for the job/establishment. The test scores are in a population standard deviation metric. The metric for job performance is the within job/establishment standard deviatio

Table 10
OCCUPATIONAL UPSKILLING IN OECD COUNTRIES

	Annual Rate by which Prof-Tech-Manag Grew more Rapidly than Manual Wkrs		Prof-Tech Managerial Share in 1990
	1970-1981[1]	1981-1990[2]	
Australia	2.34%	2.02%	24.0%
Austria	---	3.67%	20.8%
Belgium	3.86%	3.14%	25.8%
Canada	3.48%	3.87%	30.2%
Denmark	6.60%	2.50%	28.0%
Finland	6.41%	5.13%	28.6%
Fed Rep of Germany	3.67%	2.53%	19.9%
Greece	6.11%	3.76%	14.3%
Ireland	5.97%	2.10%	20.3%
Japan	4.27%	3.26%	14.9%
Korea	4.24%	5.95%	8.7%
Malaysia	---	3.03%	9.5%
Netherlands	4.46%	4.30%	28.1%
Norway	5.48%	3.85%	30.0%
Singapore	3.77%	4.79%	20.3%
Spain	3.34%	5.88%	12.8%
Sweden	2.95%	---	---
United Kingdom[3]	3.28%	3.88%	31.5%
United States[4]	**2.78%**	**2.46%**	**29.3%**

[1] Manual occupations include farming, fisheries, craft, operatives, laborers and service workers. Source: Yearbook of Labour Statistics for 1971, 1976, 1981 & 1991, International Labour Organization, Table 2B & Table 3C. Data availability problems resulted in somewhat different time periods being used for Belgium--1970-83, Canada--1971-81, Denmark 1965-81, Greece--1961-81, Ireland--1966-83, Japan--1970-80, Germany--1970-82, Netherlands--1971-81.

[2] Source: 1991 Handbook of Labour Statistics, Table 3. Absent data meant that shorter time periods were used for some countries: Austria 1984-89, Belgium 1983-89, Federal Republic of Germany 1982-89, Greece 1981-88, Ireland 1983-88, Malaysia 1981-87.

[3] Growth rates were calculated for 1971-1978 and 1978 to 1989. Source: MSC Manpower Report 1980, pg. 8 and Labour Force Survey 1988 and 1989, Office of Population Censuses and Surveys, Table 5.11.

[4] Source: Deborah Klein, "Occupational Employment Statistics for 1972-82", Employment and Earnings. Jan. 1984. 13-16; and later January issues of Employment and Earnings. Because of a change in occupational coding in 1972, the trend was calculated for the 1972-1981 period.

Table 11
The Payoff to University Education in OECD Countries During the 1980s

Country	Ratio of Unemployment Rates of Sec. Sch. Non Completers to College Graduates[1] Men	Women	Coll/HS Earnings Ratio in Late 80s[2]	Annual Rate of Change in 1980s	Initial/ Second Year	Education Groups in the Ratio
United States	5.94	4.57	1.52	.026	1979/1987	Coll.Grad/HighSchGrad
Australia	3.65	1.42	--	.004	1982/1990	Univ/Trade
Austria	6.88	2.04	--	--	--	--
Belgium	2.81	2.91	--	--	--	--
Canada	3.59	2.42	1.43	.006	1980/1985	Univ/HighSchool
Finland	7.50	8.00	--	--	--	--
Germany	4.80	1.87	1.42	.020	1981/1984	(14-18)/(11-13 yrs of sch)
Greece	0.93	0.49	--	--	--	--
Italy	1.87	1.66	--	--	--	--
Japan	--	--	1.26	.000	1979/1987	Coll/Upper Sec School
Netherlands	2.48	1.45	1.23	-.050	1983/1987	Univ/Secondary
Norway	5.50	2.00	--	--	--	--
Spain	1.48	0.65	--	--	--	--
Sweden	2.63	2.75	1.19	.006	1981/1986	Univ/Post Sec
Switzerland	1.00	0.86	--	--	--	--
United Kingdom	4.00	2.40	1.65	.015	1980/1988	Univ/No Qual.

[1] Ratio of the unemployment rate of workers who have not completed upper secondary school to the unemployment rate of workers who have one or more university degrees. Source: Organization of Economic Cooperation and Development, Employment Outlook: 1989, (Paris, OECD, 1989), p. 67.

[2] Source: Steven Davis, "Cross Country Patterns of Change in Relative Wages," 1992 NBER Macroeconomics Annual, Cambridge, Mass: National Bureau of Economic Research, April 1992.

Table 12
Wage Premiums by College Major
(Relative to Bachelors Degree in Humanities)

	Starting Salaries[a]				Median Earnings Males age 21-70 BAs in 1966[b]	Average Monthly Earnings in 1984[c]
	Year					
	1963	1969-70	1979-80	1991		
BAs in Low Wage Major						
Humanities	0	0	0	0	0	0
Social Sciences					14%	---
Economics	--	--	8%	15%	--	111%
Other Social Sciences	0	0	-1%	-3%	--	28%
Education	--	--	--	-13%	-9%	-6%
Biological Sciences	--	--	--	-1%	-11%	12%
Agriculture	--	--	--	4%	--	45%
Health	--	--	--	39%	--	12%
Bachelors in High Wage Major						
Physical Science	17%	17%	36%	24%	28%	93%
Mathematics	18%	15%	36%	24%	--	68%
Engineering					52%	114%
Chemical Eng.	23%	28%	67%	70%	--	--
Electrical Eng.	27%	24%	56%	50%	--	--
Industrial Eng.	20%	21%	53%	45%	--	—
Mechanical Eng.	24%	23%	57%	54%	--	--
Computer Science	--	--	44%	38%	--	--
Business					28%	103%
Accounting	10%	17%	21%	21%	--	--
Other Business	0	2%	11%	10%	--	--

[a] Percentage differential between the starting salary in the designated major over that received by humanities majors. The College Placement Council "Inflation and the College Graduate" 1985 and CPC Salary Survey, Sept. 1991.

[b] Percentage differential for median yearly earnings of males whose highest degree is a BA or BS in the designated major relative to median earnings of humanities majors. Current Population Reports, P-20, No. 201.

[c] Percentage differential for mean monthly earnings of men and women whose highest degree is a BA or BS in the designated major relative to earnings of humanities and liberal arts majors. Current Population Reports, P-70, No. 11, p. 13.

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WAGE DIFFERENTIALS IN THE NORDIC COUNTRIES*

by

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ABSTRACT

It is common belief in the Nordic countries that the wage differentials here are lower than in many other countries. This may have a discouraging impact on the incentives for the labour force to take part in various types of education, training and other productivity increasing measures. This, in turn, may have severe effects for the countries' future productivity growth.

With this point in mind, the purpose of the present paper is to analyse the wage structure in Denmark, Norway, Sweden and Finland on comparable data sets and with respect to a few, mainly human capital-related variables. More formally, identical human capital wage equations controlling for education, work experience, seniority, and occupational status are estimated both by gender and sector. The regression results display several interesting similarities and dissimilarities between the four countries.

1. INTRODUCTION

It is common belief in the Nordic countries that the wage differentials here are lower than in many other countries. This may have a number of consequences for the role of the Nordic economies in a world, where more and more interaction takes place between countries. A more equal wage distribution in the Nordic countries may have effects on the pattern of immigrations and on the allocation of different production processes. However, it may also have an impact on the incentives for the labour force to take part in various types of education, training and other productivity increasing measures. This, in turn, may lead to lower productivity increases in the future compared with the countries we compete and normally compare with.

A number of studies seem to propose that the return to education is fairly low in the Nordic countries compared to other countries. This could easily be explained by culture and by the set of policies related to education, the organization of labour markets, tax and other policies aimed at equalizing incomes and wages that has been pursued in the Nordic countries. The result is without doubt a more egalitarian society with fewer social tentions than in other countries. However, the cost may be that the incentives to invest in ones own education and training may diminish with severe effects for the future possibilities of regaining or catching up with the productivity growth of the Western World.

Another point of interest is the return to training and especially specific training. In some countries, this return is found to be very low for groups of workers. This could be taken as a market signal indicating that some jobs provide minor, if any, opportunities of on-the-job training or other possibilities of improving productivity. Again, this factor could be seen as a potential policy parameter to increase productivity and job satisfaction at the same time.

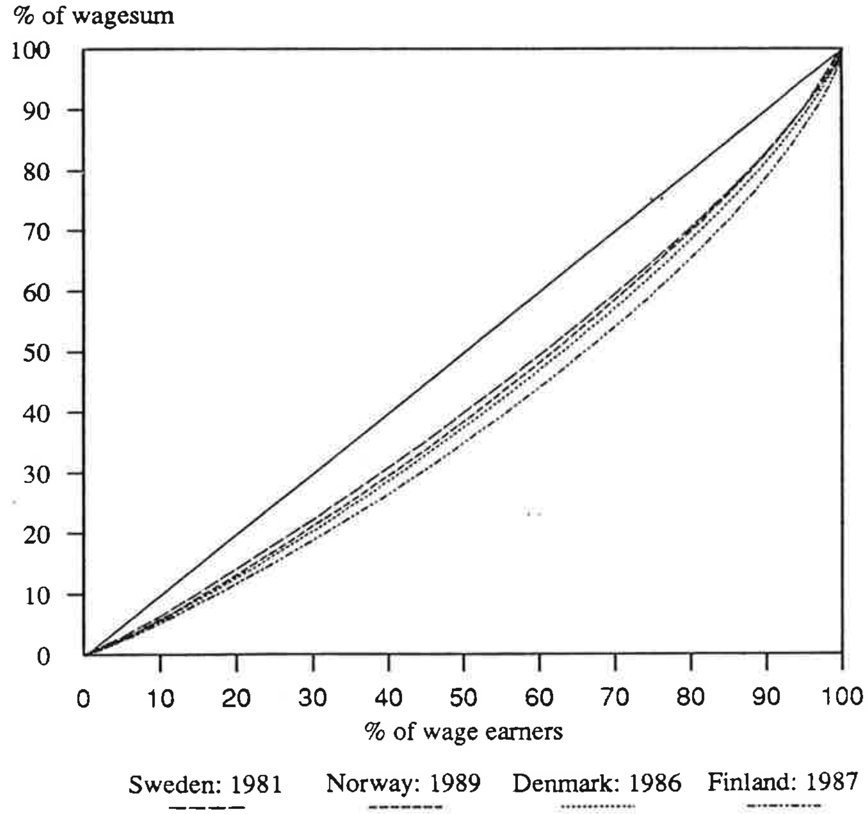
With these points in mind, the purpose of this paper is to analyse the wage structure in the four Nordic countries with respect to a few key variables. With many similarities in the structure of society it could be expected that the wage structure is characterized rather by similarities than by dissimilarities. In order to analyse this question the main emphasis in the following has been to perform the same type of analysis on comparable data sets. The drawback of using this method is that it limits the use of more sophisticated data which are available in some of the Nordic countries.

The analysis focuses exclusively on persons in paid-employment. Thus self-employed and persons not currently having a wage are excluded. Both constraints will undoubtedly introduce an element of self-selection, which may bias the estimation results.

The analytical objective of the analysis is the wage rate, defined as the hourly wage before tax. The overall distribution of sample wages is described by means of Lorenz curves in Figure 1. The figure shows distinct differences between the Nordic countries with a clear ordering of the equality with Sweden having the most equal wage rates followed by Norway, Denmark and Finland. The Gini coefficients show the same picture. There are obviously many explanations for these differences in wages. This paper attempts only to include measured factors such as formal education, experience, seniority (tenure), gender, private- and public-sector employment, and occupations.

The paper starts with a short presentation of the standard wage model to be estimated and the data and variables applied. In Section 3 some of the main results are discussed and in Section 4 the stability of the estimates over time is examined. Concluding remarks are given in Section 5.

Figure 1. Lorenz curves for wages in the Nordic countries



lo_total.cgm

The Gini coefficients:

Sweden: 0.15 Norway: 0.17 Denmark: 0.19 Finland: 0.23

2. EMPIRICAL MODEL AND DATA

The theoretical background for the analysis is the human capital theory. Various specifications of the standard human capital earnings function postulated by Mincer (1974) are estimated for each country. More formally, the log hourly wage of the *i*th individual (lnw_i) is regressed on a vector (X_i) of human capital variables, a vector (Y_i) of sector-specific characteristics, and an error term (ϵ_i):

$$(1) \quad lnw_i = \alpha + \sum \beta_j X_i + \sum \gamma_k Y_i + \epsilon_i$$

All model specifications are estimated jointly (restricted model) and separately for men and women (unrestricted model) using ordinary least squares (OLS) techniques. The restricted model allows for different constant terms for men and women but restricts the wage effects of the included explanatory variables to be the same across genders. The unrestricted model allows for variation in the estimates of these key variables, as well. Separate wage equations are also estimated for the private and the public sector.

The data used come from national cross-section data sets found most appropriate for this purpose. In Sweden, data come from *LNU (Level of Living Survey)* for 1981. In Denmark, data come from *DLDB (Danish Longitudinal Data Base)* which is a random sample of register data for the whole population covering the years 1976-86. The Norwegian data were collected as part of the 1989 *Norwegian Study of Organizations and Employees*, which is a random sample of all individuals employed in public- and private-sector establishments with two or more employees. In Finland, the data come from the *Labour Force Survey* for 1987.

All data sets are either random draws from the whole population or age segments of it. The data come from surveys partly mixed with register data, except for Denmark where the data set is constructed by merging various registers. This clearly introduces different measurement errors.

Some of the data sets are longitudinal in nature. This is the case for the Danish data and also partly for Sweden and Norway. In Sweden, the *LNU* covers the years 1968, 1974 and 1981 (data for 1991 have recently become available). The data used for Norway have been supplemented with data from the Level of Living surveys for the years 1980, 1983 and 1987. In Finland, the labour force surveys do not provide a longitudinal data base because the survey sample varies from one year to another. Moreover, 1987 is the first and, until recently, only year for which the survey data have been supplemented with tax-file income data. Since only a single cross-section survey is available, the stability of the Finnish estimates remain an open question.

The samples are limited to employed wage earners between 16 and 64 years of age. Though the data differ in some aspects, it is concluded that there are sufficient common features to make useful cross-country comparisons. It is also attempted to use as comparable definitions of variables as possible. For variables like education and occupations, various keys made by *Nordisk statistisk sekretariat* are used fully or partly. Other variables covering experience, sector and wage rates are defined in a way that makes them comparable. Yet, data sets and data sources differ and that constitutes small differences in the definitions of some variables.

A brief summary of definitions of variables used in the empirical analysis is given in Table 1 of Appendix. Sample statistics for all four countries are reported in Table 2 of Appendix.

3. DISCUSSION OF BASIC RESULTS

In this section, the estimated coefficients of crucial variables are discussed in more detail. The underlying estimation results are reported in Tables 3-8 of Appendix.

3.1. Returns to years of schooling

The average rate of return to an additional year's schooling above basic education is estimated at about 4½ per cent for Denmark, close to 5 per cent for Sweden and Norway but at no less than 7 per cent for Finland. Also the gender-specific schooling coefficients estimated for Finland exceed noticeable those obtained for the other three countries. Hence, Finland seems to clearly break the pattern of approximate similarity with respect to educational returns across the Nordic countries.

Furthermore, in all four countries the return to education is found to be significantly lower for women than for men (Figure 2). The gender gap between the estimated return to an additional

Figure 2. Estimated average returns to an additional year in postcompulsory schooling, by gender

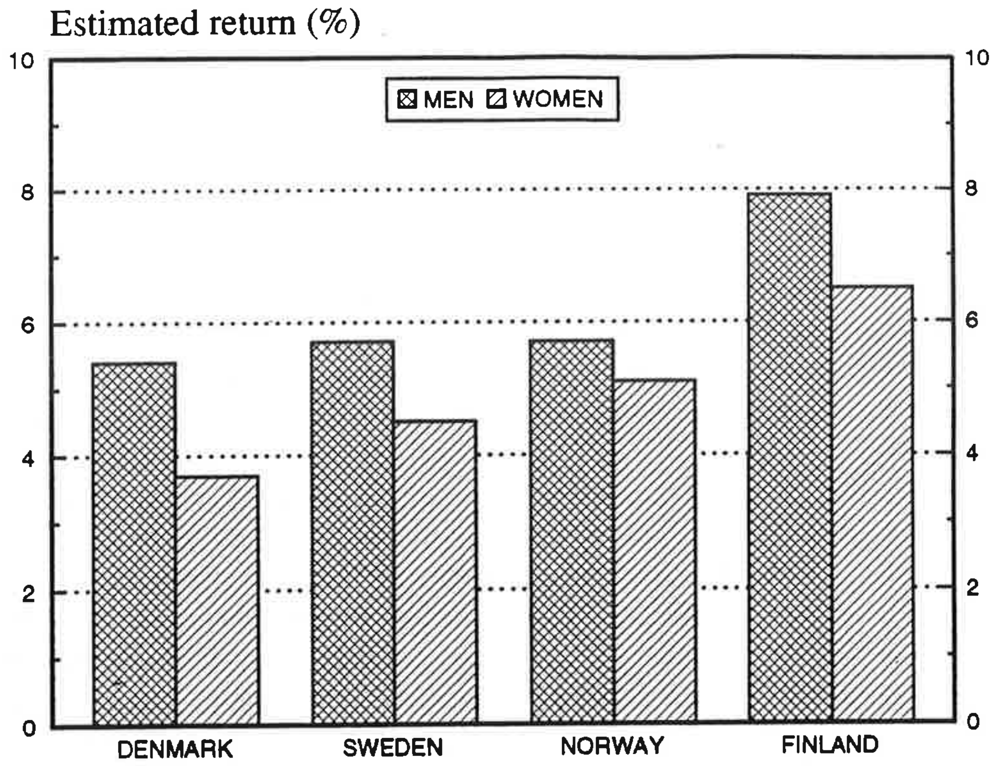
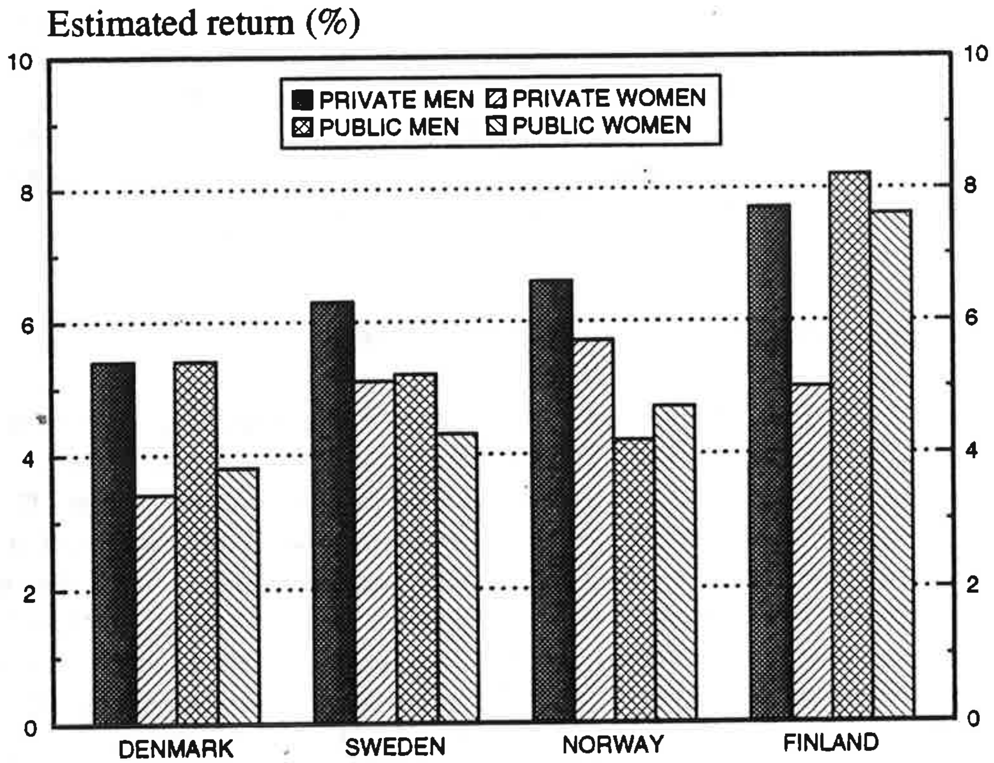


Figure 3. Estimated average return to an additional year in postcompulsory schooling, by sector and gender



year in postcompulsory schooling turns out to be largest in Denmark, slightly less in Finland and Sweden and fairly small in Norway. The large gap in the educational returns between men and women in Denmark originates in a relatively low return to education for Danish women compared both to that of Danish men and to that of women in the other Nordic countries.

Allowing the estimates to differ across sectors displays clear differences between the private and the public sector. As shown in Figure 3, the gender gap in the returns to education is throughout fairly large in the private sector. It is notably smaller in the public sector in Denmark, Sweden and Finland, whereas in Norway the return to education is found to be higher for women than for men employed in the public sector.

It would be most interesting to compare the Nordic rates of return to education with similar results from other countries in order to answer the question if the incentives to further education are lower in the Nordic countries or in some of them. Unfortunately, there is not an abundance of comparable studies, and European results are almost entirely lacking. Estimation results for the US, in turn, are scattered and, for several reasons, not directly applicable. One is that the applied data sets are not representative for the whole population; they may just cover men or men in specific ages or educational groups. In this respect, the Nordic samples are less exclusive than most others. A second and minor problem is that the earnings concept covers total earnings and thus contains a supply decision together with a function describing the prevalence of unemployment. The Nordic estimates use wage rates independent of the number of hours worked. A third reason is the measure of schooling. Some of the studies report only rates of returns for specific educational groups.

3.2. Returns to educational degrees

However, the returns to years of schooling estimated for the Nordic countries could be due to mis-specifications of the schooling function in various respects. One possible source of error is the question on the measurement of schooling. A second source of error is the problem of leaving out person-specific elements with ability as the most important variable. This may bias the effect of schooling upwards. A third source for mis-specification is the possibility that the observed wage rate is not an equilibrium wage and that the incidence of unemployment is related to the educational level.

In order to investigate if it is reasonable to assume that education should enter the wage model in a linear fashion, indicator variables are used to represent the main levels of education. These are defined according to the *Nordic Key to Educational Classification*. The five levels are: Basic school (9 years of education), Vocational training (= 12 years), Short non-university (= 14 years), BA-level (= 16 years), and Graduate level and above (= 18 years).

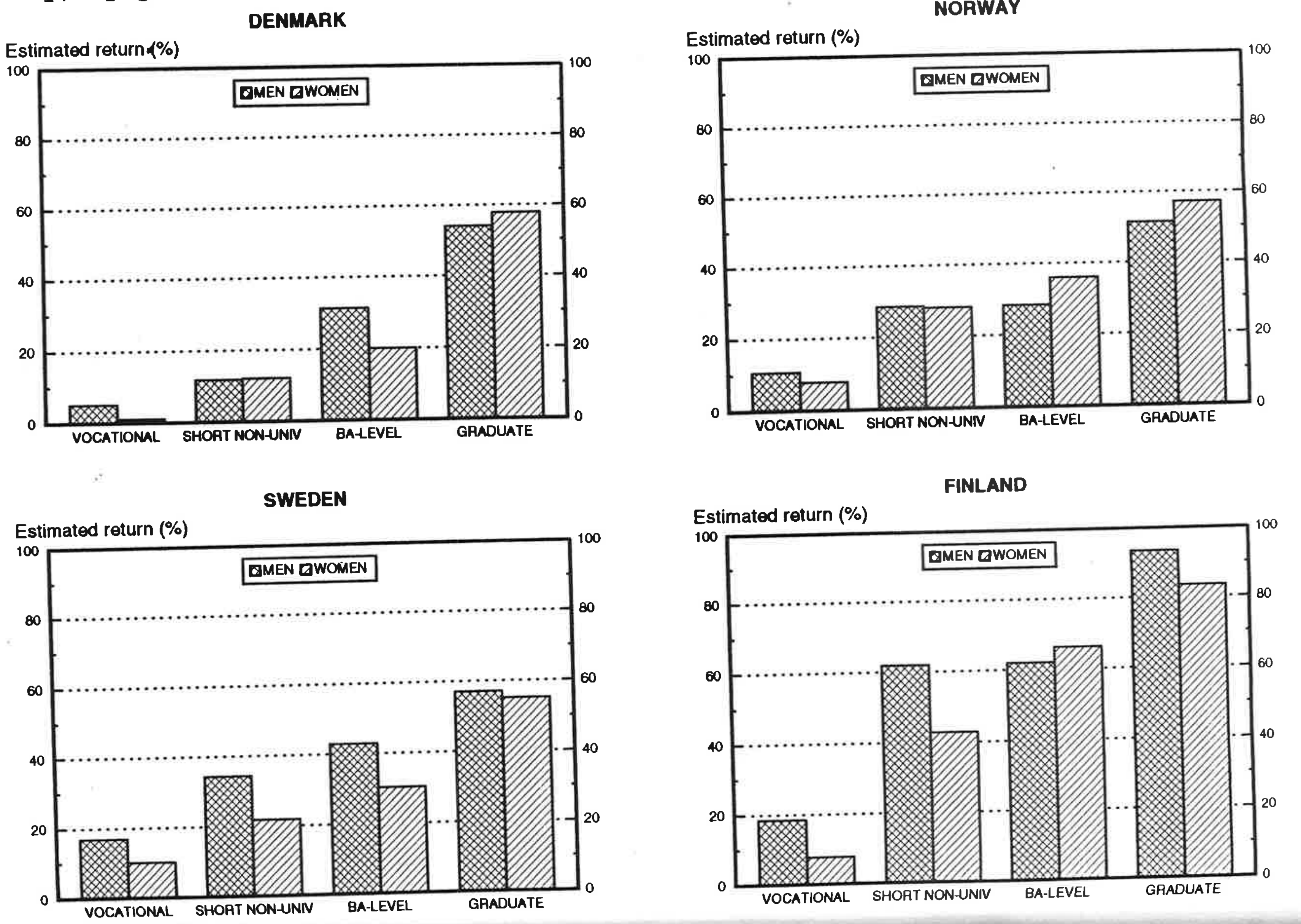
Figure 4 shows that the linear specification of the education variable may be regarded as a fairly reasonable specification, except in Denmark where the pattern of educational returns is more segmented. The main difference compared with the other Nordic countries is a remarkably low return to vocational training compared to the return received from completed basic education. Another notable difference is that all educational groups tend to receive a lower return in Denmark. But this differential is by no means equal across educational levels. The absolutely highest difference occurs in short non-university education. The return from graduation at this level is especially high in Norway and Finland for men. This, in turn, points to little, if any, incentives to continue for a degree at the BA- or higher levels.

To conclude, the structure of returns to education is found to be relatively similar in Norway, Sweden and Finland. Denmark is different mostly because of relatively low returns to low and medium educations. There also seem to be obvious problems of incentives to take futher education for those with basic education in Denmark (most severe for women) and for those with short non-university training in Norway and Finland (most severe for men). Since the relative number of people affected by this problem is highest in Denmark, the problems of low incentives can be expected to be most severe here.

3.3. Earnings effects of experience

The average work experience is between 17 and 18 years in Sweden, Norway and Finland, but only 13 years in Denmark. The reason for this difference is most likely that experience is based on register data in Denmark. In the other countries it is based on survey data which probably also comprise shorter periods out of the labour force or in unemployment. The difference implies that the earnings effects of experience estimated for Denmark will be downward biased.

Figure 4. Estimated returns to levels of education compared with the return to basic education only, by gender and sector



The overall wage effect of experience estimated for all employees is stronger in Sweden and Norway than in Denmark and Finland. A t-test shows that the differences between Sweden and Norway, on the one hand, and Denmark and Finland, on the other, are significant at a 5 % risk level. Furthermore, the estimated wage effects are fairly similar for men in all four countries but differ significantly for women. In particular, the experience-imputed wage effects are on average relatively strong for Norwegian women, slightly weaker for Swedish and Danish women, and very weak for Finnish women.

The gender gap in the wage effects of experience varies a lot. It is very large in Finland, and smaller, but still large, in Denmark and Sweden. In Norway, however, there seem to be no significant gender differential in the effects of experience. Within the human capital theory, these gender gaps can be interpreted as reflecting differences in the amount of on-the-job training. This again may be due to differences in the jobs men and women typically hold, with men having to a higher degree jobs where on-the-job training is possible and maybe even required. Another, and related suggestion would be that the promotional pattern is widely different for men and women in Finland, to a lesser degree in Sweden and Denmark and non-existing in Norway. These hypotheses are discussed in a separate paper of the project.

The wage effects of experience differ largely between the private and the public sector. For convenience, these differences are highlighted by comparing the slopes of the experience-wage profiles and the number of years it takes to reach the peak wage and the value of this peak wage. Table 1 gives the implication of the estimated linear and quadratic experience coefficients by presenting the percentage wage growth for different years of experience. The hypothesis made here is, of course, that these cross-sectional estimates will capture the dynamics of individual wage changes over the life cycle.

From Table 1 it can be seen that the wage profiles differ widely across genders, sectors, and countries. On the one extreme, Finnish men in the public sector experience a 62 per cent peak wage growth after 34 years of experience. On the other extreme, the maximum wage growth for public-sector women in Denmark is only 13 per cent after 40 years of work experience.

Generally, men tend to have steeper wage profiles than women. The exception to this conclusion is male public-sector employees in Norway who have a surprisingly low return to experience. In

Table 1. Total wage growth in % since entrance on the labour market for different number of years of experience*

	EXPERIENCE (years) 5	10	15	20	25	30	Max of profile**	obtained at
DENMARK								
Men,private	13.2	25	34.6	41.3	44.8	44.6	45.2	27
Women,private	11.3	20.6	26.9	30	29.4	25.2	30.2	22
Men,public	8.7	16.4	22.8	27.6	30.7	31.8	31.8	30
Women,public	2.5	4.7	6.7	8.5	10.1	11.4	13.2	40
SWEDEN								
Men,private	13.6	26.3	37.2	45.9	51.8	54.5	54.5	30
Women,private	11.2	21	29.9	34.4	37.2	37	37.5	27
Men,public	13.1	25.5	36.6	45.9	53	57.3	58.7	35
Women,public	7.2	13.8	19.5	24.1	27.6	29.8	30.7	36
NORWAY								
Men,private	13.6	26.1	36.7	44.8	49.7	51.3	51.3	29
Women,private	11.9	22.3	30.6	36.6	39.1	38.7	39.3	27
Men,public	7.3	13.7	18.9	22.9	25.4	26.4	26.4	31
Women,public	10.1	19	26.2	31.3	34	34.2	34.4	28
FINLAND								
Men,private	12.7	24.6	35	43.3	49.2	52.2	52.6	32
Women,private	4.8	9	12.4	15	16.8	17.6	17.7	32
Men,public	14	27.3	39.2	49.2	56.6	61.1	62.4	34
Women,public	3.4	6.7	10.1	13.4	16.8	20.1	26.6	40

* The percetage growth is calculated as the antilog of $(\beta_1 EXP + \beta_2 EXP^2)$.
** The figures indicate the experience level where the profile due to experience reaches its maximum.

fact, the wage effects of experience turn out to be smaller for men than for women in the public sector, while the reverse holds in the private sector. This explains why the gender gap in the returns to experience was found to be negligible for Norway when no distinction by sector was made in the estimations.

As for variation between sectors, the growth rates in Denmark and Norway are higher in the private sector among both men and women. In Sweden this holds for women only, whereas the sector differentials are almost negligible for Swedish men. In Finland, on the other hand, the growth rates tend to be higher in the public sector, especially for men. Also, the wage profiles in the private sector have a more pronounced curve linear character than those in the public sector. In other words, the peak earnings tend to occur at an earlier time for private-sector employees.

3.4. Earnings effects of experience and seniority

A distinction is often made in the human capital literature between experience aquired in the current firm (seniority) and previous experience. When both experience and seniority are included in the wage model, the coefficient on seniority is interpreted as an upward biased estimate of the effect of specific human capital, while the coefficient on experience is interpreted as an upward biased estimate of the effect of general human capital. Thus the sum of the coefficients on experience and seniority can be seen as partly reflecting the wage effect of total work experience (Hashimoto & Raisan, 1985).

The regression results indicate that seniority has a much smaller influence on wages than general experience. Moreover, the wage effects of seniority tend to be of somewhat greater importance in Finland and Sweden than in Norway and Denmark. In fact, seniority turns out to be most important in Finland where it accounts for about 30 per cent of the wage effects of total experience. The corresponding figure for Sweden is about one fifth. It is of much less importance in Denmark and Norway where it accounts for approximately one eigth of the total effect. Seniority is also found to be of greater importance for the wage determination of women. This is especially evident for Finland. The exception is Norway where seniority seems to have about the same impact for men and women.

The results obtained when the wage equation including seniority is estimated separately by country, sector and gender are summarized in Figures 4A-4D, which give the simultaneous effects of seniority and experience. The dark field (above) shows the wage growth related to seniority, while the lighter field (below) shows the estimated wage growth attributable to general experience. The two fields indicate, when taken together, the effects of total experience for a hypothetical individual staying with the same employer up to forty years.

Two main conclusions can be drawn from the figures. First, the return to seniority is generally larger in the public than in the private sector. The stronger effect of seniority in the public sector is most apparent for men. In Denmark, Sweden and Finland men have about the same return to general experience irrespective of sector. However, when the effect of seniority is included, the return to total experience becomes larger for men in public-sector employment. The exception is again Norwegian men in the public sector for whom the return to general experience is extremely low.

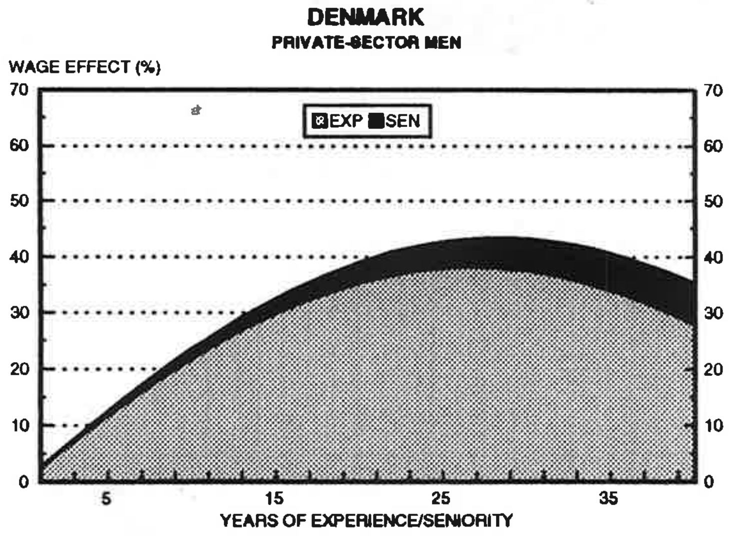
Among women, the return to seniority is found to be stronger in the public sector in Finland and Sweden. For Danish and Norwegian women, in turn, the seniority effect is about the same in the two sectors. It is also worth noting that general experience is found to have no significant effect on public-sector wages for Finnish women, implying that seniority accounts for the most part of the wage effects of total experience.

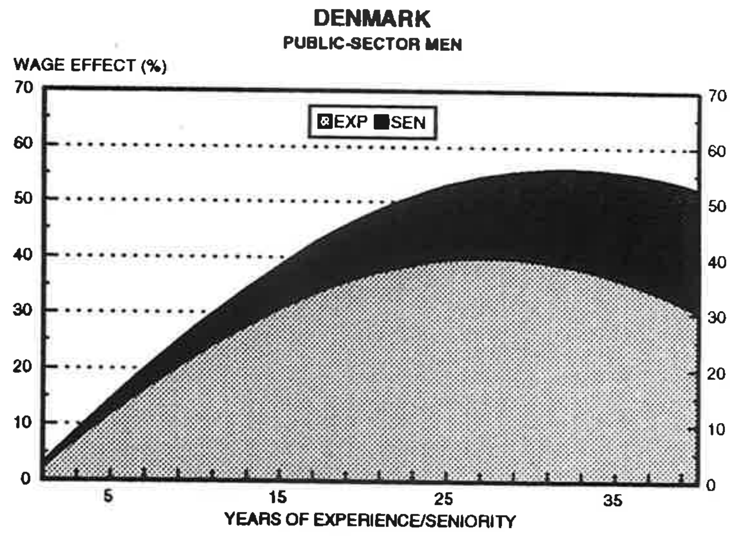
One explanation for the stronger seniority effects in the public sector is that public firms are bigger and that they tend to act on stable, predictable product markets, often in a monopoly position. Public firms therefore have the pre-requisites to establish firm-internal career labour markets which increase the probability for public employees to be promoted at the same employer.

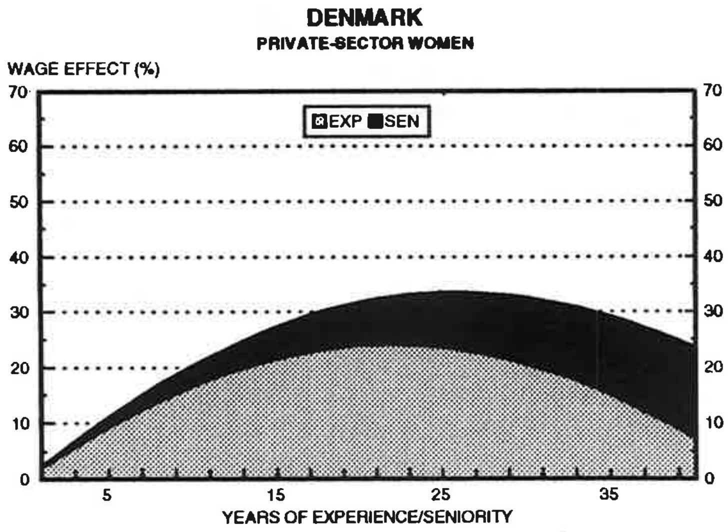
A second major finding is that the return to total experience tends to be larger for men than for women. This is due to much higher returns to general experience for men. The seniority effects, on the other hand, tend to be approximately of the same size for men and women. A possible interpretation of this result would be that men more often than women acquire skills which are transferable between firms, while the skills that women acquire to a higher degree are of a specific nature.

Work experience - and especially general experience as measured by the total number of years in the labour force - thus has a substantial impact on wage inequality in all four countries. However, a number of other theoretical approaches such as screening, agency and efficiency wage hypotheses also offer convincing reasons for these effects to occur. Hence, the estimated wage effects of seniority and experience cannot be interpreted as solely reflecting returns to general and specific human capital, i.e. to higher skills and productivity.

