

Perspectives on Human Capital

Economic growth, occupational choice
and intergenerational mobility

Anna Sjögren

AKADEMISK AVHANDLING

som för avläggande av ekonomie doktorsexamen
vid Handelshögskolan i Stockholm
framläggs för offentlig granskning
fredagen den 11 december 1998, kl 15.15 i sal 750,
Handelshögskolan, Sveavägen 65,
Stockholm



Perspectives on Human Capital

Economic growth, occupational choice
and intergenerational mobility



STOCKHOLM SCHOOL OF ECONOMICS

EFI, THE ECONOMIC RESEARCH INSTITUTE

EFI Mission

EFI, the Economic Research Institute at the Stockholm School of Economics, is a scientific institution which works independently of economic, political and sectional interests. It conducts theoretical and empirical research in management and economic sciences, including selected related disciplines. The Institute encourages and assists in the publication and distribution of its research findings and is also involved in the doctoral education at the Stockholm School of Economics.

EFI selects its projects based on the need for theoretical or practical development of a research domain, on methodological interests, and on the generality of a problem.

Research Organization

The research activities are organized in twenty Research Centers within eight Research Areas. Center Directors are professors at the Stockholm School of Economics.

ORGANIZATION AND MANAGEMENT

Management and Organisation (A)

Prof Sven-Erik Sjöstrand

Public Management (F)

Prof Nils Brunsson

Information Management (I)

Prof Mats Lundeberg

Man and Organisation (PMO)

Acting Prof Jan Löwstedt

Industrial Production (T)

Prof Christer Karlsson

MARKETING

Information and Communications (CIC)

Adj Prof Bertil Thorngren

Risk Research (CFR)

Prof Lennart Sjöberg

Marketing, Distribution and Industrial Dynamics (D)

Prof Lars-Gunnar Mattsson

Distribution Research (FDR)

Associate Prof Magnus Söderlund

Economic Psychology (P)

Prof Lennart Sjöberg

ACCOUNTING, CONTROL AND CORPORATE FINANCE

Accounting and Managerial Finance (B)

Prof Lars Östman

Managerial Economics (C)

Prof Peter Jennergren

FINANCE

Finance (FI)

Prof Clas Bergström

ECONOMICS

Health Economics (CHE)

Prof Bengt Jönsson

International Economics and Geography (IEG)

Prof Mats Lundahl

Economics (S)

Prof Lars Bergman

ECONOMICS STATISTICS

Economic Statistics (ES)

Prof Anders Westlund

LAW

Law (RV)

Prof Bertil Wiman

OTHERS

Ethics and Economics (CEE)

Adj Prof Hans de Geer

Policy Sciences (PSC)

Adj Prof Brita Schwarz

Chairman of the Board: Prof Sven-Erik Sjöstrand. *Director:* Ekon Dr Rune Castenäs

Address

EFI, Box 6501, S-113 83 Stockholm, Sweden • Internet: www.hhs.se/efi/
Telephone: +46(0)8-736 90 00 • Fax: +46(0)8-31 62 70 • E-mail: efi@hhs.se
Internet: www.hhs.se/efi/

Perspectives on Human Capital

Economic growth, occupational choice
and intergenerational mobility

Anna Sjögren



STOCKHOLM SCHOOL OF ECONOMICS
EFI, THE ECONOMIC RESEARCH INSTITUTE



A Dissertation for the
Degree of Doctor of Philosophy
Stockholm School of Economics

© EFI and the author 1998

ISBN 91-7258-498-X

Keywords: human capital, R&D, endogenous growth, scale effects, transitional dynamics, intergenerational mobility, occupational choice, talent allocation, redistribution, family background, economic incentives, mixed multinomial logit

Cover:

Anna Sjögren

Distributed by:

EFI, Stockholm School of Economics, Box 6501, SE-113 83 Stockholm, Sweden

Printed by:

Elanders Gotab, Stockholm, 1998

till Signe

Foreword

Some fish find the ocean in no time.

Not this one. This little fish played happily on its own in a safe and familiar pond until one day when it was told by a capricious perch that there are bigger waters, beyond. The once so familiar pond started closing in on the little fish. Where were those big waters? What was the water like? Were there other fish there? The temptation of finding those bigger waters got the little fish daring. It wanted to leave its safe haven.

Being such a safe place, the pond had no outlet so the only way to get out was to swim up one of the few streams that fed it, against the current which fortunately was not all that strong. The perch showed the way and the little fish swam and swam until it felt itself carried away by a strong current into a much larger and more vivid stream. The little fish was out of control and the capricious perch was nowhere to be found. There was so much bubbling and foaming water everywhere, big incomprehensible fish swimming by at tremendous speed. The little fish wanted to play in all that foam, but it just could not keep up with the current. It got lucky. A salmon swam up to the little fish and started teaching it how to swim straight through the current and even play with it. Yes! The little fish swam off with the big stream, in control. At least for a while. Then the little fish got lost. What was up? What was down? The current grew stronger but this time there was no help around. The little fish fought its way towards the bank of the stream that was by now more of a river.

There, in the shallow waters along the riverbank, big pikes, tired of small lost fish, looked at the little fish with scrutiny. "Why don't you give it up?" they said. "Why bother finding those big waters? There are nice quiet lakes not far from here that suit little fish like you much better." "But, the little fish staggered, I'll find some kind big fish to help me". "How can you be so sure that anyone will have time for you, little fish", they sighed and continued: "If it has taken you so long to get here, can you be sure to ever make it?" The little fish said nothing, but felt itself bursting with obstinacy.

The little fish swam off, desperately looking for some big fish seeming to know the way to the big waters. Seeing its desperation, some friendly fish clapped their fins in encouragement at the little fish. Strengthened it searched on, and

there! The little fish swam up to a knowing-how-to-find-big-water-looking trout and demanded help. No, was not to be taken for an answer! The little fish was not let down. The trout agreed to guide the little fish to the big waters!

The little fish was happy again! Checking every now and then that the trout was still around, it swam along, asking the trout for guidance when currents pulled in different directions. It played in the foam, explored one or two little streams on its own and was sent off by the trout to explore some others, only to be called back to the main stream when it was being carried off too far in the wrong direction. They swam for some time, the little fish and the trout, the river getting wider and wider. The little fish felt the water getting warmer. Did that mean the big water was getting closer? The trout said to keep swimming. But it was indeed getting warmer! The little fish tried to swim faster and faster and...Was that it? Could it really be? The seemingly endless river got frightfully turbulent. Splashing and bubbling the river threw the little fish into the ocean.

Acknowledgments

Writing a thesis is a terribly lonely endeavour. For me, loneliness is a low ranking state. The completion of this thesis would therefore have been impossible if it had not been for all the help, encouragement and mere presence of a number of people. Needless to say, it would not have been possible without some of the adrenaline and obstinacy stimulating resistance I met on the way either.

Mårten Palme's entrée as my adviser meant not only that I kept going, I also think he got me onto a higher level. His low key way of suggesting alternative ways ahead and, at times, of starting over, while assuring me that "this has great potential" ...if all the ifs and buts are dealt with...proved to be a winning strategy in advising an otherwise stubborn student, reluctant to ask for help and very easily drifting off along some tangent. I owe him a great deal.

Tove Strauss, my dear friend and room mate, has played an invaluable role in the writing of this thesis. Most importantly, Tove has kept me company in the office and even made it fun to go to there when the work itself was far from inspiring. She has shared the euphoria when derivatives and data delivered and she is responsible for keeping my spirits from plunging to low in precarious situations. Tove has also provided me with a wealth of critical comments and the energy and joy of vivid academic and political discussions. Thank you!

Xavier Sala-i-Martin is responsible for teaching me how to deal with human capital in a growth context, but more importantly, he is responsible for inspiring me to think and reason as an economist and for daring to do so regardless of topic. However, some of the responsibility for the final completion of this thesis rests with members of the faculty to whom I owe thanks and, of course, with my first adviser Magnus Blomström, who got me going working on human capital in the first place.

My fellow Ph. D. students, Marcus Asplund, Lena Edlund, Ann Charlotte Eliasson, Richard Friberg, Sara Johansson, Kasper Roszbach, Rickard Sandin, Patrik Säfvenblad, Susanna Sällström and Ingela Ternström of whom most have their degrees by now, have provided me with a sense of belonging and convinced me that I can do it too.

Pirjo Furtenbach made this whole venture administratively smooth, by caring for and seeing to that the little details were in place for a rather messy and

disorganized student. The instrumental role played by Lars Bergman, Anders Paalzow and Rune Castenäs in providing me with the financial means to complete this thesis is warmly recognized. Financial support from Jacob Wallenbergs Fond and from Helge Ax:son Johnsons Stiftelse also deserves profound recognition.

Music has provided the perfect balance and distraction necessary to put up with stable arms, comparative statics and never-ending estimations. Karin Bäckström, Olle Johansson, Birgitta Sommarbäck and Engelbrekts Vokalensemble are, therefore, more responsible for this thesis than they can probably imagine.

Without the unfailing support and inspiration of my family, where would I be? My in-laws have set the norm: at least one Ph. D. per married couple. My parents and brother, never failing to question or to provoke a good discussion, have given me the impertinent, stubborn and critical mind that got me through this whole thing. Philip has given me all the love in the world and on top of that Sissela and a life yet to come. What more can I ask!

Having thanked so many and yet way too few, I will conclude by assuring Brian van Arkadie that I tried to follow his advice: "Don't get it right, get it written!". I got it written, but taking such time, I just hope I got at least some of it right.

Stockholm, October 1998

Anna Sjögren

Contents

Foreword	vii
Acknowledgments	ix
Contents	xi
Summary	xiii
<i>Essay 1</i>	
Human Capital, R&D and Economic Growth	1
<i>Essay 2</i>	
The Effects of Redistribution on Occupational Choice and Intergenerational Mobility: Does wage equality nail the cobbler to his last?	41
<i>Essay 3</i>	
Occupational Choice and Family Background in Sweden	73

Summary

This dissertation consists of three essays, taking different perspectives on human capital. The first essay looks at human capital from a growth perspective. Essays two and three focus on the individual's occupational decision and its relation to family background.

The first essay attempts to capture the effects on long run economic growth and transitional dynamics of the interaction between human capital and R&D. We do this by allowing for endogenous human capital accumulation in an economy where the number of products and technologies expands because profit maximizing entrepreneurs do R&D. We find that, in the absence of scale effects, long run growth is determined by the economy's capacity to accumulate human capital. A relative lack of R&D capital causes the economy to grow slowly during its transition to the steady state, while a relative abundance of R&D capital gives high growth rates during transition.

In the second essay, the classical Roy-model of selection on the labor market is extended in order to analyze intergenerational mobility. This is done through the introduction of ability uncertainty that is linked to family background. In contrast to traditional human capital models of intergenerational mobility, this mechanism rather than differences in access to capital markets links occupational outcomes of offspring to parents. We study the effects of income redistribution on mobility and talent allocation. It is found that redistribution has implications for intergenerational mobility and talent allocation through its influence on individual occupational choices. However, we conclude that the presence of a trade-off between redistribution and intergenerational mobility depends on the extent of similarity of occupations with regard to ability sensitivity and wage rates, and on the degree of individual risk aversion. Whether redistribution occurs only within an occupation or simultaneously within and across occupations is also important for the implications for mobility and talent allocation.

In essay three, a model of occupational choice and human capital investment is developed and tested. The model allows family background to influence occupational choice through access to economic resources, differences in costs of schooling, and ability uncertainty linked to background similar to that discussed

in essay two. It is predicted that life time utility of children from less well-off background is more sensitive to economic incentives when risk aversion is strong. The model also predicts that people are more sensitive to economic incentives when considering occupations distant from their parents occupations. The implications of the theoretical model are tested and largely confirmed on Swedish data using a mixed multinomial logit framework which explicitly accounts for unobserved ability heterogeneity.

Human Capital, R&D, and Economic Growth

1. Introduction

People go to school and firms do research and development (R&D). Insufficient investment in either of these activities is brought forth as an explanation for slow growth in both rich and poor countries. The purpose of this paper is to analyze how human capital accumulation and the development of new products and technology through investments in R&D interact in the determination of economic growth by providing incentives for each other. The basic idea is that the incentive to accumulate human capital is affected by the introduction of new products and technologies. The accumulation of human capital also affects the rate of return to investments in R&D. As we will show, the effects go via the relative returns to investments in human capital and R&D. This interaction has largely been left out in previous work which has focused either on human capital accumulation or on R&D as engines of endogenous growth, e.g. Lucas (1988), Romer (1990), Grossman and Helpman (1991), Segerstrom (1991) and Aghion and Howitt (1992). By merging these two theoretical frameworks, our ambition is to construct a model of economic growth based on human capital accumulation

⁰The paper has benefitted greatly from suggestions and comments by Magnus Blomström, Sara Johansson, Karl Jungenfelt, Tomas Lindh, Lars Ljungqvist, Casey Mulligan, Xavier Sala-i-Martin, Tove Strauss and Fabrizio Zilibotti. All remaining errors and obscurities are mine.

and R&D which should ideally manage to produce predictions in line with the findings of the empirical growth literature.

Empirical studies of economic growth have introduced a variety of explanatory variables to account for cross-country variation in growth performance, e.g. enrolment rates, human capital stock proxies, labor force participation rates, fertility, private and public investment rates, foreign direct investment, equipment investment, revolutions and coups, inflation, black market exchange rate premium, market size, and number of people employed in R&D activities (see e.g. Barro 1991, DeLong and Summers 1991, Backus, Kehoe and Kehoe 1992, Levine and Renelt 1992, Mankiw, Romer, and Weil 1992, and Blomström, Lipsey and Zejan 1994). The results from these studies can be summarized in three key areas of importance for growth, namely, human capital, investments, and variables related to the business environment. In particular, empirical studies have found that a country tends to grow rapidly if it is poor relative to its human capital endowment. Most studies also find savings and investment rates (whether in physical or in human capital) to be positively correlated with growth. Furthermore, there is evidence that the increased participation in the labor force is associated with growth. Measures trying to capture the freedom to engage in and enjoy the fruits of economic activity are also found to be positively correlated with growth.¹ However, despite ample efforts to verify the existence of scale effects, there seems to be little empirical evidence of a positive effect on growth of either country size, size of the R&D sector or of other types of scale effects predicted by most R&D-based endogenous growth models.

In developing a model which recognizes that human capital accumulation and investment in R&D take place at the same time, we are inspired by the versions of the model of technological progress with expanding varieties and the Uzawa-Lucas human capital model developed in Barro and Sala-i-Martin (1995). The implications for growth are similar to those found when technological progress and human capital are analyzed separately, but by assuming that there are decreasing returns to human capital both in final output production and in schooling, the interaction between human capital and R&D generates some interesting implications for the transitional dynamics. Furthermore, elimination of scale effects, in order to comply with the empirical evidence, has implications for the determinants of long

¹Mankiw, Romer, and Weil (1992) find that as much as half of the cross-country variation in the growth rate of gross domestic product per worker can be accounted for by differences in human capital investment (enrolment in secondary school/per working population), investments in physical capital (investment/GDP), population growth, and differences in initial income.

run economic growth.

Growth models with R&D based technological progress in which the stock of human capital is fixed and exogenously determined, rely on scale effects to generate endogenous growth. In such models, the steady state growth rate, which is driven by the advances in technology, is higher the larger the scale of the economy, i.e. the larger the stock of human capital or the more resources spent on R&D.² A recent exception is Young (1998) where long run growth is driven by improvements in product quality and is independent of scale. In our model, which also does not exhibit scale effects, we find that the economy's long run growth rate of output is the same as the rate of introduction of new products and technologies. However, the growth rate of the economy is ultimately determined by the capacity to accumulate human capital, since the accumulation of human capital drives the incentives for investing in R&D.

In the Uzawa-Lucas model, output is produced from human and physical capital. Interaction between the two forms of capital accumulation results in an imbalance effect between human capital and physical capital. This imbalance effect implies that consumption and broad output grow faster, the higher the ratio of human capital to physical capital in relation to some steady state ratio.³ In this paper, we replace accumulation of physical capital by investments in a profit maximizing R&D-sector which result in what we will call R&D capital. Accumulation of R&D capital in this model has much in common with accumulation of physical capital in that both require that individuals forgo consumption of final output.

The interaction between human capital and R&D capital in our model generates an analogous imbalance effect for consumption growth, but an imbalance effect in the opposite direction for output growth compared to the Uzawa-Lucas model. We find that the growth rate of consumption is higher the higher the ratio of human capital to R&D capital relative to some steady state ratio. However, we find that the growth rate of output is lower the higher the ratio of human capital to the stock of R&D capital in excess of the steady state ratio. A relative lack of R&D capital implies poor growth because accumulation of human capital is slow when human capital is relatively abundant. Abundance of R&D capital,

²See Jones (1995) for a discussion of scale effects in R&D-models.

³Broad output is measured as the output of the final output sector plus the value (in terms of final output) of accumulated human capital, see Barro and Sala-i-Martin (1995). In the Uzawa-Lucas model, the imbalance effect on final output growth implies that output grows faster when the ratio of human capital to physical capital is not in the steady state.

on the other hand, leads to rapid growth since it implies high rates of return to human capital and thereby provides a strong incentive for rapid human capital accumulation.

The paper is organized as follows. Section 2 develops the model. The steady state is characterized in Section 3 and the dynamics of the model are described in Section 4. Section 5 discusses sensitivity of the qualitative results to changes in parameter values. Section 6 concludes.

2. The Model

There are individuals, firms and entrepreneurs. Individuals derive utility from consumption of a final good, and spend their time working in the firms or accumulating human capital. When they work, individuals earn a wage which is spent either on consumption or lent to entrepreneurs in return for interest. Firms produce final output with human capital and intermediate inputs. These intermediates can be technologies, machines, processes, a marketing model or any other type of input or idea of how production can be more efficient. In the introduction we spoke of R&D capital. We can think of this R&D capital as the stock of blueprints for how to produce the intermediates. The wider the variety of intermediates the firm has access to the better, although more intermediates will increase the demand for human capital, since a worker cannot work with an ever increasing number of intermediates without facing a reduction in the marginal product of new intermediates. Firms rent human capital from the households and buy intermediates from the entrepreneurs.

The entrepreneurs do research to come up with ideas that they develop into blueprints for new intermediates. This research and development activity consumes final output which the entrepreneur obtains by selling shares in his future profits to the households. As opposed to the modelling of R&D in e.g. Romer (1990), labor or human capital is not used in the R&D process. Furthermore, the R&D process is deterministic in the sense that the entrepreneur is sure to come up with a blueprint for a new intermediate if he uses the right amount of final output on experimentation to make a prototype. Once the entrepreneur has developed a new type of intermediate, he can convert final output into intermediates at zero cost, that is he can buy one unit of final output at cost one, turn it costlessly into an intermediate and then sell it back to the firm. The entrepreneur has monopoly power over the sale of his intermediate and can thus charge a price above marginal cost. This allows him to cover the R&D costs and pay dividends to the shareholders.

ers of his enterprise. In a setting where the entrepreneurs spend the R&D cost in order to come up with blueprints for new products which in principle could be produced without set up costs by anyone with access to the blueprint, the monopoly power of the entrepreneur needs to be legally protected through patent or otherwise. However, the entrepreneur's R&D cost could also be interpreted in terms of set up costs which are incurred for anyone interested in producing a type of intermediate. In this case, the monopoly power need not be protected, since the fixed costs assure that no entrepreneur will take up production of an already existing intermediate as that would give a certain loss.

2.1. The firm

The production of final output, Y_t , takes place in a representative competitive firm, with the following production function:

$$Y_t = A \int_0^{N_t} [h_t^{1-\alpha} X_{jt}^\alpha] dj, \quad \alpha \in (0, 1). \quad (2.1)$$

A is the general level of technology which can be thought of as being a function of institutional factors like government behavior, the maintenance of law and order, property rights etc. Production uses a continuum of different types of intermediates. N_t is the number of intermediates that have been introduced at time t , i.e. the stock of R&D capital. X_j is the quantity of the j :th type of intermediate. The intermediates can as mentioned previously be different machines, marketing technologies, organizational forms etc. That is, anything which adds to the production capacity of the firm. For each type of intermediate, the firm requires an amount of human capital, h_t .⁴ The total stock of human capital employed in final output production is aggregated over all L individuals employed in the firm. These workers split their time between working and going to school. The total human capital, H_t , employed in the firm is thus:

$$H_t = h_t N_t = \sum_{i=1}^L (1 - u_{it}) m_{it}, \quad (2.2)$$

⁴This specification of a production process which benefits from the variety of intermediate inputs builds on Ethier (1982), Romer (1987, 1990), Barro and Sala-i-Martin (1995) and others. Ethier's production function was, in turn, an application of the formulation of consumer preferences over a variety of goods developed in Spence (1976) and Dixit and Stiglitz (1977).

where u_{it} is share of time individual i spends in school and m_{it} is his human capital.

The production function formulated in equation 2.1, differs from the production functions with expanding varieties which have been employed in previous growth models with technological progress, (e.g. Romer, 1987, 1990, Barro and Sala-i-Martin, 1995). The difference stems from the idea that it is the amount of human capital per type of intermediate, h_t , that matters in production. We think of the intermediates as processes or ingredients that need to be added in different processes and that each of these processes requires human capital. Adding new ingredients and/or processes, still benefits production since it provides an alternative to increasing the quantity of each intermediate to which there is decreasing returns.⁵

The firm's demand for intermediates and human capital is determined by profit maximization with respect to quantities of X_{jt} and H_t at each point in time, when the wage, w_t , and prices, p_{jt} , are taken as given, keeping in mind that $h_t = \frac{H_t}{N_t}$:

$$\max_{X_{jt}, H_t} \Pi_t = Y - w_t H_t - \int_0^{N_t} [p_{jt} X_{jt}] dj. \quad (2.3)$$

Profit maximization implies the following demand function for X_{jt} :

$$X_{jt} = (\alpha A / p_{jt})^{1/(1-\alpha)} \frac{H_t}{N_t}, \forall j. \quad (2.4)$$

Profit maximization also requires that the marginal product of human capital equal the wage:

$$(1 - \alpha) A H_t^{-\alpha} N_t^{1-\alpha} \int_0^{N_t} [X_{jt}^\alpha] dj = w_t. \quad (2.5)$$

Equation of marginal products to the price of inputs assures zero profits for the final output producing firms since there are constant returns to scale.

⁵As we shall see, there are overall decreasing returns to the number of intermediates, N , just as to the quantity, X , of each intermediate. In equilibrium, production depends on the total number of intermediates, NX , employed in the firm. NX is then analogous to the capital stock in the Uzawa-Lucas model. If we assume that the quantity employed is the same across intermediates, we can write the production function in reduced form as $Y_t = A H_t^{1-\alpha} N_t^\alpha X_t^\alpha$. This will hold in equilibrium when all different types of intermediates enter symmetrically into the production function, provided that it is assumed that the R&D technology and the R&D cost are the same for all entrepreneurs. This shows that output of the firm depends on the total quantity of intermediates used, NX , rather than on the particular types employed.

2.2. The entrepreneur

The incentive to do R&D, comes from the monopoly rents the entrepreneur can extract due to the monopoly power he enjoys in the sale of his intermediates. The marginal cost of supplying intermediates to firms is one unit of final output. That is to say, once the entrepreneur has spent η units of final output on R&D to acquire the knowledge of how to make the new intermediate out of final output, he can turn final output into intermediates at zero cost. The entrepreneur covers the R&D cost by selling shares in his future profit to consumers. The net present value of doing R&D at time t is:

$$V_{jt} = -\eta + \int_t^\infty \left[X_{jv} (p_{jv} - 1) e^{-\int_t^v r(s) ds} \right] dv. \quad (2.6)$$

The net present value function, 2.6, shows that the fixed cost, η , involved in introducing a new intermediate only can be covered if the sales price, p_j , exceeds the marginal cost of production, one, for at least part of the time after the date of introduction t . The entrepreneur discounts his future profits by the interest rate r , which is the rate of return consumers demand on their investments. The entrepreneur prices the X_{jt} optimally, subject to the demand function 2.4 of the final goods producers. Since the entrepreneur takes human capital and the number of intermediates previously introduced as given at each point in time, maximization of V_{jt} with respect to p_j , subject to 2.4 in each instant yields a solution for the equilibrium price of an intermediate:

$$p_{jv} = p = \frac{1}{\alpha} > 1, \quad (2.7)$$

which, as we can see, depends neither on time nor on the type of intermediate. The reason being that the R&D cost is time and type invariant and that the intermediates enter symmetrically in the production of final output. The closer α is to one, the smaller the mark up. $\alpha=1$ would imply that the intermediates were perfect substitutes and there would be no room for monopoly pricing.