Figure 4A. Simultaneous wage effects of general experience and seniority estimated for a hypothetical individual staying with the same employer up to forty years







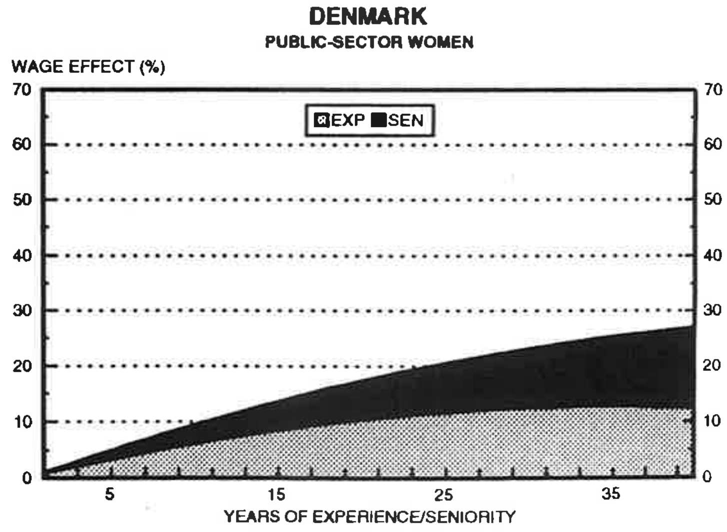


Figure 4B. Simultaneous wage effects of general experience and seniority estimated for a hypothetical individual staying with the same employer up to forty years

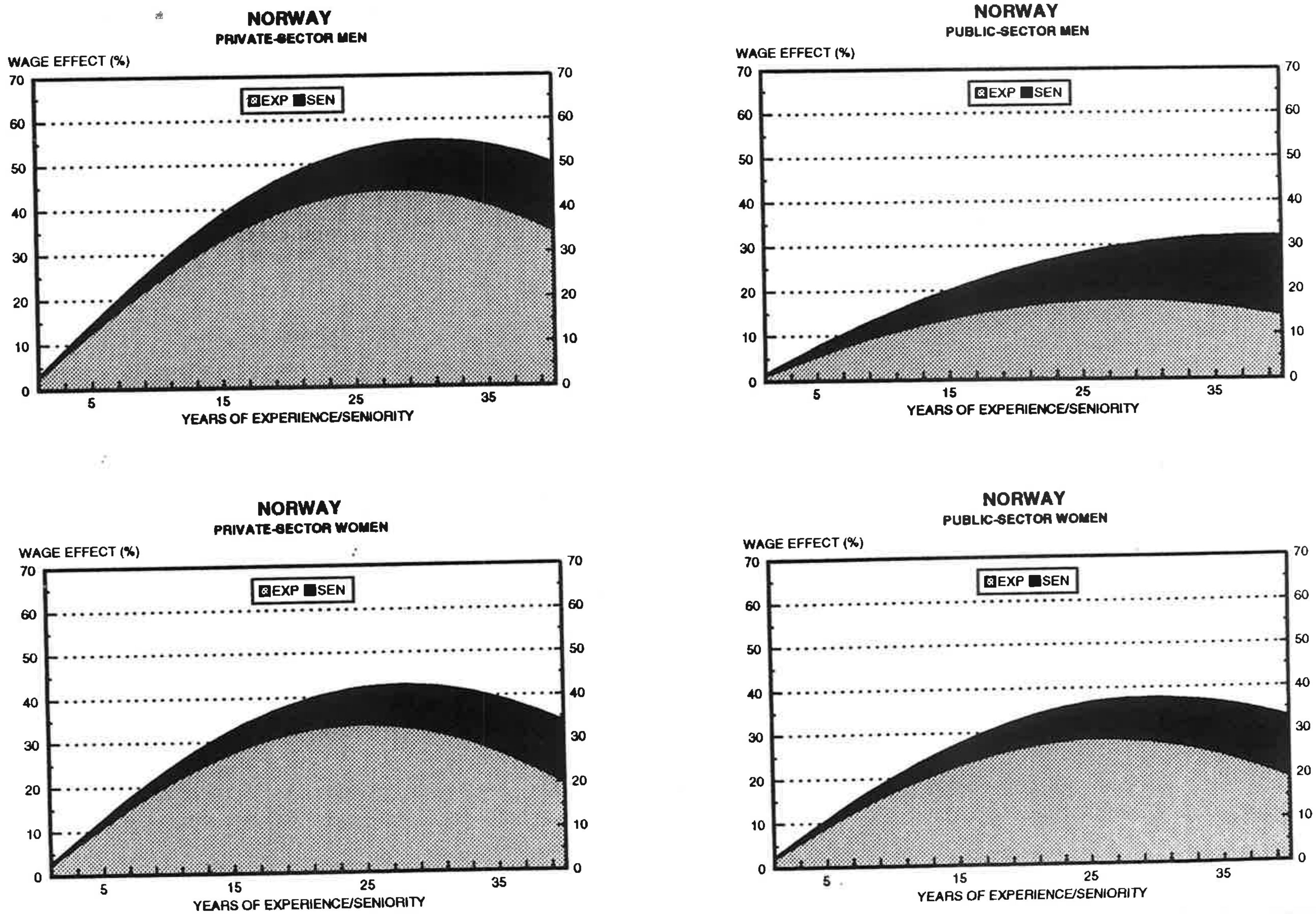
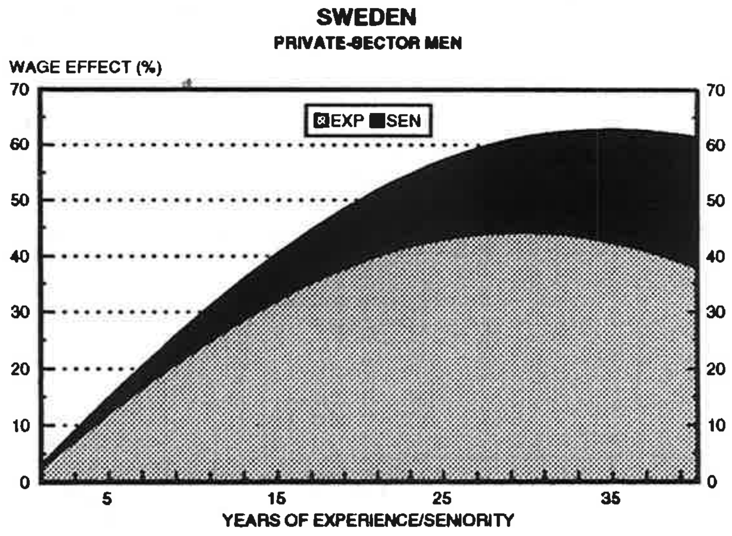
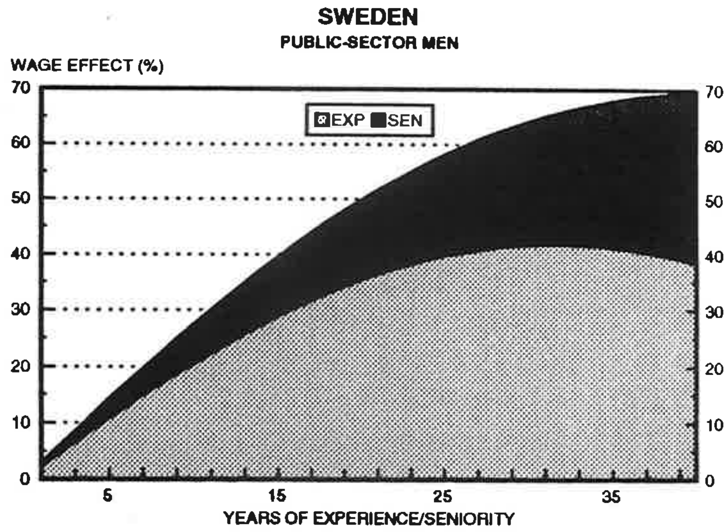
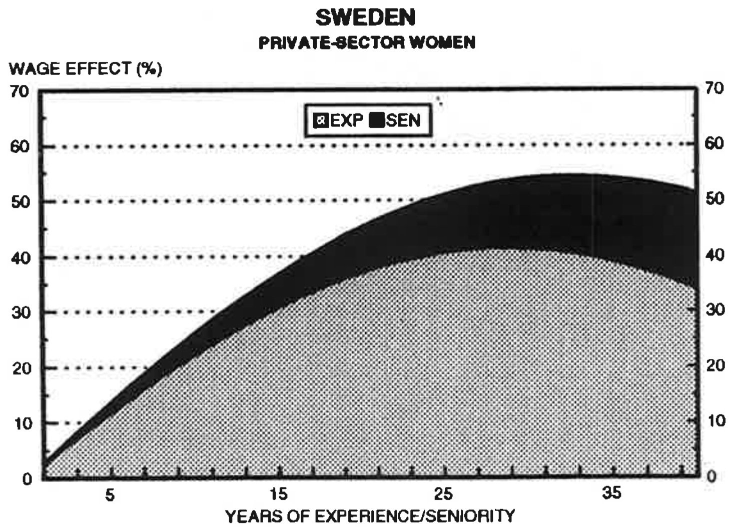


Figure 4C. Simultaneous wage effects of general experience and seniority estimated for a hypothetical individual staying with the same employer up to forty years







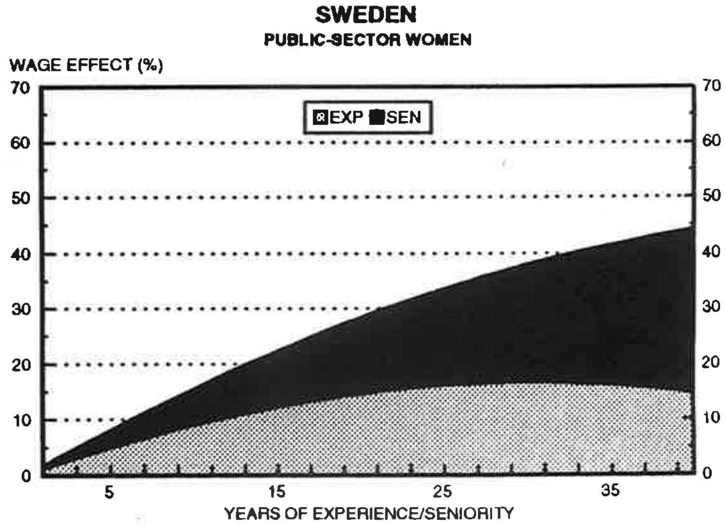
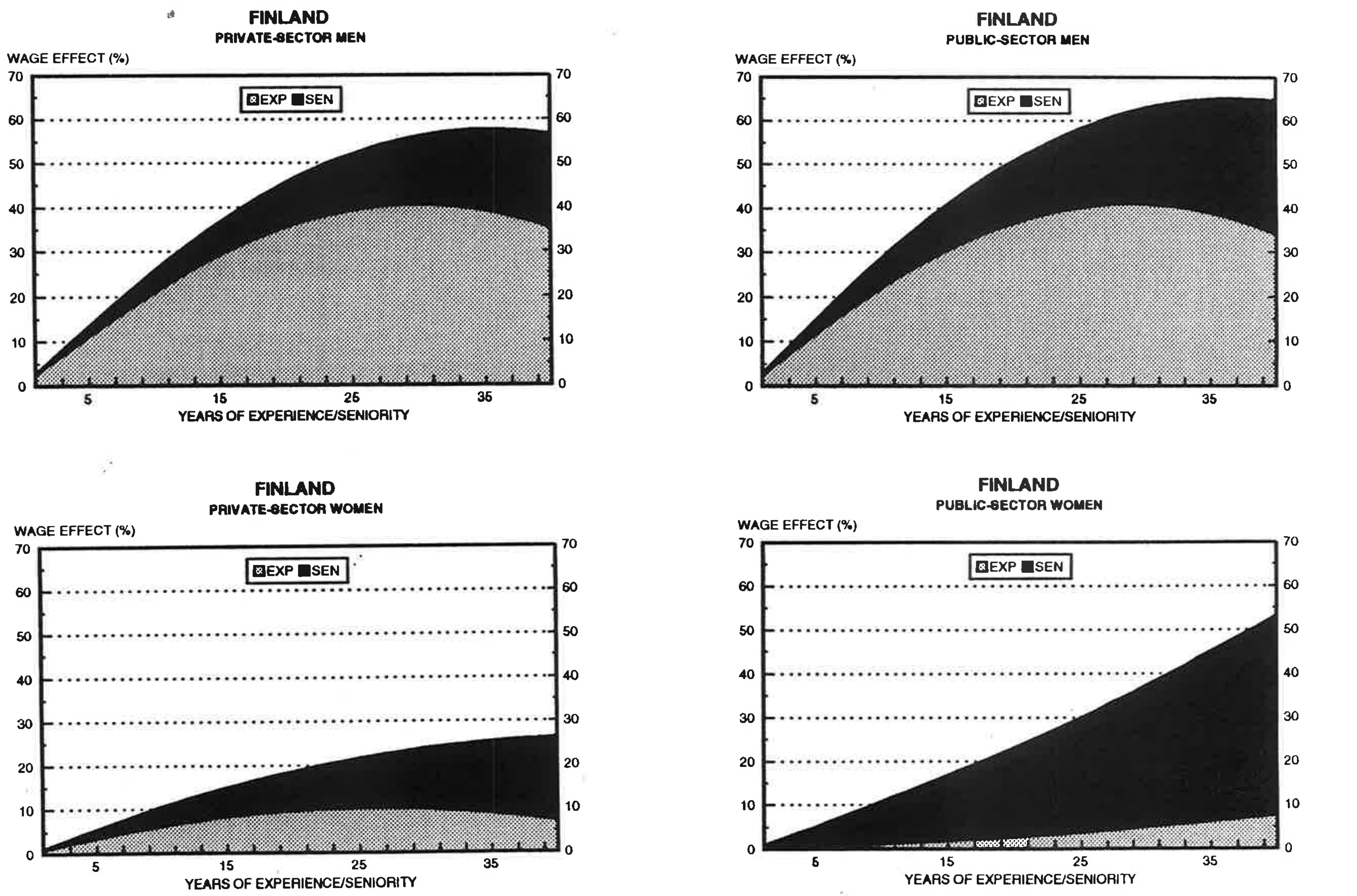


Figure 4D. Simultaneous wage effects of general experience and seniority estimated for a hypothetical individual staying with the same employer up to forty years



3.5. Private/public-sector wage differentials

There are quite large differences between the Nordic countries when it comes to private/public-sector wage differentials. When estimating this differential by the use of an indicator variable, it turns out that both Denmark and Norway have a significant and quite large negative wage differential on part of the public sector, while no significant differential shows up for Finland and Sweden; the point estimates for Denmark and Norway are 8.0 per cent and 6.2 per cent, respectively, while the 0.5-1.5 per cent point estimates for Finland and Sweden are not significantly different from zero.

In the US, a negative public-sector wage differential is not a general finding. Moulton (1990) reviews several studies in the US, all concluding "that the approximately 2.1 million non-postal federal employees receive a positive wage differential (or "gap") of 10-35 % that can be interpreted as an economic rent" (p. 247), and gives a point estimate of 3.1 per cent for recent national data. Analogous interpretation for the Nordic countries would rather indicate an economic rent on part of private-sector employees in Norway and Denmark. Another common interpretation is that a negative public-sector differential is the price public-sector employees pay for higher job security.

The private/public-sector wage differential is highly different for men and women in all four countries. More exactly, there is a significant negative public-sector wage differential for men amounting to 13 per cent in Norway, 11 per cent in Denmark, close to 6 per cent in Finland, and 4 per cent in Sweden. These gaps increase slightly when also controlling for the employees' occupational status.

For women, only Denmark shows a significant negative public-sector wage differential (5 per cent), while Swedish women face a significant positive public-sector wage differential of some 2½ per cent. In Norway and Finland, there is no significant public-sector wage differential for women. These results clearly indicate that the two genders face different labour market conditions in the Nordic countries.

3.6. Earnings effects of occupational status

The addition of occupation controls to the wage equation leads in all countries to a significant increase in the predictive power of the model. Nevertheless, the increase in R^2 due to occupation vary among the four countries: 0.080 in Finland, 0.061 in Sweden, 0.030 in Norway, and 0.016 in Denmark. Wage differences between occupational social status categories thus seem to be considerably larger in Finland and Sweden than in Denmark and Norway.

This difference is also reflected in the parameter estimates. In both Finland and Sweden, the wage level of upper-level salaried employees is about 27 per cent above that of lower-level or assistant salaried employees (reference category). In Norway, this difference is only half as large, and in Denmark it is some 20 per cent. At the bottom of the traditional occupational hierarchy, the wages of Finnish unskilled manual workers are about 15 per cent below those of lower-level salaried employees. The unfavourable position of unskilled workers is considerably less pronounced in Sweden and Norway. In Denmark there is virtually no difference between unskilled workers and lower-level white-collar employees. The overall impression of large occupational differences in wages in Finland is thus strengthened, whereas the differences are found to be fairly small in Norway and Denmark.

To the extent that the occupational position of individuals is influenced by human capital and gender, the inclusion of occupation controls in the wage equation will lead to changes in the coefficients estimated for these variables. As far as experience and gender are concerned, the addition of occupation leads to small (and often negligible) declines in the estimated coefficients in all countries. With regard to experience, small changes in the estimated coefficients indicate that the distribution of labour force experience is fairly similar in all six occupational categories considered. As far as gender is concerned, only a small part of the difference in wages between men and women seems to be due to differences in the distribution across occupational categories. However, this is not very surprising given the very broad definition of these categories.

The inclusion of occupational indicator variables leads to a substantial reduction in the estimated coefficients for schooling in Finland and Sweden, where the absolute value of the estimated return is almost halved. The reduction is much smaller in Norway, and in Denmark it is almost negligible. These results strengthen the overall impression that the occupational position is much more important in Finland and Sweden. In these countries, a large part of the effect of education on wages seems to be mediated by the employee's position in the occupational structure.

In Norway and especially in Denmark, on the other hand, wage levels are less strongly influenced by occupational status, and schooling tends to have a more direct effect on wage setting. In other words, the occupational structure seems to be less rigid in these countries. This interpretation rests, however, on the assumption that the occupational coding is equally valid in all four countries. We cannot rule out the possibility that improvements in the occupational classification would move the Norwegian and Danish results closer to the Swedish and Finnish ones. A better classification might also remove a larger portion of the gap in educational returns between men and women.

4. STABILITY OF THE ESTIMATES OVER TIME

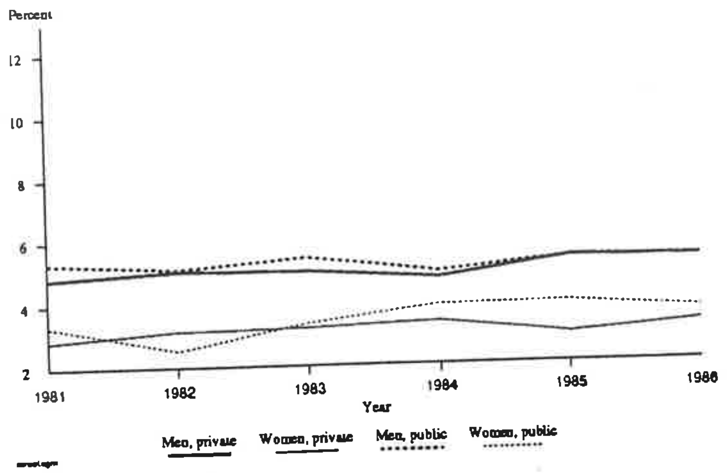
In order to get comparable results for the Nordic countries, the regressions underlying the results discussed above were all done for a single year. It may, however, be questioned how stable the coefficients are over time. Stability in coefficients is an indicator of stability in the functions generating the wage differentials. Trends are to be expected, if the market for educated undergoes changes or if the degree of discrimination changes. But instability may also be an indicator of a dubious fit. Since the possibility for analysing the time pattern of coefficients are present to varying degrees, as much evidence as possible will be reported for each country.

For Denmark, regressions are made for each year in the 1981 to 1986 period. The analysis is only done for this limited period because of problems with censored income information prior to 1981. For Norway, survey data for the years 1980, 1983, 1987 and 1989 have been used. The longest perspective is obtained for Sweden by using the LNUs from 1968, 1974 and 1981. Suitable data are not available for Finland.

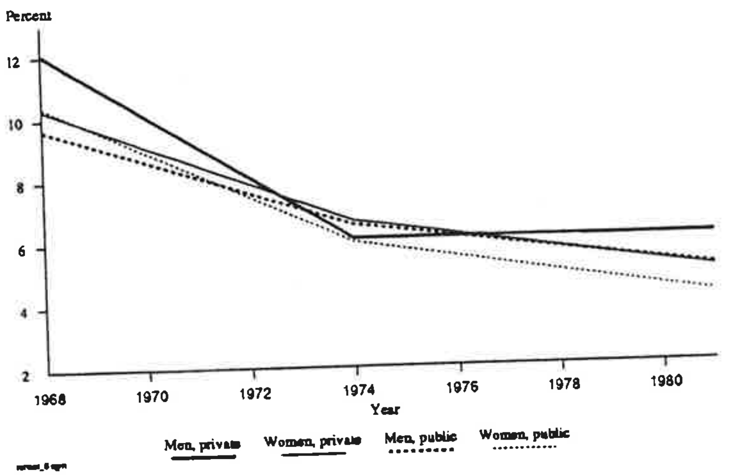
The coefficients for education are depicted in Figure 5. The graph for Denmark shows that the estimated coefficients for schooling do not change over the investigated period. The graph for Sweden reveals a substantial fall in the estimated returns for all employee categories from 1968 to 1974. The decline

Figure 5. Estimated returns to schooling for different years, by gender and sector

Denmark



Sweden



Norway

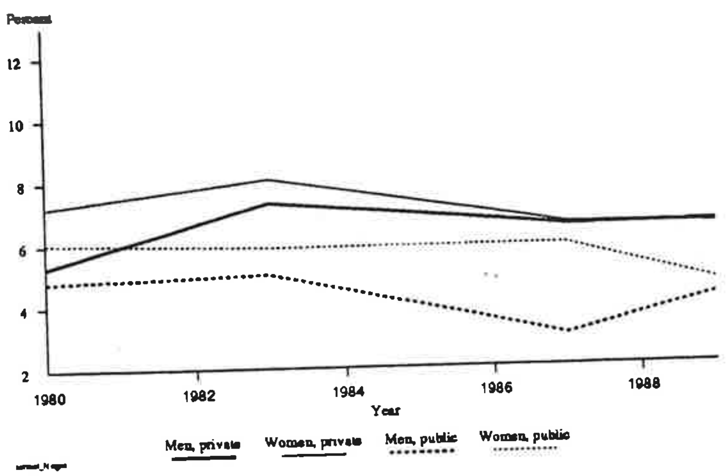
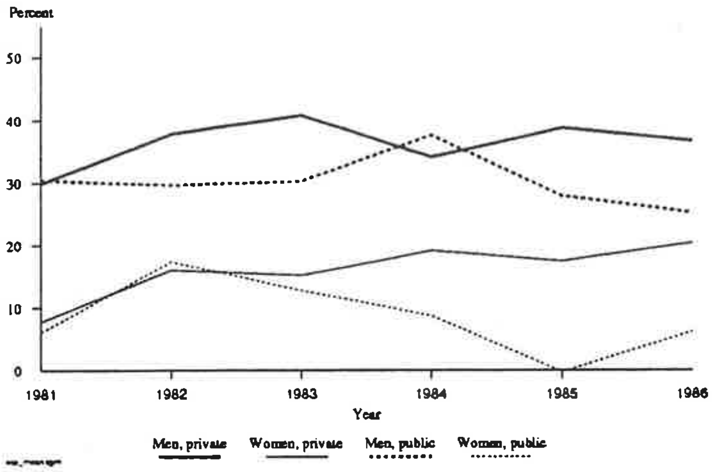
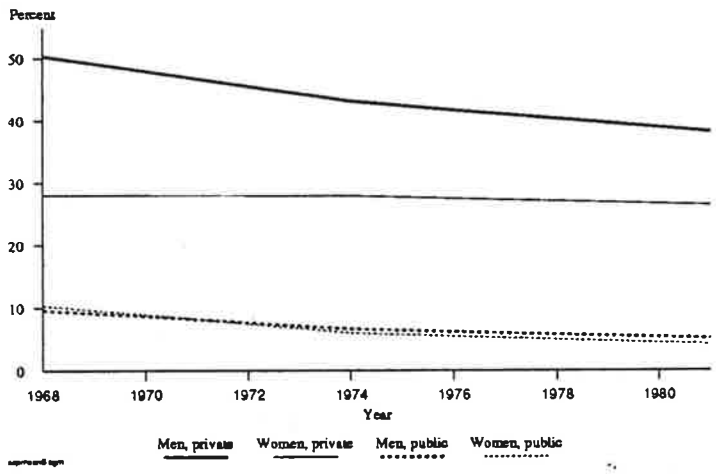


Figure 6. Wage effects of experience estimated by gender and sector for different years (the wage effect is evaluated at the mean experience level for the employee category in question)

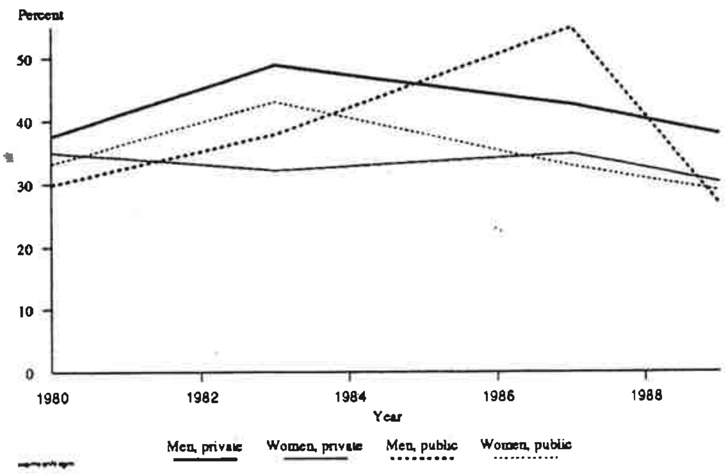
Denmark



Sweden



Norway



almost ceased in the later period. It is also worth noting that the differences between the four employee categories considered are relatively small in 1974 but increase slightly in the next period. For Norway, there seems to have been a slight increase in the return for private-sector employees and a slight decrease for public-sector employees, thus increasing the wage differential between educations of equal length.

In Figure 6, similar graphs are depicted for the wage effects of experience measured at the mean experience for the category in question. The curves show much the same picture as the curves for educational returns.

The overall conclusion then is that the return to education as well as experience has been remarkably stable during the 1980s in all three countries. The estimates for Sweden indicate sharply declining returns from the late 1960s to the early 1970s. The decline is presumably related to the worsening of the market for educated people caused by a considerable growth in the number of labour force entrants with a long education. Since the markets in Norway and Denmark have undergone the same changes, there is reason to believe that a similar pattern would be found in these countries had data been available for the early period.

5. CONCLUSIONS

Estimation of identical human capital wage equations for the four Nordic countries has displayed a number of interesting similarities and dissimilarities.

The rate of return to education is found to be substantially higher in Finland than in the other Nordic countries. A common feature of all four countries is that the returns to education tend to be significantly lower for women. Moreover, this gender gap is found to be larger in the private than in the public sector. The analysis also reveals areas of the educational scale, where the economic incentives to continue in formal education are very small. This finding is likely to have an impact on the recruitment of educated labour in the future. The three most important areas with low incentives are vocational training for men and women in Denmark, and BA-level degrees for men and women in Norway and for men in Finland. Sweden is found to have a fairly smooth structure of incentives.

The estimated wage effects of work experience are fairly similar across countries for men but differ widely for women. Thus also the gender gap in the wage effects of experience varies a lot. The picture becomes even more mixed when a distinction is made between private- and public-sector employment. Two general trends emerge, though. First, in both sectors men tend to have steeper experience-wage profiles than women. Second, private-sector wages seem to increase faster with experience in Denmark, Norway and Sweden. In Finland, however, growth rates are higher in the public sector.

Seniority is found to have a much smaller influence on wages than general experience. The wage effects of seniority tend to be most important in Finland, especially among women. Not surprisingly, the wage effects of seniority are typically larger in the public sector. This is most apparent for men. The results also suggest that the stronger experience effects estimated for men are due to their much higher returns to general experience; the gender gap in seniority effects is minor.

Further, both Denmark and Norway are found to have a significant negative wage differential on part of the public sector, while no significant differential shows up for Sweden and Finland. The pattern differs, however, between men and women. In all four countries, public-sector men receive a negative wage differential. For women, this gap is negative in Denmark, non-existing in Finland and Norway, and positive in Sweden. Apart from this, the results also point to a fairly rigid occupational structure in Finland and Sweden.

Finally, evidence obtained for Sweden point to a significant decline in the returns to education during the end of the 1960s and the beginning of the 1970s. Contrary to this, the returns to education seem to have decreased only slightly in the 1980s. Much the same picture is obtained for work experience.

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APPENDIX

Table 1. Summary of definitions of variables

Var.	Definition	Explanation
EXP	Experience on the labour market, number of years	**DK:** Measured as real experience according to ATP-records. **S:** Self-reported according to survey question. **N:** Self-reported according to survey question. **SF:** Self-reported according to survey question.
WAGE	Hourly wage rate including most types of compensation*	**DK:** Calculated from wage income from the TAX-files using the annual ATP as amount of hours. **S:** Calculated from self-reported wage income **N:** Calculated from self-reported wage income **SF:** Calculated from annual wage income from the tax rolls using an estimated annual amount of working hours.
S	Schooling, years exceeding 9 years	Measured by the length of the highest attained schooling, vocational training and formal education beyond basic school. That is number of schooling years minus 9. **DK:** Data are from registers. **S:** Self-reported. **N:** Data are from registers. **F:** Data are from registers.
WOMAN	Dummy for gender	
OCCUP	Occupation	**Dummies:** based on NORD-SEI** OCCUP1: Upper level sal.employees, NORD-SEI 005 OCCUP2: Intermediate sal.employees, NORD-SEI 004 OCCUP3: Assistant sal.employees, NORD-SEI 003 OCCUP4: Skilled workers, NORD-SEI 002 OCCUP5: Unskilled workers, NORD-SEI 001 OCCUP6: Employees, not further specified, NORD-SEI 006 **DK:** Does roughly comply to NORD-SEI **S:** Recoded, complying to NORD-SEI **N:** NORD-SEI **SF:** Recoded, complying to NORD-SEI
PUBLIC	Dummy for public/ private sector	Public services, state, municipal and institutions (ISIC codes:.......)
SENIORITY	Number of years at present employer	**DK:** Estimated from register data. **S:** Self-reported according to survey question. **N:** Self-reported according to survey question. **SF:** Self-reported according to survey question.

* National currency in nominal terms at the time of investigation.

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Table 2. Sample means for all employees

Variables	DK (1986)	S (1981)	N(1989)	SF(1987)
Number of observ.	5842	3307	3946	3892
EXP	13.49	17.970	17.186	16.77
EXP^2	282.15	478.950	421.938	388.18
WAGE	96.10	37.418	85.184	44.83
ln(WAGE)	4.51	3.581	4.396	3.72
S	2.61	2.111	3.216	2.43
WOMAN	0.476	0.476	0.465	0.510
OCCUP1	0.052	0.080	0.178	0.093
OCCUP2	0.096	0.214	0.298	0.182
OCCUP3	0.236	0.156	0.145	0.177
OCCUP4	0.143	0.160	0.079	0.180
OCCUP5	0.250	0.389	0.275	0.368
OCCUP6	0.028		0.0250	
PUBLIC	0.369	0.448	0.364	0.352
VOCATIONAL	0.419	0.321	0.543	0.509
SHORT NON.UNIV	0.078	0.124	0.113	0.057
BA-LEVEL	0.065	0.063	0.071	0.026
GRADUATE	0.043	0.060	0.049	0.049
SENIORITY[1]	5.19	8.662	8.868	8.92

1. Mean value for seniority in Denmark is for 1984.

Table 3. Additive wage model for private/public-sector employment estimated jointly and separately for men and women

	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.3270	*.011453*	3.3042	*.0123*	4.0920	*.01348*	3.4375	*.021912*
EXP	.0202	*.001201*	.0229	*.0011*	0.0237	*.00121*	0.0177	*.002122*
EXP^2	-.00036	*.000030*	-.00036	*.00002*	-.0004	*.00003*	-.00024	*.000049*
S	.0450	*.001627*	.0499	*.0016*	0.0524	*.00183*	0.0704	*.002513*
WOMAN	-.1812	*.008300*	-.1385	*.0084*	-.1719	*.00856*	-.1719	*.010621*
PUBLIC	-.0771	*.008275*	-.0047	*.0083*	-.0606	*.00888*	-.0148	*.011394*
R^2 adj	*.2895*		*.3660*		*.3556*		*.2467*	
RSS	*410.12*		*158.62*		*223.05*		*425.26*	
N	*5439*		*3307*		*3778*		*3892*	

WOMEN	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.1964	*.016353*	3.2071	*.0150*	3.91890	*0.01735*	3.3541	*.035157*
EXP	.0147	*.002505*	.0186	*.0015*	0.02293	*0.00185*	0.0091	*.003267*
EXP^2	-.00026	*.000091*	-.00031	*.00004*	-.00042	*0.00005*	-.00009	*.000075*
S	.0360	*.002401*	.0440	*.0022*	0.04953	*0.00262*	0.0626	*.003707*
PUBLIC	-.0496	*.011013*	.0251	*.0102*	-.00921	*0.01139*	0.0138	*.015977*
R^2 adj	*.1108*		*.2713*		*0.2465*		*.1422*	
RSS	*186.26*		*58.39*		*91.94*		*226.85*	
N	*2557*		*1574*		*1757*		*1986*	

MEN	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.2703	*.015124*	3.2503	*.0175*	4.0757	*.0184*	3.3457	*.026438*
EXP	.0250	*.001630*	.0273	*.0016*	0.0251	*.0017*	0.0266	*.002677*
EXP^2	-.00045	*.000038*	-.00042	*.00003*	-.0004	*.00004*	-.0004	*.000063*
S	.0524	*.002205*	.0555	*.0024*	0.0559	*.0025*	0.0764	*.003416*
PUBLIC	-.1079	*.012380*	-.0384	*.0130*	-.1198	*.0359*	-.0537	*.015600*
R^2 adj	*.2324*		*.3163*		*.2703*		*.2701*	
RSS	*219.86*		*98.13*		*128.67*		*193.36*	
N	*2882*		*1733*		*2020*		*1906*	

Table 4. Wage model estimated separately for sectors and gender

Denmark

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.2558	*.018267*	4.1477	*.024409*	4.1994	*.027207*	4.1991	*.021422*
EXP	.0273	*.001957*	.02429	*.003811*	0.0182	*.002853*	.0051	*.003298*
EXP^2	-.0005	*.000046*	-.00056	*.000142*	-.0003	*.000067*	.00005	*.000117*
S	.0526	*.002912*	.0339	*.004722*	.0530	*.003159*	.0373	*.002681*
R^2 adj	*.2033*		*.0907*		*.3361*		*.1414*	
RSS	*175.69*		*96.36*		*43.54*		*88.70*	
N	*2154*		*1175*		*728*		*1382*	

Sweden

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	3.2443	*.0211*	3.1681	*.0240*	3.2148	*.0311*	3.2595	*.0175*
EXP	.0277	*.0020*	.0234	*.0025*	.0265	*.0027*	.0150	*.0019*
EXP^2	-.00044	*.00004*	-.00043	*.00006*	-.00038	*.00006*	-.00021	*.00004*
S	.0607	*.0033*	.0500	*.0046*	.0508	*.0033*	.0419	*.0024*
R^2 adj	*.2969*		*.2286*		*.3725*		*.2844*	
RSS	*73.01*		*27.15*		*24.32*		*30.80*	
N	*1208*		*617*		*525*		*957*	

Norway

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.0262	*.0216*	3.8917	*.0245*	4.1313	*.0377*	3.9374	*.0260*
EXP	.0279	*.0020*	.0247	*.0028*	.0153	*.0031*	.0212	*.0025*
EXP^2	-.00047	*.00004*	-.00046	*.00008*	-.00025	*.00006*	-.00038	*.00006*
S	.0639	*.0033*	.0558	*.0045*	.0413	*.0036*	.04564	*.0031*
R^2 adj	*.2903*		*.2291*		*.2310*		*.2457*	
RSS	*103.26*		*52.31*		*23.61*		*39.41*	
N	*1500*		*891*		*520*		*867*	

Finland

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	3.3581	*.031637*	3.3883	*.049823*	3.2576	*.052372*	3.3377	*.051135*
EXP	0.0260	*.003073*	0.0102	*.004547*	0.0282	*.005396*	0.0067	*.004696*
EXP^2	-.00040	*.000072*	-.00016	*.000104*	-.00041	*.000130*	.00002	*.000107*
S	0.0744	*.004947*	0.0485	*.006614*	0.0790	*.004239*	0.0732	*.004237*
R^2 adj	*.2068*		*.0617*		*.4573*		*.2208*	
RSS	*158.43*		*131.54*		*34.81*		*93.78*	
N	*1422*		*1098*		*484*		*888*	

Table 5. Wage model including indicator variables for educational levels. The left out education variable is basic school (9 years or less)

Denmark	ALL coeff.	*std dev*	Men coeff.	*std dev*	Women coeff.	*std dev*
INTERCEPT	4.3831	*0.011673*	4.3245	*0.015532*	4.2314	*0.015881*
EXP	0.0198	*0.001214*	0.0255	*0.001669*	0.0133	*0.002502*
EXPSQ	-0.0004	*0.000031*	-0.0005	*0.000039*	-0.0002	*0.000091*
VOCATIONAL	0.0327	*0.00847*	0.0493	*0.011953*	0.0112	*0.011943*
SHORT NON UNIV.	0.1159	*0.014587*	0.1118	*0.024719*	0.1132	*0.017829*
B.A.level	0.2296	*0.015792*	0.271	*0.021705*	0.1818	*0.022917*
GRADUATE	0.4326	*0.018847*	0.4317	*0.022849*	0.4553	*0.034664*
WOMAN	-0.2101	*0.007978*				
Adj R-sq	0.2823		0.2094		0.1185	
RSS	414.12		226.3		184.51	
N	5439		2882		2557	

Sweden	ALL coeff.	*std dev*	Men coeff.	*std dev*	Women coeff.	*std dev*
INTERCEPT	3.2894	*0.01341*	3.2187	*0.01924*	3.2162	*0.01581*
EXP	0.023	*0.00111*	0.0273	*0.00161*	0.0186	*0.00154*
EXPSQ	-0.00036	*0.00002*	-0.00042	*0.00003*	-0.00031	*0.00003*
VOCATIONAL	0.1262	*0.00955*	0.1556	*0.01464*	0.0951	*0.01197*
SHORT NON UNIV.	0.2463	*0.0128*	0.2946	*0.01964*	0.196	*0.01598*
B.A.level	0.3094	*0.01673*	0.3569	*0.02634*	0.2638	*0.0204*
GRADUATE	0.434	*0.01731*	0.4517	*0.02306*	0.4389	*0.02721*
WOMAN	-0.141	*0.00791*				
Adj R-sq	0.3653		0.3168		0.2651	
RSS	158.93		97.94		58.81	
N	3307		1733		1574	

Norway	ALL coeff.	*std dev*	Men coeff.	*std dev*	Women coeff.	*std dev*
INTERCEPT	4.1427	*0.014269*	4.1196	*0.020265*	3.9716	*0.017684*
EXP	0.023	*0.001174*	0.0249	*0.001684*	0.02162	*0.001738*
EXPSQ	-0.0004	*0.000026*	-0.00043	*0.000036*	-0.00038	*0.000044*
VOCATIONAL	0.0886	*0.01*	0.0999	*0.014902*	0.0753	*0.01318*
SHORT NON UNIV.	0.2486	*0.014456*	0.2502	*0.021585*	0.2467	*0.019015*
B.A.level	0.2844	*0.017118*	0.2494	*0.027721*	0.3065	*0.021014*
GRADUATE	0.4182	*0.019757*	0.4138	*0.024419*	0.4513	*0.039698*
WOMAN	-0.1917	*0.008214*				

Finland	ALL coeff.	*std dev*	Men coeff.	*std dev*	Women coeff.	*std dev*
INTERCEPT	3.501	*0.023583*	3.3804	*0.02872*	3.4377	*0.036914*
EXP	0.0161	*0.002115*	0.0251	*0.002668*	0.0074	*0.003234*
EXPSQ	-0.00023	*0.000049*	-0.00039	*0.000063*	-0.00008	*0.000074*
VOCATIONAL	0.1213	*0.01279*	0.1697	*0.01737*	0.0736	*0.018346*
SHORT NON UNIV.	0.04144	*0.023419*	0.4813	*0.03472*	0.3567	*0.031633*
B.A.level	0.516	*0.028878*	0.4809	*0.050711*	0.5083	*0.034628*
GRADUATE	0.6374	*0.026121*	0.6595	*0.034622*	0.6066	*0.038852*
WOMAN	-0.1789	*0.010427*				
Adj R-sq	0.2628		0.2767		0.1718	
RSS	415.94		191.42		218.81	
N	3892		1906		1986	

Table 6. Wage model including seniority estimated jointly and separately for men and women

	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.2169	*.010660*	3.3097	*.0121*	4.098698	*0.01355952*	3.4449	*0.02221*
EXP	.0189	*.001214*	.0195	*.0011*	0.021080	*0.00125834*	0.0136	*.002231*
EXP^2	-.00035	*.000029*	-.00034	*.00002*	-0.000387	*0.00002785*	-0.00022	*.000049*
S	.0418	*.001576*	.0481	*.0016*	0.048594	*0.00177747*	0.0693	*.002418*
WOMAN	-.1688	*.007794*	-.1414	*.0078*	-0.187671	*0.00825194*	-0.1754	*.010532*
SENIORITY	.00259	*.000882*	.0056	*.0006*	0.003238	*0.00061094*	0.0058	*.000834*
R^2 adj	*.2621*		*.3817*		*0.3507*		*.2550*	
RSS	*404.08*		*154.92*		*222.07*		*417.64*	
N	*5480*		*3307*		*3740*		*3849*	

WOMEN	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.1021	*.014890*	3.2250	*.0141*	3.919211	*0.01729551*	3.3633	*.035314*
EXP	.0132	*.002549*	.0153	*.0016*	0.021187	*0.00190530*	0.0048	*.003384*
EXP^2	-.00028	*.000090*	-.00028	*.00004*	-0.000413	*0.00004830*	-0.000066	*.000075*
S	.0374	*.002298*	.0435	*.0021*	0.048458	*0.00254994*	0.0636	*.003476*
SENIORITY	.00355	*.001402*	.0052	*.0009*	0.003088	*0.00096337*	0.0066	*.001142*
R^2 adj	*.1275*		*.2836*		*0.2489*		*.1532*	
RSS	*174.85*		*57.41*		*91.06*		*223.00*	
N	*2547*		*1574*		*1742*		*1975*	

MEN	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.1638	*.013875*	3.2506	*.0172*	4.083903	*0.01873928*	3.3502	*.026998*
EXP	.0244	*.001602*	.0238	*.0017*	0.022089	*0.00178561*	0.0227	*.002850*
EXP^2	-.00046	*.000036*	-.00040	*.00003*	-0.000399	*0.00003752*	-0.00038	*.000064*
S	.0444	*.002159*	.0520	*.0023*	0.048804	*0.00247745*	.0737	*.003371*
SENIORITY	.0028	*.001150*	.0058	*.0008*	0.003351	*0.00079921*	0.0049	*.001206*
R^2 adj	*.2214*		*.3325*		*0.2480*		*.2725*	
RSS	*226.21*		*95.80*		*130.77*		*190.51*	
N	*2933*		*1733*		*1997*		*1874*	

Table 7. Wage model including seniority estimated separately for sectors and gender

Denmark, 1984

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.1853	.017080	4.0722	.022490	4.0677	.023087	4.1302	.020358
EXP	.0241	.001942	.0197	.003787	0.0246	.002657	.0069	.003449
EXP^2	-.00045	.000044	-.00045	.000135	-.00045	.000060	-.00010	.000120
S	.0465	.003047	.0351	.004667	.0497	.002959	.0395	.002667
SENIORITY	.00184	.001408	.00382	.002114	.00501	.001862	.00342	.001868
R^2 adj	.1765		.0984		.3999		.1538	
RSS	178.80		84.35		43.83		89.62	
N	2151		1155		782		1392	

Sweden, 1981

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	3.2467	.0209	3.1675	.0239	3.2252	.0340	3.2729	.0173
EXP	.0248	.0020	.0214	.0027	.0221	.0028	.0102	.0020
EXP^2	-.00042	.00004	-.00042	.00006	-.00035	.00006	-.00017	.00004
S	.0593	.0033	.0496	.0046	.0493	.0033	.0395	.0024
SENIORITY	.0053	.0010	.0040	.0016	.0068	.0013	.0065	.0011
R^2 adj	.3120		.2351		.4020		.3090	
RSS	71.39		26.87		23.14		29.71	
N	1208		617		525		957	

Norway, 1989.

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.0237	0.02170	3.8892	0.02454	4.1393	0.03738	3.9436	0.02603
EXP	0.0262	0.00207	0.0233	0.00291	0.0117	0.00322	0.0192	0.00261
EXP^2	-.00047	0.000044	-.00047	0.000081	-.00021	0.000064	-.00037	0.000061
S	0.0636	0.00333	0.0561	0.00453	0.0411	0.00361	0.0446	0.00313
SENIORITY	0.0036	0.00095	0.0033	0.00148	0.0041	0.00130	0.0032	0.00125
R^2 adj	0.2938		0.2328		0.2446		0.2470	
RSS	101.29		51.93		22.81		38.80	
N	1481		884		515		857	

Finland 1987

	PRIVATE				PUBLIC			
	men		women		men		women	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	3.3634	.032262	3.3916	.050019	3.2631	.054008	3.3456	.051057
EXP	0.0227	.003318	0.0073	.004686	0.0237	.005428	0.00068	.004899
EXP^2	-0.00038	.000073	-0.00014	.000105	-0.00041	.000131	0.000029	.000105
S	0.0745	.005002	0.0488	.006570	0.0785	.004315	0.0735	.004159
SENIORITY	0.0049	.001419	0.0044	.001516	0.0067	.002702	0.0094	.001673
R^2 adj	.2127		.0656		.4656		.2415	
RSS	155.30		130.24		33.77		90.93	
N	1396		1092		478		883	

Table 8. Additive wage model for occupations and sectors estimated jointly and separately for men and women

	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.3217	*.013963*	3.3732	*.0164*	4.1210	*.0172*	3.5845	*.023782*
EXP	.0196	*.001200*	.0192	*.0011*	.0215	*.0012*	0.0145	*.002048*
EXP^2	-.00036	*.000030*	-.00031	*.00002*	-.00037	*.000027*	-.00020	*.000046*
S	.0408	*.001879*	.0272	*.0020*	.0381	*.0021*	0.0387	*.003045*
WOMAN	-.1709	*.008839*	-.1173	*.0086*	-.1399	*.0090*	-.1698	*.011198*
OCCUP1	.1823	*.017749*	.2408	*.0182*	.1251	*.0154*	0.2432	*.023530*
OCCUP2	.0787	*.013493*	.0997	*.0128*	.0608	*.0129*	0.1095	*.017711*
OCCUP4	-.0076	*.012600*	-.0187	*.0142*	.0092	*.0178*	-.1153	*.016412*
OCCUP5	.0240	*.010343*	-.0598	*.0113*	-.0617	*.0128*	-.1443	*.013648*
OCCUP6	.0405	*.024669*			.0594	*.0267*	-	-
PUBLIC	-.0828	*.008278*	-.0102	*.0080*	-.0595	*.0087*	-.0166	*.010847*
R^2 adj	*.3061*		*.4267*		*.3860*		*.3270*	
RSS	*400.19*		*143.46*		*212.26*		*379.53*	
N	*5439*		*3307*		*3778*		*3892*	

WOMEN	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.1777	*.018478*	3.2690	*.0179*	4.0050	*.0204*	3.4993	*.034991*
EXP	.0160	*.002499*	.0159	*.0015*	.0194	*.0018*	0.0065	*.003125*
EXP^2	-.00032	*.000090*	-.00026	*.00004*	-.0003	*.00005*	-.00005	*.000071*
S	.0328	*.002940*	.0265	*.0027*	.0280	*.0031*	0.0329	*.004538*
OCCUP1	.2203	*.038165*	.1952	*.0293*	.1430	*.0214*	0.1988	*.035616*
OCCUP2	.1002	*.022764*	.0938	*.0155*	.0900	*.0161*	0.1511	*.024857*
OCCUP4	.0082	*.037820*	-.0442	*.0257*	-.0309	*.0353*	-.1981	*.028874*
OCCUP5	.0366	*.014132*	-.0453	*.0120*	-.0741	*.0141*	-.1492	*.016477*
OCCUP6	.1040	*.036771*			.0741	*.0383*	-	-
PUBLIC	-.0501	*.011046*	.0220	*.0101*	-.0011	*.0111*	-.0010	*.015505*
R^2 adj	*.1295*		*.3158*		*.3047*		*.2313*	
RSS	*181.98*		*54.68*		*84.61*		*202.88*	
N	*2557*		*1574*		*1758*		*1986*	

MEN	DK		S		N		SF	
Variables	coeff	std.dev	coeff	std.dev	coeff	std.dev	coeff	std.dev
CONSTANT	4.3009	*.018987*	3.3846	*.0292*	4.1139	*.0284*	3.5036	*.033292*
EXP	.0234	*.001645*	.0225	*.0015*	.0231	*.0017*	0.0232	*.002591*
EXP^2	-.00043	*.000038*	-.00036	*.00003*	-.0004	*.00004*	-.00037	*.000060*
S	.0462	*.002489*	.0291	*.0029*	.0444	*.0029*	0.0434	*.004044*
OCCUP1	.1502	*.020666*	.2164	*.0286*	.1033	*.0252*	0.2469	*.032630*
OCCUP2	.0580	*.017375*	.0587	*.0251*	.0317	*.0236*	0.0608	*.027306*
OCCUP4	-.0316	*.014654*	-.0578	*.0253*	.0008	*.0267*	-.0982	*.024658*
OCCUP5	-.0083	*.015526*	-.1165	*.0249*	-.0664	*.0256*	-.1436	*.025008*
OCCUP6	-.0069	*.033371*			.0321	*.0392*	-	-
PUBLIC	-.1214	*.012466*	-.0500	*.0125*	-.1261	*.0134*	-.0508	*.014761*
R^2 adj	*.2518*		*.3969*		*.2948*		*.3559*	
RSS	*213.94*		*86.35*		*124.04*		*170.29*	
N	*2882*		*1733*		*2020*		*1906*	

THE IMPACT OF FAMILY BACKGROUND ON THE RETURNS TO AND LENGTH OF SCHOOLING IN SWEDEN

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1. Introduction

It is a common observation in most societies that children to parents with high income and schooling and with high-status occupations tend to inherit the behaviour of their parents and in particular invest more in schooling than other children. This pattern is often considered a problem from both equity and efficiency points of views. It represents inequality of opportunity and possibly also inefficiency if the intellectual capacity of all children is not fully exploited. A variety of educational policies have been advocated to reduce the importance of family background for schooling decisions. No country seems, however, to have been very successful in this respect.