We can now determine the quantity that will be produced of each intermediate by substituting the equilibrium price into the expression for intermediate demand, equation 2.4:

$$X_{jt} = X_t = A^{\frac{1}{1-\alpha}} \alpha^{\frac{2}{1-\alpha}} \frac{H_t}{N_t}. \quad (2.8)$$

The quantity produced is the same for all intermediates and changes over time at the same rate as the ratio of the firm's stock of human capital to the number of

intermediates introduced. Substituting 2.8 into 2.5 we get the following expression for the equilibrium wage:

$$w_t = w = A^{\frac{1}{1-\alpha}} \left(\alpha^{\frac{2\alpha}{1-\alpha}} - \alpha^{\frac{1+\alpha}{1-\alpha}} \right) > 0. \quad (2.9)$$

The equilibrium wage is thus fixed and depends only on the general level of technology A in final output production and on the degree of decreasing returns to intermediates, α . As we can see, the wage does not depend on the availability of human capital. The reason for this is that in equilibrium, the marginal return to human capital is constant. Increasing the human capital employed in production leads to decreasing direct marginal returns, but more H relative to intermediates induces the firm to demand a higher quantity X of each intermediate which raises the marginal return to human capital by an offsetting amount.

Substituting the equilibrium quantity X and price, p , into 2.6 reduces the net present value of doing R&D to:

$$V_t = -\eta + \kappa \int_t^\infty \left[\frac{H_v}{N_v} e^{-\int_t^v r(s) ds} \right] dv, \quad (2.10)$$

where

$$\kappa = \frac{w}{p} = A^{\frac{1}{1-\alpha}} \left(\alpha^{\frac{1+\alpha}{1-\alpha}} - \alpha^{\frac{2}{1-\alpha}} \right). \quad (2.11)$$

We assume that there is free entry into the R&D-sector, that is, anyone can become an entrepreneur. This implies that the net present value of doing R&D will be driven down by new entrants. Were net present value less than zero, there would be no R&D going on in equilibrium. In an equilibrium with R&D activity going on, we therefore have the following zero-profit condition:

$$\frac{\eta}{\kappa} = \int_t^\infty \left[\frac{H_v}{N_v} e^{-\int_t^v r(s) ds} \right] dv. \quad (2.12)$$

Since $\frac{\eta}{\kappa}$ is constant, we can differentiate the zero-profit condition with respect to time, t , manipulate to obtain an expression for the integral in the zero-profit condition, which we can plug back into the zero-profit condition and rearrange to solve for the equilibrium interest rate an entrepreneur is willing to pay in return for the η units of final output he needs to borrow for his project:

$$r_t = \frac{\kappa H_t}{\eta N_t}. \quad (2.13)$$

This interest rate depends positively on the ratio of human capital to intermediates, positively on the wage relative to the price of an intermediate, and negatively on the R&D cost. Using the expression for the wage relative to the price of intermediates, κ in 2.11, it can also be shown that the interest rate depends positively on the level of technology, A , in final output production. The dependence of the interest rate on α is not monotonous. For small α 's the interest rate increases with α , whereas the relation is negative for large α 's.

2.3. The individual

The L representative individuals of the economy part their time between working to earn a wage, denominated in final output, and going to school to accumulate human capital. Individuals consume some of their wage directly and lend some of to entrepreneurs in return for future interest. The individuals, who all have the same preferences and talents, derive their utility from consumption of the final good. The individual's lifetime utility is:

$$U = \int_0^{\infty} [U(c_t) e^{-\rho t}] dt, \quad (2.14)$$

where the stream of consumption is discounted with the rate of time preference, ρ , which measures how much the individual favors consumption today over consumption tomorrow. The higher the value of ρ , the less patient is the individual. We assume that $U(c_t)$ takes the following form:

$$U(c_t) = \frac{c_t^{1-\theta} - 1}{1-\theta}, \quad (2.15)$$

where $\frac{1}{\theta}$ is the intertemporal elasticity of substitution. The higher the value of θ , the more the individual dislikes deviations from a smooth consumption path.

The individual maximizes lifetime utility subject to his intertemporal budget constraint and subject to the evolution of his human capital stock. The intertemporal budget constraint is:

$$\dot{a}_t = w_t (1 - u_t) m_t + r_t a_t - c_t, \quad (2.16)$$

where \dot{a}_t is the change in the individual's stock of assets, i.e. the amount of final output the individual lends to entrepreneurs at time t . w_t is the equilibrium wage, $(1 - u_t)$ is the share of time dedicated to working, m_t is the individual's

endowment of human capital and r_t the return on accumulated assets, a_t , i.e. the accumulated amount of final output the individual has lent to entrepreneurs. The individual's endowment of human capital evolves in the following way:

$$\dot{m}_t = B (u_t m_t)^\beta \bar{m}_t^{1-\beta} - \delta m_t, \quad \beta \in (0, 1). \quad (2.17)$$

B is a constant representing the state of technology in the educational sector of the economy. u_t is the share of time i.e. the fraction of human capital dedicated to learning activities, m_t is the individual's human capital stock, \bar{m}_t is the average endowment of human capital of the inhabitants in the economy, and δ is the rate of depreciation of human capital. This depreciation rate could be thought of as the rate at which knowledge becomes obsolete due to technological progress. For simplicity, we shall assume a constant rate of depreciation. B has to be larger than the rate of depreciation, otherwise m declines even if the individual spends all his time in school. This is not the case if the average human capital stock exceeds that of the individual, but since all individuals are alike and the individual and the average human capital stock are equal in equilibrium, we assume that $B > \delta$.

Production of human capital depends both on the individual's input of human capital into the learning process, $u_t m_t$, and on the average endowment of human capital in the economy, \bar{m}_t . This dependence on the average endowment of human capital can be interpreted as the effect of the skills of teachers and colleagues on the individual's learning process. Holding constant the individual input into the learning process, an improvement in the average level of human capital would speed up the learning process of the individual. There is, however, decreasing returns both to the individual's input of human capital and to the average endowment of human capital. When the individual decides how much effort to dedicate to learning, he regards the average stock of human capital as exogenous, that is, he will not take into account the fact that his own decision to accumulate human capital will affect the growth in the average stock of human capital. This external effect of human capital will make the decentralized equilibrium deviate from the social optimum as a result of too little investment in human capital.

The utility maximizing individual will choose how much to consume and how much of his time to spend in school. That is, c_t , and, u_t are his control variables. The state variables he worries about are assets, a_t , and human capital, m_t .

We write the individual's present value Hamiltonian:

$$\begin{aligned} \max_{c_t, u_t} \mathcal{H}_t &= \frac{c_t^{1-\theta} - 1}{1-\theta} e^{-\rho t} + \lambda_t (w(1-u_t)m_t + r_t a_t - c_t) \\ &\quad + \mu_t \left(B(u_t m_t)^\beta \bar{m}_t^{1-\beta} - \delta m_t \right). \end{aligned} \quad (2.18)$$

The first order conditions are:

$$\mathcal{H}_c = c_t^{-\theta} e^{-\rho t} - \lambda_t = 0, \quad (2.19)$$

$$\mathcal{H}_u = -\lambda_t w m_t + \mu_t \beta u_t^{\beta-1} m_t^\beta \bar{m}_t^{1-\beta} = 0, \quad (2.20)$$

$$\mathcal{H}_a = \lambda_t r_t = -\dot{\lambda}_t, \quad (2.21)$$

and

$$\mathcal{H}_m = \lambda_t w (1-u_t) + \mu_t \left(\beta B u_t^\beta m_t^{\beta-1} \bar{m}_t^{1-\beta} - \delta \right) = -\dot{\mu}_t. \quad (2.22)$$

The transversality conditions are:

$$\lim_{t \rightarrow \infty} [\lambda_t a_t] = 0, \quad (2.23)$$

and

$$\lim_{t \rightarrow \infty} [\mu_t m_t] = 0. \quad (2.24)$$

2.4. Equilibrium

The first order conditions 2.19 and 2.21 are manipulated to solve for the growth rate of consumption:

$$\frac{\dot{c}_t}{c_t} = \frac{1}{\theta} (r_t - \rho), \quad (2.25)$$

which implies that the growth rate of consumption depends on the difference between the interest rate and the rate of time preference, and on the intertemporal elasticity of substitution in the same fashion as in the Ramsey model.

Taking into account that $m_t = \bar{m}_t$, since all individuals are alike, we can manipulate the first order conditions, 2.20, 2.21, and 2.22 to derive the following expression for the rate of change in the share of time spent in school:

$$\frac{\dot{u}_t}{u_t} = \frac{1}{1-\beta} \left(r_t - \beta u_t^{\beta-1} + \delta \right). \quad (2.26)$$

The expression in 2.26 tells us that the change in the time share spent in school will depend on the interest rate, i.e. the rate of return offered on loans to R&D activity and on the rate of return to additional human capital. If the interest rate is high today, that is, if it exceeds the marginal rate of return to the individual of an additional unit of human capital, the time share spent in school increases. The reason being that a high interest rate implies that the individual initially spends little time in school (since the pay off on lending to entrepreneurs is so high), but that the schooling effort increases as the return to R&D declines relative to the return to human capital accumulation. If, on the other hand, the interest rate is lower than the rate of return to additional human capital, the individual initially spends most of his time accumulating human capital, but the time share declines until the gap between the interest rate and the return to human capital is closed.

Equilibrium in the asset market will close the model. Asset market equilibrium requires the increase in the population's total assets to be equal to the total amount of resources spent on R&D by the entrepreneurs at each point in time. Since all individuals are identical, this yields the following asset market equilibrium condition:

$$L \dot{a}_t = \eta \dot{N}_t . \quad (2.27)$$

It also follows that the present value of total assets must equal the present value of future profit flows from all existing intermediates:⁶

$$La_t = \eta N_t . \quad (2.28)$$

The asset market equilibrium conditions and the individual's intertemporal budget constraint 2.16, can be used to find an expression for the rate of change of the number of intermediates:

$$\frac{\dot{N}_t}{N_t} = \frac{L}{\eta} \left(w(1 - u_t) \frac{m_t}{N_t} + r_t \frac{\eta}{L} - \frac{c_t}{N_t} \right) . \quad (2.29)$$

Since the interest rate paid by the entrepreneurs is that received by the individuals, we can substitute the expression for the interest rate, 2.13, into the motion equations, 2.25, 2.26, and 2.29. Using, again, that $m_t = \bar{m}_t$, in 2.17, we can describe the economy as a system of four differential equations in the level of

⁶The asset market equilibrium conditions, the equilibrium quantity demanded of each intermediate, the equilibrium wage, the equilibrium interest rate, and the individual's intertemporal budget restriction, can be used to show that all final goods produced are either consumed, used to produce intermediates or consumed in the R&D process.

consumption, c_t , the share of time spent in school, u_t , the human capital stock, m_t , and the number of intermediates, N_t :

$$\frac{\dot{c}_t}{c_t} = \gamma_c = \frac{1}{\theta} \left(\frac{L}{\eta} \kappa (1 - u_t) \frac{m_t}{N_t} - \rho \right), \quad (2.30)$$

$$\frac{\dot{u}_t}{u_t} = \gamma_u = \frac{1}{1 - \beta} \left(\frac{L}{\eta} \kappa (1 - u_t) \frac{m_t}{N_t} - \beta u_t^{\beta-1} + \delta \right), \quad (2.31)$$

$$\frac{\dot{m}_t}{m_t} = \gamma_m = B u_t^\beta - \delta, \quad (2.32)$$

and

$$\frac{\dot{N}_t}{N_t} = \gamma_N = \frac{L}{\eta} \left((w + \kappa) (1 - u_t) \frac{m_t}{N_t} - \frac{c_t}{N_t} \right). \quad (2.33)$$

3. Steady State

Solving the above system involves defining what we mean by steady state in this model. A steady state situation requires that the individual's allocation of time between school and work does not change over time, that is, \dot{u}_t , has to be zero. Equation 2.32 shows that a constant u implies that the growth rate of m is also constant in the steady state. Furthermore, since equation 2.31 implies that the ratio of human capital to the number of intermediates has to be constant, we know that the growth rate of the number of intermediates is also constant and equal to the growth rate of human capital in steady state. It follows that consumption grows at the same rate and that the ratio of consumption to the number of intermediates is constant in steady state.

In order to analyze the steady state and the transitional dynamics, we transform the system into a system of three differential equations in variables which are all constant in the steady state. We do this by forming the state-like variable z , which is the ratio of individual human capital to the number of intermediates, and the control-like variable Q , which is the ratio of consumption to the number of intermediates. Together with the motion equation for the time share spent in school, 2.31, the motion equations for z and Q form a dynamic system:

$$\frac{\dot{u}_t}{u_t} = \gamma_u = \frac{1}{1 - \beta} \left(\frac{L}{\eta} \kappa (1 - u_t) z_t - \beta u_t^{\beta-1} + \delta \right), \quad (3.1)$$

$$\frac{\dot{z}_t}{z_t} = \frac{\dot{m}_t}{m_t} - \frac{\dot{N}_t}{N_t} = \gamma_z = Bu_t^\beta - \frac{L}{\eta} (w + \kappa) (1 - u_t) z_t + \frac{L}{\eta} Q_t - \delta, \quad (3.2)$$

and

$$\frac{\dot{Q}_t}{Q_t} = \frac{\dot{c}_t}{c_t} - \frac{\dot{N}_t}{N_t} = \gamma_Q = \frac{L}{\eta} \left(\left(\frac{1}{\theta} - 1 \right) \kappa - w \right) (1 - u_t) z_t + \frac{L}{\eta} Q_t - \frac{1}{\theta} \rho. \quad (3.3)$$

We can now look for a steady state, (u^*, z^*, Q^*) , in which the growth rates of u , and our new variables, z and Q , are all zero. Unfortunately, we cannot solve for the steady state explicitly, but we can derive expressions for the steady state values of z and Q in terms of u^* , and we can then show that the steady state value of u lies between zero and one for plausible parameter values. Setting 3.1, 3.2 and 3.3 equal to zero we can derive the following expressions defining the steady state values of u , z and Q :

$$\theta u^{*\beta} = \beta u^{*\beta-1} - \frac{(1 - \theta) \delta + \rho}{B}, \quad (3.4)$$

$$z^* = \frac{\theta (Bu^{*\beta} - \delta) + \rho}{\frac{L}{\eta} \kappa (1 - u^*)}, \quad (3.5)$$

$$Q^* = \frac{\eta}{L} \left(\left(\frac{\theta}{\alpha} + \theta - 1 \right) (Bu^{*\beta} - \delta) + \left(1 + \frac{1}{\alpha} \right) \rho \right). \quad (3.6)$$

We can ensure that both z^* and Q^* are non-negative by invoking the transversality condition. Furthermore, since both z^* and Q^* are increasing functions of u^* we also know that the steady state is unique if there is a unique u^* . To obtain a solution, we need to assign values to the parameters. It can, however, be shown that there is a unique u^* and that for reasonable parameter values this unique u^* lies between zero and unity.

3.1. The steady state growth rate

In steady state, consumption, the number of intermediates, and human capital all grow at the same rate. Hence, the steady state growth rate of these variables is given by the growth rate of human capital in steady state:

$$\gamma_c^* = \gamma_N^* = \gamma_m^* = Bu^{*\beta} - \delta. \quad (3.7)$$

What about the growth rate of final output? We can write equilibrium output as:

$$Y_t = A \int_0^{N_t} [h_t^{1-\alpha} X_{jt}^\alpha] dj = AN (z^* (1 - u^*) L)^{1-\alpha} X^\alpha. \quad (3.8)$$

From this equation we can see that in steady state, when u , z and X are all constant, final output grows thanks to the expansion of the number of intermediates. The steady state growth rate of final output is, thus, equal to the steady state growth rate of consumption, human capital and of the number of intermediates. The incentive of the entrepreneurs to expand the number of intermediates rises when the interest rate is pushed up by the growth in the human capital stock which, in turn, results from the individual's decision to go to school. In making the choice between going to school and working, the individual weighs the benefit of being more educated in the future against the possibility of saving to earn future rent or consuming today.

The steady state growth rate is higher the larger the share of time dedicated to education. By taking the derivative of the growth rate with respect to each of the parameters and by differentiating 3.4 with respect to u and each of the parameters, we can determine how the growth rate depends on the parameters β , θ , δ , ρ , and B . The results are presented in the appendix and show that the growth rate is higher the more efficient the educational system (i.e. the higher the technology parameter B), the smaller the rate of depreciation of human capital, the smaller the rate of time preference, ρ , and the larger the intertemporal elasticity of substitution, $\frac{1}{\theta}$. Hence, the steady state growth rate depends on the parameters of the demand function, in a fashion similar to the neoclassical growth model: the more patient and the less keen on consumption smoothing the consumers are, the faster the economy grows in the steady state.

The dependence of the steady state growth rate on the degree of diminishing returns to the individual's investment in human capital, β , is ambiguous. For small time shares invested in schooling, higher β leads to slower steady state growth, while growth increases with β for a sufficiently large equilibrium time share spent in school. For sufficiently large u , the positive effect on growth of an upward shift in β , is the result of an increase in the equilibrium u . More time spent in school results in more rapid human capital accumulation. For small time shares, the increase in the schooling effort does not result in enough human capital accumulation to offset that less effort is used to produce goods.

4. Dynamics

Having established that there is a unique steady state, we need to find out whether the economy actually converges towards the steady state or not. Ideally we would like to make a global analysis of the dynamics. That is, we want to know the shape, slope, and position of the stable arm, if such a stable arm exists, and we want to know how fast the economy converges towards the steady state along the stable arm. Since we are unable to reduce the system to a two-variable problem, we cannot display the dynamics using phase diagrams, instead we will linearize the system using a first order Taylor expansion around the steady state.⁷ We display the qualitative behavior of the model for a set of benchmark parameter values.

The parameter values in this benchmark case are chosen to calibrate the growth rate to two percent. For some parameters our choice is guided by empirical findings, while other parameter values are set arbitrarily. The benchmark value for the inverse of the intertemporal elasticity of substitution, θ , is set to 2, which is lower than what has been suggested by recent attempts to estimate, θ . Acemoglu and Scott (1994) estimate a θ between 10 and 30, and Hall (1988) find a θ of at least 5. The choice of $\theta=2$ is, however, more in line with earlier calibrations of growth models, e.g. Mulligan and Sala-i-Martin, (1993) and Jones, Manuelli and Rossi (1993). The rate of time preference, ρ , which is set to 0.03, is also set in line with previous work on growth. The depreciation rate of human capital, δ , is set to 0.05, which is in line with estimates by Mincer and Ofek (1982). It is often argued that production of human capital, education, is more human capital intensive than other production. In line with this argument, β is set to 0.7, while α is set to 0.5. This α is higher than the commonly used α of 0.3, in calibrations of models with accumulation of physical capital and a fixed labor force. The motivation is that we think of the intermediates as a wider concept than physical capital. In order for the steady state growth rate to be 0.02, the chosen benchmark parameter values require a technology parameter, B , of 0.131. The R&D cost, η , the size of the population, L , and the technology parameter A , are set arbitrarily to 1.

⁷We could analyze the system globally with the time elimination method developed in Mulligan(1991). As long as the steady state is unique, such an analysis would generate the same qualitative results as a local analysis of the system when linearized around the steady state, see Mulligan and Sala-i-Martin (1993).

4.1. Stability and the slope and position of the stable arm

The linearized system can be written on matrix form:

$$\begin{bmatrix} \dot{u} \\ \dot{z} \\ \dot{Q} \end{bmatrix} = M \begin{bmatrix} u_t - u^* \\ z_t - z^* \\ Q_t - Q^* \end{bmatrix}, \quad (4.1)$$

where M is a 3x3-parameter matrix, presented in the appendix. It can be shown that the determinant and the trace of M are negative under certain conditions. This implies that the linearized system is either stable or saddle path stable. Since we are unable to solve explicitly for the eigenvalues of M , we have to rely on the numerical analysis in section 5, which indicates that M has only one negative eigenvalue and, hence, that the system is saddle path stable for relevant parameter ranges.

Assuming that the conditions for saddle path stability are satisfied, we can now find the position of the stable arm and derive how the time share allocated to education, u , and the ratio of consumption to intermediates, Q , change as the economy moves towards the steady state for the chosen set of benchmark parameter values. We are also able to study the transitional behavior of growth rates of the variables in the model. For convenience, we will relate changes to a measure of how distant the economy is from its steady state. This distance, d , is defined as:

$$d \equiv \ln \left(\frac{z_t}{z^*} \right), \quad (4.2)$$

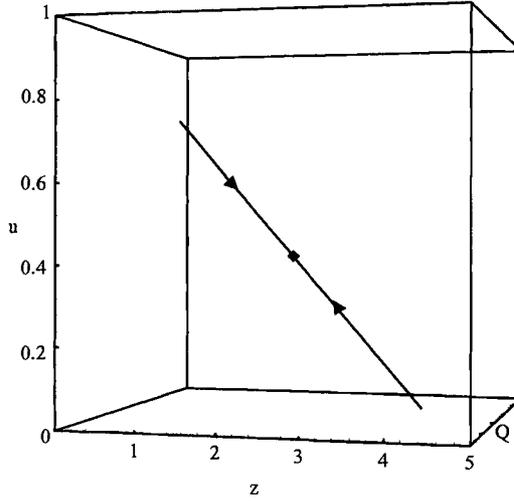
and the stable arm is defined as:

$$\begin{bmatrix} u_t \\ z_t \\ Q_t \end{bmatrix} = \begin{bmatrix} u^* \\ z^* \\ Q^* \end{bmatrix} + \frac{z^* (e^d - 1)}{v_2} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}, \quad (4.3)$$

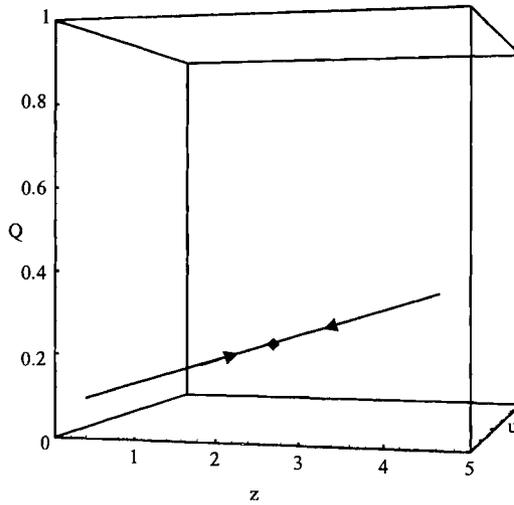
where $\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$ is the eigenvector of the matrix M , which is associated with the negative eigenvalue.

The linearized stable arm is depicted in three dimensions in the boxes in Figure 4.1 a,b.

Figure 4.1 :
The linearized stable arm depicted in (u, z, Q) -space.



a



b

There is a negative relation between the time share spent in school and the ratio of human capital to intermediates, and a positive relation between the ratio

of consumption to intermediates and the ratio of human capital to intermediates. It should be noted again that this relation between u , z and Q , holds only for a region close to the steady state.

The graphs in Figures 4.2 and 4.3 show how u and Q change as the ratio of human capital to intermediates, z , approaches its steady state position. If the economy starts out with a relative scarcity of human capital, that is $z < z^*$, individuals spend a large share of their time accumulating human capital. Because they have little time left over for work, their wage earnings are small and they can therefore only afford to consume relatively little in relation to the steady state ratio of consumption to intermediates. As the economy moves towards the steady state, the time share spent in school gradually declines and the level of consumption increases. If, on the other hand, the economy is relatively rich in human capital, u increases and Q decreases as the steady state is approached.

Figure 4.2:

The choice of the time share spent in school, u , as a function of the ratio of human capital, z , relative to the steady state position, z^* .

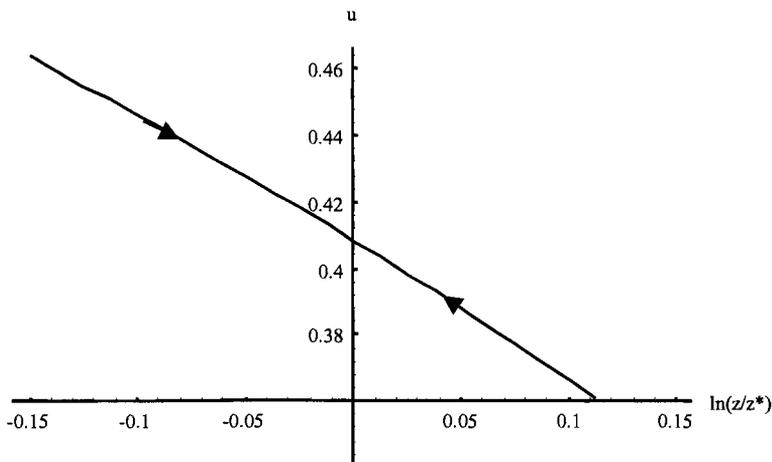
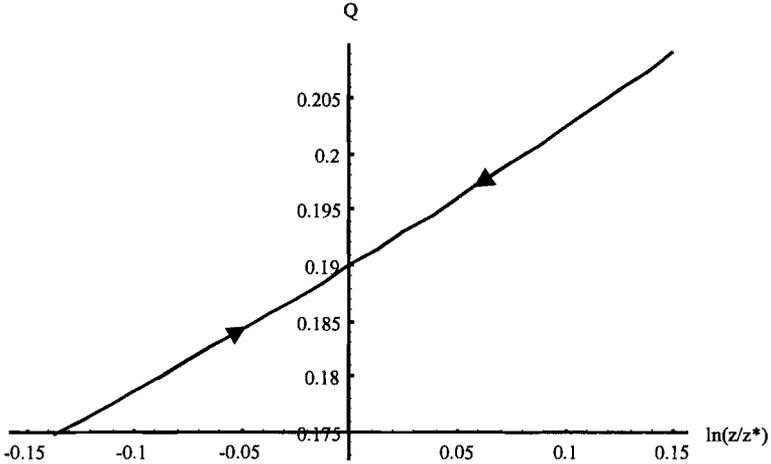


Figure 4.3:

The choice of the ratio of consumption to intermediates, Q , as a function of the ratio of human capital, z , relative to the steady state position, z^*

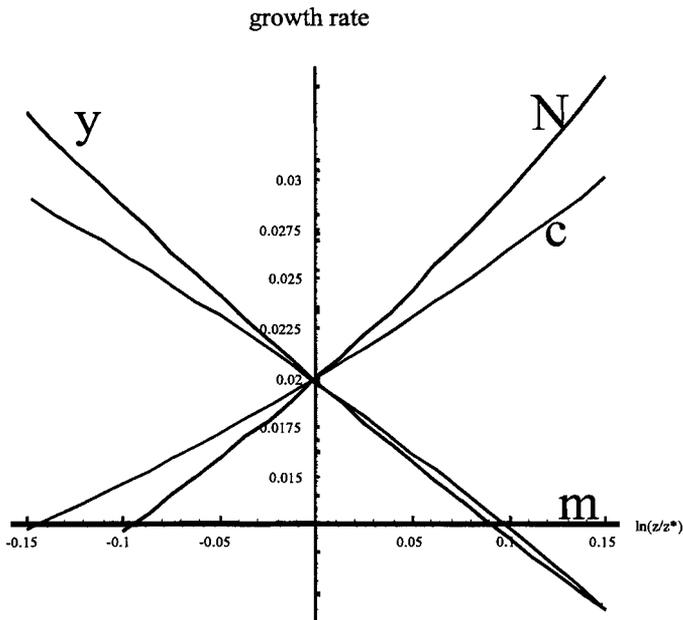


We can understand these slopes by taking a look at equation 2.26 which tells us that the change in the time share spent in school depends on the interest rate, i.e. the rate of return offered on loans to R&D activity and on the rate of return to additional human capital. If the economy has a relative scarcity of human capital, that is $z < z^*$, the rate of return to human capital is high in relation to the interest rate. The individual thus chooses to invest so much in schooling that he has little time left to work in order to earn wage income. The individual chooses to give up consumption in order to accumulate human capital and the ratio of consumption to intermediates is therefore small, despite very small investments in R&D. As the rate of return to human capital declines and the interest rate increases, the share time spent in school is decreased and investments in R&D are increased. Although the individual's incentive to invest in R&D increases, the increased wage earnings, resulting from his enlarged human capital stock and from a larger time share spent working, allows the individual to choose an increasing ratio of consumption to R&D capital as the gap between the interest rate and the return to human capital investments is closed.

4.2. The transitional behavior of growth rates

We are now interested in how the transitional behavior of the growth rates of consumption, human capital, number of intermediates, and output relate to the distance of the economy to its steady state position. We take a particular interest in how imbalances between human capital and the number of intermediates affect the growth rates in the economy. The transitional behavior of growth rates is shown in figure 4.4, which displays how the growth rates change in relation to distance of the state variable from its steady state position. Due to the linearization around the steady state, the relations shown in the figures only hold close to the steady state, i.e. close to $\ln(z/z^*) = 0$. A $\ln(z/z^*)$ -value of 0.1 implies that the state variable is ten percent larger than its steady state value.

Figure 4.4:
**The transitional behavior of the growth rates
of consumption, human capital, intermediates and output.**



The growth rate of consumption.

If the economy initially has a relative scarcity of human capital, that is $z < z^*$, the return to introducing new intermediates is low to start with. The return to human capital, however, is high and individuals therefore accumulate human capital. This causes the return to intermediates to increase. This increase in the interest rate causes the growth rate of consumption to increase during the transition to the steady state. Should the economy instead have a relatively large stock of human capital at the outset, the interest rate, and thus the growth rate of consumption, are high initially and then fall as the economy approaches its steady state. This imbalance effect is similar to the imbalance effect between human capital and physical capital found in the Uzawa-Lucas model.

The growth rate of human capital.

The growth rate of the stock of human capital is determined by how much time is spent in school. If the economy has a relative scarcity of human capital at the outset, the growth rate of human capital is initially high and then subsequently declines towards the steady state growth rate of human capital. If the economy is very abundant in human capital, the share of time spent in school is very small and the growth rate of human capital may therefore initially be negative, since the rate of depreciation of human capital may exceed the rate at which human capital is formed. The growth rate of human capital increases gradually as the steady state ratio of human capital to intermediates is reached.

The growth rate of the number of intermediates.

The growth rate of N depends on the willingness of individuals to invest in R&D. This willingness depends on the interest rate and on the individuals allocation of time between work and school. As we have seen above, time allocation depends on the relative rates of return to R&D and human capital. We know from Figure 4.3 that the ratio of consumption to intermediates increases as the economy moves from a situation of relative human capital scarcity towards the steady state. Thus, the number of intermediates must grow at a slower rate than consumption during the transition. If, on the other hand, the economy is relatively human capital abundant, the speed at which new intermediates are introduced will be higher than the growth rate of consumption, since the ratio of consumption to intermediates, Q , decreases as the economy moves closer to the steady state.

The growth rate of output per capita.

So far we have not discussed what happens to the dynamics of output in the model. If the equilibrium expressions for the demand for intermediates and the price of intermediates are substituted into the production function of final output,

we can write final output per capita, y , as:

$$y = (A\alpha^{2\alpha})^{\frac{1}{1-\alpha}} (1 - u_t) m_t, \quad (4.4)$$

which implies that the growth rate of output is:

$$\frac{\dot{y}_t}{y_t} = \frac{\dot{m}_t (1 - u_t)}{m_t (1 - u_t)}. \quad (4.5)$$

The growth in output per capita thus depends positively on the growth rate of human capital, but is, of course, also affected by changes in the time share dedicated to work. The more human capital employed in production, the higher is output. Given how m and u evolve as the steady state is approached, final output per capita grows fast, but at a decreasing rate if the economy starts out with a relative scarcity of human capital, and very slowly if the economy initially is relatively abundantly endowed with human capital. That is, a situation with plenty of human capital and little R&D capital results in lower than steady state output growth, whereas plenty of R&D capital and little human capital give higher than steady state output growth. The reason is that an economy which is rich in R&D capital has a strong incentive for accumulation of human capital and a potential for output growth through the reallocation of time from school to work. If, on the other hand, the economy has little R&D capital, individuals work most of their time and although there is a strong incentive for investments in R&D, the effect on output is small. The reason is that the increase in the number of intermediates puts a downward pressure on the interest rate which raises the relative return to human capital. This causes individuals to spend more time in school. This effect reduces the growth rate of output. Hence, the growth rate of output does not display the U-shape it does in the Uzawa-Lucas model. Our imbalance effect for output is also opposite to the imbalance effect for broad output found in the Uzawa-Lucas model.

The concept of broad output was mentioned in the introduction. As defined in Barro and Sala-i-Martin (1995), broad output is the output produced in the final output sector plus the value, in terms of consumption goods, of the accumulation of human capital. In this context, per capita broad output, O , is:

$$O_t = y_t + \frac{\mu_t}{\lambda_t} B u_t^\beta m_t.$$

It can be shown that the qualitative results that are presented for final output are valid also for this concept of broad output. We will therefore not present separate results for broad output.

The direction of the imbalance effect on output in our model leads the thought to the idea gap discussed in Romer (1993). Romer argues that lack of ideas, i.e. knowledge of what and how things can be done, is more important than lack of machines, object or even skills when one tries to understand why some developing countries grow slowly or not at all. While ideas generate demand for other factors of production, people or firms cannot demand things or services they do not know of. The model developed here, a relative lack of R&D capital which could be interpreted as idea gap, implies poor growth because accumulation of human capital is slow. Abundance of R&D capital, on the other hand, leads to rapid growth as a result of rapid human capital accumulation inspired by a high rate of return and because individuals reallocate time from going to school to working in the final output producing sector.

4.3. Speed of convergence

The previous analysis showed how decision variables and growth rates change as the economy moves towards its steady state. This section focuses on how fast these changes take place. In order to analyze the speed of convergence towards the steady state, we log-linearize the system around the steady state and write the system as:

$$\begin{bmatrix} \frac{\partial \ln u}{\partial t} \\ \frac{\partial \ln z}{\partial t} \\ \frac{\partial \ln Q}{\partial t} \end{bmatrix} = \hat{M} \begin{bmatrix} \ln \frac{u_t}{u^*} \\ \ln \frac{z_t}{z^*} \\ \ln \frac{Q_t}{Q^*} \end{bmatrix}, \quad (4.6)$$

where \hat{M} is a 3x3 parameter matrix with the same eigenvalues as the matrix M in 4.1. The solution to the system is then:

$$\ln i_t = e^{\varepsilon t} \ln i(0) + (1 - e^{\varepsilon t}) \ln i^*, \text{ for } i = u, z, Q, \quad (4.7)$$

where ε is the negative eigenvalue of the matrix \hat{M} and $-\varepsilon$ is the speed of convergence. $(u(0), z(0), Q(0))$ is the position on the stable arm at which the economy starts out at time $t = 0$. Hence, we can obtain an expression for how the economy's position in relation to the steady state, d , evolves over time, given the position at the outset:

$$d = \ln \left(\frac{z(0)}{z^*} \right) e^{\varepsilon t}.$$

We can now display graphically how decision variables and growth rates converge towards their steady state values over time, when the economy starts out

in a situation where the ratio of human capital to intermediates is half its steady state value. In the benchmark case, it takes about 2.5 years to get half-way to the steady state. This implies that the speed of convergence, $-\varepsilon$, is 0.28. To determine how the speed of convergence depends on the parameters of the model, requires us to solve explicitly for the eigenvalues of matrix M . Since, we have not been able to do so, the dependence of the convergence speed on parameter values will only be analyzed numerically.

Figure 4.5:

The convergence over time of the time share spent in school, u .

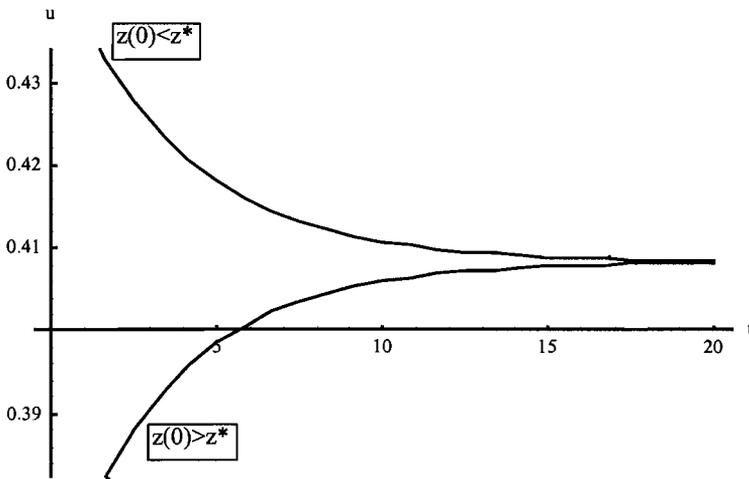


Figure 4.6:
The convergence over time of the ratio of consumption to intermediates, Q .

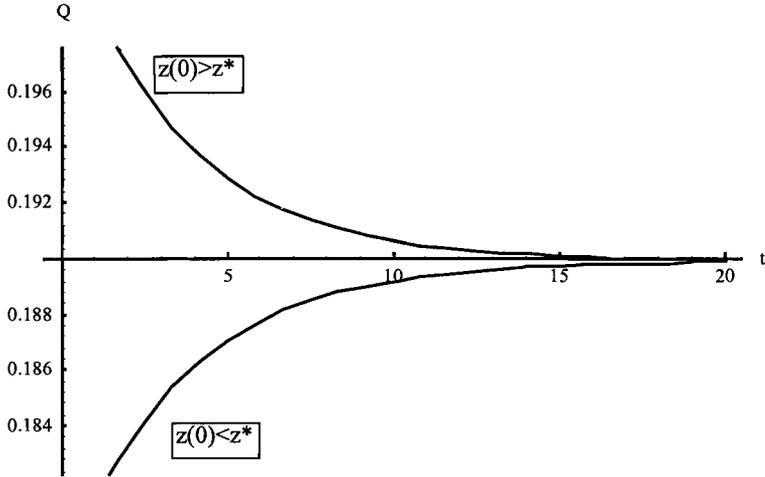


Figure 4.7:
The convergence over time of the growth rate of consumption, γ_c .

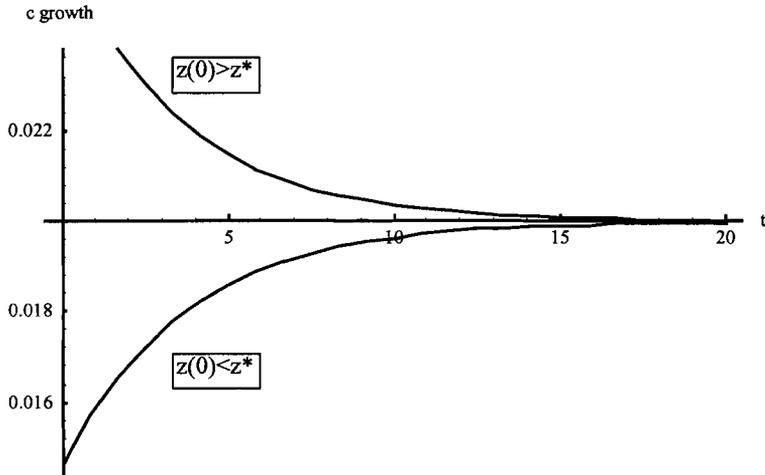


Figure 4.8:

The convergence over time of the growth rate of human capital, γ_m .

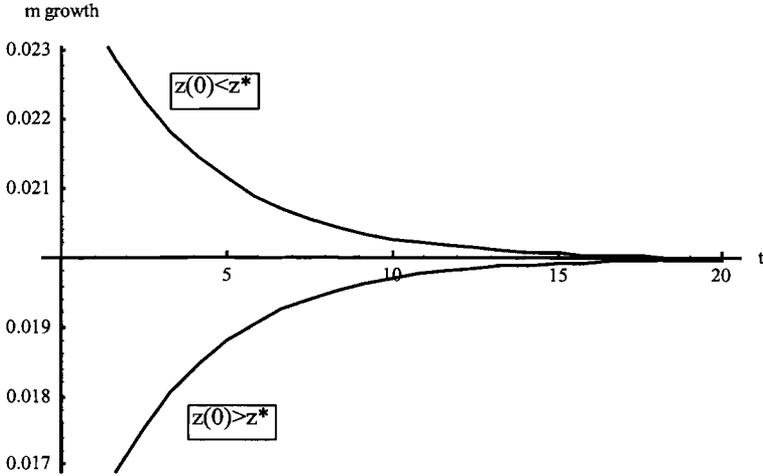


Figure 4.9:

The convergence over time of the growth rate of intermediates, γ_N .

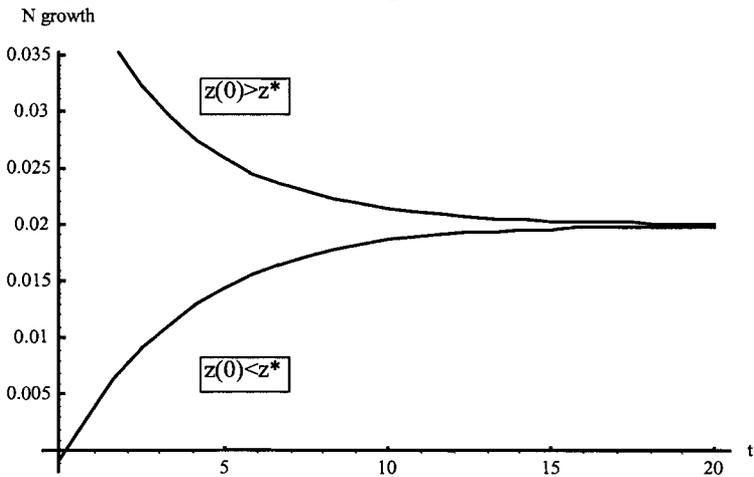
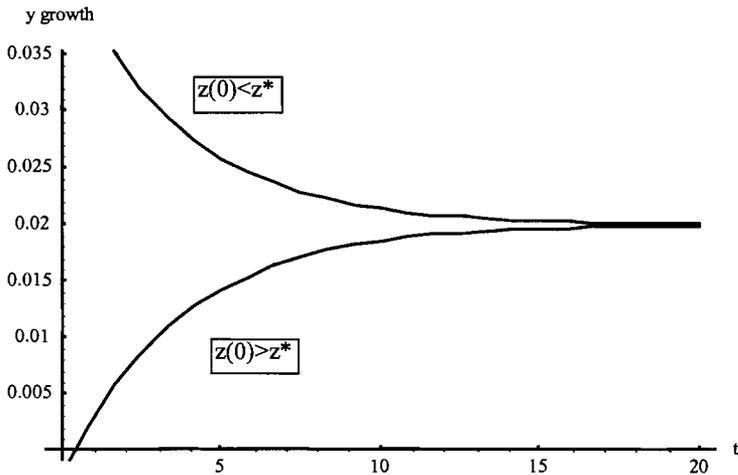


Figure 4.10:
The convergence over time of the growth rate of output, γ_y .



5. Sensitivity Analysis

As shown above, the steady state growth rate depends on the parameters of the demand function and on the parameters in the motion equation of human capital. In this section we examine how the position of the steady state, the slope of the stable arm, and the convergence speed depend on the parameters of the model. We present the results of a sensitivity analysis of the steady state and the dynamics. It turns out that the model behaves qualitatively similar for the ranges of parameter values tested.

The qualitative results of the numerical simulations to compute the steady state, the slope of the stable arm, the convergence speed, and the steady state growth rates for different parameter values, are summarized in Table 5.1, while the full results are presented in Table 5.2. Apart from showing how these depend qualitatively and quantitatively on changes in parameter values, the numerical simulations also show that the dynamics around the steady state exhibit saddle path stability, that is, there is one negative and two positive eigenvalues, for the ranges of parameter values tested here. The results reported in Tables 5.1 and 5.2 are obtained in numerical simulations in which one parameter at a time is allowed to deviate from its benchmark value, and we can thus say nothing about where the economy ends up if all parameters are altered at the same time.

5.1. Qualitative results of the sensitivity analysis

Table 5.1 presents the effects on steady state values and the convergence rate of allowing one parameter at a time to vary from the lower to the upper bound of a given interval. A plus (minus)-sign implies that the value of the particular variable increases (decreases) as the parameter value is increased. Column (1) reports the parameter and the range tested, column (2) reports the effect on the steady state growth rate of a change in the parameter. In column (3), the effect on the number of years it takes for the economy to get half-way to its steady state is reported, columns (4)-(6) report the effects on the steady state values of u , z and Q .

The results displayed in column (2), are consistent with the findings in Section 3.1 on the steady state growth rate, that is, the steady state growth rate depends on the parameters of the demand function and of the parameters of the human capital accumulation function. The more patient and the less keen the individual is on consumption smoothing, the faster the steady state growth rate. The economy also grows faster in steady state, the higher the level of technology in the educational sector and the lower the rate of depreciation of human capital. As mentioned before, there is an ambiguity with respect to the degree of decreasing returns to human capital in the learning process.

In column (3), we can see that the speed of convergence towards the steady state depends on the same parameters as the steady state growth rate, with the addition of the elasticity of the final output production function with respect to intermediates. The economy moves faster (half life is shorter) towards the steady state, the less keen the individual is on consumption smoothing and the more favorable the environment for human capital accumulation (that is the higher the level of technology). If the individual does not care very much about a smooth consumption path, he is willing to experience rapid changes in consumption levels along the transition to the steady state. Convergence towards steady state is on the other hand slower if the elasticity of output with respect to intermediates is high.⁸

⁸The effects on the speed of convergence of the level of technology in the human capital sector and of the elasticity of output with respect to intermediates are the same as those found for the model of endogenous growth with human and physical capital in Ortigueira and Santos (1997). However, in their calibrations, preference parameters exert no influence on the speed of convergence.

Table 5.1:
Qualitative results of sensitivity analysis

1	2	3	4	5	6
Parameter (range tested)	Steady state growth rate	Half life of distance to Steady State	u^*	z^*	Q^*
θ (0.5-100)	-	+	-	- +	+
ρ (0.001-0.05)	-	+	-	-	+
B (0.01-100)	+	-	-	+	+
β (0.001-0.999)	- +	+ -	+	- +	- +
δ (0-0.075)	-	+	+	-	-
L (0.01-100)				-	-
η (0.01-100)				+	+
α (0.001-0.999)		+		- +	-
A (0.05-100)				-	

empty cell=a change in the parameter has no effect, + = an increase in the parameter results in a monotonous increase in the variable, - = an increase in the parameter results in a monotonous reduction in the variable, -+ = raising the parameter first leads to a decline and then to an increase in the variable, +- = raising the parameter first leads to an increase and then to a decline in the variable.

The position of the steady state is also affected by the parameters of the model. While the time share dedicated to education is affected only by demand and human capital accumulation related parameters, the steady state positions of the ratio of human capital to intermediates, z , and the ratio of consumption to intermediates are affected also by the parameters of the final output sector and

the parameters pertaining to the R&D activity. In column (4), we see that people go to school less in steady state, the more keen they are on a smooth consumption path and the less patient they are. A high level of technology in the educational sector and a low rate of depreciation reduces the educational effort needed to keep up a certain level of accumulation, whereas a high β makes high educational efforts worthwhile since a high β implies that the degree of decreasing returns to educational effort is low.