In order to change the existing pattern it is crucial to understand the basic mechanisms that create this persistent intergenerational pattern of schooling choices. The idea in this paper - borrowed from Chiswick(1988) - is that useful insight into the mechanisms can be obtained from the relationship between the length of schooling and the marginal returns to schooling.

We start in section 2 by describing the basic analytical idea. Then we describe the data in section 3 and the empirical results in section 4. The final section offers a concluding discussion of the study.

2. The analytical approach

The analytical point of departure is that the individual who is contemplating education faces a marginal rate of return schedule for additional amounts (i.e. in practice years) of schooling. This schedule basically reflects how much the individual can raise earnings by additional schooling. The individual also faces marginal costs of financing additional schooling. These costs include first of all the interest costs to borrow the money that is necessary to finance the life as a student. But it also includes the disutility of postponing income to the future. It is reasonable to assume that the marginal rate of return is a decreasing function of years of schooling and that the marginal cost of financing schooling is an increasing function of years of schooling. By further assuming that the rational individual invests in schooling until the marginal return equals the marginal cost, the amount of schooling is determined as in part **a** of Figure 1.

Now, how can family background affect the amount of schooling in this framework? One potential explanation is that children from rich families can more easily finance the life as a student than children from poorer backgrounds. In this case - we call it **the financing hypothesis** - it is variation in the schedule for the marginal cost of financing education that generates the relationship between years of schooling and family background. This case is shown in part **b** of the figure. The interesting implication of this explanation is that there will be a negative correlation between the marginal rate of return and the length of schooling. If high financing costs represent market failures it is tempting to argue that this situation represent efficiency losses; those with a poor family background have high marginal returns on additional schooling investments but it does not take place because of high financing costs.

The other case is that those from rich families have more to get out of schooling, i.e. their marginal rate of returns is higher. We call this **the comparative advantage hypothesis**. The basic explanation of such variation in the returns to schooling can be that rich families when they raise their children emphasize skills that are useful at school more than other families do. They might also afford to invest more in activities that are useful at school.

The comparative advantage hypothesis implies the pattern shown in part **c** of the figure. The correlation between years of schooling and the marginal rate of return becomes positive.

A very straightforward way to implement these ideas is to estimate human-capital earnings functions which allow the schooling coefficient(s) to vary by family background. It is a well known fact that the marginal internal rate of return to schooling can be computed from regression equations with the logarithm of earnings (or wages) as a linear function of work experience and years of schooling where the latter variables might enter with quadratic or higher powered terms. It is the derivative of the logarithm of earnings with respect to years of schooling that is the marginal internal rate of return.[1]

More specifically, we propose the following equation:

$$\ln W_i = \alpha_0 + \alpha_1 E_i + \alpha_2 E_i^2 + \alpha_3 S_i + \alpha_4 S_i^2 + \alpha_5 FB_i + \alpha_6 (S_i x FB_i) + \alpha_7 X_i + \varepsilon_i$$

where:

$\ln W_i$ = the natural logarithm of the hourly wage for individual i

E_i = years of work experience

S_i = years of schooling

FB_i = a set of family background variables

X_i = a set of control variables

ε_i = a stochastic error term

As family background variables it is reasonable to include both such that capture the income of the parents and the educational level. Income is useful for financing studies as well as for activities that can be used to invest in skills that are useful at school. That the educational level of parents per se can affect the ability of children to get more out of school is rather evident.

We also suggest to use the number of siblings as a family background variable. The reason is that having many siblings can affect both the possibility of parents to help finance the studies and the time and the resources that can be spent on the "quality" of each child. The quality/quantity trade off proposed by Gary Becker (see e.g. Becker (1991)) suggests that such mechanisms can be present.

The comparative advantage hypothesis implies that α_6 is positive (negative) for those

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[1]The technical conditions are that there are no interactions between schooling and experience and that schooling precedes work, (see Willis(1986)).

with strong (weak) family background. If there are no family background effects on the costs of financing and the cost schedule is rising we will obtain the pattern described by Figure 1c. The pure version of the financing hypothesis implies that α_6 is zero and α_4 negative. We will then observe a pattern like in Figure 1b.

3. The data

We will use the Swedish Level of Living Surveys (see Eriksson and Åberg (1987) for details) from 1968 and 1981. (In the near future we can also use the wave from 1991). The sample is representative for the population in both 1968 and 1981. The panel property of the data is not employed in this study.

The mechanisms that we are looking for are quite general in nature, so we should be able to detect them in a homogeneous sub sample of the population with only individuals who grew up in families with both parents present and with parents who were Swedish citizens at the birth of the individual. By restricting the sample in this way we need not control for "missing" fathers or mothers and we markedly reduce the problems of comparability between immigrants and native Swede's family backgrounds. We also restrict the sample to those who were 26 to 65 years old in 1968 and 1981 respectively; at the age of 26 most people have completed their education and entered the labour market.

A further restriction is that only employed persons are included in the analysis. The reason is that good data on hourly wage rates are available for employed persons but not for self-employed and entrepreneurs.

As family background variables we use the father's social group and educational level. We use social groups 1, 2, 3 and farmers[2] as dummy variables in our regressions with social

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[2]Farmers classified in social groups 2 and 3 are included as a separate category. Some very wealthy farmers who belong to social group 1 remain in this catagory.

group 3 as the base captured by the intercept. The father's educational level is divided into (i) senior high school ("gymnasium") or higher, (ii) secondary or vocational school ("real- or yrkesskola") and (iii) others. The latter group is the base.

The background of the mother is described by a dummy variable showing whether she was mainly working in the household during the childhood of the individual and another dummy variable for education above the compulsory level. We add age, age squared, marital status, living in a big city and working daytime (1981 only) as control variables. Table 1 contains the sample means of most of the variables used in the study.

Years of schooling vary a lot by these family background variables which can be seen in Table 2. The differences between those whose father belonged to social group 1 and those with a father from social group 3 is around five years. The importance of the educational level of the father is of the same magnitude. The mother's educational level is also quite important.

In Table 3 we present simple regression equations which explain years of schooling by means of these family background variables plus age and the number of siblings. The coefficients for "father social group 1" and "father high school or higher" are lower than the "raw" differences in Table 2, but still rather large. It is also interesting to note that the number of siblings has a strongly significant negative coefficient.

4. Results

The empirical results for both sexes together and for men and women separately for 1968 and 1981 are identically organized in Tables 4a-4f. The first column in each table shows the estimates of the simple Mincer-type equation. They reveal the typical concave experience pattern and strongly significant schooling coefficients. The latter coefficients were roughly halved from 1968 to 1981 which has been noted in several previous studies. The quadratic schooling variable shown in column 2 in the tables raises the explanatory value markedly for both sexes and for men and the precision of the two coefficients is quite good. For women, however, the precision of the two schooling coefficients becomes very low.

In column 3 we keep both the linear and the quadratic schooling variables and add separate family background variables. Even though none of these variables is strongly significantly different from zero, they raise the adjusted coefficient of determination (with exception for women in 1981). The addition of these variables also reduces the impact of schooling on wages somewhat, but not very much.

Finally, we come to columns 4 to 6 in the six tables where the estimates which are central to our basic issue can be found. No coefficient of the interaction variables between years of schooling and the family background variables is significantly different from zero for both periods and for both sexes.

Even though the level of significance is low one can, however, see two patterns in the results which at least weakly support the comparative advantage hypothesis and the quality/quantity trade off. The comparative advantage hypothesis gets some support by the predominantly positive coefficients on the interaction variable for the father's education. Actually, either "father gymnasium or higher" or "father real- or yrkesskola" has a coefficient around 0.015 for all six samples analyzed. Despite the low precision, these estimates suggest that high returns to schooling might be the reason for more years of schooling for individuals with highly educated fathers.

Even though these estimates suggest that there is some comparative advantage involved in schooling decisions, they do not necessarily rule out that differences in financing costs are important too. By using the equations in column 4 in the tables 4a och 4b and evaluating the marginal return to schooling for those with different family backgrounds we get the picture in Figure 2. We have evaluated the marginal returns for the average years of schooling for the groups. The main impression from the figure is that there is neither a marked positive nor a negative relationship. For 1968 the two groups with farmers as fathers do reveal low schooling and high marginal returns which suggest that they had faced high financing costs. Apart from those with farmer background, however, the general impression is that the marginal returns are equal for the various groups. How can this result be interpreted within our analytical framework? One interpretation is that the marginal cost schedule is equal for all and completely flat. The existence of subsidized financial aid for students helps explain this interpretation. Another possibility is that family background affects both the costs and the returns so that the net effect on the marginal return is zero.

Turning next to the quantity/quality trade off hypothesis, it gets some (weak) support by the fact that the interaction variables for number of siblings predominantly get negative coefficients. For men in 1968 this coefficient is around -.0023 with t-values around 1.7. A negative coefficient suggests that those with few siblings get more skills that are useful at school than other other children with many siblings.

By comparing the results in columns 4, 5 and 6 one can see that there is some, but not very severe, multicollinearity between father's social group and educational level.

5. Conclusions

Family background has a very strong impact on the length of schooling in Sweden; in 1981 men with a father from social group 1 had 15.8 years of schooling in contrast to 10.0 years for men with a father from social group 3. This suggests that there is considerable inequality of opportunity in Sweden.

Our analysis has revealed that the returns to schooling is higher for those with a strong family background, at least the educational level of the father seems to raise the returns. This finding helps explain the persistent intergenerational pattern of schooling choice; those with a strong family background invest more in schooling because they get more out of it!

However, we can not rule out that a favourable family background also affects schooling choice via lower costs to finance schooling. We did find, though, that when we evaluated the marginal returns to schooling at the average length of schooling for various social groups they were quite equal (except for those with a farmer background who had a combination of low schooling and high marginal returns). This result is inconsistent with the notion that the intergenerational pattern of schooling choice represents a source of inefficiency.

One final caveat about the analysis is in order. We have treated years of schooling as homogeneous. Of course, it might be that those with strong family background have managed to get schooling of higher quality. We can not tell whether the higher returns are due to better schools or more appropriate investments by the parents. Whatever the reasons, however, our study suggests that those with a strong family background invest more in schooling because they get more out of it!

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Figure 1. Determination of schooling choices.

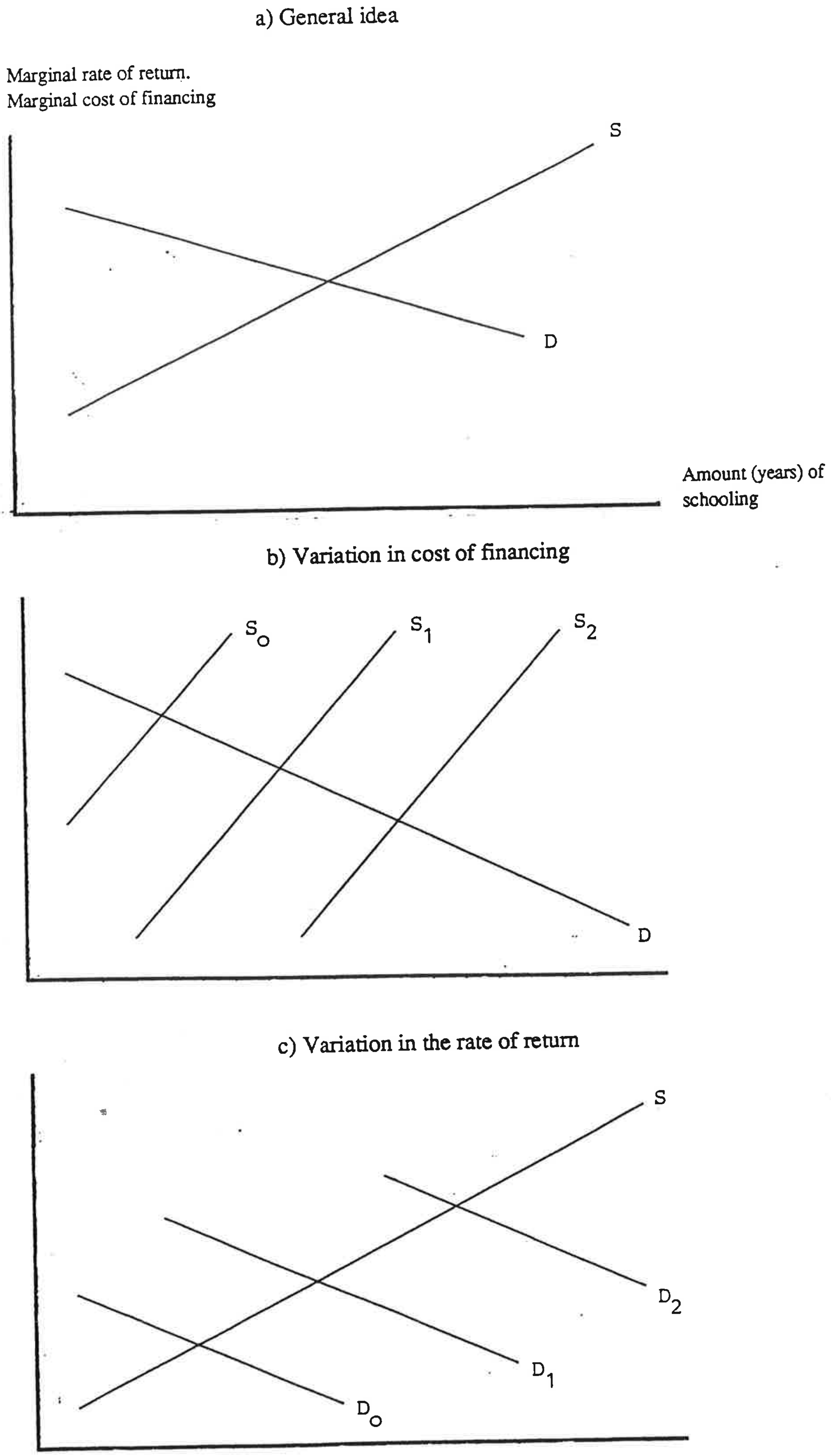
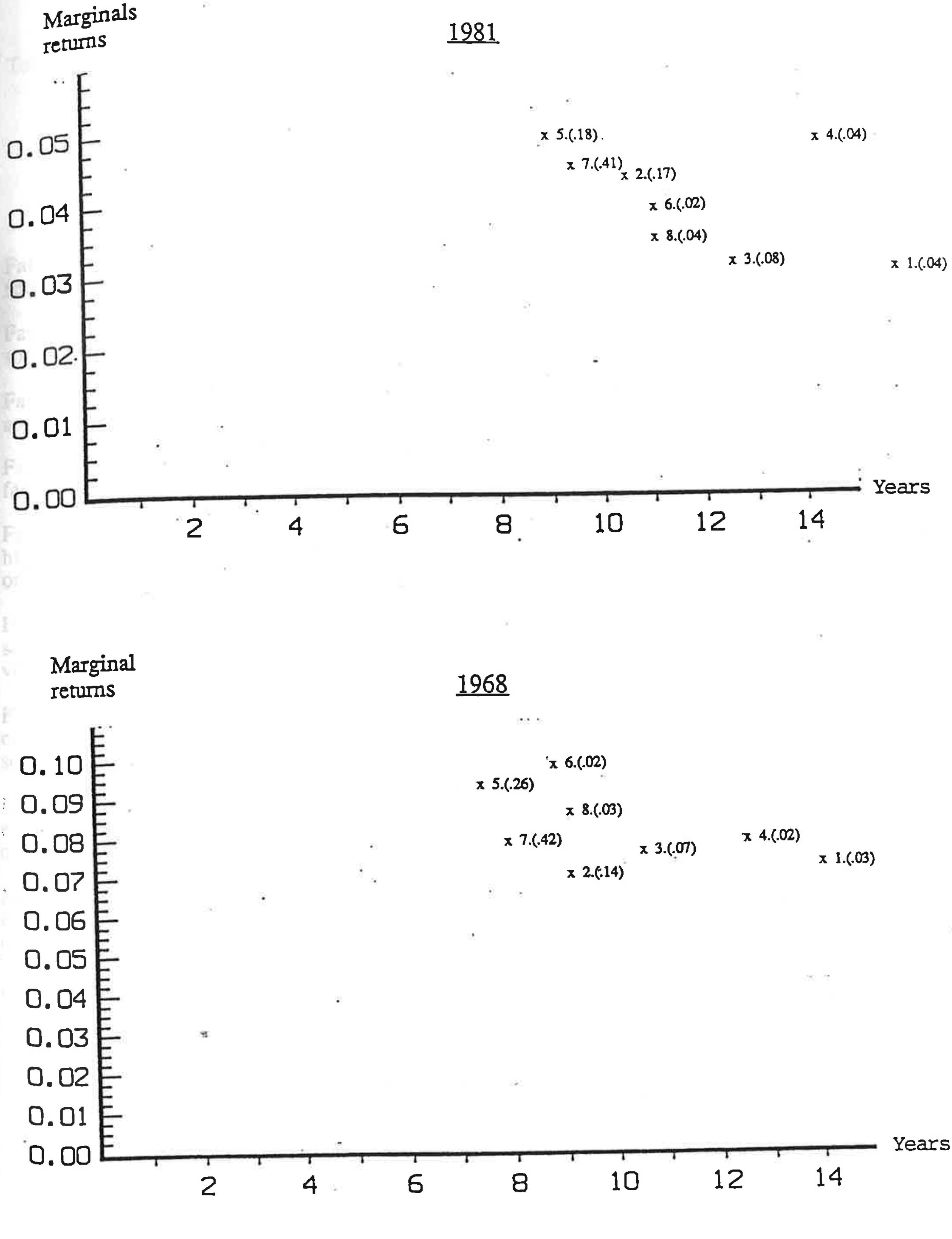


Figure 2. Marginal returns to schooling and the average length of schooling for various social groups. Sample fractions within parenthesis.



Notes: 1: Father social gr. 1 and high school or more. 2: Social group 2 and compulsory school.
3: Social group 2 and sec. or voc. school. 4: Social group 2 and high school or more.
5: Farmer and compulsory school 6: Farmer and sec. or voc. school

Table 1. Sample means.

	1968		1981	
	Men	Women	Men	Women
Years of schooling	8.5	8.3	10.7	10.3
Work experience	27.2	18.4	23.8	18.0
Father social gr. 1	0.04	0.04	0.05	0.06
Father social gr. 2	0.20	0.26	0.29	0.30
Father farmer	0.28	0.27	0.20	0.19
Father high school or higher	0.05	0.06	0.07	0.09
Father secondary or voc. school	0.13	0.13	0.16	0.16
Mother home during childhood	0.87	0.81	0.58	0.56
Mother education above compulsory level	0.10	0.10	0.16	0.17
Number of siblings	3.3	3.4	2.4	2.5
Married	0.83	0.74	0.80	0.78
Living in big city	0.35	0.38	0.35	0.35
Working daytime	-	-	0.84	0.83
n	1303	775	1294	1161

Table 2. Years of schooling by family background.

	1968		1981	
	Men	Women	Men	Women
Father social gr. 1	14.2	13.2	15.8	14.2
Father social gr. 2	10.0	9.4	12.1	11.4
Father social gr. 3	8.1	7.8	10.0	9.4
Father farmer	7.5	7.3	9.1	9.2
Father high school or higher	13.6	13.2	15.2	14.4
Father secondary or voc. school	10.1	9.6	12.7	11.6
Father compulsory school or less	8.0	7.8	9.9	9.5
Mother education above compulsory level	11.8	11.9	13.9	12.9
Mother compulsory school or less	8.2	7.9	10.1	9.7
n	1303	775	1294	1161

Table 3. Determinants of years of schooling.

	1968		1981	
	Men	Women	Men	Women
Constant	10.9 (31.0)	10.9 (29.4)	14.1 (38.3)	13.8 41.7)
Age	-.052 (-7.7)	-.071 (-9.4)	-.089 (-10.6)	-.101 (-12.6)
Father social gr. 1	3.51 (6.5)	2.12 (3.4)	2.56 (5.1)	2.02 (4.9)
Father social gr. 2	1.26 (6.1)	.94 (4.5)	1.02 (4.6)	1.09 (5.8)
Father farmer	-.43 (-2.4)	-.42 (-2.1)	-.59 (-2.5)	.18 (0.9)
Father high school or higher	1.96 (4.0)	2.29 (4.0)	2.27 (5.3)	2.38 (6.8)
Father secondary or voc. school	.98 (4.1)	1.09 (4.4)	1.58 (6.2)	1.11 (5.1)
Mother home during child-hood	-.34 (-1.5)	.28 (1.4)	-.26 (-1.4)	-.12 (-.8)
Mother education above compulsory level	1.25 (4.3)	1.81 (5.8)	1.43 (5.2)	1.19 (5.2)
Number of siblings	-.10 (-.3.4)	-.11 (-3.6)	-.18 (-4.4)	-.17 (-4.9)
n	1303	775	1293	1161
$\bar{R}^2$	.298	.370	.345	.388

Table 4a. Wage equations with family background variables, both sexes 1968. t-ratios within parenthesis.

	1	2	3	4	5	6
Constant	6.12 (43.0)	5.97 (36.3)	5.99 (36.2)	5.95 (34.0)	5.94 (34.0)	5.96 (34.0)
Work experience	.022 (7.4)	.022 (7.0)	.021 (6.9)	.022 (7.0)	.021 (6.9)	.022 (7.1)
Work experience squared/1000	-.38 (-6.2)	-.37 (-6.0)	-.35 (-5.8)	-.36 (-6.0)	-.36 (-5.8)	-.37 (-6.0)
Age	-.0045 (-.6)	-.0030 (-.4)	-.0030 (-.4)	-.0034 (-.5)	-.0032 (-.4)	-.0033 (-.4)
Age squared/1000	.051 (.6)	.039 (.5)	.031 (.4)	.038 (.4)	.034 (.4)	.037 (.4)
Women	-.271 (-14.8)	-.274 (-14.9)	-.272 (-14.7)	-.273 (-14.8)	-.272 (-14.7)	-.272 (-14.8)
Married	.137 (7.3)	.137 (7.4)	.136 (7.3)	.136 (7.3)	.135 (7.3)	.136 (7.3)
Living in big city	.096 (6.1)	.094 (6.0)	.094 (5.9)	.093 (5.9)	.093 (5.9)	.094 (5.9)
Years of schooling	.078 (29.4)	.102 (7.4)	.094 (6.7)	.102 (6.2)	.104 (6.4)	.099 (6.1)
Years of schooling squared	-	-.0011 (-1.8)	-.0010 (-1.6)	-.0013 (-2.0)	-.0014 (-2.1)	-.0011 (-1.7)
Father social gr. 1	-	-	0.143 (2.5)	.174 (.8)	.129 (2.2)	.050 (.3)
Father social gr. 2	-	-	.041 (2.0)	.086 (1.3)	.042 (2.0)	.049 (.8)
Father farmer	-	-	-.004 (-.2)	-.109 (-1.7)	-.004 (-.2)	-.114 (-1.8)
Father high school or higher	-	-	-.055 (-1.1)	-.252 (-1.4)	-.212 (-1.4)	-.056 (-1.1)

Table 4a continued

Father secondary or voc. school	-	-	.010 (.4)	-.080 (-1.1)	-.055 (-.8)	.012 (.5)
Mother home during childhood	-	-	.040 (1.9)	.045 (.7)	.032 (.5)	.045 (.7)
Mother education above compulsory level	-	-	.029 (1.0)	-.008 (-.1)	.010 (.1)	-.037 (-.4)
Number of siblings	-	-	-.001 (-.3)	.012 (1.3)	.010 (1.0)	.012 (1.3)
<u>Interactions with years of schooling</u>						
Father social gr. 1	-	-	-	-.004 (-.3)	-	.007 (.5)
Father social gr. 2	-	-	-	-.004 (-.6)	-	-.000 (-.0)
Father farmer	-	-	-	.014 (1.8)	-	.015 (1.9)
Father high school or higher	-	-	-	.018 (1.2)	.013 (1.1)	-
Father secondary or voc. school	-	-	-	.010 (1.4)	.007 (1.0)	-
Mother home during childhood	-	-	-	-.000 (-.0)	.001 (.2)	-.001 (-.0)
Mother education above compulsory level	-	-	-	.003 (.4)	.002 (.2)	.006 (.7)
Number of siblings	-	-	-	-.0016 (-1.5)	-.0013 (-1.2)	-.0016 (-1.5)
n	2078	2078	2078	2078	2078	2078
$\bar{R}^2$	.440	.441	.443	.444	.443	.443

Table 4b. Wage equations with family background variables, both sexes 1981. t-ratios within parenthesis.

	1	2	3	4	5	6
Constant	7.41 (72.3)	7.10 (59.9)	7.13 (59.7)	7.13 (29.0)	7.09 (57.3)	7.14 (56.5)
Work experience	.016 (6.8)	.014 (5.9)	.015 (5.9)	.014 (5.8)	.014 (5.8)	.015 (5.9)
Work experience squared/1000	-.25 (-5.3)	-.21 (-4.6)	-.22 (-4.6)	-.21 (-4.5)	-.21 (-4.5)	-.21 (-4.6)
Age	.0102 (1.9)	.015 (2.7)	.015 (2.7)	.015 (2.7)	.015 (2.7)	.015 (2.6)
Age squared/1000	-.088. (-1.4)	-.130 (-2.1)	-.129 (-2.1)	-.131 (-2.1)	-.134 (-2.2)	-.127 (-2.0)
Women	-.169 (-15.5)	-.175 (-16.0)	-.176 (-16.0)	-.177 (-16.1)	-.176 (-16.1)	-.175 (-16.0)
Married	.035 (3.0)	.035 (3.0)	.035 (2.9)	.035 (3.0)	.035 (2.9)	.035 (2.9)
Living in big city	.042 (4.1)	.040 (3.9)	.038 (3.6)	.038 (3.6)	.038 (3.6)	.038 (3.6)
Working daytime	-.041 -3.1)	-.041 (-3.1)	-.042 (-3.2)	-.041 (-3.2)	-.041 (-3.2)	-.043 (-3.3)
Years of schooling	.041 (25.2)	.078 (10.1)	.075 (9.6)	.076 (8.0)	.080 (8.8)	.076 (8.0)
Years of schooling squared	-	-.0016 (-5.0)	-.0015 (-4.8)	-.0016 (-4.2)	-.0017 (-4.7)	-.0016 (-4.3)
Father social gr. 1	-	-	.035 (1.3)	.155 (1.3)	.029 (1.0)	.048 (.4)
Father social gr. 2	-	-	.030 (2.4)	.008 (.2)	.031 (2.5)	.001 (.0)
Father farmer	-	-	.009 (.7)	-.016 (-.4)	.008 (.6)	-.016 (-.4)
Father high school or higher	-	-	.008 (.3)	-.252 (-2.4)	-.213 (-2.2)	.004 (.2)

Table 4b continued

Father secondary or voc. school	-	-	.000 (.0)	.051 (1.0)	.049 (1.0)	-.002 (-.1)
Mother home during child-hood	-	-	-.001 (-.1)	-.039 (-1.2)	-.035 (1.1)	-.040 (-1.4)
Mother educ. above compulsory level	-	-	.005 (.3)	.015 (.3)	.025 (.5)	-.009 (-.2)
Number of siblings	-	-	-.0015 (-.6)	.0080 (1.1)	.0084 (1.2)	.0069 (0.9)
<u>Interactions with years of schooling</u>						
Father social gr. 1	-	-	-	-008 (-1.0)	-	-.000 (-.1)
Father social gr. 2	-	-	-	.002 (.6)	-	.003 (.8)
Father farmer	-	-	-	.003 (.6)	-	.002 (.6)
Father high school or higher	-	-	-	.018 (2.4)	:015 (2.3)	-
Father secondary or voc. school	-	-	-	-.004 (-1.0)	-.004 (-1.0)	-
Mother home during child-hood	-	-	-	.004 (1.3)	.003 (1.2)	.004 (1.3)
Mother education above compulsory level	-	-	-	-.001 (-.2)	-.002 -.4)	.001 (.3)
Number of siblings	-	-	-	-.0010 (-1.4)	-.0011 (-1.4)	-.0009 (-1.2)
n	2455	2455	2455	2455	2455	2455
$\bar{R}^2$	.336	.343	.343	.344	.345	.342

Table 4c. Wage equations with family background variables, men 1968. t-ratios within parenthesis.

	1	2	3	4	5	6
Constant	6.33 (31.7)	5.96 (26.6)	5.91 (26.3)	5.95 (25.5)	5.91 25.4)	5.97 (25.6)
Work experience	.029 (5.0)	.027 (4.6)	.025 (4.2)	.028 (4.7)	.026 (4.4)	.028 (4.7)
Work experience squared/1000	-.53 (-5.3)	-.50 (-5.0)	-.47 (-4.7)	-.53 (-5.1)	-.49 (-4.7)	-.53 (-5.1)
Age	-.0219 (1.9)	-.0169 (-1.4)	-.0135 (-1.1)	-.0183 (-1.5)	-.0153 (-1.3)	-.0188 (-1.6)
Age squared/1000	.267 (2.0)	.227 (1.7)	.186 (1.4)	.244 (1.8)	.204 (1.5)	.251 (1.9)
Married	.211 (8.7)	.211 (8.7)	.209 (8.6)	.207 (8.5)	.207 (8.5)	.207 (8.5)
Living in big city	.106 (5.5)	.098 (5.1)	.098 (5.1)	.096 (5.0)	.098 (5.0)	.098 (5.1)
Years of schooling	.077 (21.4)	.133 (8.4)	.127 (7.8)	.130 (6.9)	.132 (7.0)	.127 (6.8)
Years of schooling squared	-	-.0025 (-3.6)	-.0023 (-3.4)	-.0024 (-3.3)	-.0025 (-3.4)	-.0022 (-3.1)
Father social gr. 1	-	-	0.117 (1.7)	.205 (.9)	.120 (1.7)	.124 (.6)
Father social gr. 2	-	-	.011 (.4)	.081 (1.0)	.011 (.4)	.025 (.3)
Father farmer	-	-	-.037 (-1.7)	-.200 (-2.7)	-.038 (-1.7)	-.210 (-2.9)
Father high school or higher	-	-	-.103 (-1.7)	-.226 (-1.1)	-.150 (-.9)	-.097 (-1.6)

Table 4c contined

Father secondary or voc. school	-	-	.001 (.0)	-.135 (-1.6)	-.090 (-1.1)	-.001 (-.0)
Mother home during child-	-	-	.053 (1.9)	.053 (.6)	.033 (.4)	.056 (.7)
Mother education above compulsory level	-	-	.044 (1.2)	.090 (.8)	.113 (1.0)	.068 (.6)
Number of siblings	-	-	-.001 (-.3)	.017 (1.5)	.014 (1.2)	.018 (1.6)
<u>Interactions with years of schooling</u>						
Father social gr. 1	-	-	-	-.008 (-.4)	-	.001 (.0)
Father social gr. 2	-	-	-	-.007) (-.8)	-	-.001 (-.0)
Father farmer	-	-	-	.021 (2.3)	-	.023 (2.5)
Father high school or higher	-	-	-	.013 (.8)	.005 (.4)	-
Father secondary or voc. school	-	-	-	.014 (1.7)	.009 (1.2)	-
Mother home during child-hood	-	-	-	-.000 (-.0)	.002 (.3)	-.000 (-.0)
Mother education above compulsory level	-	-	-	-.004 (-.4)	-.007 (-.7)	-.002 (-.2)
Number of siblings	-	-	-	-.0024 (-1.7)	-.0019 (-1.4)	-.0024 (-1.8)
n	1303	1303	1303	1303	1303	1303
$\bar{R}^2$	.404	.410	.412	.414	.411	.414

Table 4d. Wage equations with family background variables, women 1968. t-ratios within parenthesis

	1	2	3	4	5	6
Constant	5.71 (23.6)	6.16 21.64)	6.22 (21.2)	6.09 (18.7)	6.08 (29.0)	6.10 (18.9)
Work experience	.017 (3.9)	.020 (4.5)	.020 (4.5)	.020 (4.5)	.020 (4.5)	.020 (4.5)
Work experience squared/1000	-.29 (-3.0)	-.34 (-4.2)	-.34 (-3.4)	-.34 (-3.4)	-.34 (-3.4)	-.34 (-3.4)
Age	.0094 (.8)	.0069 (.6)	.0045 (.4)	.0048 (.4)	.0046 (.4)	.0052 (.4)
Age squared/1000	-.115 (-.9)	.096 (-.7)	-.078 (-.6)	-.079 (-.6)	-.077 (-.6)	-.083 (-.6)
Married	.028 (.9)	.022 (.7)	.027 (.9)	.026 (.9)	.027 (.9)	.027) (.9)
Living in big city	.083 (3.1)	.089 (3.3)	.090 (3.3)	.087 (3.2)	.087 (3.2)	.088 (3.2)
Years of schooling	.077 (15.9)	-.009 (-.3)	-.015 (0.5)	.009 (0.2)	.013 (.3)	.0004 (0.1)
Years of schooling squared	-	.0042 (3.0)	.0041 (2.7)	.0030 (1.5)	.0026 (1.4)	.0033 (1.8)
Father social gr. 1	-	-	0.152 (1.5)	.051 (.1)	.139 (1.4)	-.078 (-.2)
Father social gr. 2	-	-	.071 (2.1)	.139 (1.1)	.074 (2.1)	.131 (1.1)
Father farmer	-	-	.040 (1.2)	.028 (.2)	.040 (1.2)	.028 (.2)
Father high school or higher	-	-	.009 (.1)	-.181 (-.5)	-.262 (-.8)	.013 (.1)

Table 4d continued

Father secondary or voc. school	-	-	.034 (.8)	-.005 (-.0)	.020 (.2)	.037 (.9)
Mother home during child-	-	-	.032 (.9)	.073 (.7)	.071 (.7)	.073 (.7)
Mother education above compulsory level	-	-	.013 (.2)	-.073 (-.4)	-.067 (-.3)	-.104 (-.5)
Number of siblings	-	-	-.003 (-.6)	-.004 (-.2)	-.005 (-.3)	-.004 (-.2)
<u>Interactions with years of schooling</u>						
Father social gr. 1	-	-	-	.005 (.1)	-	.02 (.5)
Father social gr. 2	-	-	-	-.008) (-.5)	-	-.007 (-.5)
Father farmer	-	-	-	.002 (.1)	-	.002 (.1)
Father high school or higher	-	-	-	.017 (.5)	.022 (.9)	-
Father secondary or voc. school	-	-	-	.003 (.2)	.002 (.2)	-
Mother home during child-hood	-	-	-	-.005 (-.4)	-.005 (-.4)	-.005 (-.4)
Mother education above compulsory level	-	-	-	.008 (.4)	.007 (.4)	.011 (.6)
Number of siblings	-	-	-	.0001 (.0)	.0003 (.2)	.0001 (.1)
n	775	775	775	775	775	775
$\bar{R}^2$	.296	.304	.306	.301	.303	.302

Table 4e. Wage equations with family background variables, men 1981. t-ratios within parentheis.

	1	2	3	4	5	6
Constant	7.32 (42.4)	6.59 (32.7)	6.66 (32.8)	6.70 (32.3)	6.64 (32.3)	6.72 (32.5)
Work experience	.014 (3.0)	.005 (1.0)	.006 (1.2)	.004 (.8)	.004 (.8)	.005 (.9)
Work experience squared/1000	-.285 (-3.5)	-.127 (-1.5)	-.137 (-1.6)	-.101 (-1.2)	-.104 (-1.2)	-.111 (-1.3)
Age	.013 (-1.4)	.034 (3.2)	.032 (3.0)	.035 (3.2)	.035 (3.3)	.033 (3.1)
Age squared/1000	-.0675 (-.6)	-.276 (-2.4)	-.259 (-2.2)	-.294 (-2.5)	-.294 (-2.5)	-.281 (-2.4)
Married	.091 (5.3)	.093 (5.5)	.092 (5.4)	.091 (5.4)	.091 (5.3)	.091 (5.3)
Living in big city	.072 (4.9)	.067 (4.6)	.063 (4.2)	.062 4.2)	.063 (4.3)	.061 (4.2)
Working daytime	-.026 (-1.4)	-.029 (-1.6)	-.029 (-1.6)	-.029 (-1.5)	-.027 (-1.5)	-.031 (-1.6)
Years of schooling	.035 (12.5)	.100 (10.0)	.095 (9.3)	.087 (7.0)	.094 (7.9)	.087 (7.1)
Years of schooling squared	-	-.0026 (-6.7)	-.0025 (-6.4)	-.0024 (-5.1)	-.0026 (-5.7)	-.0025 (-5.4)
Father social gr. 1	-	-	0.072 (1.8)	.230 (1.4)	.060 (1.5)	.167 (1.1)
Father social gr. 2	-	-	.035 (2.0)	-.026 (-.5)	.036 (2.0)	-.028 (-1.1)
Father farmer	-	-	.001 (.1)	-.067 (-1.2)	-.004 (-.2)	-.066 (-1.1)
Father high school or higher	-	-	.011 (.3)	-.167 (-1.2)	-.128 (-1.0)	.004 (.1)

Table 4e continued

Father secondary or voc. school	-	-	.008 (.4)	.058 (.9)	.048 (.7)	.003 (.2)
Mother home during child-hood	-	-	.015 (1.0)	-.077 (-1.7)	-.068 (-1.6)	-.077 (-1.8)
Mother education above compulsory level	-	-	-.009 (-.4)	-.030 (-.4)	-.011 (-.1)	-.051 (-.7)
Number of siblings	-	-	-.005 (-1.5)	-.000 (-.0)	-.001 (-.1)	-.002 (-.2)
<u>Interactions with years of schooling</u>						
Father social gr. 1	-	-	-	-.010 (-.9)	-	-.005 (-.5)
Father social gr. 2	-	-	-	.006 (1.2)	-	.006 (1.2)
Father farmer	-	-	-	.006 (1.1)	-	.006 (1.1)
Father high school or higher	-	-	-	.011 (1.2)	.009 (1.0)	-
Father secondary or voc. school	-	-	-	-.004 (-.8)	-.003 (-.7)	-
Mother home during child-hood	-	-	-	.008 (2.2)	.008 (2.0)	.008 (2.2)
Mother education above compulsory level	-	-	-	.002 (.3)	.000 (.1)	.003 (.6)
Number of siblings	-	-	-	-.0005 (-.5)	-.0005 (-.5)	-.0004 (-.4)
n	1294	1294	1294	1294	1294	1294
$\bar{R}^2$	.256	.281	.283	.285	.284	.284

Table 4f. Wage equations with family background variables, women 1981. t-ratios within parenthesis.

	1	2	3	4	5	6
Constant	7.34 (55.3)	7.53 (47.1)	7.52 (46.4)	7.37 (41.3)	7.40 (42.3)	7.40 (41.7)
Work experience	.016 (5.3)	.017 (5.5)	.017 (5.5)	.017 (6.5)	.017 (5.4)	.017 (5.5)
Work experience squared/1000	-.253 (-3.9)	-.265 (-4.1)	-.265 (-4.1)	-.263 (-4.0)	-.264 (-4.1)	-.265 (-4.1)
Age	.0083 (1.2)	.0069 (1.0)	.0075 (1.1)	.0086 (1.3)	.0081 (1.2)	.0088 (1.3)
Age squared/1000	-.0718 (-1.0)	-.0631 (-.8)	-.070 (-.9)	-.081 (-1.1)	-.0753 (-1.0)	.0843 (-1.1)
Married	-.026 (-1.6)	-.025 (-1.5)	-.025 (-1.5)	-.025 (-1.5)	-.025 (-1.6)	-.026 (-1.6)
Living in big city	.008 (.6)	.009 (.6)	.008 (.6)	.006 (.5)	.007 (.5)	.007 (.5)
Working daytime	-.052 (-2.9)	-.052 (-2.9)	-.052 (-2.9)	-.052 (-2.9)	-.051 (-2.9)	-.053 (-2.9)
Years of schooling	.042 (18.4)	.012 (.9)	.011 (0.8)	.029 (1.6)	.029 (1.7)	.022 (1.3)
Years of schooling squared	-	.0013 (2.1)	.0013 (2.1)	.0008 (1.2)	.0007 (1.0)	.0011 (1.6)
Father social gr. 1	-	-	0.003 (.1)	.122 (.7)	.002 (.1)	.001 (.0)
Father social gr. 2	-	-	.028 (1.7)	.102 (1.7)	.030 (1.8)	.100 (1.7)
Father farmer	-	-	.012 (.7)	.058 (.9)	.013 (.7)	.058 (.9)
Father high school or higher	-	-	-.026 (-.8)	-.284 (-1.8)	-.244 (-1.6)	-.024 (-.7)

Table 4f continued

Father secondary or yrkesskola"	-	-	-.005 (-.3)	.043 (.6)	.060 (.8)	-.003 (-.2)
Mother home during child-hood	-	-	-.016 (-1.2)	.005 (.1)	.004 (.1)	.004 (.1)
Mother education above compulsory level	-	-	.019 (.9)	.012 (.1)	.017 (.2)	-.005 (-.1)
Number of siblings	-	-	.002 (.7)	.014 (1.3)	.014 (1.4)	.015 (1.4)
<u>Interactions with years of schooling</u>						
Father social gr. 1	-	-	-	-.010 (-.8)	-	-.001 (-.1)
Father social gr. 2	-	-	-	-.007 (-1.2)	-	-.007 (-1.3)
Father farmer	-	-	-	-.005 (-.8)	-	-.005 (-.8)
Father high school or higher	-	-	-	.019 (1.6)	.015 (1.4)	-
Father secondary or voc. school	-	-	-	-.004 (-.6)	-.006 (-.9)	-
Mother home during child-hood	-	-	-	-.002 (-.5)	-.002 (-.5)	-.002 (-.4)
Mother education above compulsory level	-	-	-	.001 (.1)	-.000 (-.0)	.002 (.3)
Number of siblings	-	-	-	-.0013 (-1.2)	-.0013 (-1.2)	-.0013 (-1.2)
n	1116	1116	1116	1116	1116	1116
$\bar{R}^2$	.240	.243	.242	.241	.242	.240

REGIONAL AND OCCUPATIONAL WAGE DIFFERENCES

Evidence from workers in Norwegian manufacturing industries.

by

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This paper presents some results from an analysis of wage differences among groups of workers in manufacturing industries in Norway, and changes in wage structures over time from 1973 to 1986. The main result is that time passes, but relative wage structures last. Some exceptions to the main rule exist. They will be outlined in the results section. The pattern of regional wage differentials and wage differences between workers of different skill groups will also be outlined.