The steady state ratio of human capital to intermediates in column (5), is higher the higher the level of technology in the educational sector and the lower the rate of depreciation of human capital. Both these parameters determine how costly it is to accumulate human capital, and the more costly it is, the lower will be the steady state ratio of human capital to intermediates. If the population is large, low human capital per worker is compensated by the large number of workers and thus the steady state ratio of human capital to intermediates decreases with the size of the labor force. This result is, of course, directly linked to the assumption that firms care about the total amount of human capital employed and not on how it is distributed among the workers. The R&D cost is positively related to the ratio of human capital to intermediates, since a high R&D cost makes the cost of intermediates high relative to the cost of human capital.

The steady state ratio of consumption to intermediates in column (6), could be interpreted as the proportion of material wealth consumed at each moment. If the individual likes a smooth consumption path and if he is impatient, the ratio of consumption to intermediates is high. If the level of technology in the educational sector is high, the individual chooses to have a larger share of his wealth denominated in human capital, and consumption as a share of wealth denominated in intermediates is therefore high. The same kind of reasoning applies to the rate of depreciation, the size of the work force and the R&D cost.

5.2. Quantitative results of the sensitivity analysis

In Table 5.2, we can go further and see how sensitive the steady state and the dynamics are to parameter changes. We have added column (2), which reports the value of the parameter being tested. It can be noted that altering the parameters of the demand function, θ and ρ , does not seem to have very large effect on the steady state and the dynamics.

Table 5.2:
Quantitative results of sensitivity analysis

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Para- meter	Para- meter value	Steady state growth	Half life of distance to Steady State	u^*	z^*	Q^*
θ	0.5	0.048	1.520	0.659	2.530	0.114
	1	0.032	2.057	0.513	2.037	0.154
	2	0.020	2.470	0.408	1.892	0.190
	3	0.015	2.670	0.365	1.866	0.208
	5	0.010	2.877	0.325	1.860	0.226
	10	0.005	3.084	0.291	1.868	0.243
	100	0.001	3.339	0.257	1.892	0.263
ρ	0.001	0.031	2.167	0.502	2.017	0.157
	0.005	0.029	2.213	0.488	1.922	0.162
	0.01	0.027	2.268	0.472	1.965	0.167
	0.03	0.020	2.470	0.408	1.892	0.190
	0.05	0.013	2.642	0.350	1.862	0.214
B	0.01	0.005	4.210	0.428	1.127	0.116
	0.131	0.020	2.470	0.408	1.892	0.190
	0.5	0.197	0.437	0.365	10.671	1.074
	1	0.437	0.208	0.357	22.486	2.273
	5	2.355	0.040	0.351	116.931	11.864
	10	4.753	0.020	0.351	234.98	23.853
	100	47.91	0.002	0.350	2359.8	239.66
β	0.001	0.080	2.675	0.000	3.036	0.489
	0.05	0.059	3.308	0.028	2.450	0.387
	0.3	0.027	4.637	0.172	1.635	0.226
	0.5	0.021	4.054	0.291	1.611	0.193
	0.7	0.020	2.470	0.408	1.892	0.190
	0.95	0.024	0.336	0.549	2.776	0.211
	0.999	0.025	0.006	0.576	3.053	0.217
δ	0	0.049	0.299	0.245	21.406	2.535
	0.025	0.025	0.307	0.251	20.78	2.441
	0.05	0.020	2.470	0.408	1.892	0.190
	0.075	0.004	3.881	0.488	1.210	0.112

benchmark results are reported in bold print

Table 5.2 cont:
Quantitative results of sensitivity analysis

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Para- meter	Para- meter value	Steady state growth	Half life of distance to Steady State	u*	z*	Q*
<i>L</i>	0.01	0.020	2.470	0.408	189.21	18.99
	0.5	0.020	2.470	0.408	3.784	0.380
	1	0.020	2.470	0.408	1.892	0.190
	2	0.020	2.470	0.408	0.946	0.095
	5	0.020	2.470	0.408	0.378	0.038
	10	0.020	2.470	0.408	0.189	0.019
	100	0.020	2.470	0.408	0.019	0.002
<i>η</i>	0.01	0.020	2.470	0.408	0.019	0.002
	0.5	0.020	2.470	0.408	0.946	0.095
	1	0.020	2.470	0.408	1.892	0.190
	2	0.020	2.470	0.408	3.784	0.380
	5	0.020	2.470	0.408	9.461	0.950
	10	0.020	2.470	0.408	18.921	1.899
	100	0.020	2.470	0.408	189.21	18.99
<i>α</i>	0.001	0.020	0.184	0.408	120.02	70.02
	0.05	0.020	1.136	0.408	3.413	1.449
	0.3	0.020	2.163	0.408	1.580	0.283
	0.5	0.020	2.470	0.408	1.892	0.190
	0.7	0.020	2.656	0.408	2.975	0.150
	0.95	0.020	2.808	0.408	17.48	0.124
	0.999	0.020	2.831	0.408	873.8	0.120
<i>A</i>	0.5	0.020	2.470	0.408	7.568	0.190
	1	0.020	2.470	0.408	1.892	0.190
	2	0.020	2.470	0.408	0.473	0.190
	5	0.020	2.470	0.408	0.076	0.190
	10	0.020	2.470	0.408	0.019	0.190
	100	0.020	2.470	0.408	0.000	0.190

benchmark results are reported in bold print

Changes in B , on the other hand, have large effects on growth, speed of convergence, and on the steady state ratios of human capital to intermediates and

consumption to intermediates. β also has a marked impact on growth and convergence speed. The individuals allocation of time between work and school, u^* , is more sensitive to changes in the degree of diminishing returns to schooling effort, β , than to any other parameter changes. Whereas the size of the work force, L , the R&D cost, the elasticity of output with respect to intermediates and the level of technology in final output production have no or little impact on steady state growth, convergence speed and educational effort, they are influential when it comes to determining the whereabouts of the steady state.

6. Discussion and Conclusion

This paper has analyzed an economy in which individuals accumulate human capital and invest in R&D which is carried out by entrepreneurs. In the model we have presented, output per capita of an economy is determined by the stock of human capital and the time share spent working. We find that the long run growth rate of an economy is determined by the capacity of the economy to accumulate human capital and by the preferences of individuals. It follows that if an economy is poor in output per capita terms relative to its stock of human capital, it will grow fast if the reason for low output per capita is that the citizens are spending their time accumulating human capital instead of working. In such a situation, the country has a strong output growth potential which is realized once people reallocate time from school to work. Our model thus implies that changes in labor participation rates should have explanatory power for growth.

In line with other growth models, we find that steady state growth increases with patience and decreases with the preference for smooth consumption. Apart from preferences, the determinants for long run growth are the efficiency of the educational system and the rate of depreciation of human capital. Our model also predicts a positive correlation between long run growth and the rate of investment in the R&D sector, as well as between output growth and investments in human capital.

Furthermore, we find that a relative lack of ideas or R&D capital, i.e. a ratio of human capital to intermediates in excess of the steady state ratio, will cause the economy to grow slowly during its transition to the steady state, while a relative abundance of R&D capital gives high growth rates during transition. This asymmetric imbalance effect can be interpreted as being the result of an idea gap. Abundance of ideas provides a strong incentive for investments in other factors of production, which leads to growth. Lack of ideas, on the other hand, is

an incentive for investments in ideas. The growth in the stock of ideas stimulate people to reallocate effort from producing output to accumulation of factors. This reallocation reduces the output growth effect induced by growth in the stock of ideas.

Although our model has little to say about why or how an economy would end up in a situation where R&D capital and human capital are out of balance, our results offer some insight as to why human capital rich economies can experience poor growth. Political decisions which affect the efficiency of human capital accumulation, are examples of events which may cause the steady state to shift. Such a steady state shift would render the ratio of human capital to R&D capital out of balance. If such a political measure had the effect of worsening the efficiency of the educational system, it would put the economy in a situation with a relative human capital abundance. People would shift from schooling to working, which would give a short run boost in output, but the economy would then grow slowly. Isolating an economy from information flows and other foreign influences, as has been the unfortunate policy in many developing countries during the post independence era is an example of such a growth hampering policy. However, if policy measures instead are positive for the efficiency of human capital accumulation, the effect is the opposite and leads to rapid growth in transition and a higher steady state growth rate.

An implication of this imbalance effect is that there is a possibility both of convergence and non-convergence in per capita output levels over time. If the citizens of two economies have the same preferences and if all the technology parameters are the same for the two countries, history will determine whether per capita output of the two economies converge over time or not. If history has endowed the two economies with the same ratio of human capital to R&D capital, they will follow the same growth path and initial income differences will be permanent. However, if history for some reason has endowed the poorest of the two economies with a relative scarcity of human capital and the richer economy with a relative abundance of human capital, output levels will converge over time. The poor economy may get closer or catch up completely, but it could also surpass the rich economy. In the case where the initially rich economy is also the one scarcely endowed with human capital, the output gap will widen. If technologies are different, long run growth rates will differ and income gaps will widen. In this case, the economy with superior capacity to accumulate human capital will always eventually be the richest economy, whether it was rich or poor to start with.

The reason for catching up or surpassing in this model is that the citizens of the catcher up (or over taker) economy have a stronger incentive to accumulate human capital than the citizens of the leader and laggard economies. This will be the case if the catcher up economy has a relative abundance of R&D capital which makes the relative return to human capital investments large. Because of the high returns to investment in human capital and, hence, large time share is spent in school, a catcher up (over taker) economy will initially have a small output per capita relative to its human capital endowment. This result finds support in the empirical literature.

The numerical simulations carried out in section 5 indicate that the transition to the steady state growth rate is rapid, in comparison with the empirical findings of rates of convergence of about 2 per cent per year. Our simulations indicate a half life of at the most 5 years in comparison to a half life of about 34 years which corresponds to a speed of convergence of 2 per cent. High speeds of convergence is, however, common to most calibrations of endogenous growth models. An implication of rapid convergence is that growth rates will deviate from the steady state growth rate only for brief periods of time, making the likelihood of catching up small unless we assume that economies for some exogenous reason are frequently pushed away from their steady states.

Apart from rendering the model interesting transitional dynamics, the R&D sector is of limited importance for growth in the long run. This is due to the absence of scale effects. Human capital accumulation is the real source of growth in the model. The individual's possibility to choose between human capital accumulation and investments in R&D as alternative ways of influencing future income is what drives the dynamics of the model, but in the steady state, the individual's savings, i.e. investments in R&D, increase at the same rate as he accumulates human capital. Production of output in the model depends on the total amount of intermediates in production, NX , which means that the number of intermediates and the quantity of each intermediate are, in fact, perfect substitutes. An implication of this is that it would be possible to sustain growth by expanding the quantity of each intermediate instead of expanding the number of intermediates. Although this would violate the zero profit condition of the entrepreneurs, a social planner could actually improve growth by forbidding R&D, thereby stopping the expansion of N and instead increasing the use of each type of intermediate. This implication which is present, albeit not discussed, in Jones (1995) appears to be a consequence of there being no scale effects from R&D. It is clear that the importance of R&D and entrepreneurship for economic growth, in the absence of

scale effects, deserves more attention.

References

- [1] Aghion, P. and P. Howitt (1990), "A Model of Growth Through Creative Destruction", *Econometrica*, vol. 60, no. 2(March), 323-351.
- [2] Backus, K.D., P.J. Kehoe and T.J. Kehoe (1992), "In Search of Scale Effects in Trade and Growth", *Journal of Economic Theory*, vol. 58, no. 2, 377-409.
- [3] Barro, R.J. (1991), "Economic Growth in a Cross-Section of Countries", *Quarterly Journal of Economics*, vol. 106, 407-443.
- [4] Barro, R.J. and X. Sala-i-Martin (1995), *Economic Growth*, McGraw-Hill, Inc.
- [5] Blomström, M., R. E. Lipsey and M. Zejan (1994), "What Explains Developing Country Growth?" in *Convergence of Productivity*, eds W.J. Baumol et al, Oxford UP, Oxford.
- [6] DeLong, J. B. and L. H. Summers (1991), "Equipment Investment and Economic Growth", *Quarterly Journal of Economics*, vol. 106, no. 2(May), 445-502.
- [7] Dixit, A. K. and J. E. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity", *American Economic Review*, vol. 67, no. 3(June), 297-308.
- [8] Ethier, W. J. (1982), "National and International Returns to Scale in the Modern Theory of International Trade", *American Economic Review*, vol. 72, no. 3(June), 389-405.
- [9] Grossman, G. M. and E. Helpman (1991), *Innovation and Growth in the Global Economy*, MIT Press, Cambridge MA.
- [10] Hall, R. E. (1988), "Intertemporal Substitution of Consumption", *Journal of Political Economy*, vol. 96, no. 2, 339-357.
- [11] Jones, C. I. (1995), "R&D-Based Models of Economic Growth", *Journal of Political Economy*, vol. 103, no. 4, 759-784.

- [12] Jones, L. E., R. E. Manuelli and P.F. Rossi (1993), "Optimal Taxation in Models of Endogenous Growth", *Journal of Political Economy*, vol. 101, 485-517.
- [13] Levine, R. and D. Renelt (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review*, vol. 82, no. 4(September), 942-963.
- [14] Lucas, R. E., Jr (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics*, vol. 22, no. 1, 3-42.
- [15] Mankiw, N. G., D. Romer and D. N. Weil (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, vol. 107, no. 2, 407-437.
- [16] Mincer, J. and H. Ofek (1982), "Interrupted Work Careers: Depreciation and Restoration of Human Capital", *Journal of Human Resources*, vol. XVII, no. 1, 13-24.
- [17] Mulligan C. B. (1991), "A Note on the Time-Elimination Method for Solving Recursive Dynamic Economic Models", *NBER Technical Working Paper*, no. 116.
- [18] Mulligan C. B. and X. Sala-i-Martin (1993), "Transitional Dynamics in Two-Sector Models of Economic Growth", *Quarterly Journal of Economics*, vol. 108, no. 3, 737-773.
- [19] Nelson, R. R. and E. S. Phelps (1966), "Investment in Humans, Technological Diffusion, and Economic Growth", *American Economic Review*, vol. 56, no. 2, 69-75.
- [20] Ortigueira, S. and M. S. Santos (1997), "On the Speed of Convergence in Endogenous Growth Models", *American Economic Review*, vol. 87, no. 3(June), 383-399.
- [21] Romer, P. M. (1987), "Growth Based on Increasing Returns Due to Specialization", *American Economic Review*, vol. 77, no. 2(May), 56-62.
- [22] Romer, P. M. (1990), "Endogenous Technological Change", *Journal of Political Economy*, vol. 98, no. 5, 71-102.

- [23] Romer, P. M. (1993), "Idea Gaps and Object Gaps in Economic Development", *Journal of Monetary Economics*, vol. 32, 543-573.
- [24] Segerstrom, P. S. (1991), "Innovation, Imitation, and Economic Growth", *Journal of Political Economy*, vol. 99, no. 4, 807-827.
- [25] Spence, M. (1976), "Product Selection, Fixed Costs, and Monopolistic Competition", *Review of Economic Studies*, vol. 43, no. 2(June), 217-235.
- [26] Young, A. (1998), "Growth without Scale Effects", *Journal of Political Economy*, vol. 106, no. 1, 41-63.

A. Appendix

A.1. Comparative statics on the steady state growth rate:

$$\frac{\partial \gamma^*}{\partial B} = u^{*\beta} + B\beta u^{*\beta-1} \frac{du^*}{dB} = \frac{u^{*\beta-1} + (\theta - 1) u^{*\beta}}{(1 - \beta) u^{*-1} + \theta} > 0, \quad (\text{A.1})$$

$$\frac{\partial \gamma^*}{\partial \delta} = B\beta u^{*\beta-1} \frac{du^*}{d\delta} - 1 = -\frac{1 + (1 - \beta) u^{*-1}}{(1 - \beta) u^{*-1} + \theta} < 0, \quad (\text{A.2})$$

$$\frac{\partial \gamma^*}{\partial \theta} = B\beta u^{*\beta-1} \frac{du^*}{d\theta} = -\frac{Bu^{*\beta} - \delta}{(1 - \beta) u^{*-1} + \theta} < 0, \quad (\text{A.3})$$

$$\frac{\partial \gamma^*}{\partial \rho} = B\beta u^{*\beta-1} \frac{du^*}{d\rho} = -\frac{1}{(1 - \beta) u^{*-1} + \theta} < 0, \quad (\text{A.4})$$

$$\frac{\partial \gamma^*}{\partial \beta} = Bu^{*\beta} \ln u^* + B\beta u^{*\beta-1} \frac{du^*}{d\beta} = Bu^{*\beta} \frac{\ln u^* + 1}{1 - \beta + \theta u^*} \geq 0 \text{ if } u^* \geq e^{-1}. \quad (\text{A.5})$$

A.2. The matrix M :

$$M = \begin{bmatrix} -\frac{1}{1-\beta} \frac{L}{\eta} \kappa u^* z^* + B\beta u^{*\beta-1} & \frac{1}{1-\beta} \frac{L}{\eta} \kappa (1 - u^*) u^* & 0 \\ \frac{L}{\eta} (\kappa + w) z^{*2} + B\beta u^{*\beta-1} z^* & -\frac{L}{\eta} (\kappa + w) (1 - u^*) z^* & \frac{L}{\eta} z^* \\ -\frac{L}{\eta} (\kappa (\frac{1}{\theta} - 1) - w) z^* Q^* & \frac{L}{\eta} (\kappa (\frac{1}{\theta} - 1) - w) (1 - u^*) Q^* & \frac{L}{\eta} Q^* \end{bmatrix}. \quad (\text{A.6})$$

Essay 2

The Effects of Redistribution on Occupational Choice and Intergenerational Mobility:

Does wage equality nail the cobbler to his last?

1. Introduction

Intergenerational mobility, or the degree to which economic and social status are transmitted from parents to offspring, has received attention both in the theoretical and the empirical literature.¹ While sociologists have focused on occupational or class mobility, economists have taken a greater interest in income mobility.

There are both equality and efficiency implications of intergenerational mobility. Concern for equality of opportunity calls for attention to the extent to which individual welfare is determined by choices and efforts within control of the individual and to what extent it is predetermined by genes and upbringing. Furthermore, it is of relevance to what extent the degree of predetermination is influenced by institutional factors that can be affected by policy. With regard to efficiency, it is of interest whether family background constrains individual choices in such a way that the allocation of talent is not optimal from society's point of

⁰I am grateful to Anne-Charlotte Eliasson, Tore Ellingsen, Richard Friberg, Sara Johansson, Johan Lagerlöf, Casey Mulligan, Märten Palme, Anders Paalzow, Björn Segendorff, Johan Stennek, Tove Strauss, Susanna Sällström and seminar participants at the Stockholm School of Economics for helpful comments.

¹See e.g. Becker and Tomes (1979, 1986), Björklund and Jäntti (1997), Eriksson and Jonsson (1996), Mulligan (1995, 1997), Rustichini et al (1996), Solon (1992), and Zimmerman (1992).

view. Baumol (1990) and Murphy, Shleifer and Vishny (1991) argue that the allocation of talent has growth implications. The reason is that failure of talented children to exploit their full potential simply because they are born into the wrong families may deprive the economy of valuable externalities from human capital.

The presence and magnitude of such a loss to society and the possibility that a compressed wage structure could reduce or aggravate the loss have been subject to debate in Sweden.² In discussing the consequences for long run economic growth of poor incentives for higher education allegedly due to progressive income taxes and labor market regulations, it has been hypothesized that individuals from weak educational/social background require stronger economic incentives in order to opt for higher education than do individuals with well educated parents. The logic of this hypothesis has fuelled arguments for policies that would increase wage dispersion, e.g. reduced taxes, since too little wage dispersion is said to deter brilliant children from educationally weak background from higher education since the returns are too low.

The aim of this paper is to further the understanding of the relation between the incentive structure, talent allocation, earnings patterns and intergenerational mobility in an attempt to answer the question "Does wage equality nail the cobbler to his last?" or put differently: Is there a trade-off between redistribution and intergenerational mobility?

Previous theoretical work by economists on intergenerational mobility, e.g. Becker and Tomes (1986) has focused mainly on the transmission of income earning capacity through mechanisms connected to human capital investments and bequests.³ Such models suggest that because inequality of opportunity is a result of inequality of outcome in the parent generation working through imperfect capital markets, policies aimed at providing equal access to education would lead toward equality of opportunity.

This paper analyzes a different mechanism by which economic status is transmitted from one generation to the next by modelling how occupational choice is influenced by family background. It can be argued that occupational choice is of particular relevance for intergenerational mobility in societies where other ways of transferring wealth and status across generations, e.g. financial bequests or human capital investments are of reduced importance because of heavy taxation

²See e.g. Henreksson (1993) and Erikson and Jonsson (1994).

³Sociologists, on their part, have been more interested in social mobility, i.e. the transmission of socioeconomic status or class, which is generally measured as some combination of mobility with regard to occupation, education and income.

or because education is free.

Family background becomes important because we assume that the occupation of the parents may influence the quality of the information a child has about what it takes to succeed in different types of careers and about the child's talent for different jobs. In particular, we assume that individuals face more uncertainty when considering a career in an unfamiliar occupation than when judging prospects in the family occupation. We thus introduce family background determined differences in access to information of a kind which is similar to what has previously been discussed by sociologists, into the study of intergenerational mobility.⁴ However, we do not make the common assumption that people from a particular background (generally those from well educated families) always have access to better information. Instead, we assume that people have good information about occupations close to that of their parents and poor information about unfamiliar occupations.

By introducing family background effects into a simplified version of Willis' (1991) formulation of Roy's classic occupational choice model from 1951, we derive how the degree of occupational mobility and how earnings patterns of people with different family background depend on the incentive structure of the economy, i.e. on wage differences between occupations and the sensitivity of earnings to ability within different occupations.⁵ We also analyze the effects on mobility and talent allocation of two forms of redistribution. First, we look at the effects of solidarity wage policy, or redistribution within an occupation. Second, we turn to redistributive taxation which redistributes income both within and across occupations.

Contrary to the results in the human capital models of intergenerational mobility, this paper illustrates that equality of outcome in the parent generation or free education do not guarantee equality of opportunity of the young generation. The information differences introduced in our model make the allocation of talent and, thus, individual earning capacity in the young generation depend on family background also in the absence of the human capital investment costs and credit market imperfections or genetic transmission of ability for that matter, that are the driving forces behind the transmission of inequality in the Becker-Tomes

⁴See e.g. Erikson and Jonsson (1996).

⁵Our treatment of occupation is close to that of Roy (1951) and Sicherman and Galor (1990). In Roy, occupations differ because they require input of different abilities (or combinations of abilities). Because people are heterogeneous with respect to their endowment of abilities they will have comparative advantage for some occupations. Sicherman and Galor define occupations according to the level and the type of human capital required.

model.

Our results further imply that both inter and intraoccupational wage differences are important for the degree of occupational mobility and for the link between family background and allocation of ability and thus earnings patterns. While wage differences between occupations always provide an incentive to opt for the high wage occupation, regardless of family background, high sensitivity of earnings to ability, i.e. the potential for earnings differences within an occupation, can attract or deter people depending on their background and attitude towards risk. The effects on total mobility, allocation of talent and earnings patterns of changes in the incentive structure will, therefore, depend on the degree of risk aversion of individuals, as well as on how different occupations are with respect to wage rates and sensitivity of earnings to ability.

We thus find no unambiguous answer to if redistributive policies enhance or reduce overall mobility. The effects of redistribution on mobility and talent allocation depend on how and where it takes place, i.e. if it takes place between or within occupations. In the latter case, it also matters if wage compression occurs in an occupation in which earnings are sensitive or not to ability. We find that upward mobility is stimulated by large interoccupational wage differences. We also find that strongly risk averse individuals become more prone to choose an unfamiliar occupation, i.e. be mobile, with the introduction of a redistributive tax system which reduces both inter and intra occupational wage dispersion while moderately risk averse individuals become less mobile.

If changes in wage dispersion are restricted to one occupation, e.g. as a result of solidarity wage policy, effects on mobility are complex, but it is interesting to note that regardless of risk aversion, upward mobility will be encouraged by a further increase in the wage dispersion of an already highly ability sensitive occupation in which earnings are low or mediocre for people with mediocre ability.

The paper proceeds as follows. Section 2 outlines a model in which occupational choice is influenced by family background. Section 3 analyses the implications of the model for the allocation of talent and for earnings patterns. The fourth section uses the tools developed in sections 2 and 3 to address the question in the title of the paper by analyzing the effects of two forms of redistribution, solidarity wage policy, which redistributes within an occupation and progressive taxation, which redistributes within and across occupations, on mobility and earnings patterns. Section 5 concludes.

2. The Model

This section outlines a simple model of how young individuals, who are heterogeneous both with regard to their endowment of abilities and with regard to their family background, make occupational choices. The structure of the model is inspired by Willis' (1986) version of the occupational choice model described in Roy (1951). The Roy-model does not deal directly with intergenerational mobility. Instead it focuses on how occupational choice governed by comparative ability advantages and on the implications of such choices on the distribution of income and allocation of talent. We introduce uncertainty about ability into the Roy-model. In order to capture that family background matters for occupational choice, we assume that people can assess their ability to work in their parents' occupation but that they are uncertain about how able they are to work in other, unfamiliar, occupations. We shall see that the degree of risk aversion will be crucial for how uncertainty regarding ability affects occupational choices. Moderately risk averse individuals may have so much to gain if they make it in the high return occupation that mobility will tend increase with intraoccupational wage dispersion and uncertainty. If risk aversion is strong enough, mobility will decrease with intraoccupational wage dispersion since individuals are more anxious about the risk than attracted by the potential gain.

2.1. Basic structure

This model attempts to capture how the occupational choice of an individual is influenced by the occupation of the parents when the individual is better at assessing his ability to work in the family occupation than at assessing his ability to work in other occupations. We will think of individuals as young and as workers. When they are young, individuals are supported by their parents. In working life individuals live off their own earnings. In their youth, individuals choose a future occupation. In order to abstract from inequality of opportunity we will assume that all individuals receive the same amount of money from their parents and that education is free. This implies that the individual's choice of occupation does not influence the level of consumption as young. The individual chooses the occupation which yields the highest expected working life utility.

Working life utility of an individual who chooses occupation i depends on the level of consumption, c_i , that is achieved while working in occupation i . This level of consumption may be subject to uncertainty because the individual cannot be sure how well he will succeed in the chosen occupation. The individual cares

about expected working life utility:

$$E[U(c_i)] \quad U' > 0, U'' < 0. \quad (2.1)$$

We assume that the utility function has constant relative risk aversion. The coefficient for relative risk aversion is γ and the higher is γ the more risk averse the individual:

$$U(c) = \frac{1}{1-\gamma} c^{1-\gamma}. \quad (2.2)$$

The individual influences his level of consumption as a worker through the choice of occupation. Because we disregard savings, consumption as a worker is determined by the wage earnings:

$$c_i = Y_i(A_i), \quad (2.3)$$

where earnings, Y_i , in occupation i depend on the individual's endowment of the occupation specific ability A_i . We define the value to the individual choosing occupation i in terms of ability as the utility level achieved if the occupation is chosen:

$$V_i(A_i) = \frac{1}{1-\gamma} (Y_i(A_i))^{1-\gamma}. \quad (2.4)$$

While the Roy-model assumes that each occupation requires a combination of abilities, we assume that there is one ability specific to each occupation. For simplicity, it is further assumed that there are only two occupations and two abilities. We also assume that each individual is endowed with ability specific to each occupation and that occupations differ precisely because they require different abilities. Each individual j has ability A_j

$$A_j = \{A_{ij}\}, \quad i = 1, 2, \quad (2.5)$$

where A_{ij} is individual j 's endowment of ability specific to occupation i . In the entire population of individuals, abilities are assumed to be joint log normally distributed with the same mean and variance such that $\ln A_1$ and $\ln A_2$ are joint normally distributed with zero mean, unit variance and correlated with ρ . Log normality implies that ability is always greater than zero and, furthermore, that the ability distribution is skewed since there is no upper bound to ability. The natural logarithm of ability, which will be used later in the analysis, is symmetrically distributed around zero.

We will make the simplifying assumption that the individual has full information about his endowment of the ability specific to his family occupation, but that he faces uncertainty about his endowment of the ability specific to the unfamiliar occupation. The individual thus forms a prior belief about the uncertain ability based on knowledge about ability in the family occupation, knowledge about how abilities are distributed in the population in general and on how abilities are correlated. For clarity, we denote the individual's family occupation, f and unfamiliar occupation, u .

We define:

$$a_i \equiv \ln A_i. \tag{2.6}$$

The individual thus forms a prior belief about a_u based on a_f and ρ . The prior distribution for a_u is:

$$f(a_u | a_f) = N(a_f \rho, \sqrt{1 - \rho^2}). \tag{2.7}$$

The standard deviation of the prior distribution is larger the closer to zero the correlation between the two abilities.⁶

We follow Willis (1986) in assuming that earnings in occupation i take the following form:

$$Y_i = W_i A_i^{\beta_i} \quad i = f, u, \tag{2.8}$$

where earnings, Y_i , depend on the wage rate, W_i , on the individual's endowment of occupation i specific ability A_i , and on the occupation specific parameter β_i which determines the sensitivity to ability of earnings in occupation i . Henceforth, $A_i^{\beta_i}$ will be referred to as the individual's productivity in occupation i . Note that productivity and earnings increase with ability sensitivity, β_i , if ability A_i , is larger than one. If ability is less than one, increasing ability sensitivity is no good for individual productivity. As an analogue to the Roy model, we can see that if individuals are randomly assigned to occupations, the distribution of the natural logarithm of earnings in each occupation i is: $\ln Y_i \sim N(\ln W_i, \beta_i)$. There is thus a positive relation between the ability intensity of an occupation and the standard deviation of earnings within the occupation. The actual distribution of earnings

⁶The density function of the conditional distribution $f(a_u | a_f)$ is:

$$f(a_u | a_f) = \frac{1}{\sqrt{2\pi(1 - \rho^2)}} \exp \left\{ -\frac{1}{2(1 - \rho^2)} (a_u - \rho a_f)^2 \right\}.$$

within an occupation will, however, deviate from this because occupational choice depend on ability and because individuals may differ in their occupational choices simply because they are of different background.

We assume that the individual sticks to the family occupation if working life value achieved in the family occupation is at least as high as the expected working life value achieved in the unfamiliar occupation.

$$V_f \geq E[V_u]. \quad (2.9)$$

Using the utility function and the earnings function we can derive the value, V , to the individual in terms of the known ability of choosing the family occupation or the unfamiliar occupation. The value for an individual who chooses to stay in the family occupation is:

$$V_f(A_f) = \frac{1}{1-\gamma} \left(W_f A_f^{\beta_f} \right)^{1-\gamma}, \quad (2.10)$$

while expected value if the individual should choose the unfamiliar occupation is:

$$E[V_u] = \frac{1}{(1-\gamma)} \int_{-\infty}^{\infty} (W_u A_u^{\beta_u})^{1-\gamma} f(a_u | a_f) da_u. \quad (2.11)$$

Developing the integral by making use of the conditional distribution of a_u , results in the following expression for the expected value if the individual leaves the family occupation:

$$E[V_u] = \frac{1}{(1-\gamma)} \left(W_u A_f^{\beta_u \rho} \xi \right)^{1-\gamma}, \quad (2.12)$$

where

$$\xi = e^{\frac{\beta_u^2}{2}(1-\rho^2)(1-\gamma)}. \quad (2.13)$$

ξ is related to the uncertainty involved in choosing the unfamiliar occupation. Depending on the coefficient of relative risk aversion, γ , this risk related factor ξ is smaller or greater than one. The individual's expected ability in occupation u is A_f^ρ . The productivity associated with the expected ability is $A_f^{\rho\beta_u}$, while the expected productivity is:

$$E[A_u^{\beta_u} | A_f] = A_f^{\beta_u \rho} e^{\frac{\beta_u^2}{2}(1-\rho^2)}. \quad (2.14)$$

⁷See appendix

These differ because of the uncertainty involved. Expected productivity is greater than the productivity associated with the expected ability as long as there is uncertainty about ability, i.e., as long as the correlation between abilities is not perfect ($|\rho| < 1$). The greater the uncertainty (the closer ρ is to zero) and the greater is β_u , the more will the expected productivity exceed the productivity at expected ability. This holds also for the relation between expected earnings and earnings associated with expected ability. The reason behind this is that productivity and earnings are convex in the natural logarithm of ability.

What about value? The value associated with the expected ability would be:

$$V [Y [E [A_u | A_f]]] = \frac{1}{(1 - \gamma)} \left(W_u A_f^{\beta_u \rho} \right)^{1 - \gamma}. \quad (2.15)$$

This value measure exceeds the *expected value* if ξ is smaller than one. This is the case when risk aversion is strong, i.e. if the coefficient of relative risk aversion is larger than one. If risk aversion is moderate the *expected value* will exceed the value associated with the expected ability.

2.2. The choice of occupation

The individual chooses to stay in the family occupation if the value of doing so is at least as high as the expected value of choosing the unfamiliar occupation. We can thus combine (2.9), (2.10) and (2.12) to derive the following condition for when the individual chooses the family occupation:

$$\frac{1}{(1 - \gamma)} \left(W_f A_f^{\beta_f} \right)^{1 - \gamma} \geq \frac{1}{(1 - \gamma)} \left(W_u A_f^{\beta_u \rho \xi} \right)^{1 - \gamma}. \quad (2.16)$$

The condition is satisfied when

$$(\beta_f - \rho \beta_u) a_f \geq \ln \left(\frac{W_u}{W_f} \right) + (1 - \gamma) (1 - \rho^2) \frac{\beta_u^2}{2}, \quad (2.17)$$

where we have used the fact that $a_f = \ln A_f$. We will henceforth refer to a as ability.

Condition (2.17) tells us that the individual's choice of occupation depends on the difference in productivity at expected ability (the left hand side), the difference in wage rates and the last term on the right hand side which captures how the value of the unfamiliar occupation is affected by the uncertainty involved. The size of the last term on the right hand side, the risk factor, depends the degree

of risk aversion. The more the individual cares about risk, the greater the risk factor. The sign of this risk factor is positive or negative depending on the degree of risk aversion. If risk aversion is strong, $\gamma > 1$, the risk factor is negative, implying that the individual will demand a higher wage to compensate for the risk in order to choose the unfamiliar occupation if the return to expected ability is the same in both occupations. If risk aversion is moderate, $\gamma < 1$, the risk factor is positive. The reason for this is that strong risk aversion is enough to curb the convexity of the earnings function with respect to ability and render the expected value concave in ability. With moderate risk aversion, the convexity of the earnings function is not dominated by the concavity of the utility function and expected value is thus convex in ability.⁸ The risk factor also depends on how informative the known ability a_f is about the uncertain ability a_u . The stronger the correlation the less uncertain is a_u and the smaller is the risk factor. The sensitivity to ability of the unfamiliar occupation also affects the size of the risk factor.

The condition implies that if the productivity difference is positive for positive ability, i.e. the family occupation is perceived to be more ability sensitive than the unfamiliar, individuals above a certain ability level will stick to the family occupation. If the unfamiliar occupation is perceived to be more ability sensitive, individuals below a certain ability level will stay in the family occupation. In general, the occupation which is perceived as more ability sensitive will attract the most able people. We define a cut off ability, a^* , for which expected value is the same in both occupations:⁹

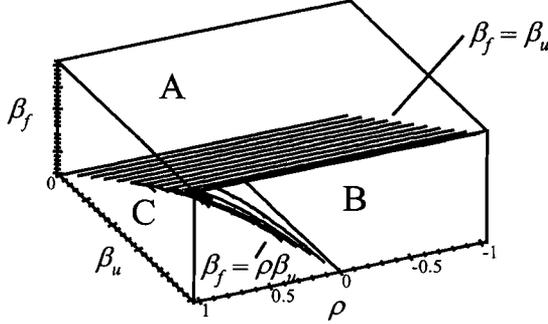
$$a^* \equiv \left(\frac{\ln \left(\frac{w_u}{w_f} \right) + (1 - \rho^2) (1 - \gamma) \frac{\beta_u^2}{2}}{(\beta_f - \rho\beta_u)} \right). \quad (2.18)$$

When analyzing the determinants and consequences of the individual's choice to stay in or leave the family occupation, three states can be distinguished based on the sign of the denominator in 2.18, i.e. depending on which occupation the individual perceives to be most sensitive to ability. Figure 2.1 illustrates these states and shows how the difference in perceived ability sensitivity between the two occupations relates to the true difference in ability intensity.

⁸This result regarding the sign of the risk premium is analogous to the discussion in Caballero (1991) regarding the sign of the investment - uncertainty relationship.

⁹Remember that the individual chooses the family occupation if expected utility is the same in both occupations.

Figure 2.1: States



- A: State 1, $\beta_f - \beta_u > 0$.
 B: State 1, $\beta_f - \beta_u < 0$ and $\beta_f - \rho\beta_u > 0$.
 C: State 2, $\beta_f - \rho\beta_u < 0$. State 3, $\beta_f = \rho\beta_u$.

State 1: The individual sticks to the family occupation if his f -ability is at least as high as the cut off ability:

$$a_f \geq a^*. \quad (2.19)$$

The family occupation is perceived to be the more sensitive to the known ability, $\beta_f - \rho\beta_u > 0$. This implies that earnings at the expected ability are higher in the family occupation, provided that ability is above average ($a_f > 0$).

The cut off ability is positive or negative i.e. above or below average ability, depending on the wage rates in the two occupations and depending on the risk factor:

$$a^* \geq 0 \quad \text{if} \quad \ln\left(\frac{W_f}{W_u}\right) \leq (1 - \gamma)(1 - \rho^2) \frac{\beta_u^2}{2}. \quad (2.20)$$

State 2: The individual stays in the family occupation if his f -ability is smaller than or equal to the cut off ability:

$$a_f \leq a^*.$$

The perceived sensitivity of earnings to f -ability is higher in the unfamiliar occupation, $\beta_f - \rho\beta_u < 0$. This condition can only be satisfied for positive correlation

between abilities. Again the level of the cut off ability depends on wage rates and risk factor.

$$a^* \geq 0 \quad \text{if} \quad \ln \left(\frac{W_f}{W_u} \right) \geq (1 - \gamma) (1 - \rho^2) \frac{\beta_u^2}{2}. \quad (2.21)$$

State 3: In State 3, both occupations are perceived as equally sensitive to ability, $\beta_f - \rho\beta_u = 0$. Ability will thus not matter for occupational choice. This last case is relevant only when abilities are positively correlated. Occupational choice depends only on the relative wage and on the risk premium. The individual sticks to the family occupation if

$$\ln \left(\frac{W_f}{W_u} \right) \geq (1 - \gamma) (1 - \rho^2) \frac{\beta_u^2}{2}. \quad (2.22)$$

The individual will require a lower/higher wage in the family occupation to convince him to stay, depending on the coefficient of relative risk aversion. If the individual is very risk averse, $\gamma > 1$, the individual demands a risk premium in order to choose the unfamiliar occupation. If the individual is less risk averse, $\gamma < 0$, the individual demands a premium in order to stay in the family occupation.

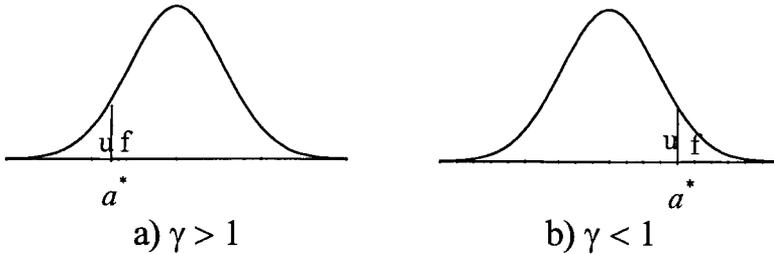
The more risk averse the individual, i.e. the higher is γ , the lower is the premium the individual asks in order to stay in the family occupation. When γ exceeds one, the premium is negative. The higher is β_u the higher are the potential gains of opting for the uncertain occupation and, thus, the higher the premium demanded in order to stay in the family occupation, provided that the coefficient for relative risk aversion does not exceed one. If γ exceeds one, the risk premium is negative since the individual is so risk averse that the negative impact on expected value of risk out weighs the positive effect of higher expected earnings in the uncertain occupation. Increasing β_u , further increases the risk, and thus makes the negative premium larger in size. The more closely correlated the two abilities, the smaller the absolute size of the premium, since closer correlation implies that there is less uncertainty.

3. Talent Allocation and Earnings Patterns

3.1. The allocation of talent

The allocation of talent of individuals with the same family background, but different attitudes toward risk when the States 1 and 2 prevail are depicted in Figures

Figure 3.1: **State 1**



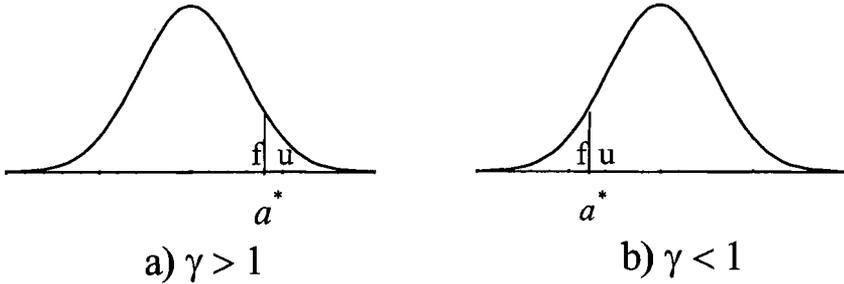
3.1 and 3.2 respectively. The figures are based on the assumption that ability is not correlated across generations, i.e. the distribution of ability is independent of family background. For simplicity it has also been assumed that the wage rate is the same in both occupations although it may be more realistic to assume that wage rates are higher in more ability sensitive occupations.

Figure 3.1a depicts a situation where risk aversion is strong and the family occupation is perceived to be more ability sensitive. This implies that the risk factor, ξ , is negative, i.e. the individual needs compensation in order to opt for the uncertain alternative. A majority will thus stick to the family occupation. Only those who have very low aptitude for the family occupation will have higher expected utility in the unfamiliar occupation. The reason for this is that the prospects in the family occupation are so poor that the chance of having higher ability in the unfamiliar occupation will make it worthwhile to take the chance.

Figure 3.1b shows the situation where individuals are moderately risk averse and the family occupation is perceived to be more ability sensitive. In this case, the risk factor, ξ , is positive and when the wage is the same in both occupations, most people will find it worthwhile to venture into the unfamiliar occupation. Only those who are very good at their family occupation will stick to it since their chances of doing even better in the unfamiliar occupation are so small.

Figure 3.2a depicts a situation with strong risk aversion and higher perceived ability sensitivity in the unfamiliar occupation. Most people will stick to the safe family occupation. Only those who think they will have very high ability in the unfamiliar occupation (remember State 2 can only prevail when ability

Figure 3.2: State 2



correlation is positive) will dare to opt for the unfamiliar occupation where they will get higher returns to their talent.

Figure 3.2b shows a situation where risk aversion is moderate and ability sensitivity is higher in the unfamiliar occupation. Because there is much to gain by opting for the unfamiliar occupation, most people will try their luck. Only for those who have very low ability in the family occupation will the risk of having equally low or even worse ability in the unfamiliar occupation be so high that they rather stick to the safe family occupation.

If the assumption of equal wage rates in both occupations is relaxed the picture gets more complex. It can be argued that occupations where ability matters more will also have higher wage rate. In the context of the model this means that, $\beta_f \geq \beta_u$ would imply that $W_f \geq W_u$. The diagram in Figure 2.1 illustrates three situations. If $\beta_f > \beta_u$, the region marked A, the wage in the family occupation exceeds the wage in the unfamiliar occupation and the individual is in State 1. When $\beta_f < \beta_u$, and $\beta_f > \rho\beta_u$, the region marked B, the wage in the unfamiliar occupation exceeds the wage in the family occupation, but the same State prevails. In the region marked C, $\beta_f < \beta_u$, the wage in the unfamiliar occupation exceeds the wage in the family occupation and the individual is in state 2.

In A, the talent allocation in Figure 3.1a will not be altered qualitatively. An even greater majority will, however, opt for the family occupation. With moderate risk aversion, the higher wage in the family occupation compensates for the premium asked in order to stay in the family occupation. If the wage in the

family occupation is high enough the cut off ability in Figure 3.1b may be pushed so much to the left that a majority decides to opt for the family occupation. In B, the talent allocations in Figure 3.1 will be affected in the opposite way. With strong risk aversion, a high enough wage in the unfamiliar occupation will convince a majority to opt for the unfamiliar occupation (i.e. make the cut off ability positive). With moderate risk aversion, even fewer will stick to the family occupation if the wage in the unfamiliar occupation exceeds the wage in the family occupation.

In C, a high enough wage in the unfamiliar occupation will convince a majority to opt for the unfamiliar occupation, even if risk aversion is strong. The cut off ability will thus become negative in Figure 3.2a. The allocation illustrated in Figure 3.2b would however not change qualitatively.

3.2. Implications for earnings patterns

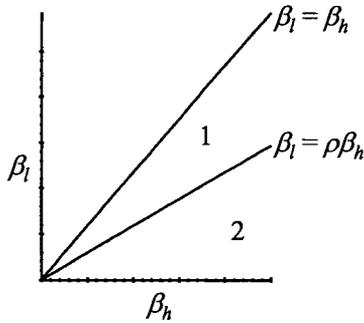
In this section we shall analyze the effects of talent allocation on the earnings patterns within occupations. In order to do so we will need to consider the occupational choices of individuals with different family background. It will thus no longer be convenient to discuss occupations in terms of family and unfamiliar occupation. Instead we shall call the occupations h (high) and l (low), where $\beta_h \geq \beta_l$. We will assume, for simplicity, that the wage rates are equal in both occupations. Depending on the ability sensitivity of the two occupations and on the correlation between abilities, the individuals with family background in the respective occupations will be in States 1 or 2. We will refer to people with family background in the high return occupation, h , as h -people and people with family background in the low return occupation, l , as l -people.

We need to consider two types of situations depending on which states prevail. These are illustrated in Figure 3.3 for positive ability correlations. When ability correlation is negative, individuals are in State 1 regardless of family background. As shown above, the allocation of talent depends crucially on the degree of risk aversion. We will focus on the case where both types of people are either strongly risk averse or moderately risk averse.

3.2.1. Situation 1: Occupations are similar: horizontal mobility

When the occupations are relatively similar in terms of return to ability and in terms of the nature of ability required (ability correlation is positive), the mobility

Figure 3.3: Situations



- 1: Both h -people and l -people are in State 1.
- 2: h -people are in State 1 and l -people are in State 2.

that takes place can be thought of as horizontal mobility.

When the return to ability is fairly similar in the two occupations (or when ability correlation is negative), strong risk aversion implies that in both occupations the few who are newcomers will be those who have low ability for their family occupations. With positive ability correlation, this means that newcomers into an occupation will on average earn less than those with a background in the occupation. If ability correlation is negative, the new comers on average earn more.