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[1] Marjo-Riitta L. Rynning has given very useful comments to a preliminary version.

1. Introduction.

Wage differentials are closely related to cost differentials among firms and to differentials in the standard of living among individuals. Affirmative action (laws) against sex discrimination in hourly pay, and the close link between the Norwegian Federation of Trade Unions and the Norwegian Labour Party, have impacts on the collective wage bargaining and may work in the interest of low-income groups. During the last two decades the petroleum sector has become a significant factor in the industrial development in Norway. The high wages in the petroleum sector have to some extent been carried over to the rest of the economy, Dyrstad (1987). However, other influences also have taken place. Some industries such as printing and publishing industries and car repair, have experienced growing markets. Foundries and shipyards have experienced declining markets from the early 1970's till 1986. What are the resulting impacts of the differential influences on wage structures over time? In the present study the effects of these changes on the wage structure will be explored.

All the firms being members of the Norwegian Employers' Confederation means that we can test the hypotheses that wage agreements within this confederation eliminates wage differences among member firms. The wage agreements between the Norwegian Employers' Confederation and the Norwegian Federation of Trade Unions implies that wage differences between lines of industries may exist because different agreements are signed by different Trade Unions covering different lines of industries. However, the agreement covers all member firms within a line of industry. Do these agreements eliminate regional wage differentials within an industry? The effects of local wage agreements at firm level, and the fact that the agreements do only regulate wage changes, and not all wage levels, imply that the national wage agreements do not eliminate regional wage differentials.

Despite national wage agreements regional wage differentials may persist. The magnitudes of regional wage differences are of interest because the existence of lower wage levels in the rural districts increases the opportunities for regional firms to survive in competitive markets. Norway has an ambitious goal for regional policy: maintaining the present regional distribution of the population. This implies needs for governmental intervention though distributional measures or through subsidizing regional firms. The lower wage levels in the rural districts, the smaller the needs for governmental intervention to keep up the regional income levels to sustain the population pattern.

2. Method.

The changes in the wage structure over time are measured comparing similar cross-sectional studies at three points in time (1973, 1982 and 1986). In each cross-sectional study we wanted to estimate the average hourly pay for different groups of workers in Norwegian industry. We used a log linear model and weighted multiple regression analysis.

Model.

The model represents individual hourly pay as a function of personal characteristics, characteristics of the job and characteristics of the firm. Using the available group-level data for wage statistics, the number of available characteristics was seriously limited.

Among the many potentially relevant individual characteristics such as sex, education, on-the-job training, seniority, age, occupation, marital status, and dwelling area, we only had information on sex and occupational group. Occupational group partly reflects the person's overall "human capital", and partly characterizes the job. Classification as a skilled worker can be attained through a program of schooling and apprenticeship or through a less formal qualification scheme with more years of work experience. This also apply to jobs as semi-skilled workers. Jobs as drivers characterizes the job, but implicitly demand the appropriate kind of driving license.

Ideally one would like to have information on job-related characteristics of the different jobs. Different job-related characteristics could mean higher productivity or less pleasant jobs, thereby creating wage differentials of different magnitudes. Among job-related characteristics for manual jobs one would like to know whether the work is production work or maintenance work, whether it is overtime or not, whether the work is paid by piecework or by hour; after all, the former categories of work can be expected to be better paid than the latter. A study by Titlestad (1983) on wage differences among Norwegian industrial workers in three industries, indicates that the most crucial missing characteristic may be that of piecework. Piecework is most frequent in certain industries and most frequent among female workers, and accounts for many more working hours than overtime work do for the groups studied.

Among characteristics of the firm line of industry and location district were available. Firm size could be generated by aggregating hours worked over all groups of workers within the firms. As all the firms in the study were members of the Norwegian Employers' Confederation we can not evaluate to which extent the wage structures differ between member firms and non-member firms. The importance of the wage policies practiced by individual firms and the impact of local wage agreements negotiated at the firm level were not taken explicitly into account as a characteristic of the firm. It is therefore possible that the observations within each firm are interdependent to some and varying extent in the empirical analysis. Only a few studies of wage differentials have taken this factor into account.

Log linear form.

We used the log linear model to facilitate comparisons over time.

In a log linear model with series of dummy variables, the estimate of the coefficient can be interpreted as a crude approximation to the percentage deviation from the pay of a reference group. The increase in nominal hourly pay over time made the log linear model very attractive. As an example the hourly wage of the reference group was estimated to about 19 NOK in 1973, 49 NOK in 1982 and 66 NOK in 1986. The log linear model, where effects are measured as constant percentages, also seems to fit the intuitive underlying structure of individual hourly pay better than the linear model where coefficients represent constant amounts measured in NOK. However, both models are presented and estimated for the population and different sub-samples of observations in Dale (1988).

Weighted analysis.

Our units of observation are occupational groups within firms. For 1982 this means that the smallest group contained 1 hour worked and the largest group contained 55 000 hours worked. With no weighting, these two and all other observations will get equal weight in the analysis regardless of the number of hours the observation represents.

There are two reasons for weighting. The first is that we want to give each hour worked the same influence on the estimated values independent of how the information is grouped in the data. The second reason for weighting relates to the regression model we use in the calculations. If hourly wage is a linear function of the independent variables, both weighted and non-weighted estimators are consistent and unbiased. The key to the weighting is the properties of the residual in the wage equation on group level. Weighting is undertaken to correct for heteroskedasticity. If the variance of the residual, given the independent variables, decrease with increasing size of the group, big groups ought to get greater weight than small. If the variance is inversely proportional to the size of the group, we get the best estimators if we weight proportional to the size of the group. Examples are: only individual effects and that the variation in the individual effects are independent of the size of the group; or only group effects where the variance on the group effect is inversely proportional to the size of the group.

We chose to weight each observation with a weight that was the number of hours worked in the observation multiplied with a constant. This constant was the number of groups in the run divided by the sum of hours in the run. We weighted proportional to the number of hours in the observation because we thought that the residual might contain individual effects to a large extent. The division with the sum of hours in the run made the weights sum up to 1, and gave a correct size of the estimated standard deviation of the coefficients. The final multiplication with the number of groups in the run is a technicality in the SPSS 9 version on DEC 20 which signals to the program that we did not have one observation but thousands of them. It is hard to compare this weighting procedure with others, because weighting is still seldom used or discussed. For example, Dyrstad (1987) used the same 1982 data without discussing the need for weighting these group-level data.

3. Data.

The data sets contained the grouped information on workers provided by member firms for the quarterly wage statistics published by the Norwegian Employers' Confederation. Included in the study was the data on the first quarter of each year: 1973, 1982 and 1986. The data for 1986 was especially prepared for this analysis. We chose the first quarter of the year to avoid periods of wage negotiations and delayed payments. The calculations presented below stem from data on more than 3500 anonymous firms, more than 14 000 worker groups and more than 79 million hours worked in the first quarter of each year. Table 1 contains the precise numbers.

4. Results.

The results are shown in Table 1. The main report, Dale (1988) also contains results on analyses of subsets of the data. Some of these will be mentioned in the passing commenting on puzzling findings.

Comparing the weighted and unweighted results.

For 1986 both weighted and unweighted results are reported in table 1. Table 1 shows that the undertaken weighting increases the adjusted degree of explanation, and does not change the magnitude of the calculated estimates of the coefficients. However, we see that the estimates of the coefficients are different, and that the estimates of the standard deviations are systematically smaller in the weighted than in the unweighted results of 1986. For most variables the estimated coefficient is significantly different in the two analysis. This is the case also for 1973 and 1982 (see Dale, 1988, tables 21 and 22). Weighting is shown to influences the reported results significantly.

Occupational differences.

As expected, the results show that occupational groups with higher skill levels earn higher wage rates. The results reported in table 1 show that working foremen were better paid than skilled workers, skilled workers were better paid than semi-skilled workers, and semi-skilled workers were better paid than unskilled. At all three points in time the difference was about 20% between unskilled workers and working foremen. Wage differences among occupational groups are relative stable over time. The group of workers under 18 years of age and apprentices attained about half the pay of skilled workers in 1973, but improved their relative wage level in the period up to 1986, as did the male drivers. There was a weak tendency towards diminishing relative differences between the "traditional" labour groups, while the differences increased sharply measured in nominal NOK. From these wage numbers it is hard to see any economic gain from choosing the career from apprentice to skilled worker instead of the "on-the job-training career" from unskilled through semi-skilled (and to skilled worker). International comparison may show that wage differences to skill levels are small in Norway relative to other countries. One reason why may be that the educational system is almost totally governmental run with no fees for pupils and students. This imply that the private returns on educational investments do not have to cover the costs of the educational system.

Data on male workers in the oil activities were not grouped separately until the mid-1970's, therefore the missing information for 1973. The off-shore workers in the oil activities get the largest pay among Norwegian worker occupations. Taking into account the effect of occupational group compensating for working off-shore and the "line of industry" effect, we see that their hourly wage is about 50% above that of most skilled workers.

Regional wage differences.

The division into regions is self made. The reason why is that I could find no other satisfactory regional division. More than 400 communities was much to detailed. A little more than 100 labour market regions meant to many (dummy) variables for the regression equation. The administrative division into 19 counties crosses natural labour market regions, but more seriously, a county hides the difference between the center and the periphery. Grouping counties into fewer groups, we get the regional division used by the Norwegian labour market statistics. However, this grouping increases the problem of putting cities and rural periphery into one group. Norway was divided into 28 regions by aggregating the more 100 labour market districts. Big city areas are grouped into separate groups. Knowledge of topography, communications and commuting have been taken into account in a less formal way. The approach takes account of the heterogeneity of Norwegian regional labour markets. Reported results of regional wage differentials between regions will indicate whether this regional division was useful. However, other divisions into regions might prove to be more efficient to bring forward regional wage dispersions.

The results show substantial regional variation in wage rates in 1973, 1982, and 1986. In 1973 the Oslo area had the top wage level. Little by little this top position has been overtaken by the Stavanger area. The low wage regions are according to table 1 the middle of the Country, except the Trondheim town area. The region of the very lowest wage rates has shifted over time from the coast to the inland.

We found that the wage level in areas including big towns like Oslo, Drammen, Kristiansand and Trondheim were well above the regional wage level of the nearby rural areas. However, the wage level in town areas like Hamar, Bergen, and Tromsø did not surpass that of the nearby rural regions.

The region Rogaland and Agder is used in the labour market statistics. In our regionalization this covers the whole of region: 14, 15, 16, 17 and parts of region: 11, 13 and 18. In 1986 the higher regional wage rates were reported in region 17: +3,3% above Oslo, and the lowest in region 11: -ca.11,3% less than Oslo. This spread of 15% percentages within a region clearly indicate the heterogeneity within the region and the usefulnes of our division into more regions.

The northern part of Norway probably had the overall worst labour market situation. This does not show up in our results on regional wage level in table 1. One reason for this may be that the regional coefficient for Troms and Finnmark in table 1 is heavily influenced by the missing information on piece work. Women in the manufacturing industry producing fish products in this region can earn fairly high wages on piece work. The fact that no correction is made for piece work may bias the regional effect. Indication that this explanation is correct comes from the separate estimations on women, and on iron and metal industry. Separate estimations on women in 1982 showed that Troms and Finnmark were the top wage region for women, followed by Oslo. However, separate estimations for iron and metal industries showed the regional wage level of Troms and Finnmark was 15% below Oslo in 1973 and 1982, and 11% below Oslo in 1986.

<u>Differences between women and men</u>.
Men earned more than women in the same occupation in 1973, 1982 and 1986. In 1973 the wage gap was substantial ranging from 19% to 24%, the group of youngsters excluded. From 1973 to 1982 female occupational groups improved their position relative to the same male groups. From 1982 to 1986 the overall decrease in wage differences between women and men stopped, but there were some occupational groups with decreasing differences and others with increasing differences. We find a decreased wage gap between women and men among skilled workers, unskilled workers and shift workers, and increased relative wage gap among semi-skilled workers, other workers, foremen and apprentices.

Because the female workers were grouped in fewer and more aggregated groups in the data set than men, women to a larger extent than men were grouped in to "low" and general occupational groups. The lack of a separate group for "female workers in oil activities" is the most obvious example. This resulted in an estimate of 59% for the coefficient of the oil extraction line of industry, when run on 1986 data for women only, see (Dale, 1986). However, it leads to underestimation of wage differences attributable to sex because a few women with high wage rates are grouped in more general occupational groups which violates the "same occupation" assumption. This is a general problem with estimation of wage gaps between men and women in labour markets with unbalanced gender distribution. In our data set this problem is more substantial in 1973 than in 1982 or 1986. Therefore the relative improvement for women from 1973 to 1986 has probably been greater than shown by our table 1. However, because the underlying occupational grouping still is less detailed for women than for men, this problem still exists in the 1986 data set. This indicates that the wage gap between the sexes is likely to be greater than shown by the 1986 figures.

Estimations on data for female workers only, and for male workers only, have shown that women get substantially less paid in industries like food and stimulants manufacturing, in printing, publishing etc., in petrochemical industry, in car repair shops, in other industry and in other activities.

The results from the separate estimations on women and men, indicate much smaller regional wage differences among women than among men. This contradicts a hypothesis that employers can use monopolistic discrimination more freely against women than against men. An alternative explanation is that men in certain central areas have been the ones to benefit in relative wage terms.

We also found that the regional carry-over effect from the oil sector only affected men. In 1986 the Stavanger area had the highest wage level for men, having passed all other regions including the Oslo area. In 1986 women in the Stavanger area still received 8% less than women in Oslo, and the regional difference was the same as in 1973.

Wage differences by firm size.

Our results show that the bigger the firm the better the pay. The coefficients for wage differences among firm sizes seem to be very stable over time.

Separate estimations on the total iron and metal industry show that wage differences by firm size were smaller in these industries, than in the results presented in table 1.

Wage differences by line of industry.

The new industries (not in the statistics for 1973), oil extraction and petrochemical industry, had top wages in 1986 and so did printing, publishing etc.. Whereas textiles and clothing industries paid the lowest wages.

In 1973 shipyards and foundries had top wages, followed by building and construction and printing etc.. From 1973 to 1986 no line of industry experienced a sharper decrease in the relative wage level than did foundries and shipbuilding. Declining markets are among the more visible explanations.

5.Conclusions.

Time passes, but relative wage differences among Norwegian workers persist. That is the main finding of the reported study. This study also indicates that wage rates are better indicators of congestion problems in the labour market than of slack problems. It shows that new industries may increase wage rates both directly and indirectly, and wage differences based on sex still exists among workers in Norway.

The study points to the necessity of taking proper account of the heterogeneity of regions and the heterogeneity of occupations by skills. The empirical results also show the importance of weighting when grouped data sets are analyzed.

Table 1. Relative differences in wage rate among Norwegian workers in 1973, 1982, and 1986 by occupational group, gender, line of industry, firm size and region[1].

Variable name	1973 weighted	1982 weighted	1986 weighted	1986 unweighted
Number of firms	3 576	4 179	3 972	3 972
Number of observations	14 283	17 389	16 292	16 292
Number of hours worked	91338040	88291394	79314575	79314575
Adjusted R2	71%	70%	68%	54%
Constant	2.940	3.884	4.1853	4.2262
Constant measured in NOK	18,92	48,63	65,71	68,46
Male occupational groups				
Male, skilled (ref.gr.)	0	0	0	0
M. craftsmen, repairers	-0.0289	-0.0273	-0.0244	-0.0253
	(.0052)	(.0048)	(.0056)	(.0079)
M. production workers	-0.0492	-0.0693	-0.0708	-0.1018
	(.0037)	(.0038)	(.0044)	(.0059)
M. semi-skilled workers	-0.0540	-0.0615	-0.0686	-0.0829
	(.0044)	(.0049)	(.0052)	(.0091)
M. unskilled workers	-0.1324	-0.1022	-0.1026	-0.1412
	(.0042)	(.0041)	(.0050)	(.0061)
Male drivers	-0.0869	-0.0358	-0.0249	-0.0797
	(.0060)	(.0055)	(.0067)	(.0061)
Other m.w.above 18 years	-0.1042	-0.0876	-0.0806	-0.1030
	(.0040)	(.0037)	(.0044)	(.0055)
Male shift workers	0.0485	0.0756	0.0723	-0.0041**
	(.0045)	(.0035)	(.0041)	(.0072)
M.w. in oil activities	M	0.3590	0.3790	0.4202
		(.0101)	(.0086)	(.0176)
Working foremen	0.0820	0.0954	0.1062	0.1129
	(.0075)	(.0066)	(.0074)	(.0062)
M.<18 & apprentices	-0.4976	-0.4321	-0.4179	-0.4722
	(.0075)	(.0054)	(.0057)	(.0055)
Female occupational groups				
Female w.above 18 years	-0.2363	-0.1747	-0.1198	-0.1744
	(.0048)	(.0059)	(.0098)	(.0097)
F. skilled workers	-0.1945	-0.0504**	-0.0185**	-0.0159**
	(.0618)	(.0405)	(.0167)	(.0130)
F. production workers	-0.2482	-0.1682	-0.1659	-0.1692
	(.0065)	(.0045)	(.0050)	(.0075)
F. semi-skilled workers	-0.2554	-0.1877	-0.2107	-0.1766
	(.0157)	(.0133)	(.0159)	(.0189)

[1]Estimated by natural logarithms. The coefficients approximate the percentage difference from the reference group: male, skilled workers, in engineering workshops, with less than 20 workers in Oslo. Estimated standard deviations in brackets.
* = not significant on 1% level. ** = not significant on 5% level. M = missing.

F. unskilled workers	-0.3155	-0.2478	-0.2090	-0.1998
	(.0230)	(.0265)	(.0119)	(.0134)
Other f.w.above 18 years	-0.2964	-0.1822	-0.1722	-0.2000
	(.0087)	(.0076)	(.0079)	(.0086)
Female shift workers	-0.1949	-0.0647	-0.0558	-0.0748
	(.0160)	(.0086)	(.0098)	(.0127)
Female, working foremen	-0.1334	0.0338**	-0.0362**	-0.0605
	(.0298)	(.0349)	(.0378)	(.0194)
F.<18 & apprentices	-0.5715	-0.4741	-0.5166	-0.5219
	(.0117)	(.0161)	(.0171)	(.0094)
Line of industry				
Iron&metal ind.(R.gr.)	0	0	0	0
Mining and sandpits	-0.0327	0.0001**	0.0203**	0.0255**
	(.0089)	(.0091)	(.0110)	(.0216)
Oil extraction	M	0.2177	0.1722	0.1839
		(.0120)	(.0106)	(.0234)
Food and stimulants man.	-0.1416	-0.0970	-0.0639	-0.1026
	(.0056)	(.0048)	(.0053)	(.0075)
Textile and clothing ind.	-0.1705	-0.1308	-0.1452	-0.1720
	(.0068)	(.0062)	(.0075)	(.0091)
Wood industries	-0.0998	-0.0649	-0.0661	-0.0933
	(.0062)	(.0055)	(.0062)	(.0087)
Paper mills etc.	-0.1644	-0.1123	-0.0857	-0.0785
	(.0063)	(.0058)	(.0067)	(.0117)
Printing, publishing etc.	0.0542	0.1251	0.2349	0.1168
	(.0069)	(.0064)	(.0071)	(.0089)
Chemical, technical ind.	-0.1287	-0.1143	-0.0943	-0.0964
	(.0071)	(.0063)	(.0074)	(.0098)
Other chemical ind.	-0.1713	-0.1317	-0.0714	-0.0899
	(.0082)	(.0094)	(.0104)	(.0173)
Man. of mineral products	-0.0931	-0.0291	-0.0207	-0.0067**
	(.0071)	(.0067)	(.0078)	(.0110)
Electrochemical ind.	-0.1107	-0.0433	0.0174	-0.0132**
	(.0066)	(.0057)	(.0065)	(.0129)
Petrochemical ind.	M	0.1399	0.1929	0.1726
		(.0134)	(.0152)	(.0358)
Iron and metal goods ind.	-0.0258	-0.0617	-0.0618	-0.0732
	(.0056)	(.0053)	(.0063)	(.0098)
Founding industries	0.0234	-0.0541	-0.0746	-0.0512
	(.0081)	(.0089)	(.0112)	(.0180)
Shipbuilding industry	0.0327	-0.0376	-0.0193	-0.0068**
	(.0052)	(.0048)	(.0059)	(.0133)
Electrotechnical ind.	-0.0077	-0.0455	-0.0195	-0.0352
	(.0072)	(.0062)	(.0070)	(.0127)
Other mechanics shops	-0.0408	-0.0209	-0.0262	-0.0208**
	(.0065)	(.0060)	(.0074)	(.0108)
Car repair shops	-0.0695	-0.0547	-0.0503	-0.0776
	(.0077)	(.0067)	(.0073)	(.0085)
Other manufacturing ind.	-0.0693	-0.0209	-0.0444	-0.0889
	(.0110)	(.0060)	(.0130)	(.0138)
Building and construction	0.0890	0.0818	0.0655	0.0140**
	(.0052)	(.0040)	(.0047)	(.0074)
Road transport	-0.1005	-0.0603	-0.0951	-0.0780
	(.0069)	(.0051)	(.0059)	(.0086)
Other businesses	-0.0753	0.0270	-0.0016**	-0.0446
	(.0085)	(.0076)	(.0086)	(.0120)

Region				
1 Oslo (Ref.gr.)	0	0	0	0
2 Østfold	-0.0528	-0.0763	-0.0772	-0.0637
	(.0039)	(.0039)	(.0047)	(.0067)
3 Asker and Bærum	0.0005**	-0.0127**	0.0207	-0.0236*
	(.0073)	(.0066)	(.0069)	(.0109)
4 Akershus - 3	-0.0462	-0.0561	-0.0474	-0.0531
	(.0058)	(.0056)	(.0065)	(.0082)
5 Hamar	-0.1343	-0.1098	-0.1106	-0.1043
	(.0068)	(.0063)	(.0077)	(.0103)
6 Hedmark - 5	-0.1535	-0.1315	-0.1351	-0.1243
	(.0076)	(.0070)	(.0094)	(.0102)
7 Oppland	-0.1401	-0.1285	-0.1340	-0.1328
	(.0058)	(.0058)	(.0063)	(.0080)
8 Drammen	-0.0434	-0.0333	-0.0373	-0.0430
	(.0051)	(.0053)	(.0064)	(.0087)
9 Buskerud - 8	-0.1049	-0.0667	-0.0921	-0.0760
	(.0084)	(.0062)	(.0063)	(.0091)
10 Vestfold	-0.0661	-0.0689	-0.0718	-0.0777
	(.0045)	(.0044)	(.0054)	(.0074)
11 Ø.Telem.+Setesdal	-0.0922	-0.0999	-0.1131	-0.0771
	(.0100)	(.0093)	(.0110)	(.0143)
12 Porsgrunn + Skien	-0.0781	-0.0714	-0.0482	-0.0604
	(.0056)	(.0052)	(.0061)	(.0097)
13 A.Agder+Kragerø-S.d.	-0.0852	-0.0923	-0.0984	-0.0946
	(.0076)	(.0067)	(.0078)	(.0109)
14 Kristiansand	-0.0824	-0.0578	-0.0790	-0.0792
	(.0060)	(.0056)	(.0071)	(.0100)
15 Vest-Agder - 14	-0.1181	-0.1011	-0.0948	-0.0895
	(.0101)	(.0078)	(.0089)	(.0125)
16 Rogaland syd	-0.1325	-0.0675	-0.0580	-0.0518
	(.0078)	(.0070)	(.0080)	(.0124)
17 Stavanger + Sandnes	-0.1011	-0.0145	0.0334	0.0017**
	(.0044)	(.0045)	(.0050)	(.0074)
18 Haugesund + Sunnhordl.	-0.0824	-0.0626	-0.0202	-0.0410
	(.0065)	(.0056)	(.0065)	(.0106)
19 Bergen	-0.1101	-0.1026	-0.1020	-0.0841
	(.0040)	(.0038)	(.0046)	(.0065)
20 Hordaland, rest	-0.1099	-0.0976	-0.1041	-0.1004
	(.0071)	(.0072)	(.0088)	(.0108)
21 Sogn og Fjordane	-0.1179	-0.1150	-0.1343	-0.1079
	(.0094)	(.0071)	(.0089)	(.0108)
22 Møre og Romsdal	-0.1654	-0.1203	-0.0959	-0.0982
	(.0058)	(.0048)	(.0056)	(.0070)
23 Trondheim	-0.1094	-0.0775	-0.0885	-0.0764
	(.0046)	(.0045)	(.0056)	(.0077)
24 Sør-Trøndelag - 23	-0.1656	-0.1010	-0.1375	-0.1290
	(.0105)	(.0086)	(.0106)	(.0117)
25 Nord-Trøndelag	-0.1572	-0.1114	-0.1034	-0.1282
	(.0066)	(.0066)	(.0073)	(.0089)
26 Nordland	-0.1085	-0.0951	-0.0798	-0.0842
	(.0057)	(.0053)	(.0058)	(.0072)
27 Tromsø	-0.1044	-0.1157	-0.1186	-0.0907
	(.0097)	(.0101)	(.0109)	(.0119)
28 Troms +Finnmark -27	-0.0802	-0.0523	-0.0831	-0.0694
	(.0072)	(.0062)	(.0074)	(.0082)

Firm size				
1 - 19 workers (R.gr.)	0	0	0	0
20 - 44 workers	0.0506	0.0370	0.0463	0.0450
	(.0040)	(.0034)	(.0040)	(.0037)
45 - 89 workers	0.0776	0.0737	0.0700	0.0662
	(.0039)	(.0033)	(.0039)	(.0041)
90 - 179 workers	0.0906	0.0776	0.1003	0.1017
	(.0039)	(.0035)	(.0041)	(.0053)
180 and more workers	0.1327	0.1275	0.1381	0.1479
	(.0038)	(.0033)	(.0038)	(.0058)

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WORKPLACE SKILL ACCUMULATION AND ITS IMPACT ON EARNINGS AND LABOR MOBILITY: The U.S. Experience

by

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ABSTRACT

This paper examines the determinants and outcomes of human capital accumulation in the United States that occurs in the workplace after formal schooling has been completed. The most common source of post school training is provided by for-profit proprietary institutions but still 60 percent of 25 year olds have received no post-school formal training in the United States. Most company provided formal on-the-job training in the United States is acquired by college graduates who are employed in finance, insurance and real estate. Those who receive training are also more likely to be managers, professional or technical employees in these industries as well and working for larger firms. One of the key differences in post-school training in the U.S. compared with training received by young workers in Europe is the lack of certificates or formal qualifications at the completion of training except for the minority who do an apprenticeship. All types of post-school training raise wages significantly. In particular, for non-college graduates, off-the-job training from proprietary institutions can be useful for increasing wages. The impact of these training variables also seems to be larger than the impact of tenure on wages. There are strong links between training and employment transitions of young workers. Those workers who are employed and receive company provided training are likely to remain longer with their employer. This suggests that most company provided training is firm specific training. Those who obtain off-the-job training are more likely to leave their employer and this would be consistent with off-the-job training being more general. In general, those workers who have received the least amount of schooling, or are employed in smaller firms are the least likely to receive additional skills training in the workplace. Yet it is these workers who are now expected to be involved in more tasks and take on additional responsibilities in the workplace. Policy makers interested in stimulating private sector competitiveness should consider policies directed at improving the skills of these workers.

I. Introduction

This paper shifts the discussion in this conference from issues related to human capital creation provided by formal education, to the determinants and outcomes of human capital accumulation that occurs in the workplace after formal schooling has been completed. In recent years this type of human capital creation has received an increasing amount of attention in the U.S. for three main reasons. First, growing international competition has forced firms around the world to identify ways in which they can increase the productivity of their labor inputs. Since labor productivity growth has been much slower in the U.S. than in other countries policies which might stimulate higher productivity growth in the U.S. are viewed as crucial for economic competitiveness. Second, rapid changes in technology, especially in the area of information technology, have resulted in the massive retraining of workers and substantial changes in the skill requirements of workers. This has been felt in all sectors but particularly in industries such as telecommunications. Finally, changing work organizations associated with the switch to "just-in-time" production from "just-in-case" production has resulted in workers rotating through a wider number of jobs. Consequently, they are being trained on-the-job in a wider set of skills. In addition, as firms decrease the number of layers within the organization and push more decisions down on to the line, workers need to have broader abilities to take on these new responsibilities.

The decision of whether or not to invest in post-school training is more complicated than the investment decision associated with schooling. In firm provided training there are two agents involved in the investment decision - the firm and the individual worker. These two agents may have very different levels of risk aversion, time horizons, information, access to capital markets, and preferences. In the standard human capital model proposed by Becker (1964) and later extended in Mincer (1974), workers have an incentive to invest in general training because this will raise their wages across all firms once the training is completed. This investment may be paid for either directly by the worker or indirectly through lower wages during general training spells. However, borrowing constraints or other constraints such as minimum wages may result in workers underinvesting in their own general training. On the other hand, firms are willing to invest in firm specific training because they can capture the returns to this training. They are not as willing to pay for the costs associated with general training because if they invest in externally recognizable general training they run the risk of their workers being "poached" or hired away by other firms. The end result is that there may be a market failure in the provision of general training. Therefore, if the demand for more generally trained workers is rising due to technological and organizational change, then those economies that have not been able to find a solution to this potential market failure may find themselves in a weaker competitive position.

There is growing consensus in the United States that firms (on average) underinvest in training compared to their international competitors - especially those in Europe and Japan. When one examines post-school training patterns across countries there seem to be four alternative training strategies followed by firms in North America, Europe and Japan (see Lynch (1992c) for a review of the outcomes across countries of these different training strategies). The first strategy, as exemplified by the German dual apprenticeship system, is characterized by coinvestment in training, codetermination of training, and certification of training. These three components of the training system result in both firm specific and general training being provided during an apprenticeship. There is coinvestment in training since employers and the government pay for the direct costs of training but workers receive much lower wages during their apprenticeship. The training program is codetermined by the unions and employers with unions pushing for more general training while employer associations bargain for more firm specific training. Finally, workers have an incentive to accept lower wages during their training because upon completion of their apprenticeship they can take an exam and receive a nationally recognized certificate for their training. This certificate acts as an insurance policy if they need to change employers and signals skills levels to potential employers.

The second strategy, followed by Japanese firms, is almost orthogonal to the German strategy. In Japan there are virtually no apprenticeships. Japanese firms are concerned with employees building up loyalty to the firm rather than to a specific occupation. Consequently, apprenticeship training is not viewed very favorably. In addition, employee turnover is much lower in Japan than in other countries (for the 40 percent of workers in the larger Japanese firms characterized by lifetime employment) since there are high costs associated with leaving an employer for the employee and for employers who are viewed as poaching workers. With lower worker turnover, firms are able to capture even the returns to investments in more general forms of training. The provision of training also differs from the German system in that it does not occur at the beginning of a worker's career but rather is embedded into the production system and occurs after workers join a firm. The ability of this system to sustain itself may be challenged as employee turnover increases in sectors such as financial services. It will be interesting to see what impact this has on the training strategies followed by Japanese firms in this sector.

A third strategy, followed in varying degrees by the Nordic countries, is a greater role of the government in the provision of skills training. In the U.S. government training programs are directed at those workers having the greatest difficulties in the labor market. However, in the Nordic countries, while it is still the case that workers experiencing unemployment are the most likely to receive training, this training is acquired by a broader cross-section of the workforce than in the United States. While this strategy may be useful in solving a market failure in the provision of more general training it can be quite costly if the government is also financing more firm specific training. In addition, papers in this conference suggests that in the Nordic countries, as in the U.S., there is a great deal of discussion over the actual returns associated with these government training programs. Therefore, more evaluation of government training programs such as those presented in this conference needs to be done.

The fourth model of training provision is one that I will call the laissez-faire approach to training and this characterizes the provision of training in the United States. In the U.S. there are four possible sources of post school training - formal and informal company provided training; off-the-job training obtained in for profit proprietary institutions (business/vocational/technical institutes, barber and beauty schools, and correspondence courses); apprenticeships (primarily in construction); and government training programs such as the Job Training Partnership Act, JTPA. As mentioned earlier, the percentage of workers in government training programs is very small and these programs are targeted at those workers with the greatest difficulties in acquiring stable employment. The remainder of post-school training is provided by the private sector. While many have argued that we underinvest in training in the U.S. there are no systematic and representative surveys of training practices of firms in the U.S., and there is relatively little information on individuals' post-school training experiences. Nevertheless, the remainder of this paper will examine the characteristics of post school training in the U.S. using one of the best sources of individual data on training.

Characteristics of Post School Training in the U.S.

There are four types of workers who require training after the completion of formal schooling. These include new entrants into the labor market; workers who are being displaced by new technology and are being retrained for new jobs in their current firm or with another employer; employed workers who need training for career development and promotion within their current firm; and the unemployed. A thorough examination of training provisions for all of these types of workers is beyond the scope of this brief paper, therefore, I will focus my discussion on the skills development of new entrants into the labor market (see Lynch (1992d) for a more detailed discussion of the findings presented in this section). This is the group that typically experiences most of the post-school training and will be the workforce of the future. Hopefully, with this background information on the experience of new entrants it should be easier to contrast the U.S. experience with other countries.

While time series data can provide insight into changes in the patterns of education and labor market activity over time, and cross section studies can correlate patterns of training with personal characteristics at a point in time, longitudinal surveys of individuals allow an even more detailed and dynamic analysis of the patterns and consequences of post school choices of young workers. One of the best sources of information on post-school training for new entrants into the labor market in the U.S. is the National Longitudinal Survey Youth Cohort (NLSY). This is a survey of a nationally representative sample of 12,686 males and females who were 14 to 21 years of age at the end of 1978. These youths have been interviewed in person every year since 1979 on all aspects of their lives. In particular, this survey contains detailed data on young people's education, jobs, military service, training programs, marital status, health, and attitudes on a wide range of issues.

In addition to asking about schooling, respondents in the NLSY were asked every year about the types of training they had received over the survey year (up to 3 spells), and the dates of training periods by source. Potential sources of training included business college, nurses programs, apprenticeships, vocational and technical institutes, barber and beauty schools, correspondence courses, and company training. Training received in formal regular schooling (including 2-year programs) is included in the schooling variables. The data on types of training received other than governmental training or schooling yield some of the most comprehensive information available in the U.S. on private sector training. The training data are separated into three categories -- company provided on-the-job training (ON-JT), off-the-job training from business courses, barber or beauty schools, nurses programs, technical and vocational institutions, or correspondence courses (OFF-JT), and apprenticeships.

Table 1 uses data from the NLSY to show by the age of 25 the patterns of human capital accumulation for youths in the U.S. in the 1980s. Almost 25 percent of males and 15 percent of females still have not completed a high school degree by the age of twenty five. Approximately 22 percent of all 25 year olds have completed a four year university degree. The percentage of 25 year old males in 1988 who had received formal on-the-job training by the age of 25 is 14 percent and the percentage of 25 year old females in 1988 who had received formal OJT is 8 percent. Females are more likely to receive off-the-job training males. Finally, very few young workers in the United States participate in apprenticeship training. While a relatively high percentage of young workers in the U.S. go on to some form of further education after high school, approximately 60 percent of young workers receive no additional training after they complete their formal schooling. In contrast over 75 percent of German youths enter a formal apprenticeship and over 50 percent of British youths enter an apprenticeship or government training program.

It is possible to examine in even greater detail the patterns of post-school training in the NLSY than is presented in Table 1 using detailed information collected in the 1988 interview of the NLSY. The following discussion presents breakdowns on the incidence of post-school training in 1988 for the NLSY respondents who were aged 23-29 at the 1988 survey and in the labor force, by educational status, union status, industry, occupation, firm size, and the duration of training.

Incidence of training by schooling. There is a strong positive correlation between schooling and company provided training. Approximately 15 percent of all college graduates in 1988 participated in company provided training programs that year. Only 5 percent of males and 7 percent of females who were a high school graduate or dropout participated in formal on-the-job training. The relationship between schooling and off-the-job training is a bit different, especially for females. Female high school dropouts are much more likely to receive off-the-job training than female college graduates (10 percent vs. 9 percent). However, for males, the more schooling, the more likely an individual is to have participated in some off-the-job training.

Incidence of training by union status. A higher percentage of union workers than nonunion workers are likely to receive on-the-job training, especially for women union members. However, this pattern reverses itself for off-the-job training with non union workers more likely to participate in off-the-job training programs than union workers. This differential pattern may be the result of union contracts containing specific policies on worker training while non union workers interested in acquiring additional skills must seek training outside the firm.

The incidence of training by industry and occupation. Almost one third of all young workers employed in finance, insurance and real estate, or in public administration received some form of training during 1988. That training was evenly divided between on-the-job training and off-the-job training. Males in finance, insurance, and real estate were more likely to receive training than females (32% vs. 25%). Other industries with higher than average training levels included transportation, communication and public utilities, wholesale trade, and business and repair services. In these industries 16-20 percent of the young employees had received either on-the-job or off-the-job training during 1988. The industries with the lowest amount of formal company provided training included retail trade and personal, professional and related services. Finally, apprenticeships were concentrated in the construction industry. Unfortunately, the industries where most young workers are employed are not the industries with the highest levels of training. For example, only 9 percent of young males and 15 percent of young females were employed in either finance, insurance and real estate, or public administration. Those industries with the lowest levels of training (retail trade, personal, professional and related services) accounted for 28 percent of young male employment and 54 percent of young female employment.

There are four main occupations in which over 20 percent of the young employees in 1988 had received some form of training - professional and technical workers, managers, clerical workers, and sales workers. In addition, over one-fifth of women employed in crafts occupations had received some training (especially company provided training). Operatives and laborers were less likely to be engaged in any type of post-school training.

The incidence of training by firm size. When one examines the incidence of training by firm size one observes that the probability of receiving company training is influenced by both the plant size and whether or not there are more than one locations in the firm. Small plants with less than fifty employees are quite likely to offer training but only if they have more than one plant. Otherwise there appears to be a linear relationship between training and firm size - the larger the firm the more likely it is that a young person will receive some training. The only other exception to this is large firms of 1000 or more employees with just one location. The probability of receiving training in these establishments is quite low.

The average duration and hours of each training spell. Most training spells, especially those provided by firms, last less than four weeks. The amount of time spent in the training programs seems to fall into two categories. Thirty eight percent of all training spells for young males last 9 hours or less per week while over 50 percent of all females training spells last less than 9 hours per week. At the same time over 37 percent of male training spells last 40 hours or more per week and 22 percent of female spells last over 40 hours per week. On-the-job training is more likely to be more hours per week than off-the-job training. This suggests a pattern of short intensive employer provided training and less intensive but spread out over a longer period of time off-the-job training.

In summary, most company provided formal on-the-job training in the United States is acquired by college graduates who are employed in finance, insurance and real estate. Those who receive training are also more likely to be managers, professional or technical employees in these industries as well and working for larger firms. Black and Hispanic youth are much less likely to have received company provided training than white males and females. Unionized workers are more likely to have received company provided training while non union workers are more likely to have participated in off-the-job training. One of the key differences in post-school training in the U.S. compared with training received by young workers in Europe is the lack of certificates or formal qualifications at the completion of training except for the minority who do an apprenticeship. As shown in Blanchflower and Lynch (1991) the certification of skills acquired by British youths in their post-school training is a major component in the return to training and raises the return relative to their U.S. counterparts. The certification improves the ability of employers to identify appropriate and qualified workers, and it provides an opportunity for young workers to carry their training from one firm to another.

The Impact of Training and Education on Wages

The previous section summarized the patterns of post school training for all young workers. However, when we discuss deficiencies in the relative competitiveness and competence of the U.S. workforce, most attention of policy makers is focused on the majority of workers who are not college graduates. Therefore, this section concentrates primarily on the impact of post high school education and training on wages for non college graduates. For the analysis of the impact of education and training on the wages of young workers a subsample of the 12,686 NLSY respondents has been selected (see Lynch (1992a) for a more complete discussion of the results reported in this section). I have excluded the military subsample from the analysis (1280 respondents) and all college graduates. The final sample is composed of individuals who had completed their schooling by the 1980 interview date (where "completed" is defined as not returning to school by the 1983 interview date). The completion of schooling requirement reduces the sample size substantially given the age structure of the NLSY (4000 respondents are still 17 or less in 1980). In addition, these individuals had to have wage observations at both the 1980 and 1983 interview dates. These selection criteria yield a final sample of 3064 individuals that will be used in the empirical work. Using a constructed weekly event history of private sector training, employment, and schooling for this subsample it is possible to examine the patterns and outcomes of training for non-college graduates.

The training data are separated into three categories -- company training (ON-JT), apprenticeships (APPT), and training obtained outside the firm (OFF-JT). OFF-JT includes training obtained from business courses, barber or beauty school, nurses programs, vocational and technical institutes and correspondence courses. Each of these three types of training are allowed to have different types of returns. Since the data are longitudinal it is possible to distinguish between spells of training in each of these categories received during employment with a previous employer and spells received during current employment. In addition, for training received on the current job, it is possible to identify both completed and uncompleted spells of training. However, the questions only refer to those spells of training that lasted 4 weeks or more (until 1988 when this restriction was finally relaxed). This suggests that the NLSY measure of training is more likely to capture formal training spells than informal on-the-job training.

In Lynch (1992a) the impact of these various types of training on the wages of non-college graduates is examined. Log wages of young workers are regressed on a function of tenure, work experience, schooling, training, and other factors. The additional factors in the wage equation include the local unemployment rate, the number of jobs held since finishing school, whether or not the respondent lives in an urban area, marital status, race, gender, coverage by a collective agreement, and health.

The results presented in Lynch (1992a) show the significant role that training plays in wage determination. Even after controlling for industry and occupation the various training measures have a significant impact on wages. Periods of off-the-job training and apprenticeship training acquired before the current employer raise wages significantly. Weeks of on-the-job training and apprenticeship with the current employer also raise wages.

Other variables that significantly raise wages include total work experience, years of school, living in an urban area, male, white, married and coverage by a collective agreement. Being disabled or living in an area with high local unemployment depresses wages significantly. Adding industry and occupation dummies to the estimated wage equation slightly reduces the size of the effect of training on wages but the training variables that were significant without industry and occupation dummies remain significant when they are added. Workers employed in the mining, construction and transportation industries earn more relative to those in manufacturing while those in wholesale and retail trade, business, repair, personal and professional related services earn less. Professional, managerial and craft workers all earn a wage premium relative to laborers and farmers.

In order to have a better sense of how the different training variables affect wages relative to other factors such as tenure and schooling, Table 2 presents calculations of hourly wages for different characteristics of the sample. This table shows that training, especially company provided on-the-job training and apprenticeships, raises wages substantially. The impact of one more year of school or one more year of current tenure (keeping experience the same) raises wages to almost to the same amount as 6 months of off-the-job training. The return to additional schooling and tenure is even smaller relative to the return to 6 months of on-the-job training from the current employer. The latter raises wages by almost ten percent while off-the-job training obtained before the current job raises wages by almost 5 percent. These findings on the role of training obtained from "for-profit" proprietary institutions are important for the current debate on whether or not Graduate Student Loans and Pell grants should be continued to be granted to students in these institutions. Some cities have expressed concern about the ability of these institutions (see INTERFACE (1989)) to provide training to welfare recipients. However, this paper shows that on average for this sample of non-college graduates that off-the-job training from proprietary institutions has a sizeable impact on wages.

Some other interesting findings contained in Lynch (1992a) concern the variables that are not significant. For example, spells of on-the-job training acquired before the current job have no impact on current wages. This suggests that ON-JT is not portable from employer to employer for young workers who are not college graduates. This may be because formal ON-JT for these workers is more firm specific than general.

Off-the-job training acquired before current employment has a significant and positive impact on wages, while off-the-job training during current employment is not significant. This may be because young workers who are acquiring training from a proprietary institution are planning to use this training to move to another employer and career track, or the findings may reflect the sharing of costs of this training with the current employer through lower wages.

Before reaching any final conclusions on the basis of the results presented so far, it is necessary to discuss in more detail the possible sources of bias in the training estimates due to self-selection. Employers may only place employees in training programs who have some unobservable characteristic, "trainability", or individuals who are more motivated would be more likely to pursue off-the-job training. In either case the estimated coefficient on the various training measure will be biased upwards (i.e. the treatment selection problem).

A variety of ways to try to address this issue are described in Heckman (1979) and Heckman and Robb (1986). One method used in Lynch (1992) was a "standard" Heckman two-stage procedure that estimates a probit for the probability of receiving on-the-job training and a probit for the probability of receiving off-the-job training and then uses the appropriate inverse Mills ratios from these probits as regressors in the wage equation. None of the previous findings are altered with the inclusion of the inverse Mills ratios (the lambdas) as regressors in the wage equation.

A second approach to deal with sample selection assumes that self-selection varies only across individuals and not over time for the individual. An individual's wage at time t can be expressed as:

$$(1) \qquad \log(w_{it}) = Z'_{it}d + f_i + e_{it}$$

where Z' is a vector of variables affecting wages that vary for each individual over time, and f_i are all the characteristics which are individual specific but time invariant. The characteristics in f_i may be correlated with whether workers undergo training. Fitting equation (1) while omitting f_i will lead to bias in estimates of b. By differencing individuals' wages between 1983 and 1980, all time invariant effects (both observed and unobserved) drop out, and the coefficients may be estimated without bias.

The results from this second approach to sample selection are presented in Lynch (1992a). A summary of these findings suggests that additional weeks of off-the-job training and apprenticeships significantly raise wage growth. Additional weeks of ON-JT, however, are never significant for the entire sample or for any demographic sub-group when the sample is divided by race, gender, or education. This suggests that there may be some problem of selection bias for those who have some ON-JT. It may also be the case that the cell sizes here are too small for a significant effect to be found.

In conclusion, private sector training plays a significant role in the determination of wages and wage growth of the 75 percent of young workers in the U.S. who do not graduate from college. Specifically, when private sector training is divided into different types (on-the-job training, off-the-job training, and apprenticeships) some very different patterns emerge. For example, the characteristics that appear to influence the probability of receiving training are primarily race and gender. Women and nonwhites are much less likely to receive training within a firm either through an apprenticeship or other forms of on-the-job training. This differential pattern in the acquisition of training by race and gender may be a partial explanation of the persistent wage gap between males and females and whites and nonwhites. Schooling raises the probability of receiving off-the-job training and apprenticeships but it had a smaller impact on the probability of receiving firm provided on-the-job training.

All types of training raise wages significantly. In particular, for this sample of non-college graduates, off-the-job training from proprietary institutions can be useful for increasing wages. The impact of these training variables also seems to be larger than the impact of tenure on wages. Finally, while on-the-job training with the current employer increases wages with the current employer, this type of training seems to be quite firm specific since on-the-job training from a previous employer is never significant for current wages. At the same time, there seems to be some evidence that if general training is being given to any group of workers on the job it is for those who have not completed high school. The finding that on-the-job training is primarily specific is consistent with recent findings from the Hudson Institute[1] which surveyed 645 firms in the U.S. and found that only 8 percent had any sort of general remedial on-the-job training programs. The fact that U.S. firms are more willing to invest in firm specific training than in general training is understandable given the inability to "capture" the returns on investments in general training. However, whether or not U.S. firms will be able to remain competitive with this strategy in the future, given the characteristics of the new entrants into the workforce and the skill demands of new technology, is questionable.

The Impact of Training and Education on Labor Mobility

The findings on the relationship between the various types of training and wages have several implications for the impact of training on mobility. One implication is that if company provided training is primarily firm specific then the probability of leaving an employer should decline if a young worker has experienced some on-the-job training. An additional implication is that if workers participate in off-the-job training programs they are more likely to leave the current employer. In this case, off-the-job training allows a young worker to change career paths and find a 'better match'. This part of the paper examines in detail the factors which influence the probability of new entrants leaving their first job, including the differential effects of company provided training, apprenticeships, and training from 'for-profit' proprietary institutions.

For the analysis presented in this part of the paper a different sample is used to analyze mobility patterns than was used to examine the determinants of wages (for a more complete discussion see Lynch (1992b)). This sample uses more recent years of the NLSY. In Lynch (1992b) I have excluded the 1280 respondents in the military subsample from the analysis. However, I have also deleted any respondent who has completed school before the 1979 interview year. The final sample is a pooled sample of young workers who have left school and not returned to school for at least four years ('permanently' out of school). Therefore, this sample is made up of 5 waves of school leavers -- those who left in 1979, 1980, 1981, 1982 and 1983. In addition, the respondents had to have obtained a job in the first year after 'permanently' exiting school. This sample had many more college graduates in it given the age structure of the NLSY compared to the sample used for the wage study. However, it did not include anyone who completed school before 1979, which substantially reduced the sample size. In addition, there was no attempt to model the decision to leave school over the period (1979-1983). Obviously this was a period in which many young people may have delayed entry into the labor market given the high unemployment rate at that time. A dummy variables for year of entry into the labor market was included in the empirical analysis to capture part of this effect, but future theoretical and empirical work would benefit from a complete modeling of the schooling/employment/training decisions taken by young workers.

Table 3 presents results from Lynch (1992b) on the relationship between tenure on the job with the first employer, and the various types of training. The first panel shows that over 80 percent of the sample have left their first employer by the fourth year in the labor market. Those who left their employer relatively early were much less likely to have had any formal on-the-job training (only 1.3 %) than those who stayed with their first employer 3 years of more (8.1%). The pattern is a bit different with participation in off-the-job training programs. Almost a quarter of those who left their first job between 2-3 years received off-the-job training. However, this percentage drops dramatically for those with 3 or more years on the job to only 11.7 percent.

The second panel is perhaps even more interesting. This panel shows, conditional on having participated in one of the types of private training, when that training spell begin during the tenure with the employer. One view of training is that it is a 'test' (Weiss and Wang (1990)) of workers and does not really represent a productivity enhancing skills investment. Instead training allows the firm to obtain additional information on the suitability or match of recently hired workers for the firm. In other words, firms use formal training programs as a way to avail themselves of private information known only by the workers. Workers who fail the test leave the firms, and those who pass do not leave. This would imply that we should observe on-the-job training occurring early in a workers's tenure with the firm. However, in this second panel we see that 60 percent of on-the-job training spells begin after one year on the job at the firm. This seems to be more consistent with a job matching story where firms(workers) make a determination within the first 6-12 months on whether or not there is a match, and if yes, the firm then invests in more costly formal O-J-T. Since the measure of training used in this paper only captures spells that last 4 weeks it may be possible that shorter formal or informal training spells are used early in the career with an employer as an indication of match quality and longer training spells follow later.

Contrary to the timing of on-the-job training spells, almost 60 percent of spells of off-the-job training begin within the first year with an employer. This may be due to employees going outside the firm to obtain training that they need for their current job, or employees deciding that there is not a job match and seeking a training program that will allow them to leave their current employer and get a better job. Finally and not surprisingly, most apprenticeships begin very early in the tenure with an employer.

Lynch (1992b) presents estimates from a Cox proportional hazard with time varying and time invariant covariates. The time invariant intrinsic characteristics of the individuals/jobs in Lynch (1992b) that seemed to influence the probability of leaving an employer included being disabled, union status, race, and school level. Disabled respondents were more likely to leave their employer while being employed in a job covered by a collective agreement or being a college graduate significantly lowered the probability of leaving the first employer. Blacks were more likely to have shorter durations on their first job than whites and hispanics. There was no significant effect on the length of time with the first employer by gender. However, there were significant differences in expected length of employment by school attainment. Those with a high school degree or less were more likely to leave their employer, whereas those with a college degree were less likely to leave.

Of the time varying 'exogenous' covariates the local unemployment rate was significant implying that those who lived in high unemployment areas were less likely to leave their employer. The hurdle for youths in high unemployment areas seems to be getting a job rather than keeping one. The number of children seemed to have no significant effect on the expected duration of the first job. Finally, those workers who were married were more likely to remain with their first employer.

With regards to the training variables, those young people who had some formal ON-JT were much less likely to leave their employer while those who participated in some form of OFF-JT were more likely to leave. This seems to suggest that ON-JT is more firm specific while OFF-JT is more 'general'. These findings are consistent with the results on training and wages.

This section of the paper has summarized the findings in Lynch (1992b) on the link between training and the probability of leaving an employer. A high percentage of ON-J-T spells begin after young workers have remained with their employer for at least one year. This seems to be consistent with a job matching story where firms(workers) make a determination within the first 6-12 months on whether or not there is a match, and if yes, the firm then invests in more costly formal ON-J-T. In contrast to the pattern associated with ON-J-T spells, almost 60 percent of spells of OFF-J-T begin within the first year with an employer. This may be due to employees going outside the firm to obtain training that they need for their current job, or employees deciding that there is not a job match and seeking a training program that will allow them to leave their current employer and get a better job.

Evidence presented in the previous sections of this paper indicated that on-the-job training for young workers in the U.S. appeared to be quite firm specific whereas off-the-job training appeared more general. The results presented in Lynch (1992b) and summarized here seem to reinforce those conclusions. Those with on-the-job training are more likely to remain longer with their employer which would be consistent with firm specific training. Those who obtain off-the-job training are more likely to leave their employer and this would be consistent with off-the-job training being more general. However, when the sample is divided by race, gender and educational attainment it is shown in Lynch (1992b) that the training variables are only significant for females.

Summary and Conclusions

By the age of 25 only 22 percent of U.S. youths have completed a college degree and almost 60 percent have not received any form of post-school training even including very short training spells of less than four weeks. If they have received some form of post school training, it is most likely to have been provided by a for-profit proprietary institution. Unfortunately, only 14 percent of employed males and 8 percent of employed females had received any formal company training by the age of 25.

Most company provided formal on-the-job training in the United States is acquired by college graduates who are employed in finance, insurance and real estate. Those who receive training are also more likely to be managers, professional or technical employees in these industries as well and working for larger firms. Black and Hispanic youth are much less likely to have received company provided training than white males and females. One of the key differences in post-school training in the U.S. compared with training received by young workers in Europe is the lack of certificates or formal qualifications at the completion of training except for the minority who do an apprenticeship. As shown in

Blanchflower and Lynch (1991) the certification of skills acquired by British youths in apprenticeships, company provided training and off-the-job training is a major component in the return to training. The certification improves the ability of employers to identify appropriate and qualified workers, and it provides an opportunity for young workers to carry their training from one firm to another.

All types of post-school training raise wages significantly. In particular, for non-college graduates, off-the-job training from proprietary institutions can be useful for increasing wages. The impact of these training variables also seems to be larger than the impact of tenure on wages. Finally, while on-the-job training with the current employer increases wages with the current employer, this type of training seems to be quite firm specific since on-the-job training from a previous employer is never significant for current wages.

There are strong links between training and employment transitions of young workers. Those workers who are employed and receive company provided training are likely to remain longer with their employer. This suggests that most company provided training is firm specific training. Those who obtain off-the-job training are more likely to leave their employer and this would be consistent with off-the-job training being more general. It is interesting to note, however, that the effect of training on the employment and nonemployment transitions of young workers is only significant for females.

In general, the primary source of skill accumulation in the U.S. after individuals have completed formal schooling is concentrated among large firms and in narrow sectors and occupations. Those individuals who complete a university degree continue to acquire additional human capital in the workplace. However, those workers who have received the least amount of schooling, or are employed in smaller firms are also the least likely to receive additional skills training in the workplace. Yet it is these workers who are now expected to be involved in more tasks and take on additional responsibilities in the workplace. Policy makers interested in stimulating private sector competitiveness should consider policies directed at improving the skills of these workers.

Footnotes

[1] as reported in E. Fowler, "Shortage of Skilled Workers Is Expected", New York Times, 31 July 1990.

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Table 1 - Schooling and Training in the United States by the Age of 25

Males

76%	High School graduates
22%	4 year college graduates
15%	2 year college
14%	formal company training
30%	off-the-job training
3%	apprenticeships
58%	NO post school training

Females

86%	High School graduates
22%	4 year college graduates
20%	2 year college programs
8%	formal company training
33%	off-the-job training
1/2%	apprenticeships
60%	NO post school training

Table 2 - Predicted Hourly Wages By Selected Characteristics (1983 wages)

Case 1.) White male, average characteristics:

no training	$5.47
24 wks during previous job OFF-JT	5.74
24 wks current employer ON-JT	5.96
24 wks previous employer apprenticeship	6.17
24 wks current employer apprenticeship	5.74
1 additional year of school	5.64
1 additional year of tenure	5.65

Case 2.) White female, average characteristics:

no training	$4.71
24 wks during previous job OFF-JT	4.94
24 wks current employer ON-JT	5.14
24 wks previous employer apprenticeship	5.31
24 wks current employer apprenticeship	4.94
1 additional year of school	4.85
1 additional year of tenure	4.88

*using the estimated coefficients from estimated log wage equations in Lynch (1992a). Average characteristics are: single, high school graduate, 99 weeks of tenure on the job, 193 weeks of work experience, local unemployment rate of 10.01%, living in the inner city, healthy, not covered by a collective agreement, and 2 jobs since finishing school.

Table 3 - Characteristics of Private Sector Training and Mobility of Workers in the 4 Years Following School Completion

Completed Tenure by % with Training by Type

Completed Tenure	% of sample	ON-JT	OFF-JT	APT
1 - 26 weeks	33%	1.3%	10.6%	0.7%
27 - 52 weeks	20%	1.5%	11.8%	0.9%
1 - 2 years	19%	2.6%	15.6%	2.4%
2 - 3 years	7%	6.6%	23.6%	0.5%
3 - 4 years	21%	8.1%	11.7%	0.8%

Conditional on having training in 1st job - when did it begin?

Year	ON-JT	OFF-JT	APT
During 1st year	39.8%	57.2%	69.4%
1st - 2nd year	25.6%	14.9%	8.3%
2nd - 3rd year	18.8%	18.1%	8.3%
3rd - 4th year	15.8%	9.7%	13.9%

Source: Lynch (1992b)

Trends in European LIFELONG LEARNING

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Summary

The welfare of Europe largely depends on the competitiveness of the European industry, which can develop new wealth through its products and services. There has always been a strong link between education and a country´s level of industrial productivity and competitiveness.(Irdac, 1991) Industry has realised that the educational level of the current workforce is not good enough.

Due to the demographic downturn, the competitiveness of industry depends on the competence of the existing workforce. Four out of every five employees in the year 2000 are already in employment. The fast development of the business environment changes the job of these people considerably before year 2000. Their competence and skills should be updated at the same speed. There is a continuous need of training and education throughout the working life.

Industry has taken up the major responsibility in adult education in all European countries. In some cases, this has created big training organisations. In order to flexibly meet the needs of continuous changes, companies work decentralised and their focus is on short term issues. Also centralised functions like human resources development have been downsized and the responsibility of training is decentralised to operational units and to the line organisation. On the other hand, the fast technical development soon renders working skills obsolete and the employee often needs to upgrade his skills and competence. Work-related training is no more enough, people need also education which can provide them with tools to meet the needs of tomorrow's jobs. Education requires a long term view and long term commitment. This is in conflict with companies short term focus and the increasing cost-effectiveness.

There are great differences between the national educational systems. Large companies have personnel training systems of their own based on the national and local circumstances. The approaches between companies vary a lot. The companies operate today Europe-wide. European employees should be able to benefit from the Europe-wide job market. There is a growing need of commonalties in developing competence throughout Europe.

Due to the increasing knowledge base in most jobs there is a growing need for continuous education. Higher educational institutions, particularly universities, are becoming important partners to industry in competence development of the personnel. The European Approach to Lifelong Learning is based on increasing co-operation between the universities and the industry.

1. Introduction

The welfare of Europe largely depends on the competitiveness of the European industry, which can develop new wealth through its products and services. There has always been a strong link between education and a country´s level of industrial productivity and competitiveness.(Irdac, 1991) Industry has realised that the educational level of the current workforce is not good enough. The competitiveness of Europe is at stake, and industry is slipping behind. The number of new jobs is growing much slower in Europe than other regions.

In the technology-driven industries of today, knowledge and competence are the major cost factors inherent in many products. But technical competence soon becomes outdated. The real investment a company makes is in its employees, its assets lie in their competence. This competence should be upgraded in par with technological development. Because of demographic shifts, there will be fewer young people with fresh education to enter the working life. Therefore the competence of companies must be based on the competence of the existing workforce. Developing this competence is becoming a crucial part of the industry´s and a nation´s competitive strategy. **Today´s working life demands ongoing training and education alongside work.** This is Lifelong Learning.

The need for Lifelong Learning is huge throughout Europe. Already in 1988 large European companies were indicating that about half of their employees needed retraining in order to perform their tasks satisfactorily (ERT, 1989). Extrapolated to the total population, this means that hundred million of working adults in Europe may need some kind of retraining and continuous education. The developments in eastern Europe have been among the biggest changes. Massive training and re-education is needed to enable these countries to participate effectively in the market economy.

Solving the problem of updating competence is not merely a matter of continuing and updating education, for an increasing number of employees lack even basic education. In many areas of the EC notably, a high percentage of the working-age population lacks any kind of formal professional qualification, according to *CEDEFOP*, the *European Centre for the Development of Vocational Training*.(EC COM(90) 334). There are big differences between the various countries in this respect. In Germany, where dual vocational education guarantees that most young people enter their work career with some kind of professional qualification, the number of young people without a formal qualification is less than 10%, and even among older people it is less than 20%. In Great Britain, where many young people leave school immediately after compulsory school-age in order to go to work, half the population lacks a formal qualification (University of Oxford, 1991). Sweden, in spite of its democratic educational system, has realised that about half its employees lack the right kind of up-to-date competence (Landell and Victorsson, 1991). Many of these people will be unable to cope with future jobs unless they get the basic education required to adopt new professional skills. The problem is complex because these people have little motivation to study.

The problem of insufficient basic education is growing because of the influx of immigrants into Europe. More and more people have no knowledge of the language of their host country and their professional education is of little value in their new environment. The problem of mass immigration is new in Europe and further weakens our competitiveness. European companies must recruit employees whose education and skills are not homogeneous and in a par with some competitors.

Companies have taken the biggest responsibility of adult education throughout Europe. Company-based training, however, follows the rules and circumstances of national and local educational policies. This has resulted a variety of company training models and practices. However, companies to day operate Europe-wide. Some commonalties in the adult education infrastructure would support the Europe-wide personnel policy. European employees have a Europe-wide job market. They should be able to benefit continuing education opportunities in all countries. In addition to the European integration there are other changes in the industrial environment that now focus on new demands on Lifelong Learning.

2. Changes in industrial environment and the impact on competence development

2.1. Fast developing technology: Need for competence development

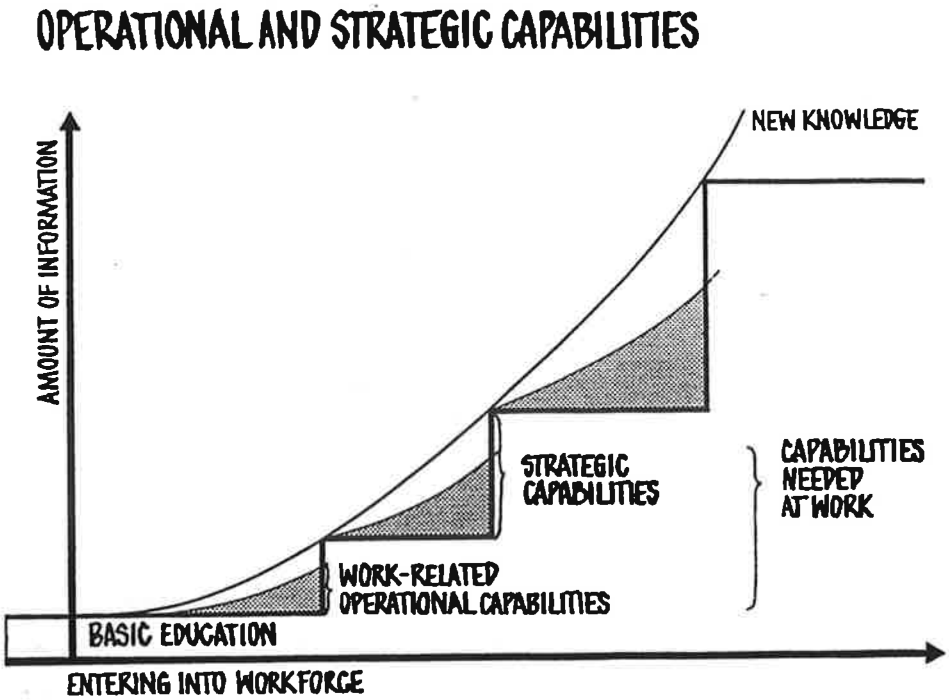
The biggest changes in working life are caused by fast developing technology. In many sectors, technology is replenished every few years. Those who develop such technologies are obliged to upgrade their competence in parallel. Technology is not only related to technology-intensive products; instead, all products benefit from the development of technology through process automation.

Technology brings changes to all jobs. Many companies have stated that there are **no more jobs for unskilled employees**. Four out of five people in the industrial world will be doing jobs differently from the way they have been done in the past 50 years (World Future Society, 1991). This means that people need different skills and new competence.

So far job-related training has been available to help one do better on the current job . Such a training is organised by industry and is aimed at improving job skills for such purposes as increasing productivity. This kind of **training** provides the individual with **operational capabilities.** For many professions and jobs, this is no longer enough. In order to learn new tasks and new skills in tomorrow's workplace, individuals need continuous **education** to provide them with **strategic capabilities**, which can be gained through theoretical studies, education, and provision of tools to understand and learn new things. As an example, the mobile telephones which have been based on analogue technology are becoming digital. This is a totally different technology from the previous one. If the same people who have been developing and producing telephones want to continue their work, a totally new technology base or a new engineer´s education is needed. A plant manager, who for the first time receives robots into his factory, can no more understand the production process without upgrading his knowledge to the new level of technology.

Fig 1. demonstrates the strategic and operational capabilities. Operational capabilities are not enough to keep up with the new knowledge and changing work. Strategic capabilities are needed to upgrade an employee to the next knowledge base.

Fig. 1 Strategic and operational capabilities.



Developing technology also **increases the need of people with higher technical education.** However, fewer young people are interested in such studies. The number of university-level students in 1988 was roughly the same in Europe, the USA and Japan; but while the USA and Japan each produced more than 75 technology students per 100.000 inhabitants, Europe managed fewer than 40 (ERT, 1989). Now the USA, too, is worried about the decreasing number of technical students. One study, by economists *Andrei Shleifer, Kevin M. Murphy and Robert W. Vishny*, even estimates that if an extra 10 % of university students went into engineering - a doubling of the current engineering enrolment - the growth rate of the GNP would rise by 0,5 % a year. By contrast, if law school enrolment doubled, the growth rate would fall by 0,3 % annually (Business Week, April 6, 1992).

In Japan the engineering studies were most popular to the later half of 1980´s. Now also Japanese young people prefer studying business economics and other. soft subjects. Efforts are made to encourage students to choose technical studies.

2.2. Internationalisation of business: New demands on management development

Many companies and individuals have found themselves in a new situation. The integrated Europe with open markets means new competition with new competitors. Simultaneously, the employment market is internationalising and, through mergers and acquisitions, many managers have to cope with an organisation encompassing many cultures and nationalities. This is not only a challenge for management skills but also for human resource development policies and practices. Many companies indicate that their training activities in the near future will focus on management training (Otala, 1992). This demonstrates how confused companies and organisations feel about the fast change of the business environment.

Internationalisation of business also increases the need for language skills. Ability to communicate in three European languages is a requirement of the industry (ERT, 1989). Communication skills generally become important when a message should be distributed throughout the organisation with members from various cultures and with different semantics.

Europe-wide job market highlights the importance of official credits and transfer of credits from one country to an other. There should be some standard inside one company to assess, e.g., engineers who have studied in the UK or in Italy. On the other hand, mobile employees need credits from studies they have pursued in one country and in one company when they move to an other. The academic accreditation for studies has been developing fast because of the need. *The European Credit Transfer System (ECTS)* launched by the *Erasmus Bureau* in Brussels has already been adopted by well over 200 universities and has enormous potential for both inter-university and university-industry programmes.

2.3. Ageing population - increasing proportion of the workforce

The need for new knowledge in industry has formerly been supplied by recruiting new people with fresh education. The demographic downturn has led to a prediction that by the year 2000 the net entry into the labour market in the Community area will be negative, with some 300.000 more people leaving the labour force than entering it. The European workforce is becoming older: by the year 2000 it is going to be five to ten years older in many of the Far Eastern competing countries (Irdac, 1991).

Four out of every five employees of year 2000 are already at work. There will be an increasing number of changes in work and occupations by the year 2000, but the competence of these people should still be appropriate in year 2000. Europe´s competitiveness depends on how effectively the skills and competence of the existing workforce can be updated and upgraded, for example, through adult education. Immigration from eastern Europe will not solve the problem of a shrinking workforce. In most cases, the educational level and working skills of the people moving to the western parts of Europe do not meet the existing competence requirements. Instead, this increases the need for effective adult education at all levels.

Some companies have already reacted to the problem of ageing workforce by organising special training programmes for older employees. As an example the Swiss Nestlé has a special management programmes for managers 50+. Spanish companies use older executives in highly appreciated staff jobs in order to benefit from the long experience of these people. But none of the European countries offer special subsidies for companies training older employees as is the case in Japan.

Obsolescence of working skills has increased peoples interest in early retirement. The cost of retirement is becoming too high for most nations particularly during an economic recession. Many countries are developing special programmes to encourage employees to continue working instead of early retirement. This requires continuing education and creating retraining opportunities for older persons.

2.4. New values for young employees...New demands on employers

Employees under 30 have **new values** at work: they are aware of their own worth. They see their abilities as their capital, which they only "lend" to an employer. This is the "Inter-rail generation". With their education, technical skills and foreign language abilities, they think regionally rather than nationally and are not afraid to be mobile with their jobs and their families. They are ready to invest in themselves to stay in tune with the times. But if they invest their time in education and training, they want the kind of recognised accreditation of their new qualifications that they can pack into their curriculum vitae and take to their next job. A career in a company is changing into a career in a competence. Young people are looking for new challenges to develop a competence they can sell to various employers or use entrepreneurially in a free market. On the other hand, no company can guarantee a lifelong continuity any more. Mergers and acquisitions can hurt job security. Lifetime employment does not exist any more.

Many companies are reacting to the requirement of young employees. They provide training and education, which has a **formal status with public accreditation**. They offer possibilities for degree studies aside work. This education is often provided by universities or other public educational institutions, or it is a combination of public university courses and company-specific training programmes. Companies pay for the education but the individuals contribute their own time and initiative. This model of integrating company training to public education is followed by technical updating of engineers like in the case of the Finnish electronics company Nokia as well as by management training like in the case of the British glass manufacturer Pilkington. The German chemical company Hoechst offers both technically or economically oriented employees an opportunity to university studies leading to a degree aside work. In these concepts, the company training programmes (operational capabilities) are credited by an university, which also provides theoretical and general courses (strategic capabilities) to the employees. The company gains new competence, the employee gains public credits or even a new degree to be packed into the curriculum vitae.

The mobility of employees has made **degrees important** even in countries which have traditionally been non-degree-oriented, like the U.K.. In Germany, where degrees have always played an important role, higher degrees are becoming more and more important. For example in 1990 seven out of new ten board members of the 20 biggest German companies hold Ph.D. (Weiterbildung 1/91)

2.5. Stagnating economy - increasing cost-awareness

Although companies' investment in training was still rising in Europe in 1991, this may soon change as a result of the recession. **Demands for cost-awareness and cost-effectiveness in training and education are also increasing**. In reaction to this, **company training is focusing on short-term needs**. Training must be well-focused and benefits are to be seen immediately. Training is integrated into a product, a process or a project - and its goal is to improve operational capabilities of employees. During recession, companies find it even more difficult to invest in strategic capabilities of employees, because the results can only be seen on a long term.

The stagnating economy forces many companies to cut costs where-ever it is possible. Activities not directly related to today´s business have a lower priority. Although the companies have realised that competence is the most valuable asset they have, in many cases the cost cuttings are started in training. Of course this is very short term thinking: what can be saved today, can cost much more tomorrow, maybe even the competitiveness of the company.

2.6. Restructuring of industry - responsibility shift towards the individual

The changes in the market are fast. In order to be competitive companies have to be fast, too. They must be flexible in order to react quickly to new requirements. International corporations **are decentralised** into strategic business units that can **act locally** and flexibly. Their central functions like **human resource development** are split, at least partially. It is the line managers, with their narrower and more local focus, who are assuming responsibility of human resource development.

The **volatile business atmosphere**, partly created by higher incidence of mergers and acquisitions, is changing the concept of loyalty for both the company and the employee. Flexibility is replacing loyalty. This means **shifting the responsibility for competence development towards the employee.**

The competitiveness of European industry now depends on simultaneously meeting two contradictory demands:

* a **short-term focus** to enable companies to adapt quickly to the immediate business environment
* a **long-term view** to develop the strategic capabilities to compete in the near future

Companies, which have up to now taken the biggest responsibility of adult education by providing work-related training **can no more take the responsibility alone.** Companies are also recognising that their current training focusing on operational capabilities is not sufficient to maintain their core competence and increase competitiveness. They are seeking new approaches. The increasing need for updating and upgrading strategic capabilities has put more pressure on public education and educational institutions. During the industrial history when vocational skills laid the ground work for a nation´s industrial success, industry and vocational schools developed a close co-operation in many countries. Now, most jobs have become more knowledge-intensive and **the workplace has a growing need that could be filled by institutions of higher education**, particularly by universities. There is a need for the same kind of co-operation between industry and universities as has earlier been emerging in vocational level.

3. Trends in Higher Education affecting Lifelong Learning

Universities are discovering that the level of education they have traditionally provided will no longer meets the society´s needs. Their targets cannot any more be just young people, but adults and companies, as well. Prompted by their own financial needs caused by cuts in government spending, many universities are awakening to new areas of responsibility and opportunity in meeting the needs of society, industry and working adults. As some examples of universities Lifelong Learning activities can be mentioned:

* The Gothenburg Business School in Sweden is offering MBA programmes free of charge. The study hours are on Fridays and Saturdays. Many companies encourage their employees to pursue MBA studies and support them by allowing the employees to use Fridays for studies.
* Employees' free time and summer vacations are used by l'Ecole Polytechnique Fédérale de Lausanne, which has about 100 doctoral students from industry. The modular study programmes are related to industry R&D projects.
* Paris XII-Val de Marne has 30% of its activities in continuing education, and 33 degree programmes are targeted to working adults.
* The University of Exeter in the UK has 5.200 part-time students in 300 study programmes, which is more than the total number of the university's undergraduate students.
* At Britain´s University of Warwick, almost 1.500 students are enrolled in part-time postgraduate courses taught by modular and distance learning networks.

In France and southern European countries, legal and traditional barriers give universities little autonomy in responding to industry´s needs. Demands are being met, instead, by private educational institutions and professional organisations.

Positive adult education practices are under way at individual universities and educational institutions, mostly in the smaller European countries like Ireland, Belgium, Switzerland, Sweden and Finland, as well as in the UK.

The Open University and distance learning approaches are making progress and have proven successful in educating adult students. **New educational tools and methods** like video-conferences and computer-based training are developing as well. Computer-based training can improve the effectiveness of training by allowing every student learn and study according to his/her own capabilities. Video conferences can multiply the teaching or a good tutor by distributing the lectures to many locations. However, these applications are used primarily for industry training because of the high initial cost.

4. Summary of co-operation in Lifelong Learning

If the main responsibility for Lifelong Learning is taken by industry, the focus is on training. It is initiated and financed by the company and has company goals. In Lifelong Learning programmes, which are initiated by institutions, paid for by society or the individual, the adult student´s personal goal is more often involved. However, such programmes often lack the link to the working life. Between the two models, there are various stages of university-industry collaboration. In these programmes, the costs are shared by industry and society. The target for Lifelong Learning meets the needs of individuals and companies. The various stages of sharing the responsibilities and co-operation can be divided into eight fundamental models:

* company training programmes using the company training faculty only, which is typical for work instruction and on-the-job-training
    - common approach throughout Europe
* in-house company training programmes using visiting teachers from universities and other educational institutions
    - common approach throughout Europe
* university programmes tailor-made for specific companies
    - e.g. the MBA-programmes common especially in the UK
* joint/collaborative programmes between universities and industry
    - examples in the Northern European countries and in Ireland
* study programmes that combine accredited company training with external university/educational institution courses
    - examples in the UK and Fennoscandinavia
* pick-and-mix programmes that are base on courses offered by a variety of higher educational institutions
    - examples in the UK, Europe-wide programmes presently developing
* publicly-funded adult education programmes, in which individuals can participate on their own volition
* self-study programmes, which often use new technical tools.

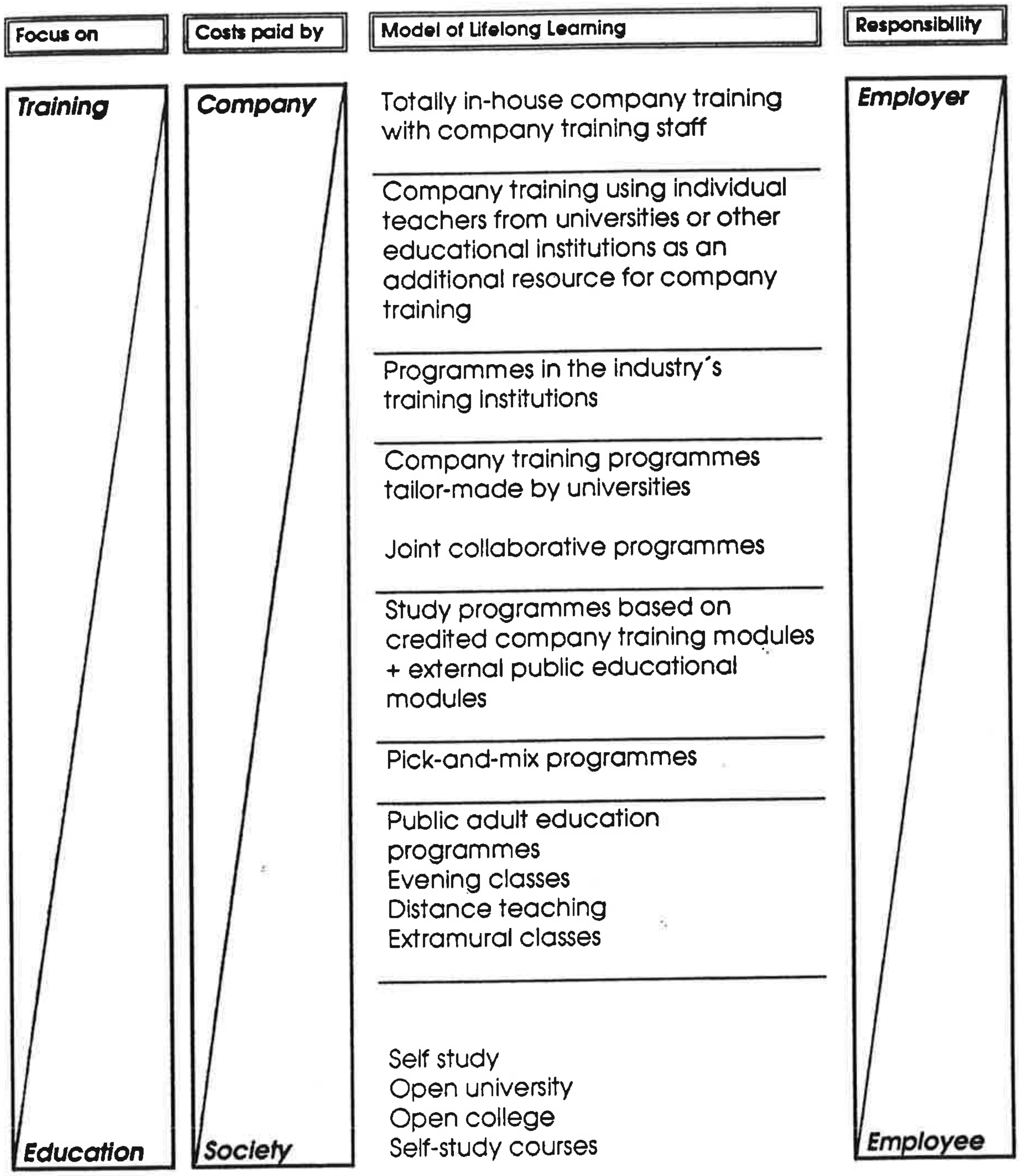
Figure 2. summarises the models and the sharing of responsibilities. There is growing evidence that as the proportion of educated knowledge increases, so does the individual´s contribution of personal time and money (Otala, 1992).

> One of the continuing education programmes which integrates universities´ resources and companies´ interest and which also has European dimension is ***the EuroPRO-programme.*** It is a joint-programme of 12 companies in the field of chemical and process industries and 10 universities all recognised as providers of high quality education in the field. EuroPRO is a degree awarded to graduates but does not include the scientific research work customary in postgraduate studies. The scope of the EuroPRO studies is 40 "credits", each credit equalling 40 hours' work. About half the credits are obtained by attending courses, and the other half by doing homework, solving special problems at work, preparing minor theses, etc. The average time for the studies is 3-5 years, after which students can obtain an EuroPRO degree. The corresponding degree could be an MBA, which is focused more on management studies, while EuroPRO can include courses in technology, sociology or any other area that supports the employee´s work. The courses must be postgraduate level and the individual study plan is approved by the *Council of EuroPRO* studies as well as by the appointed tutor at one of the named universities. Some of the university courses have been modified to suit a company's needs. They are given by university personnel but complemented by the company's own specialists. In addition, there are a number of in-house courses that can be included in the EuroPRO degree as long as they are approved by the tutoring professors.

At the national level, there is a variety of initiatives to develop policies for Lifelong Learning and adult education. The EC Commission has taken some measures to encourage the industry-university co-operation in continuing education. However, so far a general policy and framework are lacking in Europe. **A summary of the features of this framework are:**

* an intense collaboration between companies and educational institutions
* modularity of studies
* multiple sources and providers of education
* universities used as gateways to various sources of education
* accreditation of studies and transfer of credits throughout Europe
* work related studies supported by enough continuing education
* individual study plans
* benefits of new distribution media and new educational technologies.

Figure 2. Sharing responsibilities for Lifelong Learning



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BACK TO WORK?

Employment Effects of Labour Market Training Programmes[1]

by

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[1] The paper reports from the project "The Norwegian Labour Market Training Evaluation Study" by Oddbjørn Raaum and Erik Hernæs, Centre for Research in Economics and Business Administration (SNF), Oslo and Hege Torp, Institute for Social Research (ISF), Oslo

Abstract

The paper presents an evaluation of the Norwegian Labour Market Training programmes (LMT) focusing on effects on duration of reemployment within a 12 months response period. Estimating a censored regression model it is found that *labour market training may increase average employment significantly*. The effect depends, however, on the duration of training. Short and rather long courses (less than 8 weeks and more than 30) are estimated to have the best effects. A training course of 5 weeks increases average employment from about 3.1 to 4.3 months when comparing formerly unemployed nonparticipants and participants - ceteris paribus. An average course of 10 weeks has a rather small, but still positive, employment effect. Courses of 20-30 weeks have a negative effect on employment.

The hypothesis of no interaction between effect of training and level of education is not rejected. On the other hand, we must reject the hypothesis of no interaction between the effect of training and duration of previous unemployment spell. The interaction is slightly U-shaped as the marginal employment effect of training is first decreasing and then increasing by duration of previous unemployment spell.

Using nonexperimental data and single equation estimation methods, the question of *selection bias* arises. If a nonrandom process determines enrolment for training, and if there is a dependence between the enrolment rules and the determination of employment on *unobservables*, such methods give biased estimators for training effects.

Including a variant of "Heckman's lambda" gives a significant - and positive - parameter estimate and reduces the estimated employment effect of training. This indicates a *positive selection to training*. Taking the positive selection to training into account, only very short courses have a positive employment effect. The estimated employment effect of an average course of 10 weeks is *no longer positive*.

1. Introduction

The long term goal of labour market policies is to make the labour market more efficient, and to get a better match of supply and demand. The short term goal is to reduce unemployment.

One way to characterize labour market policies is to make a distinction between *passive* and *active* measures; i.e. either to *support* the unemployed or to *employ and train* them.

The goal of active measures is to help people back to work. This can be done by public information and exchange assistance, by supply-side measures - i.e. training and education; or by demand-side measures - such as wage subsidies, public work etc.

The reasons for giving priority to active measures are both short term and *welfare* related - and long term and *market efficiency* related. Most unemployed are supposed to be better off if they participate in employment or training programmes than if they are openly unemployed. The programmes give the participants a possibility to preserve and enhance their human capital, and thereby to improve their job opportunities (Ashenfelter, 1978, Bassi, 1984, Barnow, 1987, Card and Sullivan, 1988).

It is, however, unclear whether labour market programmes increase the *level* of employment (the demand for labour), or if the *queue* of the unemployed is just *rearranged*!

Labour market programmes may also have negative effects. Participation makes it less necessary to search - and gives less time to search for ordinary work. Participants are not *effectively* unemployed. This kind of *hidden* unemployment does not have the same moderating effects on the wage formation as *open* unemployment has[2].

Labour market statistics show that unemployment is decreasing

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[2] These questions are discussed in some detail by Calmfors og Forslund (1990), Calmfors and Nymoen (1990), Eriksson et al (1990), Holmlund (1990) and Jackman et al (1990).

with level of education. The unemployment level is higher among persons with only compulsory school than among persons with secondary school, college or education at university level[3]. More education is supposed to improve job opportunities at the individual level, and hopefully to give a better match at the macro level, as well as to increase the efficiency of the labour market.

The main target of labour market training programmes is *to complement the ordinary education system*, and to maintain and increase the skills of the unemployed, and thereby to bring them *back to work*; alternatively to motivate and prepare unemployed - and others with unstable working careers - for further education.

In Norway the Labour Market Training programmes (LMT) are organized by the National Labour Market Board. The training is provided by public and private institutions, and is primarily aimed at unemployed and others at risk of loosing their job. Vocational training is dominant and a wide range of subjects and crafts are covered. Most of the courses are rather short, from 5 to 20 weeks. Some last for a whole year (40 weeks). The courses are free of charge, and unemployed participants who are not entitled to unemployment insurance benefits, receive a training grant (somewhat less than the unemployment insurance benefits).