Figure 3.4: Horizontal mobility: strong risk aversion

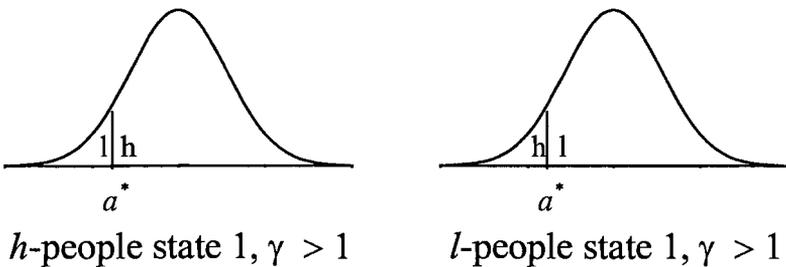


Figure 3.5: **Horizontal mobility: moderate risk aversion**

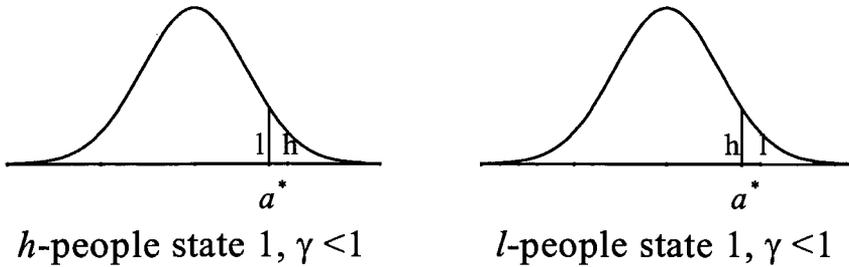
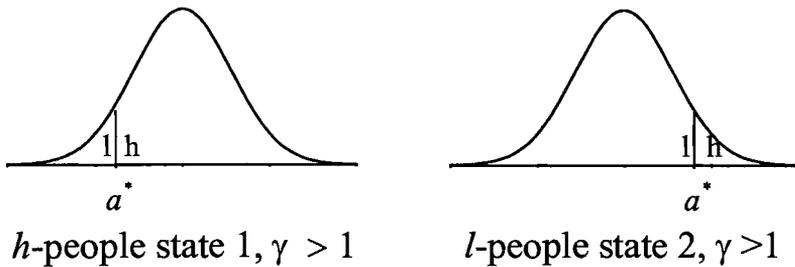


Figure 3.6: **Vertical mobility: strong risk aversion**



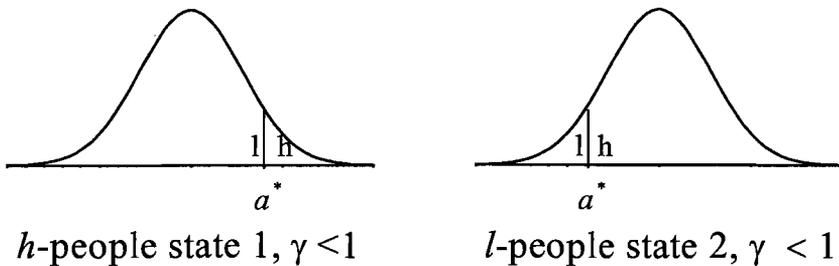
When return to ability is fairly similar (or ability correlation is negative) and risk aversion is moderate. Mobility will be high. However, the same kind of earnings pattern as with strong risk aversion will prevail.

3.2.2. Situation 2: Occupations are different: vertical mobility

When the return to ability is sufficiently much higher in one occupation than in the other, we call the mobility that takes place vertical mobility. Here we assume occupation h is more ability sensitive than occupation l .

When risk aversion is strong, the few l -people who venture upward into occupation h will be very able and thus earn more on average than the h -people who stayed in their family occupation. The rare few h -people who choose occupation l will be low ability people and they will therefore earn less than the l -people who

Figure 3.7: Vertical mobility: moderate risk aversion



choose to stay in occupation l .

When the return to ability is sufficiently much higher in occupation h than in occupation l , and when risk aversion is moderate, the majority of the l -people will venture into occupation h and only the most brilliant of the h -people will stay in their family occupation. The result is that the h -people who choose to stay in their family occupation will on average earn more than the newcomers. In occupation l only the least able of the l -people will remain. The large group of h -people who opt for occupation l will thus on average earn more than the l -people who stay in their family occupation.

So far we have assumed that people have the same degree of risk aversion regardless of family background. If instead we assume that people from well to do background, i.e. from high wage, ability sensitive background are moderately risk averse while people from low ability sensitive background are strongly risk averse, the pattern of vertical mobility and earnings is altered. Depending on how much higher (if at all) the wage rate is in the ability sensitive occupation, people would tend to be more or less mobile. The larger the wage difference, the lower the mobility of the high sensitivity background people and the higher the mobility of the low sensitivity background people. Whether newcomers or those with family background in the occupation will earn the most on average also depends on the wage difference and on the degrees of risk aversion.

4. Mobility, Earnings Patterns and Changes in the Incentive Structure

This section analyses how mobility and earnings patterns of people from different background are affected by policies that change the incentive structure. Although the model has not so far allowed for government policy or institutional changes, we will interpret parameter changes in terms of increased or reduced wage compression resulting from more or less solidarity wage policy¹⁰ and introduce a more or less progressive redistributive welfare system. A reduction in the sensitivity of earnings to ability, β , in an occupation will be regarded as an effect of increased solidarity wage policy since it implies a change in the direction of "equal job equal pay", regardless of productivity. Increasing the progressiveness of the redistributive system is defined as a simultaneous proportional reduction of sensitivity of earnings to ability in both occupations in combination with a reduction in wage rates leading toward equalization of wage rates.

The effects on mobility and earnings patterns of changes in the incentive structure will depend on where the economy starts out. We will compare effects of more or less solidarity wage policy and more or less progressive redistributive in the following situations:

- 1 wages are equal, return to ability is similar.
- 2 wages are equal, return to ability different.
- 3 wage is higher in high return occupation, returns to ability are different.

We continue to refer to the occupations as h (high) and l (low), where $\beta_h > \beta_l$

The results in this section are based on an analysis of the comparative statics of cut-off ability of people with h and l background with respect to β_h and β_l . Reducing the β in an occupation represents an introduction of more solidarity wage policy into the occupation. We will also experiment with a progressive redistributive system in the whole economy by assuming that the disposable earnings function in occupation i takes the following form

$$Y_i^d = Y_i^{1-t}, \quad 0 \leq t < 1, \quad (4.1)$$

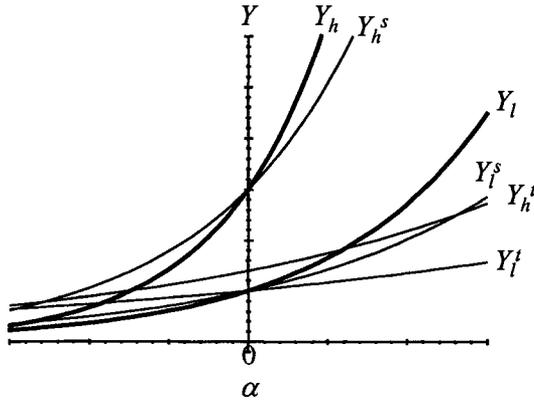
and the average tax rate τ

$$\tau = 1 - \frac{Y_i^d}{Y_i} = 1 - Y_i^{-t}, \quad (4.2)$$

¹⁰See e.g. Edin and Holmlund (1993) for a critical discussion of solidarity wage policy as the cause behind Swedish wage compression.

is increasing in earnings. The larger is t , the more progressive the tax system. Figure 4.1 illustrates the experiments to be analyzed.

Figure 4.1: Earnings as a function of ability



Y_i = Earnings in occupation i , Y_i^s = Earnings in occupation i under solidarity wage policy, Y_i^t = Earnings in occupation i with redistributive welfare system, h = high return occupation, l = low return occupation.

If we introduce taxation into the model, we can derive cut off ability:

$$a_i^* \equiv \left(\frac{\ln \left(\frac{W_i}{\bar{W}_i} \right) + (1-t)(1-\rho^2)(1-\gamma) \frac{\beta_j^2}{2}}{(\beta_i - \rho\beta_j)} \right). \quad (4.3)$$

The derivatives with respect to the incentive structure parameters are:

$$\frac{\partial a_i^*}{\partial \beta_i} = - \frac{\ln \left(\frac{W_i}{\bar{W}_i} \right) + (1-t)(1-\rho^2)(1-\gamma) \frac{\beta_j^2}{2}}{(\beta_i - \rho\beta_j)^2}, \quad (4.4)$$

$$\frac{\partial a_i^*}{\partial \beta_j} = \frac{(1-t)(1-\rho^2)(1-\gamma)\beta_j}{(\beta_i - \rho\beta_j)} + \rho \frac{\ln \left(\frac{W_i}{\bar{W}_i} \right) + (1-t)(1-\rho^2)(1-\gamma) \frac{\beta_j^2}{2}}{(\beta_i - \rho\beta_j)^2}, \quad (4.5)$$

$$\frac{\partial a_i^*}{\partial t} = - \frac{(1-\rho^2)(1-\gamma) \frac{\beta_j^2}{2}}{(\beta_i - \rho\beta_j)} \quad (4.6)$$

The effects on occupational choices of solidarity wage policy depend both on the attitude toward risk and on the ability of the individual. In general, disregarding uncertainty, a reduction in the sensitivity of earnings to ability makes an occupation more attractive to an individual with negative ability and less attractive to an individual with above zero ability. Uncertainty about ability will, however, affect the individual's reaction to changes in the sensitivity of earnings to ability in the unfamiliar occupation. The ability level at which the individual finds that a reduction in ability sensitivity makes the unfamiliar occupation more or less attractive may thus differ from zero. If risk aversion is strong, a reduction in ability sensitivity of the unfamiliar occupation will make that occupation more attractive also for moderately positive abilities because the reduction in return to expected ability is compensated for by the reduction in risk. If risk aversion is moderate, however, a reduction in ability sensitivity of the unfamiliar occupation makes that occupation less attractive for individuals with moderately negative ability because the reduction in risk does not compensate for the substantial loss in terms of expected earnings. In other words, the effect of solidarity wage policies on the mobility of people with different background will thus depend on the position of the cut off abilities. The position of the cut off abilities is, as we have seen, in turn determined by the degree of risk aversion, the relative wages and the difference in perceived sensitivity to ability.

A general feature is that for given parameter values, the cut-off abilities associated with equality of wage rates between occupations define the maximum mobility of h -people and the minimum mobility of l -people, given the assumption that $W_h \geq W_l$.

4.1. Introducing solidarity wage policy in the low return occupation.

Strong risk aversion With strong risk aversion, solidarity wage policy in the low return occupation will increase the mobility of the h -people since the marginal h -individual, who has low ability for the h -occupation, will find the low return occupation more attractive due to the reduction in uncertainty.

If the return to ability is sufficiently similar in both occupations, both h - and l -people will regard their family occupations as the most ability sensitive. Strong risk aversion then implies that only the least able of the l -people choose the unfamiliar occupation unless the wage is very much higher in the other occupation.¹¹ The marginal l -individual will thus have below zero ability and a reduction in the

¹¹ and this is perhaps not so likely if the occupations are very similar.

ability sensitivity of the l -occupation will, therefore, make that occupation more attractive. Hence, mobility declines even further. Within each occupation, average earnings will initially tend to be higher for those with family background in the occupation. Solidarity wage policy in the low return occupation will make average earnings of people from different background more equal in the l -occupation, but more unequal in the h -occupation.

If, on the other hand, the occupations are sufficiently different so that people of both backgrounds agree that the h -occupation is more ability sensitive, the most able of the l -people will opt for the h -occupation. The cut-off ability will be positive (and hence, mobility low) provided that the wage in the h -occupation is not sufficiently high. With positive cut-off ability, the marginal individual will find the l -occupation less attractive if its ability sensitivity decreases and mobility will therefore increase. With a negative cut-off ability (and high mobility) mobility will decrease. In this case, l -people will initially earn more on average than h -people in both occupations. Unless wages are very different (in which case effects are unclear because average earnings increase for all groups), background differences in average earnings will become smaller in both occupations.

Moderate risk aversion With moderate risk aversion the mobility of the h -people will be high because only the most able of the h -people will choose to stay in their family occupation unless the h -wage is very high. Solidarity wage policy in the l -occupation will thus make the l -occupation less attractive and reduce mobility of the h -people. If the wage is sufficiently much higher in the h -occupation, cut-off ability will, however, be so low that reduced ability sensitivity in the l -occupation makes it attractive to leave the family occupation.

In a situation when the occupations are relatively similar, a minority, and only the most able of the l -people will choose to stay in their family occupation when risk aversion is moderate. The marginal individual will thus find that reduced ability sensitivity in the family occupation makes it less attractive and mobility will, therefore, increase as a result of solidarity wage policy in the l -occupation. When returns to ability are similar, the between background comparison of average earnings favor those who have stayed in their family occupation also in the case with moderate risk aversion. Solidarity wage policy in the low return occupation will, however, reduce between group earnings differences in the h -occupation and enhance differences in the l -occupation when wages are not too different. If wage differences are large, effects are unclear because average earnings increase for all groups.

If, however, the occupations are different and the l -people agree that the h -occupation is the more ability sensitive, it will still be the case that a majority opts for the h -occupation, but now those who choose to stay in the family occupation are the least able. Because cut-off ability is negative the marginal individual will benefit from a reduction in ability sensitivity and mobility will, therefore, decrease. If occupations are sufficiently different and risk aversion is moderate, average earnings in both occupations will be higher for h -people than for l -people. Solidarity wage policy in the low return occupation will tend to reduce between group earnings differences unless wages are very different in which case the effects are unclear, again because average earnings increase for all groups.

4.2. Introducing solidarity wage policy in the high return occupation.

Strong risk aversion When risk aversion is strong, a majority of the h -people will stick to their family occupation and cut off ability will thus be negative. This implies that reducing the sensitivity to ability in the h -occupation makes it more attractive to the marginal h -individual. Mobility therefore decreases.

If the occupations are similar so that the l -people perceive their family occupation to be the more ability intensive, the most able of the l -people will choose to stay in their family occupation. Unless the wage is sufficiently much higher in the h -occupation, the cut off ability will be low enough to make the marginal l -individual find the h -occupation more attractive as a result of reduced sensitivity to ability in that occupation. Hence, with strong risk aversion, mobility will increase. If, however, the wage is sufficiently high in the h -occupation,¹² mobility will decrease because the rare few who choose to stay in the l -occupation are so able that they will not benefit from reduced ability intensity. As mentioned above, when occupations are similar, average earnings in an occupation are higher for people who have stayed in the family occupation. Solidarity wage policy in the high return occupation will make between group earnings differences larger in the l -occupation and smaller in the h -occupation.

In the case when occupations are different enough to make people of both background agree that the h -occupation is more ability sensitive, the most able of the l -people will choose the h -occupation. If the ability sensitivity is sufficiently much higher in the h -occupation while the h -wage is only moderately higher than the l -wage, the mobility of the l -people will decrease as a result of reduced ability sensitivity in the h -occupation, otherwise mobility will increase. If occupations

¹²This may not be likely given that the occupations are similar.

are different, average earnings decline irrespective of background and occupational choice. The effect on between group earnings differences is thus unclear. If, however, the ability sensitivity is very much higher in the h -occupation while wages are not too different, between group earnings differences will increase.

Moderate risk aversion Turning to a situation when risk aversion is moderate we find that the mobility of the h -people will depend on how much the h -wage exceeds the l -wage. When wages are the same or when h -wage is moderately higher, the cut-off ability is positive and, hence, reducing the ability sensitivity in the family occupation will make the h -people more mobile. If the h -wage is sufficiently high, cut-off ability is negative and mobility will decrease since the reduced ability sensitivity makes the h -occupation more attractive to the marginal h -individual.

When the occupations are fairly similar, a minority and the most able of the l -people will chose the low return occupation. Cut-off ability is positive and, hence, a reduction in the ability sensitivity of the h -occupation will reduce mobility of the l -people. Solidarity wage policy in the h -occupation will make average earnings differences across people from different background smaller in the l -occupation and larger in the h -occupation unless wages are very different.¹³

If occupations are different enough for people of both backgrounds to view the h -occupation as the more ability intensive, a majority and the most able of the l -people will choose the h -occupation. As in the situation with strong risk aversion, mobility of the l -people will increase as a result of reduced ability sensitivity in the h -occupation.¹⁴ When people of both backgrounds regard the h -occupation as the more ability intensive and when wages are similar, h -people will earn more on average in both occupations than l -people. If wages are not too different (and the difference in ability sensitivity not too large), solidarity wage policy in the h -occupation will enhance background differences in average earnings. If wages are sufficiently different, average earnings decrease for all groups.

4.3. Increasing the progressiveness of the tax system

Raising t has the same effect on mobility whether the returns to ability are similar or not. There will be a reduction of mobility of both l - and h -people who are

¹³In which case average earnings decrease regardless of background and occupational choice.

¹⁴This is the case unless the ability sensitivity is sufficiently much higher in the h -occupation while the h -wage is only moderately higher than the l -wage.

moderately risk averse while strongly risk averse people will become more mobile, regardless of background. Regardless of attitude toward risk, background related earnings differences in both occupation will be reduced provided that the occupations are different enough. If the occupations are similar average earnings increase for all groups if risk aversion is strong and decrease for all groups if risk aversion is moderate. Thus, when occupations are similar, effects on average earnings of people from different background are not clear.

4.4. Demand and supply effects on talent allocation and mobility

So far we have not at all considered equilibrium effects of supply and demand for workers in the different occupations. If we assume a well functioning labor market where wages are set such that the labor market clears, the analysis is fairly straight forward. First, we should consider a situation where there for some reason, technological change, migration or other, is a shift in the supply or demand for one occupation. If such a shift leads to an increase or decrease in the relative wage in an occupation, people will, regardless of background, to a larger extent choose the occupation with the increased relative wage. People of different background will, however, not react equally much. The reason being that the effects on cut off abilities differ, as well as do the initial cut off abilities. Second, if markets are to clear, the type of policies discussed in the previous section which affect the total number of people choosing an occupation will also affect wage rates.

To give an example of what would happen in the case of a positive demand shift in one occupation or in the case of a policy shifting people out of an occupation, consider the following. If the wage in occupation j increases as a result of a increased demand for people in occupation j (or as a result of a policy that had shifted people out of occupation j), cut off abilities of both j and i -people will be affected.¹⁵

Increasing w_j always make j -people less mobile and i -people more mobile. Depending on the initial cut off abilities, average earnings of people of different background will become more or less different.

¹⁵The derivatives of the cut off abilities are respectively: $\frac{\partial \alpha_j}{\partial w_j} = \frac{1}{-w_j(\beta_j - \rho\beta_i)} \geq 0$ if $\beta_j - \rho\beta_i \leq 0$ and $\frac{\partial \alpha_i}{\partial w_j} = \frac{1}{w_j(\beta_i - \rho\beta_j)} \geq 0$ if $\beta_i - \rho\beta_j \geq 0$.

5. Conclusions and Discussion

We have analyzed the role of family background for occupational choice and the implications for intergenerational mobility of changes in the incentive structure. Our analysis sheds light on the recent Swedish debate about the importance of economic incentives for educational and occupational choices of children from different social background. The results show that policy makers interested in equality of opportunity, need to carefully consider the incentive effects of redistributive policies. We show that even if occupational choices are free in the sense that human capital investments are costless, uncertainty about ability to make it in an unfamiliar occupation is enough to make family background influence talent allocation and earnings. Therefore, equality of outcome in the parent generation or free education do not guarantee that there will be equality of opportunity in the young generation.

We can further conclude that there is no simple answer to the question posed in the title of this paper: Does wage equality nail the cobbler to his last? Thus, our analysis provides no whole hearted support for increased wage dispersion as a means to increase the efficiency of the talent allocation through improved mobility. Whether there is a trade off between redistributive policies and intergenerational mobility depends on a number of factors.

In general, we find that upward mobility increases with the size of the wage gap between occupations, regardless of risk aversion. Total mobility, however, depends on the degree of risk aversion. Total mobility is higher if wage differences are large between different occupations than if wages are equal when risk aversion is strong, but if risk aversion is moderate, total mobility is highest when the wage gap between occupations is small.

In the analysis of the effects of redistribution, we looked at two forms of solidarity wage policy, a) wage compression in the low returns to ability occupation and b) wage compression in the high returns to ability occupation. We also analyzed the effects of a welfare system which redistributes both within and across occupations at the same time.

We find that wage compression in the low returns to ability occupation leads to increases in upward as well as total mobility provided that risk aversion is strong and wage rates are not too different. The reason for this is that wage compression in the low return occupation makes the low return occupation less attractive to the marginal individual with family background in the low return occupation because their ability is above average. Wage compression thus reduces

their productivity in the low return occupation. If the marginal individual with background in the high returns to ability occupation has below average ability, wage compression in the low return occupation makes it more attractive to be mobile.

If risk aversion is moderate, compressing earnings in the low return occupation always reduces upward mobility. It is also the case that total mobility is reduced provided wage rates are similar. The reason for this reduced mobility is that when the marginal individual has below average ability, as is the case for people with low returns to ability background and moderate risk aversion, a compression of wages in the low returns to ability occupation makes it more attractive to stick to the low returns to ability occupation. When the marginal individual with background in the high returns to ability occupation has above average ability, wage compression in the low returns to ability occupation will make it more attractive to stick to the high returns to ability occupation.

A compression of wages in the high return occupation increases upward mobility regardless of risk aversion if occupations differ sufficiently in terms of wage rates. The reason for this is that due the large wage difference also below average ability people choose the high return occupation. A reduction in ability sensitivity will therefore make the high return occupation more attractive to the marginal individual. If, however, wage rates are similar and ability sensitivities differ a lot, upward mobility will decline if wages in the high returns to ability occupation are compressed. This result implies that an increase in the sensitivity of earnings to ability in an occupation which is already very ability sensitive and in which earnings are mediocre for the mediocre talent, will attract upward mobility into the occupation. The effects on total mobility of wage compression in the high return occupation are, in general, ambiguous.

The effects on mobility of a redistributive welfare system are more straight forward. If risk aversion is moderate, people become less mobile with the introduction of a redistributive welfare system because there will be less to gain by taking chances and hoping for high ability to work in the unfamiliar occupation. If risk aversion is strong, people become more mobile since the welfare system acts as an insurance against bad outcomes if the unfamiliar occupation is chosen.

In summary, the results in this paper imply that increased wage dispersion between occupations is positive for upward mobility, although not necessarily for total mobility. Increased wage dispersion within occupations, on the other hand, does not necessarily increase upward mobility. Increased wage dispersion within the high return occupations will result in less upward mobility, except into

extreme return occupations like golf or tennis. Increased wage dispersion in the low return occupation, will however, act as a push effect on people and increase upward mobility if people are moderately risk averse or if they are strongly risk averse and the wage in the high return occupation is sufficiently much higher than in the low return occupation.

References

- [1] Baumol, W. J. (1990), "Entrepreneurship: Productive, Unproductive, and Destructive", *Journal of Political Economy*, vol. 98, no. 5, 893-919.
- [2] Becker, G. S. and N. Tomes (1979), "An Equilibrium Theory of the Distribution of Income and Intergenerational Mobility", *Journal of Political Economy*, vol. 87, no. 6, 1153-1189.
- [3] Becker, G. S. and N. Tomes (1986), "Human Capital and the Rise and Fall of Families", *Journal of Labor Economics*, vol. 4, no. 3, pt. 2, S1-S39.
- [4] Björklund, A. and M. Jäntti (1997), "Intergenerational Income Mobility in Sweden Compared to the United States", *American Economic Review*, vol. 87, no. 5, 1009-1018.
- [5] Caballero, R. J. (1991), "On the Sign of the Investment-Uncertainty Relationship", *American Economic Review*, vol. 81, no. 1, 279-288.
- [6] Edin, P-A. and B. Holmlund (1993), "The Swedish Wage Structure: The Rise and Fall of Solidarity Wage Policy?", *NBER Research Working Paper*, no. 4257, Jan. 1993.
- [7] Erikson, R. and J. O. Jonsson (1996), "Introduction. Explaining Class Inequality in Education: The Swedish Test Case" in *Can Education be Equalized?*, eds Erikson and Jonsson, Westview Press.
- [8] Erikson, R. and J. O. Jonsson (1994), "Ökade Löneskillnader-Ett sätt att ta tillvara begåvningsreserven?", *Ekonomisk Debatt*, årg. 22, nr. 6, 581-594.
- [9] Henreksson, M. (1993), "Humankapital, produktivitet och tillväxt", rapport till Ekonomikommisionen, i *Nya Villkor för ekonomi och politik*, SOU 1993:16, Bilagedel 1. 349-396. Allmänna Förlaget, Stockholm.