While unemployment in Norway is triplicated since 1987 (from 32 000 to 100 000 in 1991), the volume of LMT is almost multiplied by ten: The average number of persons occupied by LMT was 2 300 in 1987; in 1991 it was almost 19 000. During this year (1991) probably more than 100 000 persons attended training programmes. The total cost in 1991 was 2 070 mill NOK or 0.3 percent of GDP (1991).

There has been no thorough evaluation of LMT in Norway so far. The Labour Market Board has, however, collected data on participants

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[3] Norwegian unemployment rates for these three groups by level of education are 2, 5 and 8 percent respectively (Labour Force Sample Survey, 1990).

and unemployed non-participants in 1988 and 1989 (Moen 1990, 1991). The mean employment rate six or twelve months later is approximately 10 percentage higher for participants than for non-participants. The superior performance by the LMT participants may however reflect better human capital resources rather than an effect of the training.

The present paper analyzes register data and data from a 12 months follow up survey, comparing formerly unemployed participants in training programmes and formerly unemployed nonparticipants. The analysis is part of a *pilot study* to prepare "The Norwegian LMT Evaluation Study". The focus of the pilot study and of this paper is *employment effects of labour market training of unemployed* (Hernæs et al, 1991; Raaum, 1991a, 1991b; Raaum and Torp, 1992).

Analyzing nonexperimental data some concern is, however, on the question of *selection bias* as well. This question and the possibilities to correct for it, which has been extensively discussed in the litterature, will be more thoroughly investigated by the forthcoming LMT study, which will give a mixture of experimental and nonexperimental data, and also otherwise a much richer set of data[4].

The organization of this paper is as follows: Section 2 gives some background and theoretical motivation for the analyses. Next we present the empirical model (section 3) and the data (section 4). Results on the enrolment rule are presented in section 5. Section 6 presents the estimated employment relation, the effects of training and the test of selection bias. Section 7 concludes the paper. A more general model than the one estimated, is briefly discussed in Appendix.

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[4] The pro's and contra's of experimental and nonexperimental data for evaluations of social and labour market programmes have been discussed for a long time in USA (Burtless and Orr, 1986; Heckman and Robb, 1986; Lalonde, 1986; Fraker and Maynard, 1987; Heckman and Hotz, 1989).

2. Effects of Labour Market Training

The point of departure is the hypothesis that - just as ordinary education - labour market training increases the job opportunities of unemployed; both in terms of the probability of getting a new job, and the ability to keep it.

Ordinary education beyond compulsory school is voluntary, but costly as the entry to the labour marked is delayed. Evaluating labour market effects of ordinary education we expect to find that those with higher return on education take more education than those with the lower return. Estimated employment (and wage) effects of education based on those with more education, will overstate the possible effects for those with the less education (Mincer, 1974, Willis, 1986).

As we shall see the decision to participate in LMT is quite different from that of ordinary education, and raises other problems of selection.

Return on training

Concerning the marginal return of labour market training we expect to find a positive wage effect as well as a positive employment effect. We concentrate on the latter for two reasons. Both from the unemployed person's point of view, and as an indicator of efficiency in labour market policies, employment effects are more important than wage effects. Second, and partly as an result, data on wages are not collected.

Hypothesis 1: Labour market training has a positive employment effect.

The marginal effect may, however, depend on individual characteristics, especially the pre training level of education. One argument goes like this: Suppose return on education is decreasing - as most inputs in productive processes. Then we would also expect the return on LMT to be decreasing. We expect the employment effects of LMT to be less among unemployed with secondary or higher education than among those with only compulsory school.

Another argument postulate the opposite: As knowledge and skills increase ability to learn, we would also expect the return on LMT to be increasing by education. This leads us to two alternative hypotheses as regards the marginal return on LMT:

Hypothesis 2A: The marginal employment effect of training increase with level of education

Hypothesis 2B: The marginal employment effect of training decrease with level of education

Long term unemployment is supposed to demotivate unemployed persons, and probably reduce the market value of their human capital resources. This leads to a negative duration dependence: The probability of getting a job decrease with the duration of unemployment[5]. This may also be the case for the motivation and ability to learn, or at least: Potential employers may think this is the case.

Hypothesis 3: The marginal employment effect of training decrease with the duration of previous unemployment spells

Previous Research

In a *Danish* study on effects of labour market training Jensen et al (1991) demonstrate that both wage effects and employment effects are

[5] On the other hand: If the reservation wage is decreasing, the job probability may increase.

small - and may even be negative[6]. The wage effects (one year later) are positive, but only for participants with no or little unemployment experience prior to the training: Hourly wages increase by 1.0 - 1.6 percent for participants with unemployment spells shorter than 15 weeks compared to nonparticipants. With substantial unemployment experience the wage effects of training programmes are negative: Hourly wages decrease by 1.5 - 2.0 percent, comparing participants and nonparticipants.

The estimated effects on the risk of unemployment are similar. The risk is reduced for participants with no or little unemployment experience while the risk is increased for participants with some or very long unemployment experience.

Jensen et al (1991) argue that these results do not imply that the effects of training *per se* is negative. The key question is *selection* on unobservables. It seems to be two channels into training: One along the line of initiative and motivation (positive selection). The other through the local employment office - helping and urging the less competitive to participate (negative selection).

In *Sweden* wage effects of training after a factory close-down have been analyzed by Edin (1988). Edin finds a negative short term effect of training, and a positive, but not significant, long term effect. Second there is a study by Ackum (1991) analyzing the wage effects of training unemployed youths (aged 16-24). Compared to (ordinary) employment, training gives a negative wage effect of two percent (one year later). More disappointing is the fact that the effect of training compared to unemployment is insignificant. Testing for sample selection bias and endogenity of program participation does not change these conclusions.

Björklund (1989, 1990) finds positive, but very small and often insignificant effects analyzing the Swedish LMT programmes 1976-

[6] These training courses are more like ordinary adult education than the Norwegian LMT; the participants are not necessary unemployed. The organisation of the courses, the subjects and the volume of the courses are, however, very similar to the LMT in Norway.

1980.

Studying a representative sample of *Austrian* men who left unemployment in 1986 Zweimüller and Winter-Ebmer (1991) find that about 60 percent suffered a repeat spell within a period of 12 months. Controlling for individual employment history and personal characteristics, the estimated effect of labour market training is insignificant (and with the "wrong" sign).

To correct for selection into training Zweimüller and Winter-Ebmer (1991) also estimates a *two equation model* (with bivariately normally distributed error terms). The results indicate that people with unfavourable expected unemployment careers are more frequently selected into training. Second, taking account of enrolment to training by estimating the enrolment rule and the equation of recurrent unemployment simultaneously, the estimated employment effects of training turn out to be *positive and significant.*

Selection into training

Analyzing Swedish data on young persons in relief jobs and labour market training Ackum (1991) found *no evidence of selection bias*. The Austrian results, however, demonstrates that it may be crucial to take the enrolment rule into account.

The decision to participate in LMT is quite different from that of going to school, college or university as a teenager. In Norway the decision is made partly by the unemployed person herself, and partly by the local employment office; sometimes in cooperation with an external program administrator.

Unemployed persons who refuse to accept offers of "suitable jobs or suitable training" may loose their unemployment insurance benefit. As job offers are rare, and as the number of courses and the capacity of each course are limited, these formalities are of little or no practical importance.

Taking part in LMT is not only *voluntary*, LMT is also *rationed.*

Only about 50-75 percent of the qualified applicants are accepted[7].

If LMT were not rationed, there might be a *positive* selection; just as with ordinary education. That is, the employment (or wage) gain of training would be higher among those who participate than among nonparticipants - also after controlling for observable heterogeneity (human capital resources, local labour market conditions etc).

On the other hand, if LMT is regarded as a "second best" to full time and efficient search for a job (as it is by some unemployed), the more motivated and competitive would make up a larger proportion of the nonparticipants than of the participants, i.e. a *negative* selection into LMT.

As the participants are selected from the applicants by the local employment office and the program administrator, it is not possible á priori to tell if there is a negative or a positive selection. The program administrator (and the instructor) may have incentives "to cream", i.e. to choose the best among qualified applicants (Bassi, 1984, Heckman and Robb, 1986, Burtless and Orr, 1987, Mare and Whinship, 1988). The local employment office may, on the other hand, give priority to the unemployed with the more unfavourable expected labour market careers. Then we get a negative selection bias.

Asking representatives from local and regional employment offices, one gets different kinds of answers[8]: "..... applicants with the best prospects are given priority"; " ... honestly seeking and hard working unemployed are preferred"; "....those who will benefit most from training get training ... "; ".... our first choice is unemployed with no other opportunities"; ".... we try to make a programme career for each individual ... " etc

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[7] This is a rough estimate made by the Labour Market Board in 1990. Rationing varies by season and among courses and regions.

[8] During the planning of the 1992 LMT project we had discussions with representatives from regional employment offices. Priorities and selection of participants to different kinds of labour market programmes are also discussed in Altern (1991a, 1991b).

3. The Empirical Model

Let T be the theoretical variable of employment duration, indicating labour market success. Let M be the *observable* variable; i.e. the number of months employed during a limited *response period.* (We return to the censored sample of M later). The variables T and M are supposed to depend on participation in LMT, represented by the dummy variable D = 0,1 (and the kind of training, the duration of the course etc). Employment also depends on a vector of independent variables X (age, sex, education, past employment and duration of past unemployment spells, local labour market condition etc) and an iid error term u.

The variable D takes the value 1 iff the *training score* R is positive; otherwise D = 0. The latent variable R (and the probability of D = 1) is assumed to depend on a vector of independent variables Z (age, sex, education, past employment and unemployment, the local supply of LMT etc) and an iid error term e:

(1) $T_i = a\,X_i + b\,D_i + u_i$ $\qquad$ $i = 1,2, \dots n$
$\qquad$ n = no of observations

$$E(u_i \mid X_i, D_i) = 0$$
$$\text{var}\,(u_i \mid X_i, D_i) = s_{uu}$$

(2)
$$R_i = c\,Z_i + e_i$$
$$E(e_i \mid Z_i) = 0$$
$$\text{var}\,(e_i \mid Z_i) = s_{ee}$$

As the parameters of c are estimated up to a scale factor only, we assume unit variance; $s_{ee} = 1$.

$$D_i = 1 \text{ iff } R_i > 0$$
$$D_i = 0 \text{ iff } R_i \leq 0$$

(3) $$P(D_i = 1 \mid Z_i) = E(D_i \mid Z_i) = P(\,e_i > -\,c\,Z_i)$$

A more general selection model taking care of interaction terms with observed *as well as un*observed personal characteristics is briefly discussed in Appendix. This is a *switching model with endogenous switching*; see Maddala (1983). Within this more resticted model we estimate the enrolment rule i.e the participating probability $P(D_i = 1 | Z_i)$ given by (3), by a simple discrete choice model following the normal distribution; a PROBIT model (with normalized iid error terms, (0,1)):

(4) $$p_i = P(R_i > 0) = P(D_i = 1 \mid Z_i) = F(c\,Z_i)$$

Our interest is, however, primarily on the employment function (1) and to estimate the employment effects of participation. If participants are *selected by observables*, it is sufficient to use a *control function* (Heckman and Robb, 1986, Heckman and Hotz, 1989). That is: OLS and other one stage and single equation methods will give efficient and consistent estimates of the parameters a and b in (1) if the variables Z of the participation relation (2) are included as right hand side variables in the employment relation (1) just as the X variables. If the effects of LMT are the same for all, the OLS estimator of b is to be interpreted as the effect both for participants and nonparticipants (see Appendix for a discussion of the more general model).

Including Z in X the null hypothesis is that D and u are *in*dependently distributed:

H_0: $$E(u|D, X) = E(u|D = 1, X) = E(u|D = 0, X) = 0$$

Then we have

$$\begin{aligned} E(T|D, X) &= aX + bD + E(u|D, X) \\ &= aX + bD \end{aligned}$$

If participants are *selected by unobservables*, and if D and u are dependently distributed, we have to use other methods like two stage or three stage methods, or maximum likelihood estimation of two equation models.

If the error terms are bivariately normally distributed, the bias is expressed by

$$\text{(5)} \qquad E(T \mid D, X) = aX + bD + E(u \mid D, X)$$
$$= aX + bD + s_{ue}[D\, W_1 + (1 - D)W_0]$$

where W_1 and W_0 are the "Heckman lambda's" or the "hazard rates" (see Berk, 1983 and Brian et al 1990), and where s_{ue} is the covariance between the error terms of (1) and (2). Different from models with *sample* selection bias, we need both "lambda's" (and weighted by participation D) as both participants and nonparticipants are selected into our sample (Goldstein, 1991).

Introducing the cumulative function and the density function of the normalized normal distribution as N() and n() respectively, W_1 and W_0 are given by

$$W_1 = n(-cZ)[\ 1 - N(-cZ)\ ]^{-1}$$
$$W_0 = (-1)\ n(-cZ)[\ N(-cZ)\ ]^{-1}$$

$$\text{covar}\ (u,e) = s_{ue}$$
$$\text{var}\ (e) = s_{ee} = 1$$

This alternative hypothesis is then

H_1: covar (u,e) = s_{ue} # 0

The censored regression model

During a response period of 12 months the observable labour market success variable M, is restricted both from below and from above: Zero is the absolute minimum, and 12 is the absolute maximum of the dependent variable M. Assuming that the error term u is normally distributed (0, s_{uu}), we use a TOBIT estimation model instead of OLS. Selection bias in censored regression models is briefly discussed in Appendix.

By observing the individual values of M, we identify three different groups of persons

NO JOB	$M = 0$
PARTLY employed	$M = a X + b D + u$
EMPLOYED the whole period	$M = 12$

The probability distribution of this censored dependent variable M, is given by the distribution of the error term u:

$$(6) \quad \begin{aligned} P(\text{NO JOB}) &= F(- aX - bD) \\ P(\text{PARTLY}) &= F(12 - aX - bD) - F(- aX - bD) \\ P(\text{EMPLOYED}) &= 1 - F(12 - aX - bD) \end{aligned}$$

With a censored dependent variable there are three different "concepts of expectation": First, the expected value of M in the base line model i.e. relation (1); here indicated by $E(M_0)$. Second, the expected value of M for the noncensored observations, $E(M_1)$. And third, the expected value of M for all observations, $E(M_2)$. We take advantage of Maddala (1983) and use some short hand writing based on the cumulative function and the density function of the normalized normal distribution:

$$\begin{aligned} N(1) &= N((12 - aX - bD)/s_u) &&= F(12 - aX - bD) \\ & &&= 1 - P(\text{EMPLOYED}) \\ N(0) &= N((- aX - bD)/s_u) &&= F(- aX - bD) \\ & &&= P(\text{NO JOB}) \\ n(1) &= n((12 - aX - bD)/s_u) &&= f(12 - aX - bD) \\ n(0) &= n((- aX - bD)/s_u) &&= f(- aX - bD) \end{aligned}$$

We then get

$$E(M_0) = aX + bD$$

$$(7) \quad \begin{aligned} E(M_1) &= E(M \mid 0 < M < 12) \\ &= (aX + bD) \\ &\quad + E(u \mid - aX - bD < u < 12 - aX - bD) \\ &= (aX + bD) + s_u[n(0) - n(1)] [N(1) - N(0)]^{-1} \end{aligned}$$

$$(8) \quad \begin{aligned} E(M_2) &= E(M) \\ &= (aX + bD) [N(1) - N(0)] \\ &\quad + s_u[n(0) - n(1)] + (1-N(1)) 12 \end{aligned}$$

From (7) and (8) the *marginal* effects of X on $E(M_1)$ and $E(M_2)$ may be calculated

(9) $dE(M_1) / dX = a [1 - (n(1) ((12 - aX - bD)/s_u) - n(0) ((- aX - bD)/s_u) (N(1) - N(0))^{-1} - (n(1) - n(0))^2 (N(1) - N(0))^{-2}]$

(10) $dE(M_2) / dX = a [(N(1) - N(0)) - (n(1) - n(0))(aX + bD)/s_u - n(1) ((12 - aX - bD)/s_u) + n(0)((- aX - bD)/s_u) + n(1)(12/s_u)]$

$= a (N(1) - N(0))$
$= a P(PARTLY)$

From (10) it is clear that the estimates of the parmeters in the vector of a should be "corrected" by the probability of "PARTLY employed" to get the marginal effects of X on the expected value of $E(M_2)$.

The effects of *nonmarginal* changes, for instance in dummy variables as D (that is from nonparticitpation D = 1 - to participation D = 1), should be calculated by the change in (estimated) expected duration given by $E(M_2 | D=1) - dE(M_2 | D=0)$.

4. Data

The data used are from the register of the Labour Market Board matched with data collected in a postal follow up survey. The data cover a representative sample of participants in LMT during spring 1989 and a representative sample of persons registered as unemployed in March 1989.

The analysis is based on observations of 3 248 participants in vocational training courses, and 3 388 nonparticipants - all formerly unemployed persons. The treatment group and the comparison group.

The labour market outcome is measured by the number of months employed during a 12 months response period from June 1989 to May 1990. In addition to *LMT participation* as such, the job probability is assumed to depend on *duration* of the course (duration by weeks in quadratic form). We also have some information on the field of training.

As explanatory variables we use typical human capital indicators as *sex*, *age* (years of age in quadratic form), level of *education* (3 dummies) and *previous unemployment experience*, measured by the duration of last spell before training or before time of registration (weeks in quadratic form). In addition we know whether the respondents have been employed - or not - during the past year (unfortunately we have no "history" of unemployment, employment and wages).

We also have some indicators of *local labour market conditions*. That is the average number of vacant positions divided by the average number of unemployed people in home county during the response period given by V/U, and changes in level of unemployment during the response period given by dU.

Table 1 presents some mean values for the trainees and the comparison group. As we can see there is a pretty close agreement of the means. Table 2 provides the distribution on different kinds of courses, the average duration of the courses, and the percentage of women.

Table 3 presents the censored sample distribution and the sample mean values of employment in the response period. From these aggregate figures we see that the treatment group performs better than the comparison group. The percentages of left hand side censored (no job) are 40 and 45 and of right hand side censored (employed) 18 and 12; both in favour of the trainees.

5. Enrolment

Table 4 presents the results from estimating the enrolment rule, i.e. the participation probability by a PROBIT estimation model. The table shows that unemployed women participate more often than unemployed men, medium aged persons more often than elderly, and educated more often than unemployed with only compulsory school. Persons with medium long unemployment spells (8-12 weeks and 13-25 weeks) participate more often than those with very short or very long unemployment spells. Those who had just been in another kind of programme, participate more often in LMT than others.

Included in the model is also an indicator on *local supply* of training courses. The last variable in the table, "participation rate", measures the number of participants relative to the number of registered unemployed persons in the home county (average 1989). As expected, persons living in regions with relative more training courses participate more often than others.

Alternative models, as GLS and LOGISTIC regression, give similar results (not shown here).

6. Employment Effects

To estimate the employment effects of LMT we start out with three variables and three unknown parameters. First we have a dummy variable, i.e. participation or not. The estimated parameter indicates a shift in the level of the linear employment relation. Second we have a duration variable, i.e. to discriminate between employment effects of long and short courses. Third we have the duration of training in quadratic form to test whether the marginal effect is increasing or decreasing.

After testing the significance of these three parameters, we include interaction terms. The purpose is to test whether the return on training is decreasing or increasing by human capital indicators such as level of education and duration of previous unemployment spells. In our last analysis we specify 13 training dummies for different fields of training.

Tables 5, 6, 7 present estimates of the different models; all of them indicating a *positive employment effect of training.*

First comparing the results of column (1) and (2) in table 5, we find that including the three variables for participation and duration of LMT in the TOBIT model increases the goodness of fit significantly. We *reject* the hypothesis that training has *no effect* on employment. The loglikelihood test is rejected even at a 1 percent level.

From column (2) we see that the estimated marginal effect of LMT on employment is significnatly positive. The effect depends, however, on the period of training; short to medium long and rather long courses (5-10 weeks or more than 35 weeks) have positive effects, semi long courses (20-30 weeks) have no - or negative effects.

To estimate the effects of nonmarginal changes (no training # training) on average employment, we have to calculate the change in the value of $E(M_2)$ given by (8). For some fixed values of the X-variables (the reference group[9]), we find that a labour market training course of 5 weeks increases the average duration of employment fraom 3.1 to 4.3 months; that is by 1.2 months.

From column (2) (and 1) we see that individual characteristics also have distinct effects: Women are expected to be employed for a shorter period than men; about 0.5 months during the 12 months response period (the estimated parameter 1.096 times 0.43 equals 0.47).

As expected, we also find that employment is increasing by education. Persons with secondary school are better off then those with only compulsory school. On the other hand, those with education on university college level, are not significantly better off.

Employment is decreasing by duration of previous unemployment period. The effect is, however, not linear. The base line relation (1) reaches the minimum at 81 weeks[10]. By age employment is first increasing and then decreasing; relation (1) reaches it maximum at 37 years.

Selection Bias

Second we try to test for selection bias. The test is based on "Heckman's lambda" (Heckman, 1979). The variable *weighted lambda* in column (3) is calculated according to the expression in brackets on the very right hand side of relation (5). The values of W_0 and W_1 are based on the observed values of the Z-variables and the estimated values of the parameters presented in table 4. These predicted "hazard rates" of participation and nonparticipation are then *weighted* with the observed value of the variable D.

As the dependent variable of the model is censored, this two-

[9] The reference group has the following characteristics: Male, 30 years, only compulsory school, 10 weeks of previous unemployment, have not had a job, V/U = 0.07 (average) and dU = 0.3 (average).

[10] By chance (?) this coincidence with the duration of the unemployment benefit period in Norway, which is 80 weeks (during a period of 2 years).

stage-estimation method does not have the same efficient characteristics as the original "Heckman's lambda". There are still analytical problems to be solved to find a similar efficient method correcting for selection bias in censored regression models. See Appendix for a discussion of this question.

As shown by column (3), table 5, the estimated parameter of *weighted lambda* (which is an approximated estimator of the covariance s_{ue}) is positive and significantly different from zero. This indicates a *positive dependence* between the error terms of the two estimated equations. *The hypothesis of no selection to training is rejected.*

Comparing the results of column (2) and (3) we also see that introducing *weighted lambda* as a right hand side variable in the TOBIT model, *reduces the estimated employment effect of training*, as well as it changes some of the other parameters (the effect of education is increased).

Concerning the employment effects of training, the estimated *level effect* is reduced while the estimated *duration profile* is unchanged. As a result only short courses have a positive estimated employment effect. The calculated effect of an average course of 5 weeks (for the same fixed X-values) is reduced from 1.2 to only 0.9 months within the response period.

Estimating the selection bias we have assumed that the enrolment rule is the same for *all* courses. Enrolment for short and long courses, and for different kinds of courses may, however, differ. If the enrolment rule for short, medium and long courses is not the same, the estimated duration profile may still be biased.

Interaction with education and unemployment

Table 6 presents the results introducing interaction terms for return to training and level of education, column (4), and return to training and duration of unemployment, column (5).

As seen from the table, the estimated interaction terms for effect of education increases somewhat, however, and the difference between men and women is reduced. The explanation may be that some courses with more educated participants have (are estimated to have) little employment effects (technical training, computer and office work), and that some courses dominated by women, are estimated to have large employment effects (hotel and restaurant).

Again we note that estimating the selection bias we have taken for granted that the enrolment rule is the same for *all* courses. If this is not the case, the estimated effects of different courses may still be biased.

7. Concluding Remarks

The results of the analysis give some support to the idea that labour market training programmes improve job opportunities of unemployed persons; either by preserving and enhancing skills, or by stimulating their search effort, and thus preventing them from becoming long term unemployed. We are however not confident that the estimated differences in employment are *caused* by LMT training. The problems of *selection bias* are not solved. The estimates of the training effect are positively biased if the most *motivated* and the most *competitive* of the unemployed are *selected* into the LMT training; they are negatively biased in the opposite case.

Including a variant of "Heckman's lambda" in the TOBIT model gives a positive and significant parameter estimate. This indicates a *positive selection bias* i.e. the simple TOBIT estimates will overstate the employment effects of training. Trying to take account of this selection, the estimated employment effect of training is reduced. *Only short courses are estimated to have positive employment effect.*

The persistently high level of unemployment and the increasing amount of money spent on labour market programmes have made the question of effects and the efficiency of the "active labour market policies" part of the public debate in Norway. The short term effects on employment (as we have studied here) is only one kind of effects - and probably the easiest one to measure. Still there are serious methodological questions to investigate - and analytical problems to be solved before we are confident with the answers to the question of employment effects of training unemployed.

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Appendix

This appendix outlines a more general model for selection (into labour market training) than the one specified in section 3 of the paper. Comparable to equation (1) and (2) we have:

(a1) $T_i^1 = a_1 X_i + u_i^1$ for participants

(a2) $T_i^0 = a_0 X_i + u_i^0$ for nonparticipants

(a3) $R_i = c Z_i + e_i$

where T_i^1, T_i^0 and R_i are simultaneously distributed and the error terms are supposed to be normally distributed. The realized variable T_i is defined as

$T_i = T_i^1$ iff $R_i > 0$ which is equivalent to $D_i = 1$
$T_i = T_i^0$ iff $R_i \leq 0$ which is equivalent to $D_i = 0$

$E(e_i) = E(u_i^k) = 0$
$var(u_i^k) = s_{kk}$ all $i = 1,2,\ldots n$
$var(e_i) = s_{ee} = 1$ and $k,j = 1,0$
$covar(u_i^k, u_i^j) = s_{kj} = r_{kj}\, s_k\, s_j$
$covar(u_i^k, e_i) = s_{ke} = r_k\, s_k\, s_e$

Then we have

$$T_i = D_i T_i^1 + (1 - D_i) T_i^0$$

Compared to this model, the model presented in section 3 is restricted by the error terms and the vectors of parameters being identical; $u^1 = u^0$ and $a^1 = a^0$. The right-hand-side variable D of the restricted model is included in the vector X in the more general model.

The argument for the more general model is that the *employment process* (including the stochastic part of the process) may be quite different for participants and nonparticipants. Second we consider the *potential* outcomes T^1 and T^0 to be factors of some importance for the selection process (ie for D = 1 or D = 0). Then both of them - and their error terms u^1 and u^0, must be defined over the whole population; although we only observe either T^1 or T^0 for each individual. This is what Maddala (1983) calls a *selection model of endogenous switching* (different from the mixture distribution model).

From the marginal distributions of T^1 and T^0 given by (a1) and (a2) and from the assumption that (u^1, u^0, e) are normally distributed (0, S), it is possible to derive the conditional distribution of T^1 given D=1 and of T^0 given D=0. The conditional expectation of T is given by equation (a4) and (a5) - comparable to equation (5) in section 3 of the paper:

(a4) $E(T^1 | X, D=1) = a^1 X + E(u^1 | X, D=1)$
$= a^1 X + s_{1e}\, n(-cZ)\, (1 - N(-cZ))^{-1}$

(a5) $E(T^0 | X, D=0) = a^0 X + E(u^0 | X, D=1)$
$= a^0 X - s_{0e}\, n(-cZ)\, (1 - N(-cZ))^{-1}$

From (a4) and (a5) we may calculate the expected advantage of the LMT for participants; given by the difference

$$E(T^1 | X, D=1) - E(T^0 | X, D=1)$$

The expected advantage of the LMT for nonparticipants is given by

$$E(T^1 | X, D=0) - E(T^0 | X, D=0)$$

As we see the expected advantage depends on $(a^1 - a^0)$ and $(s_{0e} - s_{1e})$; see Maddala (1983) for more details.

Censored regression
Presenting (and estimating) the censored regression model in section 3, we did not take the selection bias and the possible covariance between the error terms u and e (ie u^1,e and u^0,e) into account. It turns out that the distribution of the censored regression variable M - conditional on D - is quite complicated:

We have two bivariate distributions - both on censored variables; (u^1,e) and (u^0,e) respectively. In this case FIML is an efficient estimation method - if the model is correctly specified. In the analyses presented in the paper, we used a two-stage, single equation procedure. This method has favourable asymptotic characteristics. As the distribution of the censored regression variable M is heteroscedastic, three-stage procedures would have been more efficient. FIML and three-stage methods have not been tried out yet; here we only give some brief indications on the distribution of the dependent variable[11].

Let the variables S^+ and S^- indicate right-hand-side, and left-hand-side censoring of the M variable:

$S^+ = 1$ iff $M = M(max) = 12$
else $S^+ = 0$

$S^- = 1$ iff $M = M(min) = 0$
else $S^- = 0$

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[11] I'm grateful to Harald Goldstein, University of Oslo, Dept of Economics, who gave me "the key" to the problem. Any mistakes are on my own responsebilty.

The value of M is then given by

(a6) $$M = M(max)\, S^+ + T\,(1 - S^+)\,(1 - S^-) + M(min)\, S^-$$

$$M = 12\, S^+ + D(a^1 X + u^1)\,(1 - D)(a^0 X + u^0)\,(1 - S^+)\,(1 - S^-)$$

The simultaneous distribution of u^1, u^0 and e, and the six different "legal" combinations of D- and S-values give the distribution of the censored variable M

D	S+	S-	Observable M
1	0	1	M(min) = 0
1	1	0	M(max) = 12
1	0	0	$a_1 X + u^1$
0	0	1	M(min) = 0
0	1	0	M(max) = 12
0	0	0	$a_0 X + u^0$

From the bivariate normal distributions of (u^1,e) and (u^0,e) it is possible to calculate the probability of each of the six cases, as well as the joint distribution of all observable M-values.

Let us have a closer look at the third case; ie participation D = 1, and noncensoring $S^+=0$, $S^-=0$. This event is given by:

$$e \geq -cZ \quad \text{and} \quad -a^1 X \leq u^1 \leq 12 - a^1 X$$

The probability of this event is defined by the simultaneous distribution of e and u^1:

(a7) $$F^* = P(e \geq -cZ,\ -a^1 X \leq u^1 \leq 12 - a^1 X)$$

and the conditional expected value of M is given :

(a8) $$E(M \mid X, D=1, S^+=0, S^-=0) = a^1 X + E(u^1 \mid X, D=1, S^+=0, S^-=0)$$

The expected conditional value of the error term u^1 in (a8) is found by integrating the joint distribution of (u^1,e). To get more convenient expressions we define two new error terms, û and ê, normally distributed with zero means, unit variance and correlation coefficient r_1

$$\hat{u} = u^1 / s_1$$
$$\hat{e} = e / s_e$$

The we redefine the selection and censoring criteria:

$$\hat{e} \geq b_0 = -cZ/s_e$$

$$b_1 = -a^1 X / s_1 \leq \hat{u} \leq (12 - a^1 X)/s_1 = b_2$$

The probability F^* and the conditional expected value of u^1 is now given by

(a7) $$F^* = P(\hat{e} \geq b_0, b_1 \leq \hat{u} \leq b_2)$$

(a8) $$E(u^1 | X, D=1, S^+=0, S^-=0) = s_1 E(\hat{u} | \hat{e} \geq b_0, b_1 \leq \hat{u} \leq b_2)$$

To find the conditional expected value of û we start out with the formula of the mean value in a bivariate normal distribution (see Maddala, 1983 and Rosenbaum, 1961), and combine this with the following:

(a9) $$F^* E(\hat{u} | \hat{e} \geq b_0, b_1 \leq \hat{u} \leq b_2) = F^1 E^1(\hat{u}) - F^2 E^2(\hat{u})$$

where F^* is given by (a7) and

$$F^1 = P(\hat{e} \geq b_0, \hat{u} \geq b_1)$$

$$E^1(\hat{u}) = E(\hat{u} | \hat{e} \geq b_0, \hat{u} \geq b_1)$$

$$F^2 = P(\hat{e} \geq b_0, \hat{u} \geq b_2)$$

$$E^2(\hat{u}) = E(\hat{u} | \hat{e} \geq b_0, \hat{u} \geq b_2)$$

After some calculations we derive at

(a9) $$F^* E(\hat{u} | \hat{e} \geq b_0, b_1 \leq \hat{u} \leq b_2)$$

$$= n(b_1) [1 - N(b_{01}^*)] + r\, n(b_0) [1 - N(b_1^*)] - \{ n(b_2) [1 - N(b_{02}^*)] + r\, n(b_0) [1 - N(b_2^*)] \}$$

$$= n(b_1) [1 - N(b_{01}^*)] + r\, n(b_0) [N(b_2^*) - N(b_1^*)] - n(b_2) [1 - N(b_{02}^*)]$$

The arguments of the normal distribution functions in (a9) is given by

$$b_{01}^* = (b_0 - r_1 b_1) (1 - r_1^2)^{-1/2}$$
$$b_{02}^* = (b_0 - r_1 b_2) (1 - r_1^2)^{-1/2}$$
$$b_1^* = (b_1 - r_1 b_0) (1 - r_1^2)^{-1/2}$$
$$b_2^* = (b_2 - r_1 b_0) (1 - r_1^2)^{-1/2}$$

Similar calculations are easily done for the case of nonparticipation D = 0, and noncensoring $S^+=0$, $S^-=0$. This event is given by:

$$e \leq -cZ \quad \text{and} \quad -a^1 X \leq u^1 \leq 12 - a^1 X$$

Tables

Table 1. Labour Market Training.
The participants and the comparison group.

	LMT participants Percent	Comparison group Percent
All	(N = 3248)	(N = 3388)
Women	48,5	39,5
Men	57,5	60,5
Age		
Under 20 years	7,9	7,0
20-24 years	26,8	24,0
25-29 years	17,0	18,1
30-39 years	25,5	22,0
40-49 years	18,0	13,9
50 years and more	4,7	14,9
Education		
Compulsory (7-9 years)	20,5	33,9
Secondary school (10-12)years	68,6	56,9
University or College	10,9	9,3
Previous unemployment		
1 - 3 weeks	13,4	20,0
4 - 7 weeks	11,8	13,1
8 - 12 weeks	14,0	11,0
13 - 25 weeks	33,0	27,1
26 - 39 weeks	14,6	14,9
40 - 52 weeks	5,9	5,4
53- 80 weeks	5,6	6,4
More than 80 weeks	1,7	2,2

Table 2. Participants by different training courses. Average duration of courses. Percentage women.

	Percent	(N =)	Duration by weeks	Percentage women
Technical training	6,0	(196)	8,3	31,1
Nursing	4,5	(147)	14,0	95,2
Computer and office work	48,6	(1577)	9,5	72,9
Oil and off shore industry	3,2	(105)	7,0	0,0
Transport	5,5	(179)	5,9	12,8
Welding and mechanical work	8,4	(272)	9,7	7,4
Electrical work	2,2	(70)	5,7	24,3
Wood work	6,0	(195)	13,4	3,1
Building and construction	4,2	(138)	9,4	3,6
Machine and motor power work	2,0	(64)	6,4	3;1
Hotel and restaurant	4,1	(134)	11,4	75,3
Primary industries˙	2,7	(88)	9,3	14,8
Other training	2,6	(83)	17,7	44,6

Table 3. Employment during the 12 months response period. Percentage with no job, partly employed and employed the whole period. Average duration of employment.

	Left hand side censoring	Right hand side censoring		No censoring
	NO JOB in the period	EMPLOYED the whole period*		PARTLY employed
	M = 0	M = 12	M < 12	0 < M < 12
All	42.0 pct	13.6 pct	1.1 pct	42.7 pct
LMT participants	39.9 pct 0 mns	15.4 pct 12 mns	2.2 pct 9.6 mns	42.5 pct 5.8 mns
Comparison group	45.3 pct 0 mns	11.9 pct 12 mns	—— ——	42.9 pct 6.1 mns

Note: * Some of the LMT courses lasted beyond the starting date of the response period. For these respondents the right hand side censoring is *lower* than 12. This is taken into account in the TOBIT estimation model as well.

Table 4. Estimated probability of participation.
PROBIT estimation model.

Variable	Estimated effect	Standard deviation
Intercept	-0.093	(0.089)
Women	0.162**	(0.033)
University or College	0.365**	(0.060)
Secondary School	0.367**	(0.039)
Age - Reference group 40-49 years		
Under 20 years	- 0.190**	(0.072)
20-24 years	- 0.270**	(0.052)
25-29 years	- 0.258**	(0.056)
30-39 years	- 0.113*	(0.052)
50 years and more	- 0.746**	(0.070)
Unemployment - Reference group 8-12 weeks		
1-3 weeks	- 0.399**	(0.060)
4-7 weeks	- 0.180**	(0.064)
13-25 weeks	- 0.068	(0.054)
26-39 weeks	- 0.238**	(0.062)
40-52 weeks	- 0.180*	(0.082)
53-80 weeks	- 0.319**	(0.082)
More than 80 weeks	- 0.391**	(0.128)
Have had a job last year	- 0.503**	(0.041)
Prior participation	0.799**	(0.057)
Participation rate	0.690**	(0.077)
N	6 636	
Log likelihood	- 4126.697618	

Note: Estimated standard deviations are given in parenthesis. Parameters marked with ** and * are significantly different from zero by a two tailed t-test at 99 and 95 percent respectively.

Table 5. Estimated employment effects of training. Test for selection. TOBIT estimation model.

Model Independent variables	(1)	(2)	(3)
LMT	---	5.686** (0.467)	4.841** (0.582)
Weighted Lambda	---	---	0.416** (0.173)
Duration of LMT weeks	---	- 0.575** (0.061)	- 0.574** (0.061)
Duration of LMT weeks squared	---	0.011** (0.002)	0.011** (0.002)
Women	- 1.123** (0.254)	- 1.096** (0.252)	- 1.049* (0.252)
Age - by years	0.548** (0.066)	0.477** (0.065)	0.484** (0.065)
Age - years squared	- 0.007** (0.001)	- 0.006** (0.001)	- 0,007** (0,001)
University or College	1.045* (0.467)	0.694 (0.462)	0.815 (0.465)
Secondary school	1.292** (0.300)	0.961** (0.298)	1.088** (0.303)
Have had a job	4.370** (0.325)	4.574** (0.327)	4.381** (0.335)
Unemployment weeks	- 0.146** (0.016)	- 0.154** (0.016)	- 0.152** (0.016)
Unemployment weeks squared	0.001** (0.000)	- 0.001** (0.000)	0.001** (0.000)
V/U	17.227** (5.353)	16.998** (5.294)	17.425** (5.293)
dU	- 1.127** (0.221)	- 0.999** (0.219)	- 1.049** (0.220)
Intercept	- 9.379** (1.242)	- 8.830** (1.228)	- 8.508** (1.234)
Estim. s_u^2	9.203** (0.144)	9.077** (0.142)	9.070** (0.142)
N	6 636	6 636	6 636
Log likelihood	- 13416.09085	- 13339.34724	- 13336.19599

Note: Estimated standard deviations are given in parenthesis. Parameters marked with ** and * are significantly different from zero by a two tailed t-test at 99 and 95 percent respectively.

Table 6. Estimated employment effects of training on employment. Interaction terms: Level of education and duration of former unemployment spells. TOBIT estimation model.

Model Independent variables	(4) Estimated effects	Standard deviation	(5) Estimated effects	Standard deviation
Woman	- 1.045**	(0.252)	- 1.048**	(0.252)
Age - by year	0.480**	(0.065)	0.471**	(0.065)
- years squared	- 0.007**	(0.001)	- 0.006**	(0.001)
Univ. or Coll.	1.031	(0.645)	0.788	(0.465)
Secondary Sch.	1.238**	(0.392)	1.070**	(0.302)
Have had a job	4.379**	(0.335)	4.444**	(0.337)
V/U	17.490**	(5.294)	17.425**	(5.291)
dU	- 1.046**	(0.220)	- 1.046**	(0.219)
Unempl. dur. weeks	- 0.152**	(0.016)	- 0.146**	(0.019)
Unempl. dur. w. sq	0.001**	(0.000)	0.001**	(0.000)
LMT	5.156**	(0.754)	5.203**	(0.698)
Weighted Lambda	0.406**	(0.174)	0.377*	(0.173)
LMT dur. weeks	- 0.575**	(0.061)	- 0.581**	(0.061)
LMT dur. w. sq.	0.011**	(0.002)	0.011**	(0.002)
LMT*Univ. or Coll.	- 0.490	(0.923)	---	---
LMT*Sec. Sch.	- 0.364	(0.592)	---	---
LMT*8-12 w. of unempl	---	---	- 0.883	(0.592)
LMT*13-25 w. of unempl	---	---	- 0.304	(0.512)
LMT*26-39 w. of unempl	---	---	- 0.770	(0.683)
LMT*40-52 w. of unempl	---	---	- 0.285	(0.935)
LMT*more than 53 w.	---	---	1.952*	(0.952)
Intercept	- 8.581**	(1.240)	- 8.368**	(1.241)
Estim. s_u^2	9.070**	(0.142)	9.062**	(0.142)
N	6 636		6 636	
Log likelihood	- 13335.96865		- 13330.63518	

Note: Parameters marked with ** and * are significantly different from zero by a two tailed t-test at 99 and 95 percent respectively.

Table 7. Estimated employment effects. Different types of courses. TOBIT estimation model.

Independent variables	Estimated effects	Types of course	Estimated effects
Woman	- 0.677** (0.280)	Technical training	3.811** (0.887)
Age - by year	0.503** (0.065)	Nursing	4.171** (1.011)
Age - year squared	- 0.007** (0.001)	Computer and office work	3.779** (0.649)
University or College	1.150* (0.475)	Oil and off shore industry	6.948** (1.098)
Secondary School	1.233** (0.305)	Transport	4.360** (0.889)
Have had a job	4.241** (0.335)	Welding and mechanical work	5.538** (0.829)
Weighted Lambda	0.387* (0.171)	Electrical work	6.740** (1.267)
Duration of LMT - weeks	- 0.519** (0.066)	Wood work	5.500** (0.988)
Duration of LMT - weeks squared	0.010** (0.002)	Building and construction	4.215** (1.041)
Unemployment duration by weeks	- 0.148** (0.016)	Machinery and motor power work	7.005** (1.350)
Unemployment duration -weeks squared	0.001** (0.000)	Hotel and restaurant	6.677** (1.072)
V/U	18.136** (5.301)	Primary industries	6.292** (1.198)
dU	- 0.946** (0.221)	Other training	-0.176 (1.469)
Intercept	- 9.196** (1.243)	Log Likelihood	-13312.1817
Est s_{uu}	9.028** (0.141)	N	6 634

Note: See table 5.

Continuing education and Schumpeterian competition : Elements for a theoretical framework

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ABSTRACT

Who should pay for the accumulation of general human capital by workers after schooling ? This question has been essentially studied in a competitive and static framework. In this context G. BECKER's theorem states that the firms will not share the expenses, unless some very rigid contract is signed by the workers, normally not allowed by the law. Hence there is a high risk of underprovision of general competences and ensuing low performance of the firms and the economy. This paper shows that in a more realistic Schumpeterian framework which pictures competition as a creative destruction process driven by innovators, the latter should sponsor part of the expenses to obtain the quasi-rent, and can pay out of it. The argument starts from the basic idea that the design and inplementation of innovation requires for a firm new and higher competences.

Finally the paper suggests that a dynamic competition framework can be integrated with recent theoretical advances on economic organization to provide a basis for a much richer study of the demand and supply of the competences of the workers and some important insights on economic performance.

Introductory remarks[1]

Human capital accumulation has been essentially studied in a static theoretical framework until recent models of endogeneous growth (ROMER/1990/, AZARIADIS and DRAZEN/1990/ for instance). These models have the scope but also the limitations of aggregate models. There remains a need for a careful analysis of the accumulation processes at the microeconomic level of the individual and the firm. Such an analysis can develop our understanding of the timing of education over the life cycle, the distribution of education among heterogeneous individuals, the links between education and performance of the firms, and the identification of the payers. This is not a closed list and both the positive and the normative levels are implied.

Such a microeconomic research is anyhow necessary to contrast with the standard human capital theory which has been developed at that level.

The present paper tackles the task of looking at the role of continuing education in an economy caracterized by competition à la Schumpeter - *creative destruction*[2]. Innovation in goods and processes as well as competition on prices is central to the competition between firms and between countries. It is therefore the framework into which education processes and normative decisions on continuing education should be modelled and discussed.

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[1] I gratefully acknowledge the financial support of the Direction de l'Evaluation et de la Prospective, Ministère de l'Education Nationale, Paris, for the present phase of the E.R.M.E.S. project on "continuing education, performance and growth". I am grateful to Philippe CAZENAVE and the participants in the Helsinki seminar for many remarks which have improved this manuscript. All errors remain mine.

[2] ELIASSON (1992) in this book offers parallel and complementary foundations for a micro-macro analysis of the effects of education on growth.

Specialists of the economy of technical change have mentioned its evident impact on the demand for higher skills, yet no or very little theoretical work seems to to have been done[3]. This may be because it is a rather formidable task for the theorist, since very few models capture the essential features of the Schumpeterian competition[4]. Most of those which do are microanalytic simulation models such as those of NELSON and WINTER/1982/ and ELIASSON/1985/. Yet some well defined problems may be dealt with mathematical tools which give more general answers. Setting first a general theoretical framework then seems a prerequisite to model building.

We will start by tackling in this paper a specific topic, the challenge to G. BECKER's theorem on the financing of general human capital investments. It will allow us to point out to important features of the economy which are invoked when one wants to criticize that theorem. It will lead us to sketch some elements of a schumpeterian economy with human capital .

The paper will be devided as follows. First we will try to summarize very briefly the state of the debate on BECKER's theorem (I). Then we will present our own thesis that aims to prove that firms should share the costs of general training, a thesis based on Schumpeterian competition (II). Finally we will use the paradigmatic framework to describe some of the important features of human capital creation and workers allocation which cannot be dealt adequately in a static framework (III). Some final notes (IV) will look at the consequences for the competitiveness of the economies.

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[3]For instance STONEMAN/1983/, p.159 . KATSOULACOS/1986/ offers a detailed study of the effect of innovation on aggregate employment, yet it takes labour as an homogeneous factor (except in chap. 8, but he does not consider the problem of training).

[4]See GAFFARD/1990/ for a detailed review of some models and AGHION and HOWITT/1990/ for a recent endogenous growth model.

I.The debate on G.BECKER's theorem

G.BECKER/1975/'s theorem states that employees should pay for the accumulation of *general* human capital because it is embodied in themselves and they may leave with it so that the firms will not get the returns in competitive markets. Employees may pay directly or by getting wages lower than their marginal product (the market wage) while being trained.

The argument has a strong logical force and has gone almost unchallenged until recently[5]. Yet it is well documented that firms spend important ressources on training. This is interpreted as expenses on the creation of specific human capital (which should be shared), or as expenses on general human capital paid back by the lower wages.

However BISHOP/1991a/ uses detailed data on OJT (on the job training) for newly hired employees and shows that productivity rises much faster than wages, contrary to the prediction of general human capital theory. Moreover this training is considered by the employers as useful in other firms and therefore general. FEUER, GLICK and DESAI/1991/ find no evidence that the employees whose employers paid for some of their formal schooling have obtained lower wages.

Uncontroversial evidence will always be difficult to obtain,

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[5]For instance the otherwise useful review of the litterature on the role of firms in training by PARSONS/1990/ does not question BECKER's framework. Howerver STERN and RITZEN/1991/ offer a collection of contributions generally critical of BECKER's theorem which have fed this section. BISHOP/1991b/ supplies an extended review of the state of knowledge on employer's training.

notably because of the impossibility to control completly for the differences of ability between workers. There is therefore an urgent need for alternative theories to support the recent results.

The normative question of who should pay for the accumulation of general human capital is anyhow of the highest social and economic importance. It is a widely held view that lack of competitiveness and unemployment on the one hand, and training on the other are negatively correlated, both at the level of the individual and the nation. The high unemployment rate in France and continuous complaints about insufficient and inadequate training urge to discuss the possibility of underprovision of training.

However one should distinguish explanations of the low expenses of workers on general human capital creation from the theories that explain that firms should (or do) share the costs. The former explanations are well known. First the *minimum wage* acts as an upper boundary to the worker's contribution. This is not very convincing because of the possibility of offering a part-time job and payment, with the worker being trained during unpaid hours. BROWN/1990/ reviews the evidence on this subject and finds it unconclusive. Secondly the *liquidity constraints* caused by the limitation to borrowing in the absence of a collateral and the presence of uncertainty (future demand for the human capital of the employee and moral hazard from his part) prevent an important direct or indirect contribution. Third *risk aversion* lowers the expected utility from uncertain returns to training, even though this is not an argument as convincing for continuing education of an employee as for formal schooling (initial or post entry for an unemployed or non-participant).

These explanations of low provision may call for government intervention, but *per se*, do not imply that firms should pay for general training. We have found three different theories for the sharing of the general investment costs, but there may be more.

The first two imply the association of general and specific human investment, which has the important advantage of providing a fairly general *viability condition* for the sharing by the firm of the costs of general human capital investment.

This viability condition developed by GLICK and FEVER/1984/(p.123) states that firm-sponsored training is not vulnerable to poaching risks *if the sum of the worker's return on his specific training investment plus his share of the returns from his firm's general training investment exceeds the market value of that general training.*

Complementarity of general and specific human capital acquisition is an explanation for the sharing of the costs by the firm provided the viability condition is fulfilled[6]. If it is not, the firm will simply have a larger number of less skilled employees do the work. If it is not and there is complementarity in use as well, which is likely in the case of joint production of the two types of human capital, the level of production will be constrained by the investment of the employees.

Another explanation is the *exchange of hostages* theory developed by FEUER, GLICK and DESAI/1987/.They argue that there is an asymetric bargaining situation between the firm and the employee in the bilateral monopoly over specific human capital returns. The employee then needs an insurance to accept to pay a share of the specific investment.

The firm can provide general training as an *hostage* offered to the employee who offers his own investment in specific human capital as an hostage. This exchange of hostages enhances the actual value of the contract, because it will increase its expected duration. It is a very economical hostage since the firm benefits of part of the returns of the general training, under the

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[6]See STERN and RITZEN/1991/ p.5 for some complementary discussion of that case.

viability constraint.

While these theories are intellectually appealing, they rely on the statement that the employees pay for part of the specific training, which is also a theorem of Human Capital Theory. It might need a closer look however because the explanations for underprovision by the employees apply here also.

A third explanation is the *accreditation theory*. The general human capital acquired outside the *formal scholing system* may not be easy to signal to a firm other than the firm in which it is acquired. Hence it has no or little market value. From the point of view of the workers, it looks like a specific human capital.

Firms should then accept to pay part of the costs, and the workers will not accept anyhow to pay all of them, since they may be fired by the firm.

This is certainly an important explanation of the actual sharing of the costs, yet it is partial. Part of the general experience acquired by workers is acknowledged by the external labour market.

These theories have somewhat extended the environment in which human capital accumulation is discussed, notably by assuming away the transparency of information or honesty of the parties. However, we think that more fruitful study of the role and accumulation of human capital requires a new framework, which can be provided by Schumpeterian theory, with new goods and new processes, and the corresponding exit of the old goods and processes. This framework at the same time offers compelling arguments for the firms to invest in general as well as specific human capital. Furthermore it justifies sophisticated human ressources policies by firms.

II. Innovation and the sharing of general training expenses

We offer here in six steps a proof that BECKER's theorem does not hold in Schumpeterian framework[7]. A seventh point deals with the determinants of the relative shares of the firm and the employee.

1. The firm which introduces a new good and/or a new process which is viable earns a quasi-rent.

2. This quasi-rent will be eroded away by the entry of competitors, but the empirical studies show that it takes time, notably because the necessary building of the competences (human capital) is a time consuming process. It will also be eroded away by later inventors with new goods (having some better caracteristics in the sense of LANCASTER/1966/ or higher quality[8]). Some day the quasi-rent might be come zero or negative. The firm will have to divert its ressources from that good and/or process. There is creative destruction.

3. The firm must use new processes or technology. A strong case can be made for a production function which, at a certain date, involves almost fixed proportions in the inputs. Changing the proportions is costly. Secondly these inputs are many, and among them, there is a vector of competences (or human capital types). These can be ranked from the totally general to the totally specific (to the technology).

This caracterization of the technology remains very rough, but seems enough for our reasoning. However a richer view below enables to describe more carefully the demand for continuing education and its supply.

From the technology, one obtains a derived demand for

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[7]A mathematical model does not seem to be necessary for our present purpose, but is on our agenda to derive partial and general equilibrium results.

[8]See BEATH and KATSOPOULOS/1991/ for a detailed analysis of product differentiation.

competences. One has to translate it into a demand for workers, and it is no easy task if workers have several competences and are heterogeneous. However it is simpler and more realistic to consider the problem of adjustment at the time of introduction of a new process. The labour force has a certain endowment in competences. Some are no longer in demand or too high, some are missing or too low.

The change of the derived demand is on average biased towards a larger number of competences, and higher levels in more general competences. The argument is not empirical, but can be made theoretical in a Schumpeterian environment. It is based on the idea that many of the new goods must be of better quality to take a share of the market, and the new processes have higher requirements (at least but not only through servicing). This should be possible to document with the example of the quest for zero default. However it is sufficient for the argument that some new type of general competence or some higher level in the existing general competences is required[9].

4. Employees invest in too low levels of general competences. The reasons of this underprovision have been exposed: Liquidity constraints is the first. Risk aversion and accreditation are the others. They should lead to a lower level of investment than in a risky but static environment. The creative destruction assigns a zero value to many competences for the rest of the life cycle. It lowers the expected return for the employee, because it lowers the expected lenght of the period of return.

Therefore the introduction of a new process involves in the firm

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[9] BISHOP /1991b/ p. 21 mentions some studies which show a positive correlation between the rate of technological progress in an industry and the intensity of training of the workers.

an excess demand for some of the more general competences[10]. Some other general competences are now in excess supply.

5. The firm must pay out of the quasi-rent for the R and D expenditures or patents to obtain innovations in the future. *The crux of our argument is that some of the remaining quasi-rent should optimally be devoted to the investment in general human capital which is necessary to obtain a renewed quasi-rent*[11]. If the shareholders or the managers refuse to do so, for instance because of a high preference for short term profits (high dividends, profit based earnings), then there will be no future quasi-rent because the competences will be too low to produce the good efficiently even if the firm has a monopoly on the exploitation of the innovation.

6. The firm can pay the market wage and prevent poaching as long as the innovation yields a quasi-rent high enough relatively to the other firms [12]. It contrasts with the pure competion case which supports BECKER's theorem. When the quasi-rent gets low, some firms which have an excess demand for some general competences held by some employees of the firm may poach .

As far as non wage induced quits are concerned, they reduce the profits, but do not imply the losses that justify BECKER's theorem as in perfect competition.

7. How are the shares of the employees and the firm in general

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[10]There might as well be an excess demand for some competences which are process specific and complementary to the general competences.

[11]If borrowing is done, the quasi-rent pays for the investment. If the investment is paid out of non distributed profits, the quasi-rent pays for the investment which will yield the future quasi-rent. This does not seem essential to the argument.

[12] If this makes sense in the economy we describe which implies that firms set their own wages for incentive reasons (see III below).

training investment determined?

It depends logically on the bargaining powers of the two parties between the threat points. The threat point of the individual employee is determined by the minimum of the liquidity constraint and the other uses of his wealth. Unions will have better bargaining positions. The threat point of the firm is the minimum of the quasi-rent (after provision for the R and D expenditures) and a wage sufficient to poach outsiders with the required competences [13].

III. Continuing education in a schumpeterian framework. Some preliminary ideas.

The Schumpeterian framework is not only helpful to challenge BECKER's theorem, it can be integrated with other recent theoretical ideas to study carefully the demand and financing of continuing education, both from a positive and negative point of view. We will therefore introduce the organization of work in more detail with the tool of the hierarchical production function. Then we will have a look at general human capital as an input in the production of specific human capital in a dynamic framework. Finally, we will consider briefly the path dependancy of technology on the accumulation of competences.

III.1. Hierarchical production functions

The production and sale of a good requires, besides physical capital and intermediary inputs, different types of functions

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[13] The latters may not exist however, notably because some competences may be acquired by learning by doing in the new process.

exerted by the labour force[14]. If one leaves aside finance, marketing... and considers production only, he should recognize that the division of labour entails a hierarchy of employees and that those above the bottom level *manage and supervize* rather than produce. The production function is hierarchical (ROSEN/1982/).

The efficiency of employees at the different levels depends on their competences, their *effort*, the quality of the supervisors management and the hours. This corresponds to the case where their result is separable from the result of the other employees at the same level[15]. If they work in teams, it also depends on the efforts of their colleagues. Their effort depends on the efficiency of their supervisor, and so on to the top.

This means that even if some minimum levels in the competences are required for each position in the hierarchy, some substitutability between competences and effort exists. However effort - which has disutitity, at least above some level - depends on incentives as agency theory has shown. Hence the costs must be weighted, all the more that fairness considerations limit the changes in relative wages inside a firm.

Another consequence is that wages are set by the employer under an incentive compatibility constraint, and they will therefore differ between firms. There will be no market wage, but a participation constraint endogenous to the market, which will be defined in terms of discounted life cycle utility.

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[14]Functions correspond better to the work done by a large fraction of the employees of a firm nowadays as opposed to tasks. A function can be defined by an objective or a set of objectives whereas tasks are precisely defined. Functions are more difficult to monitor.

[15]An indirect marginal productivity can be defined for the supervisors.

If production is not separable at some level of the hierarchy, employees work in teams and can probably combine their competences more easily and complement one another. However teams lead to incentive (free rider) problems which are different from those applicable to the separability case and not easy to solve.

The point we want to argue on the base of this description of the organization of work is that when a new technology replaces an old one, the firm must modify the organization of work to some extent. In some extreme case, the lenght of the hierarchy line must be changed (there is a tendancy to shorten it), in some cases the number of jobs in each position (or hierarchical level) is changed. In all cases some changes in competences are necessary.

This leads to another crucial statement i. e. that the structure of the hierarchy influences the creation of the new competences. It can be illustrated by studying specific topics.

III.1.1. Teamwork and training

If employees work in teams, it is easier to replace an employee in production to give him some formal training than when the employees have jobs with a definite set of functions to fill alone. First effort of the other members may be stimulated, and second, some employees may have the assignment of replacing employees who are trained.

It also facilitates the mutual teaching as AOKI/1988/ has shown.

III.1.2. Rotation on jobs and training

The rotation of workers on jobs at some level in the firm, but with different functions, leads to an accumulation of different types of specific human capital through learning by doing. Such a wide array of specific competences enables the employee to deal with unpredictable situations, and this capability can be labelled to some degree a *general competence or human capital*, since it can be transfered to another function or firm.

A rotation policy is a policy decided by the firm. It has a cost, temporary lower productivity. Part of this cost is paid by the firm since the latter is not committed to carry it to the point where it becomes general human capital.

This is therefore a supplementary argument for the firms to pay for general human capital creation.

II.1.3. Promotions and the allocation of training

If the positions are filled from inferior positions in the firm, this practice has a considerable influence on the continuing education/training policy of the firm. The argument is by no means new, yet it must be mentioned because it takes its significance in a hierarchical production function framework.

The supervisor observes the abilities and effort of an employee in a certain position over a substantial period of time[16]. He selects the most able and motivated to invest education in them[17]. This investment is justified by the competences required by the fuynctions in the superior position. It is probably shared, but one wonders if the investment in effort and the hours necessary to assimilate the training do not constitute the employees share. In that case, no reduction of wage can be observed.

The employer will promote the selected employee when the superior position becomes vacant. This system, widely observed, yields a

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[16]Even in teams some evaluation is sometimes possible. Otherwise, some internal competition/exam may be organized as in the french mail company.

[17]The selection process may feed back in the effort as stated by tournament theory. This leads to an extremely selective human capital creation investment by the firm.

very efficient allocation of the ressources devoted to human capital accumulation by the firm.

III.2. General human capital as an input in the production of specific human capital in a schumpeterian world

General human capital improves the efficiency of the production of specific human capital, the other factors being given. It is a different argument from the complementarity assumption. The accumulation of the two types is sequential and the argument is stronger. In a world with a flow of new goods/processes, a specific competence or type of human capital becomes obsolete fairly quickly and another type must be created. General human capital is therefore intensively used to produce new specific human capital . It should have higher returns on average in a schumpeterian world than in a static world and there is a stronger case for the firms to finance it[18].

III.3. Human ressources as a determinant of future technology and performance.

The endowment of competences at some date acts as a determinant of the future quasi-rent: it influences the *technological trajectory* because the competences-technology complementarity at some date will determine the learning by doing and the costs to training[19] . A high endowment in general competences appears very efficient becauses it enables to choose in a larger set of technologies, through innovation or imitation. The firm can seize better profit opportunities.

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[18]LYNCH/1992/ offers empirical evidence that individuals with more schooling have a higher probability of obtaining OJT and more off-the-job continuing education. Schooling can be considered as a proxy of general human capital. Of course, this is not direct evidence that firms offer more general training.

[19]See DOSI/1984/ on this notion.

However a dynamic argument can be made for the voluntary specialization in some specific competences[20]. There may be increasing returns to training in some competences. The employees able to teach the competences are numerous in the firm when the average level in the competences is high. One sometimes speaks of the competence of the firm. The firm will then specialize and be very performant.

On the other hand a narrow specialisation of competences may lead to failure if shocks on demand at the microeconomic level are important.

These remarks should show that within the broad framework of a schumpeterian economy, there are many arguments for the firms to sponsor some of the expenditures on continuing education, and that far-sighted strategies can be a key to performance. Modelling some of these arguments is on our agenda of research.

IV. Some notes on the consequences for the competitiveness of the economies

Firms are innovators or imitators. An economy will be composed of many innovating firms and also many more firms which will adopt progressively the innovations and drive the quasi-rents to zero. To do comparative statics, and study the effects of some variables, we can conceive the notion of a flow equilibrium level of the quasi-rent. The microeconomic quasi-rents disappear and are replaced by others. Some firms disappear and are replaced by others.

High aggregate investment in the competences required to renew the quasi-rents should yield a high competitiveness of a nation in

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[20]There is also an involuntary specialization by a natural tendancy to forget the unused competences.

the world economy, provided that the firms in the other nations invest less, or have some other unfavorable factors (low capital stock, low natural resources...).

Leaving aside these other factors, firms in other nations should however provide also optimally for human capital creation and the nations should be equally competitive.

Different reasons may explain differences in the rates of investment in human capital by firms between nations, and we will review briefly some of them.

Financial constraints is one of them. R and D has a highly variable and unpredictable economic outcome. The quasi-rent is a highly stochastic variable. Even at the level of a nation, the quasi-rent may fluctuate at some date. Not enough funds may then be available for general training. Governments should be aware that there may be an irreversible effect on the future accumulation of competences.

The rate of peference for short run profits and the dividends policy on one hand, the cost of labour on the other may vary from nation to nation and act as constraints on the funds available for training in firms, in the context of a severe international price competition.

Finally firms underinvest in general human capital when there is no cooperation to overcome the free-rider problem. From a social point of view , the quits of workers with general training are not a social loss, but rather a social gain (because of better matching).

Countries where the institutions or the cultural environment favor cooperation of firms in the provision of continuing education may have an advantage in the accumulation of general education and competitiveness.

The role of the government in a Schumpeterian framework may then be to set the incentives for the firms to invest in general training, rather than only act as a substitute to a worker unable to finance an investment he should pay, as is the case in BECKER's framework. Such incentives may for instance take the form of setting a minimum rate of investment by firms, subsidizing firms which lose from mobility, improving the information on competences held by workers.

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EDUCATION, COMPETENCE DEVELOPMENT AND ECONOMIC GROWTH - A MICRO EXPLANATION TO MACRO ECONOMIC GROWTH

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In this paper I define education broadly and indirectly as the investment activity that produces the kind of competence capital that contributes to economic growth, as measured. Hence, this essay is partly a study of proper economic measurement. I am concerned both with the particular educational activity that occurs in educational institutions, separated from the job context, and learning in a broader sense, on-the-job or in the context of the job. I ask:

1) Why is *education* in a narrow and a broad sense important for economic growth?

2) What do we know about the quantitative relationships involved, and the incentives that promote competence development?

3) What can governments do? Are there well defined parameters? What knowledge is required to achieve political ambitions?

With the growth objective in focus the knowledge capital that drives economic growth will necessarily be broadly defind. This is one important point. Above all we cannot restrict ourselves to competence embodied in individuals. Competence embodied in teams, in the organization of firms, of markets and the entire economic system will have to be accounted for. Here the micro-to - macro model of IUI will be a useful intellectual tool.

Once the incentive problem is allowed in, and the imperfections of markets for competence accepted, the analysis is taken down to the micro level. The argument will be that the dynamics of agent behavior and markets matter for macro. More specifically, the benefit of efficient markets will be the capacity of the economic system to take decisions down to locations where the appropriate competence resides.

Hence, the problem addressed in this paper includes three tasks. *First*, identify the educational factor that contributes to economic growth, *second* learn how the markets for education should be organized for incentives to develop competence to be strong, *third*, once this has been done, study how educational production can be efficiently organized? This paper is mainly concerned with the first task.[1]

One "magic" variable will run through the entire analysis; the rate of return to invested capital over the interest rate, the temporary monopoly rent that the firm captures. I will call it $\hat{\varepsilon}$, and define it exactly in section 4. This variable is an important incentive variable in the capital market. Firms strive to keep it high. The expected $\bar{\varepsilon}$ drives investment behavior in the firms of the Swedish micro macro model. The present value of future expected such rents of the firm is evaluated all the time in the stock market. In finance theory this rent is labelled the risk premium. Most important of all, as I will demonstrate in the concluding section, there is a direct relationsship between the measured change in this competence rent and the rate of total factor productivity change, or the shifting of the macro production function. With the help of this magic variable we will be able to tie the growth, the incentive and the educational problems together.

1. Growth explanation or accounting?

The importance of knowledge for the economic wealth of a nation has been discussed in literature for centuries. To connect education with growth, and to define the content of knowledge contributing to growth - which is the main purpose of this paper - we need theory. It is convenient to keep four different theoretical approaches apart.

a) Pre-quantitative times.
b) Neoclassical analyses.
c) The "new" growth theory.
d) Micro based macro analyses

[1] In a parallel paper, prepared for the OECD: *The Markets for Educational Services* the whole range of questions are surveyed and studied.

a) Early thinking about education - pre quantitative times

Most early treatises in economics recognized the importance of knowledge, competence and skills. Such recognition was not so demanding in times when quantification was not required for "proper" analysis. In fact, already in 1768[2] - before *The Wealth of Nations* - the Swedish economist Johan Westerman was very clear about the importance of skills and knowledge for the international competitiveness of Swedish production. He traveled to England and to Holland to learn about superior production techniques, and he observed that labor productivity in the British shipyards was twice that in the Swedish shipyards. He concluded (already in 1768!!!) that the new machines were good to have, but what really mattered was the know-how to use them, and about how to organize work around them.

Awareness of the nature and importance of education and of production organization was by no means as explicit among the academic economists of these days, but it was there at least until John Stuart Mill (1848). But then it mysteriously disappeared, a disappearence in literature for about 100 years (Abramowitz 1988).

The reason should be sought in the nature of this particular capital item. It is not only difficult to measure, but also difficult to represent analytically in the kind of mathematical models that began to appear with the marginalist revolution. Knowledge is vested in human beings and acquired through the educational process (broadly defined). It applies very flexibly, and differently, depending upon use. It cannot be analytically disentangled from its carrier, and it doesn't depreciate from use as ordinary capital.[3] The easiest way was

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[2] Westerman, J. 1768, *Svenska Näringarnes Undervigt emot de Utländske, förmedelst en trögare Arbetsdrift*, Stockholm.

[3] Literature, until now, does not recognize depreciation of knowledge capital (see e.g. von Weizsäcker 1986 and Romer 1986).

to disregard it. Heterogeneity is the frustration of capital theory. The most heterogeneous capital item one can think of is knowledge (Ysander 1978b).

b) Neoclassical analysis

Neoclassical analysis is a natural extension of classical Ricardian analysis of the late 19th century. In the immediate postwar period it took on a very concrete shape, as more and more statistical data were brought together. Input output analysis picked up the notion of a macro production function, which was ultimately refined by Solow and his followers.

As macroeconomic development of the postwar Western economies surpassed past benchmarks, the profession began to worry whether they had gotten their numbers properly organized. Above all, the Ricardian-Marxian notion of a production system fed with machines and manual labor hours, and possibly land, was not sufficient to explain observed, rapid productivity growth. Many researchers (Denison 1967, Jorgensen-Griliches 1967 etc.) began to look for *quality* dimensions of factor inputs, that could explain measured productivity growth. They all, however, more or less stayed within the equilibrium framework of neoclassical economics, and notably Jorgensen-Griliches (1967), who designed a sophisticated method of correcting factor inputs one by one for quality change, using the implicit price structure of an equilibrium system. In doing so they more or less removed the residual, unexplained technical or productivity factor. This, however, has to be the result by virtue of the method used. It can be demonstrated (see Eliasson 1987, 1990c, and below) that unaccounted for factor inputs, or factor inputs not paid the equilibrium price, will nevertheless contribute the market value to production, and hence, instead contribute a residual value to the owner of capital. Since this residual profit has been created by factor inputs not measured, or measured, but not properly paid, it will exhibit itself as an unexplained residual growth factor in macro production function analysis. If you correct factor inputs for errors of measurement in price statistics, you remove the corresponding unexplained production factor by definition. Jorgensen (1984) and Jorgensen-Fraumeni (1989, 1990), and others have used that method recently to demonstrate the importance of education in macroeconomic growth. In doing this they find that education matters economically very much, since pay differences, whether being the result of education, original underlying talent or some market imperfection, explain a large part of total factor productivity growth.

As a consequence they also find that the decline in relative compensation for education since the middle of the 70s, and the strong increase in relative compensation for education thereafter (Blackburn-Bloom-Freeman 1990), also explain a large part of (or much of) the disappearance in the 70s, and "the return" in the 80s of total factor productivity growth. The method guarantees such results, and even though they are plausible, they have to be more carefully studied before any firm conclusions on educational policy can be drawn.

It is important to keep in mind that if Jorgensen's method was applied to Swedish data, with more compressed wage differences than in the US, and longer lasting, large divergencies between marginal productivity and compensation, because of Swedish distributional policies, the result technically will be that slow production growth, if it correlates well with the so corrected factor inputs, can be explained in terms of these corrections, i.e., by the equalitarian wage policies pursued in Sweden. Also this is a very plausible explanation, but much more analysis than such correlations is required for policy advice. To this I return in the micro section below.

The macro production function approach establishes one-to-one links between labor qualities and the corresponding output. It, however, misses important characteristics associated with imperfect markets and changes in the organization of production within firms, and in markets. Such organization embodies technology of various kinds within firms and in the organization of the institutions of markets, notably contract technology, (see Eliasson 1992b). Changes in such technology normally violate standard aggregation assumptions of macro production function analysis. If the contribution of organizational change to economic growth is disregarded, too much weight will be given to individual factor quality change and education. Hence such change has to be made explicit. Thus, it becomes natural to discuss what changes in *industrial structure* mean for the demand for particular labor qualities. It also becomes natural to discuss what more education at different levels will mean for output growth. As I will argue later this is, however, the wrong way to ask the question. A recent "puzzle" has been the increased demand for highly educated labor in the US (Blackburn-Bloom-Freeman 1990, Kosters 1990 and Bishop-Carter 1990) being accompanied by a matching increase in the return to education. On this, Berndt-Morrison-Rosenblum (1992) find that these increases are related to growth in highly technical (office and information technology) capital. There is, however, no reported positive relationsship between growth in such competence or in highly educated labor on the one hand, and labor productivity on the other. The problem is to capture the nature of technology change and the interaction of supply and demand of human capital. As we will see such answers require that we step down to the micro level. First, however, a few additional variations on the macro theme.

c) The "new" growth theory

The so called "new" growth theory originated in Lucas (1988) and Romer (1986). It has generated a cascade of variations on the theme. The reason for its popularity probably is its close mathematical connections with the above standard neoclassical production theory. The mathematics is the same, and some members of the old neoclassical school, like Dale Jorgensen, would argue that the "new" is no more than a modification of the "old" macroeconomic growth theory.

The idea is simple. Romer (1986) introduces an "infrastructure" knowledge competence as an externality in his model economy. This knowledge factor confers scale economies to all other factors of production. Since Romer's model is essentially the old static general equilibrium model his problem is to obtain an internal solution, despite the existence of increasing returns. His trick is to assume strongly diminishing returns to knowledge accumulation ("education"). The only difference between Romer's model and the classical (or neoclassical) model, hence, is that he has shifted the exogenous productivity or trend assumption of macro production function analysis backward in the investment production chain, *from* the exogenous total factor productivity assumption *to* the productivity assumption associated with the educational process that shifts the production function. The new growth theory also makes it more natural to introduce all kinds of externalities in the analysis of productivity advance, notably know-how created in other sectors. Thus, for instance, Government sponsored education, health care and insurance carry spill over effects to private firms.

Suppose, following Romer (1986, p. 1015) and Eliasson (1989), that the production function

$$Q = F(k_i, K, x_i) \tag{1}$$

is concave as a function of measured factor inputs k_i and x_i for any fixed value of K. K is the *level of general knowledge* which improves the productivity of all other factors. K is a capital good with an increasing marginal product. As long as there are diminishing returns in the activities that create K, the static general equilibrium model will have a finite solution.

I will now translate Romer's model for the general equilibrium setting of an entire economy to a firm model.

Let me assume that measured factor inputs are:

k_1 = Machinery and equipment capital

k_2 = Product-oriented R&D capital

k_3 = Marketing capital

x_i = Labor input, standard hours, allocated to the various capital items,

$i = 1, 2, 3$

K is the general, unmeasured knowledge base *of the firm* that is accumulated as part of the ongoing production process. In so far as some "tacit knowledge" has been compensated in the form of wages to other factors X_i, the K incorporates the general organizing knowledge needed to organize all other factors into a team, a firm (Eliasson 1990b). K has thereby been defined as the recipient of residual profits when all other factors have been paid. This is a capital input traditionally associated with the risk taking of owners, but it can as well be associated with all knowledge (competence) inputs of the owners (Eliasson 1988b). In so far as top-level managers hold stock in the company, they get paid two ways for their competence input; in the form of salaries and in the form of dividends and capital gains on company stock, if their competence contributions generate excess profits.

The main point here is that the competence capital K generates increasing returns to all other factors of production of the company, but that it is a scarce resource whose production occurs at diminishing returns. The K factor input is assumed not to depreciate from use, as do other factor inputs.

It now only remains to show that K in fact has the "scale" or "leverage" properties we have postulated. To do that - following Romer (1986) - assume F() to be homogeneous of degree one as a function of (k_i, x_i) when K is constant. This is an insignificant further restriction. Given that, for any $ø > 1$.

$$Q = F(øk_i, øK, øx_i) > F(øk_i, K, øx_i) = ø\, F().$$

F now exhibits increasing returns to scale in K. In the growth process of the firm, K is the know-how created, say from organizational learning that can be exploited by increasing the size of the firm.

The proof I have given has been in terms of the traditional, static production function. We can then use the term economies of scale, although economies of scope may be more appropriate. However, even this term is not the right one, since we are talking about an *organizational learning process* that creates tacit competence embodied in the organization and its people.

If both traditional economies of scale and unspecified embodied knowledge accumulation are present, the two cannot be econometrically separated. And if the tacit knowledge capital - whatever it is - is perfectly correlated with "scale", a prior scale formulation will reinterpret improvements in organizational competence as originating because of scale and vice versa. The acquisitions of Zanussi (Italy) and White Consolidated Industries (U.S.) by Swedish Electrolux provide a good illustration. Obviously the acquisitions enlarged the scale of Electrolux in physical terms. There should be mechanical scale benefits to exploit. However, the success of Electrolux over the years has to do with more than that in the sense that top management in other firms doing exactly the same thing would not necessarily have created the same successful results, because they lacked the particular experience the Electrolux management team had obtained over the years. Even though one can give several examples of pure, physical economies of scale with economic implications (e.g. the natural laws controlling electricity transmission, see Smith 1966), the notion of scale becomes the wrong concept if the exploitation of economies of scale requires technology, i.e., knowledge. The question, then, is how to represent the dominant competence input in the production process mathematically. The above production function representation, borrowed from Romer (1986), is a step in the right direction, but it does not take us out of the static neoclassical world, since it does not explain the accumulation of the competence. This has to be done simultaneously with the explanation of production, if competence, or knowledge capital, is "tacit" and "learned" through participation in production. Then dynamics is created in the form of a "path-dependent" economic process to which we now turn.

2 Micro based growth Analysis

There are two problems to deal with. Neoclassical, or the "new" growth theory are no theories of growth. They describe measured economic growth, but the growth engine is essentially exogenous. In particular, they don't capture the importance for macro of agent behavior in dynamic, "imperfect", markets, and of organizational change within firms and between firms. And these factors matter significantly.

Second, knowledge and competence are human embodied "factors" that occur as micro phenomena. To understand them, one has to begin with the behavior of micro agents. Once we have accepted economic growth as the policy objective, and defined the circumstances of the production system that contribute positively to growth, we can derive certain tangible (definable) characteristics of the competence capital that we want to increase. This is necessary to say something on the organization of educational production. To identify the knowledge factor behind microeconomic growth at the macro level it is necessary to begin with each of the three different agents involved;

- the *firm*, the employer
- the *individual*, the employee (incentives)
- the *policy maker* (macro and distribution)

Each of these agents operate in an economic environment called:
- the *market*

It is obvious from this presentation that the ways micro behavior is combined (aggregated) to macro behavior matter for economic growth. The way individual behavior results in macro economic output then depends upon how individuals team up in firms, how competition in markets affects firms and how rules imposed by the policy maker affect competition. Hence, there are two aggregation problems to recognize; *within* the hierarchies of the firm and *through* markets.

Since competence and knowledge are inherently heterogeneous (this proposition will be elaborated in the next section) and since knowledge can confer strong economies of scale (here I buy the idea of the "new" growth theory) it matters very much for growth whether knowledge is efficiently allocated. The combined proposition of this paper (to be stated already here, see also Eliasson 1992) is that macro economic growth critically depends on *the capacity of the economic system to take decisions down to the levels where the appropriate competence resides*. This means that relevant growth theory *has* to be micro (firm, individual) based and that the competence or knowledge endowment of a nation includes the particular organizational knowledge that makes this allocation possible.

The firm, employer

To identify the nature of the competence capital at work in a business firm the firm has to be characterized in terms of its market environments. As will become clear from what I say, the mainstream economic model will take us along the wrong track, since it does not allow for the relevant characteristics of the firm.

The business firm organizes people with competence to satisfy financial (profit) targets. This involves recruiting people, coördinating people and upgrading their competence. This process is controlled by a top level *organizational competence* [vested with the top competent team, (Eliasson 1990b)] that also has to learn to make superior organizational decisions.

The firm of the mainstream model makes no mistakes. All *information* is available (in principle, at a cost) for the market or the auctioneer to arrange an equilibrium, full information solution. Conditions have to be *assumed* to be such for the aggregation assumptions of the above macro approaches to human capital based growth theory to be upheld. Modern IO theory, allowing for asymmetric and costly information arrives at the same result, provided the market is free from various kinds of selection problems, notably the lemons problem (Akerlof 1970, Greenwald 1986). I will demonstrate below that these problems are typical of markets, notably the labor market and, hence, necessitate the micro based macro analysis that I attempt here. The lemons problem is also the key troublemaker of the incentive system (see next section).

The individual

The firm looks for competence in the labor market, not for labor hours. The individual supplies the same qualities.

The individual is, however, at a disadvantage. It is risk avert by mental design (and assumption) and it commands no resources, except its talent and knowledge (= competence), that is, however, difficult, perhaps impossible to assess prior to inspection. A certain market or contract technology is needed to establish the trade in human competence that eventually moves economic growth.

There is a market for educational services, for intermediation services, in the labor market (search) and for insurance for the income risks over the individual's life cycle in the labor market. The absence of, or the failure of the market system to create viable such markets, or the political destruction of already functioning such markets through regulation, are sufficient causes for reducing the efficiency of the allocation of competence in the economy, and hence macroeconomic growth.

The market

The nature of the firm or the individual as they appear in economic theory depends on the theory of the markets in which they are supposed to operate.

The classical model offers little help here, since it is totally silent on the dynamics of competition and of firms as well as on the significance of knowledge, except as it appeared in macro production function analysis above.

This is not a particularly promising foundation for an inquiry into the nature of the knowledge base that contributes to economic growth. For this we need an alternative to the classical model, a model of dynamic markets which never clear, but are characterized by an evolutionary ongoing economic process, moved by ex ante unpredictable entrepreneurical initiatives, some generating success stories but also a steady flow of mistaken decisions. I have called this the *experimentally organized economy*[4] (1987, 1988a, 1991c), since this economy thrives on a certain amount of local uncertainty caused by individual agent behavior, and looses performance from the imposition of too much order.

Hence, the experimentally organized economy does not only allocate given resources on given uses. It is also – and more importantly – part of the creation (entry) and the allocation of new resources, and of forcing obsolete resources to move, or to exit. In the labor market such innovative activity takes on particular forms since it concerns human beings that are both creative and capable of upgrading and changing their ability characteristics. Education and experience accumulation in a broad sense is part of this selection and allocation process. Economics and pedagogics have been caught, over a couple of decades, in a long winding controversy over the relative importance (for economic growth and individual proficiency) of this selection, on the one hand and educational investment on the other. The classical economic model which reallocates given resources to given and known uses

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[4] For a presentation of the distinguishing characteristics of the EOE see Eliasson (1987, 1988a, b, 1990b, 1991c). It is obtained by a seemingly innocent modification of the assumptions of the classical, static equilibrium model, forcing bounded rationality on the agents of the economy, namely a sufficient expansion of the state space (called the opportunity set) of the economy and a provision for free innovative entry. All conclusions in favor of a centrally planned order have been achieved by assuming a sufficiently small or transparent (at no cost) state space in models with no entry.

is, by its very assumptions limited to the analysis of the educational investment decision (human capital theory), disregarding more or less the selection effects. Its representatives tend to push this particular view hard as an empirical phenomenon, by assumption. It is obvious that the theory of the experimentally organized economy allows a much broader view of the educational process, allowing explicitly for both the educational investment process and selection phenomena. In fact, studies on the Swedish micro-to-macro model – an approximation of the experimentally organized economy (Eliasson 1990c, 1991b, c) – suggest that the selection component of total factor productivity growth may be the by far most important one (Eliasson 1991a, Carlsson 1991).

The ability of the individuals of the economy to cope with the unexpected change of the selection dominated experimentally organized economy constitutes part of the human capital of the economy. As will become apparent as I go on this ability depends on the capacity of the economic system to provide adequate *insurance* (see further Eliasson 1992) in an economy where risk avert individuals are subjected to rather rough treatment as a consequence of business mistakes being in turn a normal cost of economic growth.

3. Organizational learning and Competition drive economic growth

Once we have left the accounting framework of macro theory and taken the growth explanation down to the level where agents operate in dynamic markets organizational learning, knowledge and technological competition become the mechanisms behind a viable growth explanation.

The limits to learning

New competence can be acquired through internal education, or in the market through recruitment and through the acquisition of competent firms or parts of firms (Eliasson 1991d). At some rate such acquisition of new competence is perfectly reliable, but the economic value of the competence is reduced to the extent that competitors acquire the same or better competence faster. If, on the other hand, the firm tries to acquire competence very rapidly it normally incurs a higher cost in the form of a higher rate of business failure. When seen at the aggregate level of a sector or the entire industry, business mistakes constitute a standard cost of economic development. The more rapid (everything else the same) competence accumulation of a firm, a group of firms or a whole industry, the larger the incidence of failure, but also the larger the probability of a major business success. Since the economic value of acquired know-how depends on what other competitor firms do, *strongly diminishing returns to learning* or the acquisition of knowledge should be exhibited because of the rapidly increasing rate of business failure (Eliasson 1990c). This means that no individual firm will be able to raise K in (1) through allocating all its resources on learning and thus, forever outcompete its competitors through the consequent gains in economies of scale. The same results should hold for a country.

The strongly increasing rate of failure, the faster the ex ante rate of learning has to do with the inability of a decentralized economy to cope with massive innovative behavior that disrupts the stability and coordinating capacity of its price system.[5]

[5] It should be noted for the record that this does not mean that a hierarchical order (central planning) will do it better. Under the relevant conditions of the experimentally organized economy, the necessary condition for transparency (perfect information) are not upheld.

The content of economically valuable knowledge

Apparently, the content of economically valuable knowledge is a quite complex blend, that has to be defined at different levels of aggregation: It is multidimensional beyond emprehension from one point of assesment and only parts of it are applied on each occasion. Individuals also embody human capital of different quality. Firms organize individuals into competent teams, contributing through their organizational technology something in addition to the component indivudal qualities. The economy as a whole merges - through its organization (the economic system) - individuals and firms to generate economic values (output). The number of possible combinations, if we start from the level of the individual and move up, is enormous and beyond everybodys understanding. This is the "basic fact" of the experimentally organized economy. Each "merge" has been achieved through experimentation in markets and hierarchies, not through careful analysis and explicit decision. The key to macro economic performance, hence, is to organize the economy such that the mass of heterogenous human and firm based competence residing in an industrial economy is optimally exploited. This, first of all, means organizing the economy such that decisions are taken down to levels where the appropriate competence resides, i.e. in general at the level of firms and individuals, and away from central hierarchies.

But this is only part of the organizational, "tacit" knowledge capital of a national economy. The enormous complexity of this organization means that there exists no simple optimal point. There are several "high levels" and even though the economy may be temporarily close to one optimum, nobody in the system will be aware of it. The economy, hence, is constantly in a flux, being moved by agents striving to reach better positions, pushing other agents out of their established positions (Eliasson 1991c).

The ability of the agents to compete successfully through innovation is in principle a "learning" phenomenon, as is the ability of agents to cope with unexpected change.

The continuing flux of the competitive market process also means that the exact nature of firm or individual competence required for success, will also constantly change. There is no stable specification of the characteristics of the optimal knowledge at each allocation (organization). Since requisite knowledge is not a well defined item that can be replaced, when needed, knowledge capital, as all other capital has to be depreciated, and increased through new investment (education).

The complex nature of such knowledge makes it more or less unmeasurable, except indirectly in terms of the present value of future expected returns of firms as assessed in the stock market, or directly in terms of the cumulated value of investments in "education" of a firm or an individual. The reader should take note of a particular distinction here. Human, capital theory assumes the existence of stable earnings functions, implying the existence of perfect markets, being perfect in terms of their capacity to perfectly evaluate the human capital embodied in an individual. Such measures will always be biased by the imperfections of the labor market.

At the same time the standard method in capital theory is to accumulate investments in machines, buildings and inventories, assuming a certain depreciation rate, thus obtaining a measure of capital stock. Even though I say that competence capital, due to its complex and varying specification, is not directly measurable, what I propose to do is to apply the standard capital measurement method in economics to measure competence. The only distinction to add, however, is that it may be possible to measure certain simple capital items, like machines directly through explicit specification of performance characteristics, which is done in engineering contexts, but rarely in economics.