- [10] Mulligan, C. B. (1995), "Economic and Biological Approaches to Inheritance: Some Evidence", University of Chicago, manuscript.
- [11] Mulligan, C. B. (1997), *Parental Priorities and Economic Inequality*, The University of Chicago Press.
- [12] Murphy, K. M., A. Shleifer and R. W. Vishny (1991), "The Allocation of Talent: Implications for Growth", *Quarterly Journal of Economics*, vol. 51, no. 2.
- [13] Orazem, P. F. and J. P. Mattila (1991), "Human Capital, Uncertain Wage Distributions, and Occupational and Educational Choices", *International Economic Review*, vol. 32, no. 1(February), 103-122.
- [14] Roy, A. D. (1951), "Some thoughts on the distribution of earnings", *Oxford Economic Papers*, 3:135-146.
- [15] Rustichini, A., A. Ichino and D. Checchi (1996), "More Equal but Less Mobile? Education Financing and Intergenerational Mobility in Italy and in the U.S.", Università Bocconi, manuscript.
- [16] Sicherman, N. and O. Galor (1990), "A Theory of Career Mobility", *Journal of Political Economy*, vol. 98, no. 1, 169-192.
- [17] Solon, G. (1992), "Intergenerational Income Mobility in the United States", *American Economic Review*, vol. 82, no. 3(June), 393-408.
- [18] Willis, R. J. (1986), "Wage Determinants: A Survey and Reinterpretation of Human Capital Earnings Functions" in *Handbook of Labor Economics*, vol. 1, ch. 10, 526-602, eds O. Achenfelter and R. Layard.
- [19] Zimmerman, D. J. (1992), "Regression Toward Mediocrity in Economic Stature", *American Economic Review*, vol. 82, no. 3(June), 409-429.

A. Appendix

A.1. The expected value in the unfamiliar occupation

The expected value in the unfamiliar occupation is:

$$E[V_u] = \frac{1}{1-\gamma} \int_{-\infty}^{\infty} (w_u A_u^{\beta_u})^{1-\gamma} f(a_u | a_f) da_u. \quad (\text{A.1})$$

Given the utility function and the conditional distribution function we have:

$$E[V_u] = \frac{W_u^{1-\gamma}}{(1-\gamma) \sqrt{2\pi(1-\rho^2)}} \int_{-\infty}^{\infty} (A_u^{\beta_u})^{1-\gamma} \exp\left\{-\frac{1}{2(1-\rho^2)}(a_u - \rho a_f)^2\right\} da_u. \quad (\text{A.2})$$

Because $(A_u^{\beta_u})^{1-\gamma} = \exp\{(1-\gamma)\beta_u a_u\}$ we can write the integral:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{2(1-\rho^2)(1-\gamma)\beta_u a_u - (a_u - \rho a_f)^2}{2(1-\rho^2)}\right\} da_u. \quad (\text{A.3})$$

Separating out terms which do not contain the integrand we can write the integral:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{-(\rho a_f)^2}{2(1-\rho^2)}\right\} \exp\left\{\frac{-a_u^2 + 2[(1-\rho^2)(1-\gamma)\beta_u + \rho a_f]a_u}{2(1-\rho^2)}\right\} da_u. \quad (\text{A.4})$$

We can complete the square in the second exponent by multiplying and dividing by $\exp\left\{\frac{-[(1-\rho^2)(1-\gamma)\beta_u + \rho a_f]^2}{2(1-\rho^2)}\right\}$ in the second and first exponent respectively:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{[(1-\rho^2)(1-\gamma)\beta_u + \rho a_f]^2 - (\rho a_f)^2}{2(1-\rho^2)}\right\} \exp\left\{\frac{-a_u^2 + 2[(1-\rho^2)(1-\gamma)\beta_u + \rho a_f]a_u - [(1-\rho^2)(1-\gamma)\beta_u + \rho a_f]^2}{2(1-\rho^2)}\right\} da_u. \quad (\text{A.5})$$

This can be simplified to:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{[(1-\rho^2)(1-\gamma)\beta_u]^2 + 2(\rho a_f)(1-\rho^2)(1-\gamma)\beta_u}{2(1-\rho^2)}\right\} \exp\left\{\frac{-(a_u + [(1-\rho^2)(1-\gamma)\beta_u + \rho a_f])^2}{2(1-\rho^2)}\right\}. \quad (\text{A.6})$$

Moving the first exponent out of the integral gives us:

$$E[V_u] = \gamma \frac{W_u^{1-\gamma}}{(1-\gamma)} \exp \left\{ (1-\rho^2)(1-\gamma)^2 \frac{\beta_u^2}{2} + \rho a_f (1-\gamma) \beta_u \right\} \quad (\text{A.7})$$

$$\frac{1}{\sqrt{2\pi(1-\rho^2)}} \int_{-\infty}^{\infty} \exp \left\{ \frac{-(a_u + [(1-\rho^2)(1-\gamma)\beta_u + \rho a_f])^2}{2(1-\rho^2)} \right\} da_u.$$

We can now use the fact that $\frac{1}{\sqrt{2\pi(1-\rho^2)}} \int_{-\infty}^{\infty} \exp \left\{ \frac{-(a_u + [(1-\rho^2)(1-\gamma)\beta_u + \rho a_f])^2}{2(1-\rho^2)} \right\} da_u$ is the integral of a normal distribution with mean $[(1-\rho^2)(1-\gamma)\beta_u + \rho a_f]$ and variance $(1-\rho^2)$. The integral from $-\infty$ to ∞ of a normal distribution is always equal to one. This gives us:

$$E[V_u] = \frac{W_u^{1-\gamma}}{(1-\gamma)} \exp \left\{ (1-\rho^2)(1-\gamma)^2 \frac{\beta_u^2}{2} + \rho a_f (1-\gamma) \beta_u \right\}, \quad (\text{A.8})$$

which we can rewrite as:

$$E[U_u] = \frac{1}{(1-\gamma)} \left(W_u A_f^{\beta_u \rho} e^{\frac{\beta_u^2}{2}(1-\rho^2)(1-\gamma)} \right)^{1-\gamma}. \quad (\text{A.9})$$

Occupational Choice and Family Background in Sweden

1. Introduction

A positive correlation between the earnings of parents and off spring has emerged as one of the "stylized facts" in empirical labor economics. Recent research, surveyed in Solon (1998), has estimated this correlation to ranging between 0.2 and 0.5.¹ Despite new and improved techniques to measure intergenerational earnings correlations, Solon concludes that "we remain fairly ignorant about the causal processes underlying the intergenerational transmission of earnings".

The traditional human capital approach to intergenerational transmission of earnings capacity and economic status formulated in Becker and Tomes (1979, 1986), offers at least two explanations for the observed intergenerational earnings correlations. The first, and most emphasized, is access to capital for human capital investments. A second explanation is that off spring's endowment or ability to earn an income (apart from the human capital one can accumulate through investments) is influenced by the parents. Ability is partly genetically transmitted, partly learned and influenced through upbringing, e.g. individual ability is influ-

⁰Comments from John Dagsvik, Tore Ellingsen and Mårten Palme have greatly improved this paper. Sune Karlsson's help with the estimations has been invaluable.

¹See e.g. Björklund and Jäntti (1997) and Mulligan (1997).

enced by externalities from the parent's human capital and abilities. The result that various measures of socioeconomic background enter significantly into wage equations when schooling has been controlled for can be interpreted as support for this second explanation for transmission of earnings capacity.²

This paper attempts to extend the insights from human capital theory by investigating how family background influences the importance people place on economic incentives when making educational and occupational choices. As a point of departure for our investigation we take an empirical regularity which is well known in the sociological literature, namely that children tend to end up in occupations not too distant from their parents'. This pattern is illustrated in Table 1, which presents a transition matrix of occupations of father and offspring compiled from data from the Swedish Level of Living Survey (1991).³

Apart from rejecting that the occupational distributions of fathers and offspring are independent, the transition matrix brings out an interesting pattern of intergenerational occupational mobility, or *immobility* across occupational groups. Among individuals working in the first four occupations, there is an over representation of individuals with a background in any of these occupations as is indicated by the bold face figures. There is a similar tendency among the other occupations although much weaker. The pattern is broken by people with background in transport and communications and in services. If we are to explain the overall pattern, it is tempting to bring forth that the first four occupations have in common that they are largely white-collar professions. The other occupations are to a large extent blue-collar professions although there are exceptions such as pilots, navigators and flight engineers in the transport and communications occupation and military and police officers in the service occupation.

²See Haveman and Wolfe (1995) for a survey of studies.

³See section 4 for a description of the data set as well as the selections made for this study.

Table 1:
**Transition matrix: father's occupation (down)
vs individual's occupation (across)**

	prof	soc	adm	sale	agr	trans	prod	serv	N of f's
prof	154 (87.4)	87 (81.8)	101 (94.3)	46 (38.6)	10 (17)	19 (36.9)	73 (113.1)	33 (54)	523
soc	10 (9.2)	11 (8.6)	12 (9.9)	7 (4.1)	0 (1.8)	1 (3.9)	7 (11.9)	7 (5.7)	55
adm	73 (52.3)	50 (48.9)	78 (56.4)	30 (23.1)	2 (10.2)	15 (22.1)	42 (67.7)	23 (32.3)	313
sale	49 (47.9)	35 (44.9)	70 (51.8)	46 (21.2)	5 (9.3)	18 (20.2)	40 (62.0)	24 (29.6)	287
agr	107 (138.3)	128 (129.5)	115 (149.3)	43 (61.1)	86 (26.9)	56 (58.4)	189 (179)	104 (85.5)	828
trans	52 (61.5)	60 (57.5)	66 (66.4)	23 (27.2)	8 (12)	52 (25.9)	66 (79.6)	41 (38)	368
prod	222 (257.1)	227 (240.7)	255 (277.6)	98 (113.6)	23 (50)	120 (108.5)	434 (332.7)	160 (158.9)	1539
serv	28 (34.2)	41 (32.1)	50 (37)	12 (15.1)	3 (6.7)	6 (14.4)	36 (44.3)	29 (21.2)	205
other	9 (16)	20 (15)	13 (17.3)	6 (7.1)	0 (3.1)	10 (6.8)	24 (20.8)	14 (9.9)	96
N of ind's	704	659	760	311	137	297	911	435	4214

prof=professional, soc=social/medical, adm=administrative, sale=sales, trans=transport and communication, prod=production, serv=services, f's=fathers. Figures in brackets indicate expected number in the category, given row-column independence. Bold figures indicate over representation in the category. χ^2 -test of row-column independence: $\chi^2 = 440.4$. Independence rejected at $P = 0.00$.

The tendency of choosing occupations not too distant from that of the father does not find its explanation in traditional human capital models of mobility. Hence, in order to address the issue of how occupational choice influences mobility and the transmission of earnings we need to extend earlier models. The model of educational investments and occupational choice presented in this paper extends earlier models by introducing occupation specific ability, inspired by Roy (1951), and by assuming that there is ability uncertainty. The model allows family background to influence educational and occupational choice in three ways: the economic resources available for human capital investments, differences in costs of schooling due to imperfect capital markets or information costs, and family background related uncertainty about individual ability to work and succeed in different occupations. The first two mechanisms are present in traditional human capital models. The third mechanism, which extends the traditional human capital approach, suggests that since individuals do not have perfect information about their ability for various occupations and because it is likely that ability uncertainty is greater when considering distant occupations, risk averse individuals will be more reluctant to choose distant occupations than familiar ones. The theoretical model generates a number of testable implications for how family background may influence the valuation of economic incentives under different assumptions regarding risk aversion.

In the second part of this study, data from the Swedish Level of Living Survey (LNU 1991) is used to estimate a mixed multinomial logit (MMNL) model of how occupational choices of people from different family background are determined by economic incentives, such as earnings prospects, earnings dispersion, return to education and return to experience. Although the focus of the paper is on the influences of family background on the occupational choice, our empirical approach is inspired by previous empirical studies of occupational choice, e.g. Boskin (1974), Robertson and Symons (1990), Orazem and Mattila (1991), and Flyer (1997). While these studies ignore completely or include rough measures of ability, our study recognizes explicitly the lack of observed occupation specific ability measures as an important source of unobserved heterogeneity. The mixed multinomial logit (MMNL) estimation method, discussed thoroughly in McFadden and Train (1997), enables us to take into account that we cannot observe all factors that influence occupational choice by introducing a random element in the estimated coefficients.

This study finds empirical evidence for that both occupational and educational background influence how people react to incentives when they make occupational

choices. We also find that people are more sensitive to economic incentives and reluctant to take chances when considering unfamiliar occupations. In line with the predictions of our theoretical model, assuming strong risk aversion, our results indicate that less well off children are more sensitive to economic incentives than are rich children. Return to education is of greater importance for people from less well off or blue collar background, while people with educated parents tend to go for occupations requiring long educations, caring less about the actual returns to education. Furthermore, while less well off children tend to dislike wage dispersion, wage dispersion is actually regarded as positive by individuals with university educated parents and rather unimportant by individuals with white collar parents. We also find that it is important to consider heterogeneity with regard to preferences and unobserved factors affecting the returns to occupations in the estimation of the model.

The paper is organized as follows. In section 2, we briefly review implications for family background effects on occupational choice that can be drawn from a human capital approach to occupational choice and intergenerational mobility. Furthermore, we outline a simple model of occupational choice. Section 3 presents the empirical specification. Section 4 describes the data and constructs incentive variables using wage regressions. Section 5 presents results of MMNL estimations of family background determined differences in attitudes toward incentives. Section 6 concludes.

2. A Human Capital Approach to Occupational Choice, Incentives and Family Background

Within the human capital framework, occupational choice is widely viewed as an investment decision where the individual chooses the occupation and makes the educational investment which maximizes life time utility. Among the benefits associated with choosing an occupation appear future earnings prospects and nonpecuniary returns, while the costs involve training and forgone earnings etc.⁴ Family background may potentially influence both how large these costs and benefits are as well as the individual's valuation of them.

The traditional human capital-approach to intergenerational mobility, developed in Becker and Tomes (1979, 1986), assigns an important role to capital markets and the family's capacity to finance educational investments. Due to

⁴See e.g. Boskin (1974).

imperfect capital markets the cost of financing education is typically higher and sometimes even inhibitive for poor families. Family background could, however, also affect the benefit side. Individual productivity and hence earnings are commonly assumed to be determined by individual ability which is at least partly inherited. Furthermore, some skills that are of value on the labor market may also be transmitted through upbringing.

The individual's assessment of earnings prospects (as well as training costs) may also be affected by family background. First, patience and attitude towards risk are partly inherited or fostered. Second, the individual's information about his own ability and about how far it would get him in a particular occupation may be influenced by his family background. Furthermore, the importance the individual places on earnings will also depend on how diversified his future income is. Savings and the prospect of future inheritance or bequests from parents will of course affect the degree to which the individual's life time utility depends on the occupational choice and how non-pecuniary and pecuniary returns are valued.

It is obvious that, all other things being equal, we should expect a high wage occupation to be preferred to a low wage ditto. However, because the individual does not have full information about his prospects in a particular occupation, i.e. uncertainty about where in the wage distribution of that particular occupation he would end up, we can identify two counter acting forces which are present in determining how the individual will behave when faced with wage dispersion. On the one hand, risk averse individuals dislike the uncertainty associated with wage dispersion. On the other hand, the prospect of earning a very high wage if talent turns out to be high may compensate for the risk and make an occupation with large wage dispersion tempting.

2.1. A simple model of occupational choice

We now outline a simple model of how occupational choice can be influenced by family background. The structure of this model is inspired by the intergenerational model of Mulligan (1995) and by Willis' (1986) version of the occupational choice model described in Roy (1951).⁵

Each individual lives in two periods, as students and as workers. When they are students they live off money they receive from their parents net of what ever they have to pay for their education. In the working period of their lives, people live off their earnings. To keep the model simple, we abstract from loans and savings,

⁵The slightly different version of the model is thoroughly analyzed in Sjögren (1998).

and we ignore the possibility of receiving bequests or inheritance in period 2. The individual will choose the amount of education and occupation which gives the highest life time utility. Utility is additive over the two periods and is derived from consumption. Utility of an individual who chooses occupation j depends on the level of consumption while a student, c_{1j} , and on consumption while working in occupation j , c_{2j} . Second period consumption is subject to uncertainty because the individual cannot be sure of how well he will succeed in the chosen occupation. Life time utility is thus:

$$U(c_{1j}, c_{2j}) = u(c_{1j}) + \gamma E [u(c_{2j})], \quad \gamma > 0, \quad u' > 0, \quad u'' < 0. \quad (2.1)$$

The individual influences his level of consumption in both periods through the choice of occupation and through the amount of education he invests in the first period. A larger educational investment implies less consumption in the first period. Second period consumption will also depend on the choices made in period 1 since the productivity of an individual, and hence earnings, in a particular occupation depends on the individual's endowment of an occupation specific ability, how much education he has invested in, as well as on wage rates and the ability intensity of the occupation.

The budget constraint while a student is:

$$Y_1 - k_j H_j = c_{1j}, \quad (2.2)$$

where Y_1 is the money the individual receives from his parents. This amount may differ across individuals according to the income and generosity of the parents. H_j is the human capital investment associated with choosing occupation j , k_j is the per unit cost of human capital investment in occupation j . This cost is likely to be higher for people from poor or uneducated background, but it also depends on the occupation e.g. because some educations require more effort. c_{1j} is consumption in period one. The budget constraint in period two is:

$$Y_{2j} = c_{2j}, \quad (2.3)$$

where Y_{2j} is the earnings of the individual in occupation j . Earnings depend on the amount of human capital, H_j , the individual has invested in, the individual's endowment of occupation j specific ability A_j , the wage rate, W_j , and on the occupation specific parameter β_j determining the ability sensitivity of earnings in occupation j :

$$Y_{2j}(A_j) = W_j H_j A_j^{\beta_j}. \quad (2.4)$$

We assume that the individual has a prior belief about his abilities for each occupation such that

$$\ln A_j \sim N(\bar{a}_j, \rho_j). \quad (2.5)$$

We also assume that the individual is better at assessing his ability in occupations similar to that of his parents than at assessing how successfully he would make it in unfamiliar occupation. Hence, the standard deviation, ρ_j , of the prior distribution is assumed to be larger the more distant from the parental occupation is occupation j . It is further assumed that in the entire population, occupation specific ability is also log normally distributed such that

$$\ln A_j \sim N(0, 1) \text{ for all } j. \quad (2.6)$$

In line with Roy (1951), this implies that if individuals were randomly assigned to education level and occupation, the log of earnings are also normally distributed, $\ln Y_{2j} \sim N(\ln(W_j \bar{H}_j), \beta_j)$, where \bar{H}_j is the average education of those in the occupation. Hence, there is a link between the earnings dispersion within an occupation and the sensitivity of earnings to ability.

2.2. The choice of occupation and human capital investment

The individual chooses the occupation which yields the highest life time utility. That is, the individual chooses occupation i if utility in occupation i is higher than utility in occupation j , i.e.:

$$E[U_i(H_i^*)] - E[U_j(H_j^*)] \geq 0, \text{ for all } j \neq i, \quad (2.7)$$

where H_i^* and H_j^* are the optimal human capital investments associated with each occupational choice.

In order to compare utilities, we need to determine what the optimal human capital investments are. Since the dependence of utility on education in each occupation will depend on the endowment of ability specific to the occupation and on the intensity by which that ability is used and on the wage, it is not necessarily the case that the individual finds the same human capital investment optimal given different occupational choices.

The optimal human capital investment is found by maximizing with respect to H the expression for lifetime utility, 2.1, subject to the budget constraints 2.2 and 2.3. We will assume that the utility function takes the following form with constant relative risk aversion (intertemporal substitution elasticity) where the coefficient for relative risk aversion, $\frac{1}{\sigma} > 0$. The higher $\frac{1}{\sigma}$ the more risk averse the individual:

$$u(c) = \frac{1}{1 - \frac{1}{\sigma}} c^{1 - \frac{1}{\sigma}}. \quad (2.8)$$

The optimal human capital investment, given that the individual chooses occupation j , is thus determined by maximizing the following expression for lifetime utility with respect to H_j .

$$E[U_j] = \frac{1}{1 - \frac{1}{\sigma}} (Y_1 - k_j H_j)^{1 - \frac{1}{\sigma}} + \frac{\gamma}{1 - \frac{1}{\sigma}} \int_{-\infty}^{\infty} (W_j H_j A_j^{\beta_j})^{1 - \frac{1}{\sigma}} f(a_j) da_j, \quad (2.9)$$

where $(\frac{1}{\gamma} - 1) \geq 0$, is the rate of time preference.⁶

The first order condition is:

$$k_j u'(c_{1j}) = \gamma \int_{-\infty}^{\infty} u'(c_{2j}) W_j A_j^{\beta_j} f(a_j) da_j, \quad (2.10)$$

which states that the value of foregone consumption in period one must on the margin equal the value of the gain in consumption in period two. Using the utility function, this first order condition can be manipulated to obtain the following expression for the optimal human capital investment given that the individual chooses occupation j :⁷

$$H_j^* = \frac{Y_1}{k_j + k_j^{\sigma} \gamma^{-\sigma} (W_j \bar{A}_j^{\beta_j} \xi_j)^{1 - \sigma}}, \quad (2.11)$$

⁶Remember that $\ln A_j = a_j$, and that the density function of the normally distributed a_j is:
 $f(a_j) = \frac{1}{\sqrt{2\pi\rho^2}} \exp\left\{-\frac{1}{2\rho^2}(a_j - \bar{a}_j)^2\right\}$.

⁷See appendix A.1 for details.

where

$$\xi_j = \exp \left\{ \frac{\beta_j^2}{2} \rho_j^2 \left(1 - \frac{1}{\sigma} \right) \right\} \quad (2.12)$$

is a risk adjustment factor. The risk adjustment factor, $\xi > 1$ if risk aversion is moderate ($\frac{1}{\sigma} < 1$). The risk adjustment factor, $\xi < 1$ if risk aversion is strong ($\frac{1}{\sigma} > 1$).

Comparative statics on this optimal H , presented in appendix A.2, give that the optimal human capital investment increases with Y_1 and decreases with the cost, k . However, an increase in the W , induces higher human capital investment only if the individual is moderately risk averse. In the case of strong risk aversion, which also implies that the individual wants a smooth consumption path, the high wage is a substitute for human capital investment. Higher uncertainty about ability, ρ , will induce higher human capital investment. Increased sensitivity to ability, β , within an occupation will cause the strongly risk averse to invest in more human capital unless expected ability, and hence expected earnings are very high. When risk aversion is moderate, human capital investments will increase unless expected ability is very low, in which case the individual does not consider the pay off on the investment sufficient.

2.3. Expected life time utility in an occupation

We can now derive the following expression for expected life time (indirect) utility given the optimal human capital investment and given that the individual chooses occupation j :

$$E [U_j^*] = \frac{1}{\left(1 - \frac{1}{\sigma}\right)} \left((Y_1 - k_j H_j^*)^{1 - \frac{1}{\sigma}} + \gamma \left(W_j H_j^* \bar{A}_j^{\beta_j} \xi_j \right)^{1 - \frac{1}{\sigma}} \right), \quad (2.13)$$

which we can develop, using 2.11 to get:

$$E [U_j^*] = \left(1 - \frac{1}{\sigma} \right) Y_1^{1 - \frac{1}{\sigma}} \left\{ 1 + \gamma^\sigma k_j^{1 - \sigma} \left(W_j \bar{A}_j^{\beta_j} \xi_j \right)^{\sigma - 1} \right\}^{\frac{1}{\sigma}}. \quad (2.14)$$

Making use of the envelope theorem, we can now derive comparative statics on the expression for expected utility disregarding the effect on $E [U_j^*]$ of changes in H^* . These comparative statics, presented in appendix A.3, show that an increase

in the amount received from the parents, Y_1 , increases utility whereas increasing the cost, k_j , of human capital investments reduces utility. Increasing the wage, W_j , improves the utility associated with choosing an occupation. Furthermore, if uncertainty about ability, ρ , increases, utility increases when risk aversion is moderate and decreases when risk aversion is strong. Increases in the sensitivity of earnings to ability, β_j , will increase utility if ability is high enough and reduce utility if ability is low. The cut off ability will however depend on the degree of risk aversion. If risk aversion is strong, higher β_j , will increase utility only if ability is very high. With moderate risk aversion, utility will increase unless ability is very low.