The firm of my market reference model, *the experimentally organized economy* (see Eliasson 1991c) makes plenty of mistakes, because of the general non-transparency of its local market environment and the unpredictability of the responses of its competitors. The firms are, however, supposed to be capable of coping with such a competitive market environment, or go bancrupt and exit, even though firms frequently try to protect themselves from market competition, thus creating market imperfections. Hence, unique, but transient knowledge and the competence to identify and correct decision errors early dominate firm success (Eliasson 1990b). *Individuals,* on the other hand, being assumed to be normally risk averse, cannot be expected to be able to cope with their experimentally organized market environment alone, and, hence, have to be treated specially.

Since the unique knowledge base of the firm is constantly exposed to competitive peril threatening the firm with sudden obsolescence, coping with change, forgetting and organizational learning are key critical competence characteristics that also dominate firms' recruiting.

The recruitment problem of the firm is, hence, schizophrenic. At each point in time the firm needs a particular package of competence characteristics. But firm management does not know, and will not be able to predict with any accuracy the nature of that package. It will have to develop the required characteristics through experimentation, and suffer from repeated failure along the way.

This means that a firm will be as concerned with getting rid of people with the wrong competence, as it is with acquiring people with the right competence (in expectation) provided internal retraining programs, that are also profitable, cannot be organized.

This behavior on the part of the firm also determines the local environment of its employees. Employees, typically characterized as being *risk averse* do not like this environment. As a consequence, labor directly, and indirectly through unions or through the political process has exercised a demand on the firm for *insurance* for the vagaries of market life.

Even though knowledge capital cannot be directly measured and its content still remains more or less a mystery, we can say that besides *education* broadly defined, individuals as well as firms require the *additional ability to cope with unexpected change*. This is partly a capacity acquired through experience in the market. For individuals this means that a *functioning labor market* is part of their educational experience. It also requires that appropriate and efficient *insurance* markets exist to make individuals overcome their innate risk aversion that is otherwise detrimental to their human capital accumulation.

Technical change creates more competition

At this junction we may make a choice. We can tell a (1) *neoclassical* story about exogenous technical change, which will be partly untrue and misleading and (2) we can do micro-macro analysis and also explain technical change. I will do both, and begin with the micro-macro analysis and then simplify it in the next section through imposing some strong aggregation assumptions, such that the outcome looks very neoclassical and devoid of the important and interesting economic knowledge content.

The micro-macro analysis will be done verbally in terms of what may be called a Salter curve analysis.

In this section the magic variable $\bar{\varepsilon}$ will be defined. Its presence in my story - besides being a useful tool to derive neoclassical macro analysis as a distilled version of dynamic micro-macro analysis - becomes a natural part of a nice chronology of economic doctrines.

Since the marginalist revolution diminishing returns have been needed to secure internal solutions in economic models. But diminishing returns have constantly failed to show up in empirical studies, which has been a source of constant concern. Knight (1944) suggested that observed increasing returns must be the result of an unmeasured knowledge input.

McKenzie (1959) came back to the same problem, observing that measured factor payments constantly failed to exhaust total production value. This difference, again, when divided through by employed capital, constitutes - as we shall see - the epsilon value. And McKenzie suggested that this difference must be the return of (the rents from) some unmeasured knowledge capital that can be associated with individuals or firms.

At the micro level such rents are both positive and negative signifying business sucess or failure. Hence, in the computable risk environment of modern finance theory the epsilon constitutes a risk premium only, since finance theory, being shaped in the classical model without selection does not recognize the presence of unmeasured competence capital (Eliasson 1988b).

In the experimentaly organized economy of our analysis, uncertainty, as distinct from risks prevails (Eliasson 1990b). Already Knight (1921) suggested that the competence to convert uncertainty into ex ante computable risks constituted the rational foundation of a firm. So the two devices come together naturally in a world where both uncertainty and risks prevail, and then allow an empirically better founded explanation than that of finance theory alone.

The story can therefore be nicely concluded if the competence rent, that I have called ê, can be demonstrated to be related to the shift factor in production function analysis.

With competence being the ultimate, dominant capital input of a firm, its incentive system has to be organized such that returns to the competence to coordinate inputs to the benefit of the owners of the firm are satisfactory. At the firm level, however, such competence has to be much more broadly defined than technological competence. It resides in the people of the organization and how they have learned to work together in teams. And the top competent team of the firm is instrumental in achieving this coordination through integrating the three dimensions. Exploiting market imperfections is an important business activity and eliminating the results of such imperfections from productivity measurements may be directly misleading. Competence is, however, human or team embodied and not subject to the same contractual property rights as physical goods. It is acquired through experimental learning in the market. It is not easily tradable and difficult to learn or imitate by outsiders, if they lack the requisite receiver competence. Failures are, hence, frequent, both when learning is through imitation and when innovative and bold. It follows that "lost competence" or "obsolescent" competence can rarely be replaced by crash learning or innovation programs, especially on a broad industry-wide basis. Strongly diminishing returns to learning rapidly set in, due to frequent failures.

The dynamic competition story on the allocation of educational knowledge services can be nicely expressed in terms of so-called Salter distributions of epsila ($=\hat{\varepsilon}$), or the rents from competence (See Figure 1). I will discuss this market in terms of competing firms but it is equally valid for competition among individuals in the labor market.

Competition creates technical change

Firms in Figure 1 are lined up from the left in terms of their ability to generate rents or a return above the market interest rate ($=\hat{\varepsilon}$). The size of the rent is measured vertically and the size of the firm (its capital in per cent of total capital of all firms) is measured horisontally. There is a layer of ex ante such distributions at each moment of time, depicting the ex ante perceived rents of all existing firms, of all firms including entering firms and excluding exiting firms, and (very important) the corresponding expected distributions as anticipated by each firm. All these distributions change as decisions taken are ultimately realized ex post, reflecting over time the dynamics of competition in financial markets, being driven by the organizational competence of firms.

Let me briefly go through the dynamics of competition in the capital market as it occurs in the Swedish micro-to-macro model (Eliasson 1991c). Each firm in the model is represented in each market by a ranking on the vertical axis or the epsilon distribution, the width of the column measuring the size of the firm in percent of all other firms. (Fig. 1 shows that even though the firm indicated has increased its rate of return between 1982 and 1992 it has lost in ranking).

Each firm also has its own potential productivity frontier, under which it is operating to position itself on the productivity and rate of return rankings. This is still actual ex post performance. The dynamics of markets on the other hand is controlled by a second set of *potential ex ante* distributions, that capture the planned actions of all other firms, including new entry.

There is a third set of Salter curves that tell how *each firm sees itself positioned relative to other firms*. The real world of the experimentally organized economy, and its model approximation, the Swedish micro-to-macro model both show large *divergencies between actual and perceived positions*. Those ex ante distributions indicate the potential for a given firm to outbid all other firms in wages, or in paying a higher interest rate.

The firm learns directly if competitors can do better. Management then knows that it had better improve in order not to be pushed down along the Salter distribution, and, perhaps, out. Similarly, when the firm finds itself close to the top, it knows that close competitors are taking actions to better their positions through innovation or imitation. If potential Salter distributions are sufficiently steep in the top left-hand group, firms attempt to improve their positions on the Salter curve through innovative activity, or through entry. No firm is ever safe under these market circumstances, and constantly has to take action to better its position. This moves the entire economy through a selfperpetuated, growth creating, competitive process. The other side of this growth process that concerns us, is the steady change in the environment of the employees, as each firm tries to outcompete its competitors. Large opportunities are created for everyone capable of capturing them. In doing so they push their competitors down and right on the curve. During the 60-s and part of the 70-s it was thought that better planning would replace this experimentally organized competitive process, and measures were taken that slowed down the process, lowered competitiveness of firms and slowed down economic growth, eventually causing even more hardship on the people. Currently economic political sentiment seems to be moving in the contrary direction, as more and more sectors are deregulated, and even the most hard core of all protected production, the public sector is gradually opened up to competition. My a priori position (also expressed in an earlier book, Eliasson 1992) is that the preferred policy is to make people accept and learn to cope with the volatile environment of the experimentally organized economy. This is essentially an argument for improved insurance in the labor market. In this insurance education plays a fundamental role.

The story will therefore be nicely concluded if the competence rent, that I have called $\hat{\varepsilon}$, can be demonstrated to be related to the shift factor in production function analysis.

4. Connecting Organizational Competence back to Competition and Economic Growth

Competence coordination and monitoring is a matter of managing people with competence. It involves not only incentives to contribute but also to stay with the team. In this section I link the "unmeasurable knowledge" or innovative competence function to firm objectives (profits) and the creation of economic value over and above the value of resources put in (total factor productivity growth = DTFP)[6]. I will do this mathematically in terms of the information and monitoring system of a firm as it appears in the Swedish Micro-to-Macro

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[6] The mathematical derivation has been taken directly from Eliasson (1990c).

(M-M) model. The task is to establish a relation between the competence rents (= $\overline{\varepsilon}$), firm total productivity change (DTFP) and growth in output (DQ).

In doing so I cut right through the dynamics of competition discussed in the previous section. I thus exclude the endogenous growth drive of the macro economy by assuming perfect competition and making ex ante equal to ex post. In doing so I remove the explanation to economic growth and take the model back to the neoclassical accounting format.

Let me assume for simplicity that the only measured inputs needed to produce output (Q) are labor (= L) and capital (= K). DX stands for the rate of change in X.

Define:

$$\varepsilon = PQ - TC \tag{2}$$

$$\bar{\varepsilon} = \varepsilon/K \tag{3}$$

$$TC = wL + (r + \rho - \frac{\Delta p^K}{p^K})K \tag{4}$$

$$R^{NE} = R^N + (R^N - r)\phi \tag{5}$$

$$R^N = M\alpha - \rho + \frac{\Delta p^K}{p^K} \tag{6}$$

$$M = 1 - \frac{w}{p}\frac{1}{\beta} \tag{7}$$

It follows immediately that:

$$\bar{\varepsilon} = R^N - r \tag{8}$$

$$pQ = TC + \bar{\varepsilon}K \tag{9}$$

R^N = nominal rate of return to total assets K

R^{NE} = nominal rate of return to net worth (E=K-D)

ρ = rate of depreciation

M = operating surplus per unit value

D = nominal debt

w = cost per unit of labor input (=L)

r = interest rate

p^K = capital goods deflator

p = value added (=Q) deflator

Φ = D/E

α = pQ/K (capital productivity, uncorrected for relative (p,p^K) price change

β = Q/L (labor productivity)

$\bar{\varepsilon}$ is the difference between the rate of return on total assets (R^N) and the interest rate (r) paid by the firm. $\bar{\varepsilon}$ can be positive or negative. But a firm will not survive for ever with a negative $\bar{\varepsilon}$. Compare (2) and (7) and you will see that ($r+\bar{\varepsilon}$) is the equilibrium price for capital services that exhausts total value (=pQ) product when $R^N=r$ and $\bar{\varepsilon}=0$.

$\bar{\varepsilon}>0$ arises - as suggested by McKenzie (1959) - as a consequence of unmeasured (or not measurable) capital, not included in K. This asset has a time dimension in the sense that returns may come with a delay. Even if $\bar{\varepsilon}$ is negative the corresponding asset, hence, might very well have a large positive present value. Part of this time dimension can be interpreted as a risk factor that demands a reward (a risk premium).

To explain growth, however, you have to explain the way $\hat{\varepsilon}$ arise (innovation) and are competed away. This is done in the micro based macro model or in the theory of the experimentally organized economy. In neoclassical macro growth analysis aggregate $\hat{\varepsilon}$ are assumed or measured, but not explained.
To the extent one $\bar{\varepsilon}$ measures value created by a not measured capital input in a firm it must have something to do with economic growth. I therefore prove (see appendix) the following relationship:

$$DQ = s_1 DL + s_2 D\bar{K} + \frac{\Delta\varepsilon}{pQ} \qquad (10)$$

s_1 and s_2 in (10) measures labor and capital income shares respectively. Apparently $\Delta\varepsilon=0$ when these shares exhaust total value added.

A whole lot of technologies are compatible with constant income shares s_1 and s_2, the most well-known being the power function (so-called Cobb-Douglas) specification.

After differentiation the entire class of functions:

$$Q = CL^{s1}K^{s2}T \quad (11)$$

becomes (10), where T is a shift factor, usually assumed to represent exogenous disembodied technical change.

Apparently from (10) and (11) total factor productivity change becomes:

$$DTFP = DT = \Delta\varepsilon/pQ \quad (12)$$

under the assumption of Cobb-Douglas technology. This is enough for my purpose. I have demonstrated - for one particular production technology - that the estimated (on specification (10)) shift factor (DTFP) picks up a host of economic influences related to the allocation of resources and the exercising of competence within the firm. As a consequence the return to that unmeasured capital - that I have labeled $\bar{\varepsilon}$ - also shows up in the "technical shift factor". This competence input - by definition - also includes the ability to deal with uncertainty (successfully taking on business risks). Hence, the interpretation of $\bar{\varepsilon}$ in the modern theory of finance becomes part of this more general formulation.

The technology factor, however, also picks up the contribution of the entrepreneur, or trader, from exploiting market imperfections, for instance to successfully hire talented people at lower wages or salaries than their marginal productivities. Also capital gains will appear in ε. Since capital gains are also the result of trading in imperfect markets they reflect the competence of the entrepreneur to trade and should not be deflated away in productivity measurements. This competence can be seen to be exercised through the formation of synergistic teams, in which individual contributions are magnified through the exercising of top entrepreneurial competence.

Scale effects originating in the application of top entrepreneurial knowledge by definition make markets imperfect. Whether the firm operates as a

Kirznerian (1973) equilibrator or trader or imitator, making money from moving the economy closer to equilibrium, or as a Schumpeterian entrepreneur, enhancing the productivity of the system through changing its parameters and disturbing the equilibrium, it creates (in both cases) positive value additions to output.

It is not, however, universally accepted to allow such improvements in allocational efficiency to appear as technical change in macro production function analysis, and much work has been devoted to correct price indexes for the effects of such market imperfections. (For a discussion see Dargay 1988 and Färe-Grosskopf 1990, Morrison 1990).

If, for instance, prices used are equilibrium prices - corrected or not - a new competitive situation is reflected in a new set of equilibrium prices, and all quantities adjust to this new price configuration along the production frontiers. This is the method of computable equilibrium modeling. The a priori production technology chosen usually demands a particular price index to leave the shift factor (DTFP) invariant to such adjustments.

The preceding discussion, however, raises a much more profound question. If imperfections in markets are fundamentally due, not to asymmetrically distributed information or slow learning or adjustment behavior, but rather to fundamental inconsistencies in beliefs, competence endowments or the formation of business judgements, actions taken on the basis of such inconsistent opinions will constantly reshape the structures that at each point in time represent the productivity characteristics of the firm or the economic system, that in turn shape future ex ante perceptions of what is to come and so on. The path the economy takes will spin off ex ante/ex post realizations that will be reflected in the shift factor DTFP in (12) since they represent positive or negative value contributions to output.

This paper has been devoted to showing that the use of economic knowledge embodied in the organization of the firm or the economy, notably the organization of human talent, determines the character of the value added contributions that appear as total factor productivity change in macro production function analysis. The ultimate organizational technology of a nation then becomes the art of organizing itself - through experimental learning - such that these value added contributions are steadily positive. Then economic growth occurs. Hence, an analysis of the macroeconomic effects of competence also requires (1) an analysis of the capacity of markets to stimulate (reward) competence development and allocate competence and (2) the capacity of firms and schools to organize learning efficiently.

5. Summing up

I have shown in this paper that the returns to some unmeasured capital input that I call knowledge or competence by definition makes up the excess returns or rents on measured capital in firms, while the change in these excess returns to figures importantly in total factor productivity change in macro production function analysis.

So presented we have no explanation to economic growth, only measurement or growth accounting. Growth theory or a growth explanation demands that the dynamics of rent creation and destruction through competition in markets also be explained at the micro level. In such a model of what I call the experimentally organized economy, the creation of new knowledge (innovation) in firms and the destruction of old knowledge capital through technological competition through the use of such new knowledge become the driving forces behind macro economic growth. I also argue that the competition to create such new knowledge and rents is as much a matter of how people with competence are allocated in the market or team up in firms as it is the result of well defined educational investements in people. Since this allocation is very much a matter of how the institutions of markets for educational services and competence are organized, this organization of markets in turn becomes a major explanation to economic growth.

Appendix: *Proof of (9)*

From (1) and (2);

$$PQ = wL + (r + \rho - \frac{\Delta p^K}{p^K})K + \varepsilon$$

Take differences, assuming (p, w, r, p^K) fixed;

$$P \cdot \Delta Q \equiv w\Delta L + [\ \ ]\ p^K \Delta \bar{K} + \Delta\varepsilon$$

Thus,

$$\frac{\Delta Q}{Q} = DQ \equiv \frac{wL}{pQ}DL + \frac{[\ \ ]\ \Delta p^K \bar{K}}{pQ} \cdot D\bar{K} + \frac{\Delta\varepsilon}{pQ}$$

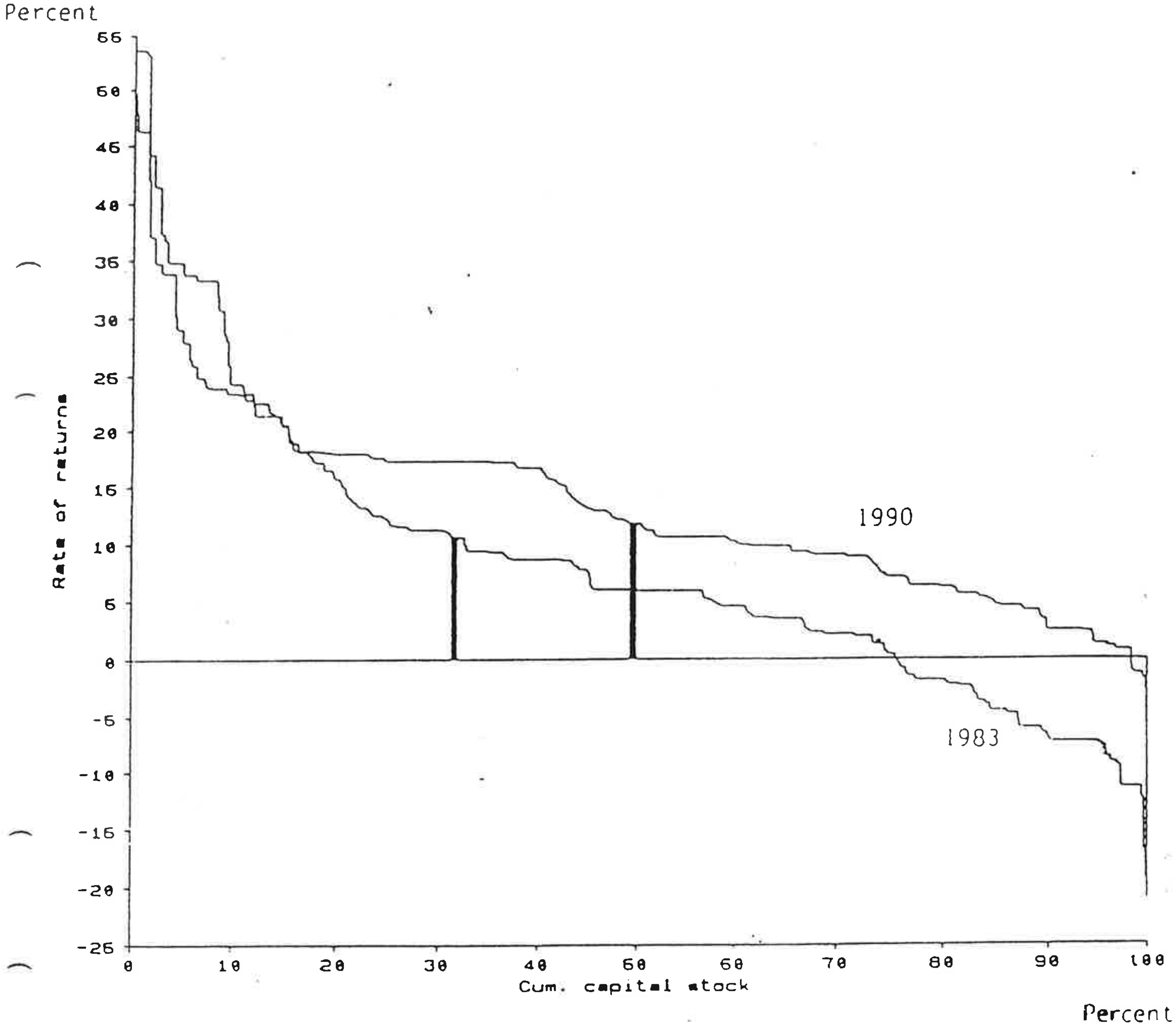
$$DQ = S_1 DL + S_2 D\bar{K} + \frac{\Delta\varepsilon}{pQ}$$

$$S_1 = \frac{wL}{pQ}$$

$$S_2 = \frac{[r + \rho - \frac{\Delta p^K}{pK}]p^K}{pQ}$$

$\frac{\Delta\varepsilon}{PQ}$ is, by definition DTFP. QED.

Figure 1 Epsilon distributions (salter curves)



Excess rates of return (=$\hat{\varepsilon}$) distributions 1983 and 1990.

Source: Eliasson (1991c, p. 164)

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HUMAN CAPITAL, SPECIALIZATION AND GROWTH*

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- VERY PRELIMINARY DRAFT -

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ABSTRACT

A model of endogeneous growth with overlapping generations of identical, two-periods-lived individuals, is developped in this paper. Growth hinges only on the accumulation of heterogeneous human capital.

The purpose of the paper is to analyse the role of specialization versus multivalence of the agent in the different activities on growth under a certain and an uncertain conjuncture.

In certainty, we characterize as in ARTHUR (1988) a lock in effect since agents prefer to specialize in one human capital that has the most important short run return even if it is not an efficiency choice in the long run.

On the opposite, in an uncertain world, we show that the agent becomes multivalent in several activities, and growth is increased. In particular, the more risk averse the agent is, the more he will invest in the "education" asset which provides certain returns.

INTRODUCTION

The purpose of the paper is to study the impact of the investment in different kinds of human capital in an endogeneous growth model. We focus on the role of the agents' specialization in one capital versus the multivalence. The analysis is made under a certain and a stochastic world.

Several recent works have focused on growth and the investments in human capital. Thus, LUCAS (1988) and AZARIADIS & DRAZEN (1990) analyze the role of the investment in human capital and externalities on the long run growth rate of the economy. However, the incidence of specialization and multivalence has not been studied so much in that kind of model. The advantages of specialization are well-known since SMITH and RICARDO. A concern of this paper is on the contrary to characterize a lock-in effect as in ARTHUR (1988), which focuses on the negative possible incidence of specialization on growth. The idea is straighforward. If activities increase in pay-off the more they are undertaken (because of learning effect), the activity that is chosen the first, will continue to be chosen after. The optimal initial choice leads the rational agent to be locked in it, through a self-reinforcing mechanism, even if it is not necessarily an efficient choice in the long run.

Moreover we are interested in the stochastic aspects of this issue. From this, it is necessary to determine which behavior an agent adopts when he faces a cyclical conjuncture. Whereas under conditions of certainty the agent specializes ought to the learning effect, we show that under uncertainty, the agent is induced to multivalence since he can then adapt quickly to the stochastic conjuncture. The idea is based on the same argument that the portfolio choice theory introduced in 1952 by MARKOVITZ and applied to the monetary analysis by TOBIN (1958).

In this paper, we consider an economy similar to the AZARIADIS & DRAZEN one but we introduce heterogeneous human capital and no physical capital is taken in account. The heterogeneity comes from the existence of several kinds of activities requiring different knowledges, general knowledge acquired by education, and specific ones as traditional or high technological know-how.

The paper is organized as follows. In the next section the model is set up in the certainty case. The uncertainty case is charaterized in section 3. Then section 4 focuses on the introduction of education. Section 5 investigates the impact of agents'expectations. Section 6 concludes the paper.

2. THE MODEL UNDER CERTAINTY

2.1. HOUSEHOLDS

We consider an overlapping generations model à la ALLAIS (1947)-DIAMOND. At period t, the total population is the sum of the young generation born in period t, N_t , and the old generation born in t-1, N_{t-1}.

$$N_t = (1+n) N_{t-1}$$

The variable n denotes the population growth rate.

Identical agents live and work for two periods. An agent born in t has the following utility function :

$$U(c_t , d_{t+1}) \tag{1}$$

where c_t and d_{t+1} stand for the consumption of the agent, respectively in period t and t+1. These two consumptions are equal to :

$$c_t = [1 - u_v - u_y] w_t x_t \tag{2}$$

$$d_{t+1} = w_{t+1} x_{t+1} \tag{3}$$

The variable w_t denotes the wage rate for an efficiency unit of labor supplied and can be normalised to one as it will be shown in section 2.2. The number of efficiency units of labor services per unit of time the young inherit and the average quality of labor of both young and old agents at period t are represented by the variable x_t. This average quality is defined by the human capital stock level in the two different activities : an old one, v_t, and a new one, y_t. So the human capital stock is heterogeneous and can be written as :

$$x_t = v_t + y_t \tag{4}$$

When he is young, an agent can devote the fraction of time u_v in investment in the human capital associated to the old activity and u_y in the new activity. The sum of the investments in the two types of human capital is bounded by one :

$$u_v + u_y < 1 \tag{5}$$

Investment in human capital in the first period increases the second period human capital stock.

$$v_{t+1} = h_v[u_v , v_t] \, v_t \tag{6}$$
$$y_{t+1} = h_y[u_y, y_t] \, y_t \tag{7}$$

For simplicity, we assume that there is no physical capital. Agents do not save. The main results are not changed but the dynamic is simplified.

An agent born in t seeks to maximize (1) subject to (2) and (3) in order to settle the optimal investment rate in each human capital.

Therefore the agent's program can be written as :

$$\max_{u_v,\, u_y} U(c_t, d_{t+1}) \qquad (8)$$

$$\text{s.t. } c_t = (1 - u_v - u_y)\, x_t$$

$$d_{t+1} = x_{t+1}$$

The first order conditions leads to : (8')

$$\frac{\delta L}{\delta u_v} = - u'_1 \; x_t + u'_2 \; h'_{uv} v \quad \begin{cases} = 0 & \text{if } u_v > 0 \\ < 0 & \text{if } u_v = 0 \end{cases}$$

$$\frac{\delta L}{\delta u_y} = - u'_1 \; x_t + u'_2 \; h'_{uy} y \quad \begin{cases} = 0 & \text{if } u_y > 0 \\ < 0 & \text{if } u_y = 0 \end{cases}$$

u'_1 and u'_2 denotes respectively the utility derivatives with respect to consumption in the first and in the second period.

The agent invests in the two kinds of human capital until :

$$h'_v \, v = h'_y \, y \qquad (9)$$

If $h'_{uv} v > h'_{uy} y$, he invests only in the old capital. (10)

If $h'_{uv} v < h'_{uy} y$, he invests only in the new capital. (11)

2.2. THE FIRM

Production is carried out by competitive firms having the same production function. There is no physical capital so output is produced rising only an efficiency labor factor L_t :

$$Q_t = F(L_t) \tag{12}$$

The production function is linearly homogeneous in labor with the normal and concave properties. The variable L_t stands for the efficiency labor of both generations in period t :

$$L_t = (1 - u_v - u_y)\, N_t\, x_t + x_t\, N_t \tag{13}$$

In the case of a Cobb Douglas function ($Q_t = \gamma\, L_t$), the wage rate may be expressed as a constant and normalised to one for simplicity. Indeed, the existence of firms is not necessary to the comprehension of the model.

2.3. HUMAN CAPITAL DYNAMIC

The dynamic is based only on human capital. The lock-in effect is easily characterized if the old human capital accumulation increases at each period at a decreasing rate and at a constant one for the new human capital when the agent always invests the same amount in the corresponding activity.

$$v_{t+1} = h_v\, [\, u_v\, , v_t\,]\, v_t \text{ with } h'_{uv} \geq 0 \tag{14}$$

$$y_{t+1} = h_y [u_y , y_t] y_t \text{ with } h'_{uy} > 0 \tag{15}$$

As an example, we can have :

$$v_{t+1} = [1 + \frac{a u_v}{1+v_t^2}] v_t \tag{16}$$

$$y_{t+1} = [1 + b u_y] y_t \tag{17}$$

Since individuals inherit an important amount of old human capital from their parents, but a low one of new human capital, the case (10) may occur, that is to say :

$$h'_{uv} v > h'_{uy} y \tag{18}$$

In our example, the derivatives are :

$$h'_{uv} = \frac{a v_t}{1 + v_t^{3}} \tag{19}$$

$$h'_{uy} = b y_t \tag{20}$$

As the agent inherits from their parents a high level of old human capital and a very low one of new human capital, v_t is sufficiently higher than y_t ($y_t \# 0$), so inequality (18) is satisfied. The agent then invests only in the old human capital. Due to the learning effect, he will always keep on this choice.

Therefore, the dynamic is based only on the old human capital. The equilibrium is then a steady state.

If the agents has invested in the new human capital, all variables would have grown at a constant rate (for example, b is that rate in equation (17)). The dynamic would have converge to a balanced growth path at a constant rate. The lock-in effect results in the specialization of individuals and leads to a reduced growth.

3. MODEL UNDER UNCERTAINTY

3.1. HOUSEHOLDS

For exogeneous motives (development of new technologies for instance), the conjuncture is unstable in the sense that each human capital return becomes uncertain. Our analysis concentrates to demonstrate that in this case the agent chooses to invest in all kinds of human capital : then he has the ability to adapt quickly to the most efficient activity and to reduce the risk to be locked in the activity the return of which is the lowest (because of obsolescence). The intuition is straightforward and hinges on the same basis that the portfolio choices theory used by TOBIN (1958). The return of each human capital is now randomly distributed. Therefore the following expression remains :

$$h_y = 1 + \lambda u_y \qquad (21)$$

$$h_v = 1 + \delta u_v (1+v_t^3)^{-1} \qquad (22)$$

The random variables λ and δ are normally distributed according to the following parameters values : N($m_\lambda;\sigma_\lambda$)and N($m_\delta;\sigma_\delta$). The variables m_δ and m_λ denote the expected returns associated to each human capital, and σ_δ and σ_λ represent a risk measure associated to them.

We also consider a utility function defined on mean and variance. This hypothesis is justified if the random return process follows a normal distribution or if the VON NEUMANN and MORGERNSTERN utility function is as follows (see HENIN, 1981) :

$$u(x) = ax^2 + bx \ , \text{ with } a < 0 \qquad (23)$$

This concavity of the function illustrates the fact that the agent is risk averse.

The expected utility is of the form :

$$E\ u(x) = bE\ x + a(\sigma_x^2 + E\ x^2) \qquad (24)$$

The individual chooses the multivalence if the combination of the different kinds of capital provides a gain, in other words if the combination decreases the total risk.

Therefore, the agent's maximisation program is now :

$$\underset{u_v,\ u_y}{\text{MAX}}\ E[\ u(c_t) + \beta\ u\ (d_{t+1})\ ] \qquad (25)$$

$$\begin{aligned} \text{s.t. } c_t &= (1 - u_v - u_y)\ x_t \\ d_{t+1} &= x_{t+1} = h_y\ y_t + h_v\ v_t = x_t + M_t \\ h_y &= 1 + \lambda\ u_y \\ h_v &= 1 + \delta\ u_v (1+v_t^3)^{-1} \end{aligned}$$

So the expected utility (24) becomes :

$$E\ u(c_t) + \beta\ E\ u\ (d_{t+1})$$

$$= a\ (\ 1 - u_v - u_y\ )^2 x_t^2 + b\ (\ 1 - u_v - u_y\ )\ x_t$$
$$+ \beta\ E\ (\ a\ h_y^2 y_t^2 + a\ h_v^2 v_t^2 + 2\ ah_y\ y_t\ h_v\ v_t + b\ h_y\ y_t + b\ h_v v_t\ )$$

$$= a\ (\ 1 - u_v - u_y\ )^2 x_t^2 + b\ (\ 1 - u_v - u_y\ )\ x_t + \beta\ a\ x_t^2$$
$$+ \beta\ bx_t + \beta\ (\ b + 2\ ax_t)\ E\ M_t + \beta\ a\ (\sigma_M^2 + E^2 M_t) \qquad (26)$$

With :

$$E\, M_t = u_y\, y_t\, E\, \lambda + u_v\, v_t\, (1 + v_t^3)^{-1}\, E\, \delta \tag{27}$$

$$\sigma_M^2 = u_y^2\, y_t^2\, \sigma_\lambda^2 + u_v^2\, v_t^2\, (1+v_t^3)^{-2} + 2\, u_y\, u_v\, y_t\, \sigma_\lambda\, \sigma_\delta\, v_t (1+v_t^3)^{-1} r \tag{28}$$

r is the correlation coefficient between $[\lambda\, y_t\ ,\ \delta\, v_t (1+v_t^3)^{-1}]$

First order conditions lead to :

$$\frac{\delta E\ U}{\delta\ u_v} = 0 \quad \text{if } u_v > 0 \qquad < 0 \quad \text{if } u_v = 0 \tag{29}$$

$$\frac{\delta E\ U}{\delta\ u_y} = 0 \quad \text{if } u_y > 0 \qquad < 0 \quad \text{if } u_y = 0$$

So four cases can mathematically occur. However, the case of $u_v = 0$ and $u_y = 0$ is out of economic interest. Besides, the cases of specialization are found as under certainty, but with uncertainty, a new behavior rises as an optimal one : the choice of multivalence. This last case is characterized by $u_v > 0$ and $u_y > 0$.

Thus individuals invest only in the new human capital ($u_v = 0$), if :

$$x_t^2(g_2-g_1) + x_t(-V_1^2 - g_1^2 + rV_1V_2 + g_1g_2) + \beta[g_2(V_1^2+g_1^2) - rV_1V_2 - g_1g_2] < 0 \tag{30}$$

The symmetric case of specialization in old human capital occurs if:

$$x_t^2(g_1-g_2) + x_t(-V_2^2 - g_2^2 + rV_1V_2 + g_1g_2) + \beta[g_1(V_2^2+g_2^2) - rV_1V_2 - g_1g_2] <0 \quad (31)$$

The last case is multivalence, it rises when :

$$u_v = (\frac{2ax_t + b}{2a}) \frac{F_1}{F_2} >0 \quad (32)$$

and $$u_y = (\frac{2ax_t + b}{2a}) \frac{F_3}{F_2} >0 \quad (32')$$

with :

$$F_1 = x_t^2 (g_1-g_2) + x_t(g_1^2-g_1g_2+V_1^2+\beta rV_1V_2) + \beta(rV_1V_2g_1-V_1^2g_2)$$

$$F_2 = x_t^2[(g_1-g_2)^2+ (V_1-V_2)^2+ 2V_1V_2(1-r)]$$
$$+ \beta \quad V_1^2 V_2^2 \ (1-r^2)+(V_1 g_2 -V_2 g_1)^2 + 2V_1 V_2 g_1 g_2 (1-r)$$

and $$F_3 = x_t^2 (g_2-g_1) + x_t(g_2^2-g_1g_2+V_2^2+\beta rV_1V_2) + \beta(rV_1V_2g_2-V_2^2g_1)$$

$$g_1 = y_t E \lambda$$
$$g_2 = v_t (1 + v_t^3)^{-1} E \delta$$
$$V_1 = y_t \sigma_\lambda$$
$$V_2 = v_t (1 + v_t^3)^{-1} \sigma_\delta$$

The sign of the expression $[\frac{2ax_t + b}{2a}]$ is determined by the risk aversion degree of the agent.

F_2 is always positive, so the agent's behavior depends on conditions between variables in F_1, F_3 and on the above expression.

Uncertainty allows the existence of the new behavior consisting to diversify investment. F_1 and F_3 can obviously be expressed as a function of expected returns and variances differences. It depends also on the correlation coefficient. The idea is straightforward : in case of perfect correlation between the returns (r=1), the whole risk is a linear combination of each human capital risk according to the investment in each capital. In the opposite case, if the correlation is not perfect (r<1) or inverse (r=-1), the whole risk is inferior to the combination of both risks ; therfore, it provides a gain. β expresses the preference for future and have some influence on the sign of both F_1 and F_3; so the choice of the agent may also take into account the value of β. Finally, the conditions $u_v > 0$ and $u_y > 0$ can be met for a large set of these parameters values.

3.2. HUMAN CAPITAL DYNAMIC

The lock-in effect disappears for the following reason : multivalence can occur at each period even if at the previous period the agent had specialized. Moreover, in most of the cases, multivalence is preferred. Now we turn to the implications on growth.

Using again the example of section 2.3., we obtain :

$$h_v = \left(1 + \frac{u_v \delta}{1 + v_t^3}\right) v_t^3 \qquad (33)$$

$$h_y = (1 + u_y \lambda) y_t \qquad (33')$$

Since both u_v and u_y can be positive, dynamic hinges on both old and new human capital accumulation :

$$x_{t+1} = y_{t+1} + v_{t+1} \qquad (34)$$

In section 2.3., we showed that under certainty, the economy converges to a stationary state. Considering the uncertainty, a balanced growth path with a positive growth rate may exist.

4. THE ROLE OF EDUCATION

The previous analysis can be extended to the consideration of many different kinds of human capital. Especially, an interesting extension concerns the introduction of education. The agent can invest in education at the first period and then receives the return in the second one. The "education" asset is a quite interesting one since it presents also indirect returns : education gives a general knowledge allowing the agent to learn faster new technologies.

Under certainty, including education in the system (8), the equations become :

$$\max_{u_v, u_y, u_z} U(c_t, d_{t+1}) \tag{35}$$

$$\text{s.t. } c_t = (1 - u_v - u_y - u_z)\, x_t$$
$$d_{t+1} = x_{t+1}$$

where u_z denotes the investment in education.

The resolution of this program leads to a sensibly similar condition. The agent invests in the three kinds of human capital if :

$$h'_v\, v = h'_y\, y = h'_z\, z \tag{36}$$

As in the previous model, this condition is not easily satisfied, since the individuals have an important old human capital and do not find profitable to invest in education. Agents invest only in this old human capital although education may have induced a balanced growth path dynamic for a function h_z well specified.

Under uncertainty, education plays a crucial role. Education can be assumed to have certain returns. A similar analysis to the one run in section 3.2. would lead to the conclusion that under similar condition the agent will invest in the three assets. However, the more the agent is risk averse, the more he will invest in education since it gives back a certain return and reduces the whole risk. In terms of growth, the same preceding conclusions remain. The investment in education may increase growth.

5. THE ROLE OF AGENTS'EXPECTATIONS

Previously, section 3 shows the importance of the agent's expectations. Thus it is interesting to study their impact if they follow a Markov process.

We assume that two states of the nature can occur : in the first one, the return of the old activity is higher than the one of the new activity. In this case :

$$h_v'^1 > h_y'^1 \qquad (37)$$

The second one represents the inverse situation :

$$h_v'^2 < h_y'^2 \qquad (38)$$

Education is the sole certain asset in the model.

Each state of the world occurs with probability p_a and $(1 - p_a)$. The probabilities depends on the agents'expectations and are assumed to follow a Markov process. Indeed, it is reasonable to suppose that the previous effective state influences the agents'expectations about the future state.

The Markov process is represented by the following transition matrix denoted by T :

p_a	$1-p_b$
$1-p_a$	p_b

p_a and p_b stand for the probabilities of transition from a state to another. p_a and p_b denote the probabilities to remain respectively in state one and in state two, during two following periods.

However, agents are neither pessimistic nor optimistic about the future. In the two states of the nature, the second period consumption remains globally the same if the agents make the optimal investment (therefore, future consumption in the first state, d^1_{t+1} equals to future consumption in second state, d^2_{t+1}).

Without loss of generality, to simplify, we assume now the utility function to be a logarithmic one (since it is concave, the agents are risk averse). The agents maximize the following Von Neumann and Morgernstern expected utility function if they think that state one will occur:

$$E[U_t]= p_a(\text{Log } c_t + \beta d^1_{t+1}) + (1-p_a)(\text{Log } c_t + \beta\ d^2_{t+1}) \qquad (39)$$

The agents' program is :

$$\begin{aligned} &\text{MAX } E[U_t] \\ &\text{s.c. } c_t = (1 - u_x - u_y - u_z)\ x_t \\ &\qquad d^i_{t+1} = x^i_{t+1} \quad \text{for } i = 1, 2 \end{aligned} \qquad (40)$$

First order conditions are : (40')

$$\frac{\delta L}{\delta u_v} = -\frac{x_t}{c_t} + \frac{\beta}{d^1_{t+1}} p_a (h'_v) v^1_t + \frac{\beta}{d^2_{t+1}} (1-p_a) (h'^2_v) v_t$$

$=0$ if $u_v > 0$
<0 if $u_v = 0$

$$\frac{\delta L}{\delta u_y} = -\frac{x_t}{c_t} + \frac{\beta}{d^1_{t+1}} p_a (h'^1_y) y_t + \frac{\beta}{d^2_{t+1}} (1-p_a) (h'^2_y) y_t$$

$=0$ if $u_v > 0$
<0 if $u_v = 0$

$$\frac{\delta L}{\delta u_z} = -\frac{x_t}{c_t} + \frac{\beta}{d_{t+1}} (h'_z) z_t \begin{cases} =0 & \text{if } u_z > 0 \\ <0 & \text{if } u_z = 0 \end{cases}$$

The agent invest in the three assets if :

$$h'_z z_t = p_a h'^1_v v_t + (1 - p_a) (h'^2_v v_t) \quad (41)$$
$$= p_a h'^1_y y_t + (1 - p_a) (h'^2_y v_t)$$

This means that expected returns of the new and the old actvity are equal to the education return. If an expected return is inferior to the education return, nobody will invest in it. The investment rate in each capital depends on each initial capital stock and on the individuals'expectations.

This analysis enhances the weight of expectations on one hand, and of initial conditions on the other one, in the dynamic.

Thus the shape of the Markov matrix has an impact on the investment rate. If the Markov matrix is regular, then $p_a \neq 1$ and $p_b \neq 1$, the initial capital stock has no influence, dynamics depends only on expectations and it may converge towards a balanced growth path. The limit probabilities vector P is given by :

$$(T-I)\ P = 0 \tag{42}$$

When the matrix is contractant, different cases may occur :

If $p_a = 1$ and $p_b = 1$, it corresponds to the certain case because only the initial capital stock has an impact. Agents will invest in the activity which has the highest return at the beginning. So the dynamic will converge to a stationary state or to a balanced growth path, depending on the accumulation process of the activity chosen.

If p_a or p_b equals to 1, and the other does not, both the initial capital stock and the anticipations drive the dynamic.

6. CONCLUSION

In this paper, we show that growth shoud be increased under an uncertain world with respect to a certain one. When the conjuncture is stochastic, the agent is induced to diversify his human capital investments. Thus the more he is risk averse, the more he will invest in education since it provides certain returns. The diversification will provides growth. This result is quite surprising since economists like **SMITH** or **RICARDO** enhanced the advantages (absolute or comparative) of specialization. More recently, the theory of organizations have the objective to explain and to describe the structure of organizations. Most of the theories developped in this tradition hinges on information problems and bounded rationality. Thus in **WILLIAMSON**, the structure of organization in the firm rises as a result of the repartition of information and the unabilty for agents to capture the whole information. In our paper, the structure of organization (specialization or multivalence) results from the reactions of the agent who faces more or less uncertainty, which is a slightly similar interpretation of bounded rationality. However, results are different. Williamson considers that specialization allows to decrease the uncertainty on information, since the focus is reduced, so that the reliability of the agent to take the best decision is raised. On the opposite, our paper shows that specialization may lead to a lower pay-off in the long run.

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