The expected utility of individual i associated with choosing occupation j as a function of incentives and personal characteristics can be summarized as follows:

$$E [U_{ij}^*] = F(Y_{1i}^+, k_{ij}^-, W_j^+, \beta_j^{+-}, \bar{A}_{ij}^+, \rho_{ij}^+, \gamma_i^-), \quad (2.15)$$

where the signs above the arguments of the function indicate how the marginal valuation of the occupation changes with marginal changes in the arguments.

2.4. Family background and the sensitivity to economic incentives

The expression in 2.15 can now be used in order to derive predictions about differences in sensitivity to economic incentives due to family background. We conduct the analysis by deriving expressions for the effect of background on the marginal valuation of economic incentives, the derivative of the marginal utility of the incentive variable in question with respect to family background. This is defined as: $\partial \frac{\partial E[U]}{\partial I} / \partial F$, where I is the economic incentive variable and F is the family background variable. Sensitivity to an incentive is defined as the magnitude of the absolute value of the marginal valuation. Thus, a person is said to become more sensitive to the incentive variable if $\partial \frac{\partial E[U]}{\partial I} / \partial F$ has the same sign as $\frac{\partial E[U]}{\partial I}$ and less sensitive if they have the opposite signs.

The incentive variables considered are the wage, W_j , the sensitivity of earnings to ability, β_j . As family background variables we will consider, Y_1 , the economic support received from parents, k , the cost of educational investments which can be argued to be higher for people from uneducated or poor background, and ρ , which captures that the distance in terms of ability uncertainty of the occupation in question to the occupation of the parents.

2.4.1. The sensitivity to the wage rate

$$\begin{aligned}
 \frac{\partial \frac{\partial E[U]}{\partial W}}{\partial Y_1} &= \frac{\partial^2 E[U]}{\partial c_2^2} \frac{\partial c_2}{\partial H^*} \frac{\partial H^*}{\partial Y_1} \frac{\partial c_2}{\partial W} + \frac{\partial E[U]}{\partial c_2} \frac{\partial^2 c_2}{\partial W \partial H^*} \frac{\partial H^*}{\partial Y_1} \quad (2.16) \\
 &= \left(1 - \frac{1}{\sigma}\right) \gamma (W_j H^*)^{-\frac{1}{\sigma}} \left(A_j^{\beta j} \xi\right)^{\left(1 - \frac{1}{\sigma}\right)} \frac{\partial H^*}{\partial Y_1} \\
 &\quad \begin{cases} > 0 \text{ (more sensitive)} & \text{if } \left(1 - \frac{1}{\sigma}\right) > 0 \\ < 0 \text{ (less sensitive)} & \text{if } \left(1 - \frac{1}{\sigma}\right) < 0. \end{cases}
 \end{aligned}$$

$$\begin{aligned}
 \frac{\partial \frac{\partial E[U]}{\partial W}}{\partial k} &= \frac{\partial^2 E[U]}{\partial c_2^2} \frac{\partial c_2}{\partial H^*} \frac{\partial H^*}{\partial k} \frac{\partial c_2}{\partial W} + \frac{\partial E[U]}{\partial c_2} \frac{\partial^2 c_2}{\partial W \partial H^*} \frac{\partial H^*}{\partial k} = \quad (2.17) \\
 &\quad \left(1 - \frac{1}{\sigma}\right) \gamma (W_j H^*)^{-\frac{1}{\sigma}} \left(A_j^{\beta j} \xi\right)^{\left(1 - \frac{1}{\sigma}\right)} \frac{\partial H^*}{\partial k} \\
 &\quad \begin{cases} > 0 \text{ (more sensitive)} & \text{if } \left(1 - \frac{1}{\sigma}\right) < 0 \\ < 0 \text{ (less sensitive)} & \text{if } \left(1 - \frac{1}{\sigma}\right) > 0. \end{cases}
 \end{aligned}$$

The expression in 2.16 shows that strongly risk averse individuals become less sensitive to the wage rate with increases in the income received from the parents. Furthermore, 2.17 shows that as the cost of education increases, the sensitivity to the wage rate is increased for the strongly risk averse. The reason for this is that marginal utility of consumption decreases rapidly when risk aversion is strong and that the increase in consumption that is made possible by a higher wage is valued less when the level of consumption is high at the outset. When the individual is moderately risk averse, however, utility becomes more sensitive to the wage rate as the income received from the parents increases and less sensitive if the cost of education increases.

$$\begin{aligned}
 \frac{\partial \frac{\partial E[U]}{\partial W}}{\partial \rho} &= \left(1 - \frac{1}{\sigma}\right) \gamma (W_j H^*)^{-\frac{1}{\sigma}} \left(A_j^{\beta j} \xi\right)^{\left(1 - \frac{1}{\sigma}\right)} \left(\frac{\partial H^*}{\partial \rho} + H^* \beta^2 \rho \left(1 - \frac{1}{\sigma}\right)\right) \quad (2.18) \\
 &\quad \begin{cases} > 0 \text{ (more sensitive)} & \text{if } \left(1 - \frac{1}{\sigma}\right) > 0 \\ > 0 \text{ (more sensitive)} & \text{if } \left(1 - \frac{1}{\sigma}\right) < 0, \text{ unless } W \text{ very small.} \end{cases}
 \end{aligned}$$

Increased ability uncertainty will, as is shown in 2.18, tend to increase the sensitivity to the wage rate. There are exceptions in the case of strong risk aversion when the wage rate is very small in which case $\frac{\partial H^*}{\partial \rho}$ is large enough to make the last bracket in the expression positive.

2.4.2. The sensitivity to ability sensitivity (wage dispersion)

$$\begin{aligned} \frac{\partial \frac{\partial E[U]}{\partial \beta}}{\partial Y_1} &= (1 - \frac{1}{\sigma}) \gamma H^{*-\frac{1}{\sigma}} (W_j A_j^{\beta j} \xi)^{(1-\frac{1}{\sigma})} \left(a + \beta \rho^2 (1 - \frac{1}{\sigma}) \right) \frac{\partial H^*}{\partial Y_1} \quad (2.19) \\ &\geq 0 \quad \text{if} \quad (1 - \frac{1}{\sigma}) < 0 \left\{ \begin{array}{l} a \text{ small} \\ a \text{ large} \end{array} \right\} \text{ i.e. less sensitive} \\ &\geq 0 \quad \text{if} \quad (1 - \frac{1}{\sigma}) > 0 \left\{ \begin{array}{l} a \text{ large} \\ a \text{ small} \end{array} \right\} \text{ i.e. more sensitive.} \end{aligned}$$

$$\begin{aligned} \frac{\partial \frac{\partial E[U]}{\partial \beta}}{\partial k} &= (1 - \frac{1}{\sigma}) \gamma H^{*-\frac{1}{\sigma}} (W_j A_j^{\beta j} \xi)^{(1-\frac{1}{\sigma})} \left(a + \beta \rho^2 (1 - \frac{1}{\sigma}) \right) \frac{\partial H^*}{\partial k} \quad (2.20) \\ &\geq 0 \quad \text{if} \quad (1 - \frac{1}{\sigma}) < 0 \left\{ \begin{array}{l} a \text{ large} \\ a \text{ small} \end{array} \right\} \text{ i.e. more sensitive} \\ &\left\{ \begin{array}{l} \geq 0 \quad \text{if} \quad (1 - \frac{1}{\sigma}) > 0 \left\{ \begin{array}{l} a \text{ small} \\ a \text{ large} \end{array} \right\} \text{ i.e. less sensitive.} \end{array} \right. \end{aligned}$$

From expression 2.19 we have that moderately risk averse individuals become more sensitive to ability sensitivity as the income received for the parents increases. In other words, the individual is more positive when ability is large enough and more negative when ability is low. However, 2.20 shows that when the cost of education increases, the sensitivity to ability is reduced. Strongly risk averse individuals, on the other hand, become less sensitive to ability sensitivity when the income received from the parents increases and more sensitive to ability sensitivity as the cost of education increases.

$$\begin{aligned} \frac{\partial \frac{\partial E[U]}{\partial \beta}}{\partial \rho} &= (1 - \frac{1}{\sigma}) \gamma (W_j H^* A_j^{\beta j} \xi)^{(1-\frac{1}{\sigma})} \quad (2.21) \\ &\left[\left(\frac{\partial H^*}{\partial \rho} H^{*-1} + \beta^2 \rho (1 - \frac{1}{\sigma}) \right) \left(a + \beta \rho^2 (1 - \frac{1}{\sigma}) \right) + 2\beta \right] \\ &\left\{ \begin{array}{l} \geq 0 \quad \text{if} \quad (1 - \frac{1}{\sigma}) > 0 \left\{ \begin{array}{l} \text{unless } a \text{ very small} \\ a \text{ very small} \end{array} \right\} \text{ i.e. more sensitive} \\ \geq 0 \quad \text{if} \quad (1 - \frac{1}{\sigma}) < 0 \left\{ \begin{array}{l} a \text{ large} \\ \text{unless } a \text{ large} \end{array} \right\} \text{ assuming } W \text{ not too small.} \\ \text{i.e. more sensitive.} \end{array} \right. \end{aligned}$$

In expression 2.21, it is shown that increased ability uncertainty increases the sensitivity to ability sensitivity for moderately risk averse people. For strongly risk

averse individuals the effect of increased ability uncertainty is difficult to evaluate, but assuming that the wage rate is not very small (smaller than unity), people will tend to become more sensitive to ability sensitivity as ability uncertainty increases.

2.5. Summarizing the implications of the model

The implications of our model depend on the degree of risk aversion of individuals. If people from different background have similar attitudes toward risk we can summarize our results as follows:

If risk aversion is moderate, individuals from well off, well educated background are more sensitive to incentives than are individuals from less privileged background. That is, they are more sensitive to the wage rate and they are more positive towards wage dispersion if their ability is high enough, and more negative if ability is low. If risk aversion is strong, individuals from less privileged background are more sensitive to incentives than are individuals from well off background.

Regardless of risk aversion, individuals are more wage sensitive and more sensitive to wage dispersion when considering an occupation which is unfamiliar than when considering a familiar occupation.

3. Empirical Specification and Estimation

3.1. A random utility model

We use the model developed above as a point of departure for the specification of a mixed logit model of occupational choice. From equation 2.14 we have that choosing the occupation which maximizes expected utility is equivalent to maximizing $\left(\frac{W_j \bar{A}_{ij}^{\beta_j} \xi_{ij}}{k_{ij}}\right)$. This allows us to derive a reduced form for what governs occupational choice. We, thus, define individual i 's random utility associated with choosing occupation j as:

$$V_{ij} \equiv \ln \left(\frac{W_j \bar{A}_{ij}^{\beta_j} \xi_{ij}}{k_{ij}} \right) = \ln W_j + \beta_j \ln \bar{A}_{ij} + \ln \xi_{ij} - \ln k_{ij} \\ = \mathbf{X}_j(\bar{\Phi} + \Phi_f + \boldsymbol{\mu}_{ij}) + \varepsilon_{ij}, \quad (j = 1, \dots, M), \quad (3.1)$$

where V_{ij} is the expected life time utility for individual i , who has family background f , of choosing occupation j . \mathbf{X}_j is a vector of attributes of occupation j reflecting the returns, risk and costs associated with choosing the occupation. Together, $\bar{\Phi}$, Φ_f and μ_{ij} capture the individual's marginal valuation of economic incentives, as discussed in our theoretical model in section 2.3. The coefficient vector $\bar{\Phi}$ captures the mean of the marginal valuation of the occupational attributes of people and Φ_f captures deviations from this mean marginal valuation that depends on the family background f of individual i .

As our theoretical model showed, the marginal valuation of incentives may differ across family background also when there are no systematic background differences in preferences *per se*. However, Φ_f , captures also systematic background related deviations in preferences. The coefficient vector μ_{ij} captures stochastic individual deviations from this $(\bar{\Phi} + \Phi_f)$ which result from unobserved heterogeneity due to e.g. unobserved occupation specific ability or individual preference differences that are not shared for people of the same family background. However, we allow the distribution (e.g. variance) of this individual heterogeneity to differ across family backgrounds. ε_{ij} is an individual and occupation specific random disturbance which is assumed to be i.i.d. extreme value. This ε_{ij} captures e.g. that an individual may have a special interest in a particular occupation which has nothing to do with ability or background or interest for other occupations.

We let \mathbf{X}_j contain variables that reflect $\ln W_j + \beta_j \ln \bar{A}_{ij} + \ln \xi_{ij}$, which is closely related to expected working life earnings in an occupation and hence includes measures of returns and risks. A measure of the length of education typically required in the occupation is also included to reflect the occupation specific element of the cost of human capital investments, $\ln k_{ij}$. We base our measures of returns and risks the earnings function of the theoretical part of the paper, 2.4, which has it that $\ln Y_j = \ln W_j + \ln H_j + \beta_j a_j$.

However, since 2.4 represents working life earnings in a two-period model it does not include work experience. In the empirical analysis, we need to take experience into account for three reasons. First, we need to correct for differences in the age distribution between our occupations. Second, because individual ability can be argued to be of importance for how much the individual is able to advance and learn on the job, return to experience may capture an element of the return to ability in the occupation. Third, high return to experience may also be a indicator that there are skills that can be acquired only with experience, i.e. that the first years on the job involve investments that pay off in the future.

Hence, we will assume that the underlying wage structure in occupation, j ,

can be described by an ability augmented Mincer type earnings function:

$$\ln y_{ij} = \varphi_{0j} + \varphi_{1j}s_i + \varphi_{2j}x_i + \varphi_{3j}x_i^2 + \varphi_{4j}a_i + u_{ij} \quad (3.2)$$

where y is earnings, s is schooling, x is working experience, a is ability and u_{ij} is a random disturbance which is assumed to be i.i.d. in the population as a whole.⁸ φ_{0j} corresponds to $\ln W_j$, φ_{1j} captures returns to schooling, φ_{2j} and φ_{3j} capture the return to experience, and φ_{4j} corresponds to β_j , which is linked to wage dispersion in the occupation.⁹

However, schooling and the return to experience can be argued to be linked to the ability of the individual. From our model we have that investment in human capital or schooling is endogenous and depends on ability, background and returns. It is also the case that return to experience is linked to the ability to advance and learn on the job and thus also captures an element of the return to ability. Thus, estimates of φ_{1j} , φ_{2j} , φ_{3j} and φ_{4j} all include elements of the return to ability and since ability is uncertain, they also capture elements of risk adjustment factor ξ_{ij} , which is linked to family background through ρ_{ij} .

Because we lack data on occupation specific ability, we are not able to estimate each individuals' true expected returns associated with each occupation from data. The contents of \mathbf{X}_j are thus occupation specific, but not individual specific. Our estimation method, the mixed logit model, handles this by instead allowing the estimated marginal valuations to vary across family background and individuals. Hence, the heterogeneity in these estimated marginal valuations reflect differences in preferences, heterogeneity in valuation and unmeasured heterogeneity in the measured returns, risks and costs. The estimation of \mathbf{X}_j from earnings data is discussed below.

Our theoretical model gives that occupational choice will depend on family background by influencing the marginal valuation of economic incentives. Our model also emphasizes different aspects of family background. First, family background influences (in the model it determines) the resources available for educational investments. Second, family background influences the cost of education because of possible imperfections in access to financial markets and because well educated parents may have better information about the educational system and thus face lower information costs. Third, our theoretical model also gives that family background will influence how well the individual can assess his ability to make it in different occupations. That is, the more distant from the family

⁸See Willis (1986) for a discussion of earnings functions.

⁹See the argument of Roy (1951), presented in section 2.1.

occupation, the poorer is the quality of information the individual has about his ability. An implication of this last aspect of family background is that people who share the same background in terms of distance to other occupations, have similar quality of information about their ability to perform other occupations.

The first two aspects of family background are those discussed previously within the human capital approach to intergenerational mobility, in particular by Becker and Tomes (1979, 1986) and by Mulligan (1995, 1997). The third aspect is a novelty of the model presented here and should be seen as complementary to rather than as competing with the other two.

3.2. Estimation

The individual chooses occupation j if $V_{ij} \geq V_{in}$, for all n .¹⁰ When ε_{ij} are i.i.d. extreme value, the choice probability conditional on $\boldsymbol{\mu}$,¹¹ is:

$$L_j(\boldsymbol{\mu}) = \frac{\exp(((\bar{\Phi} + \Phi_f) + \boldsymbol{\mu}_{ij})\mathbf{X}_j)}{\sum_n \exp(((\bar{\Phi} + \Phi_f) + \boldsymbol{\mu}_{in})\mathbf{X}_n)} \quad (3.3)$$

regardless of the distribution of $\boldsymbol{\mu}$.¹² However, since $\boldsymbol{\mu}$ is not known, the unconditional probability of choosing occupation j , P_j , is the integral of 3.3 over all values of $\boldsymbol{\mu}$ weighted by the density of $\boldsymbol{\mu}$:

$$P_j = \int L_j(\boldsymbol{\mu})f(\boldsymbol{\mu} | \Omega)d\boldsymbol{\mu}. \quad (3.4)$$

$f(\boldsymbol{\mu} | \Omega)$ is the density function of $\boldsymbol{\mu}$ and Ω are the fixed parameters of this density function. This integral generally has no closed form and hence needs to be approximated through simulation. Thus, for a given set of values for the parameters, Ω , a value of each element $\boldsymbol{\mu}$ is drawn from its distribution. The logit formula, $L_j(\boldsymbol{\mu})$, is calculated using this draw. This process is repeated, and the average of the resulting $L_j(\boldsymbol{\mu})$'s is the approximate choice probability. The sum over all individuals of the logs of this approximate choice probability is the simulated log-likelihood function and the estimated parameters are those that maximize this simulated log-likelihood function.¹³

¹⁰We ignore the option of not choosing an occupation at all.

¹¹ $\boldsymbol{\mu}$ is a vector of stochastic individual deviations from the marginal valuations of incentives common to people of background f .

¹²See Brownstone and Train (1996).

¹³The gauss code used for our estimations is generously made available on the home page of Kenneth Train, Department of Economics, University of California, Berkeley. Our estimations are based on 200 repetitions.

McFadden and Train (1997) show that any random utility model can be approximated with a mixed logit through appropriate choice of explanatory variables and distributions for the random parameters. Furthermore, they state that an appropriate specification test for the MMNL model is a likelihood ratio test for omitted variables with the corresponding MNL model as the restricted model.¹⁴

4. Data and Measurement

The empirical analysis uses data extracted from the Swedish Level of Living survey (LNU).¹⁵ The data set used contains information on age, occupation, years of education, type of education, hourly earnings in 1991, and family background variables such as father's education and occupation for a representative sample of 6773 individuals born between 1915 and 1973.

From this sample we have selected 4214 individuals of working age who have a registered occupation. Since the normal retirement age in Sweden is 65, our sample includes individuals between the ages of 20 and 65. Hourly earnings have been computed using data on total monthly earnings and hours worked. Individuals with hourly earnings exceeding SEK 900 are not included in the sample. The sample is further reduced by the exclusion of the occupational category agriculture. The reason for excluding individuals working in agriculture is that the earnings function estimated in order to generate occupation specific incentive variables fails completely to capture how agricultural earnings are determined. The reason for this failure is likely to be that earnings in agriculture are to a great extent explained by size and location of farm. The empirical analysis is therefore conducted without people working in agriculture. Hence, the empirical analysis is based on a sample of 4077 observations.

In order to estimate a model of occupational choice with background effects, we need to obtain individual data on occupational choice, economic incentive variables and family background. Definitions and measurements of the data analyzed are discussed in the rest of this section.

¹⁴In this paper, we will assume that the random parameters are normally distributed. However, there may be situations where we do not want to allow the parameters to take different signs for different people. In such cases, it may be preferable to assume that parameters are log normally distributed.

¹⁵See Erikson and Åberg (1987) for a detailed description of the Swedish Level of Living Survey.

4.1. Occupational categories

Based on NYK80 occupational codes,¹⁶ we have defined 8 occupational categories. The 8 occupations correspond to the 1-digit NYK80 categories, except that mining and production workers have been put in the same group. The occupations are presented in Table 4.1a.

Table 4.1a:
Occupations classified

Occupation	NYK80	Description
professional	001-099	Professional, technical and related work: technical, scientific, educational, religious, law, literary, journalistic, artistic
social/ medical	101-199	Health, nursing and social work: Medical, nursing, physiotherapy, dental, pharmaceutical, social, health protection
administrative	201-299	Administrative, managerial and clerical work: Public and business administration, accounting, clerical, IT, economics and statistics
sales	311-399	Sales work: sales (business services, assets and goods), purchasing
agriculture	400-449	Agricultural, forestry and fishing work: Agriculture, horticulture, livestock and forestry management and work, wildlife protection, fishing
transp&com	601-649	Transport and communications work: Drivers, Train and flight personnel, telecom's workers.
production	501-599 701-891	Mining and production work: mining, textile, leather, metal processing, machine, electrical, wood, chemical, food, construction, painting.
service	901-989	Service work: Civilian protection, lodging and catering, cleaning, laundring, military.

At this aggregate level, it is obvious that each occupational category spans a vast range of activities. The reason for choosing this kind of classification rather than one based more closely on years of education is that we are interested in a concept of occupation like that suggested in Roy (1951) where occupations are

¹⁶NYK80 = Nordic occupation classification

occupations because they require different types of, or combinations of, abilities. So, in principle, what we are assuming by using the classification we do, is that a nurse and a medical doctor use the same type of ability. The difference between them is that they have different amounts of education.

Table 4.1b presents some descriptive statistics for our occupational categories except agriculture, which is excluded from the analysis for reasons discussed above. It is clear from Table 4.1b that there are large gender differences between the different occupations.

Table 4.1b:
Descriptive figures for 7 broad occupational categories

	male					female				
	obs	av w/h	s.d. w	ed yrs	s.d. ed.yrs	obs	av w/h	s.d. w	ed yrs	s.d. ed.yrs
prof	403	81.9	48.9	13.7	3.82	301	68.6	42.0	13.9	3.01
soc	88	77.8	54.0	14.9	4.1	571	66.1	62.0	11.5	2.8
adm	285	87.8	60.6	13.0	3.17	475	64.8	32.9	11.4	2.62
sales	159	78.2	84.8	11.6	2.89	152	45.5	40.6	10.6	2.92
trans	196	57.3	37.6	10.1	2.57	101	57.7	29.8	10.3	2.24
prod	743	62.4	46.5	10.2	2.38	168	41.8	52.4	9.2	2.65
serv	173	64.3	61.6	10.6	2.83	262	46.8	54.3	9.2	2.6
total	2047	71.3	54.9	11.6		2030	59.7	49.6	11.2	
m+f	4077	65.5	52.6	11.4						

obs=number of observations, av w/h=average hourly wage, s.d.w= standard deviation of wage, ed yrs=average years of education, s.d. ed yrs=standard deviation of average years of education, m=male, f=female.

Women outnumber men only in the social/medical occupation and in services. The dominance of men is particularly high among production workers. If we consider average hourly wages and years of education, it is also clear that the type

of jobs held by men and women in each occupational category are not necessarily the same. This is obvious in the social/medical occupation where women earn less and have markedly less education. In all but one of the occupational categories do men earn more and have more education than women. The exception is transport and communications where the gender difference is very small.

If occupations are ranked according to mean wage or average years of education, it is also clear that there are large gender differences. For men, administration tops the wage ranking, before professionals and sales. For women, the wage ranking is topped by professional, social/medical is second and administration is third.

4.2. Constructing incentive variables

The next step is to obtain measures of the occupational attributes in \mathbf{X}_j . Because we lack data on ability, estimation of 3.2 will be subject to omitted variable bias. Furthermore, even if we had data on ability, the endogenous nature of schooling and the possibility that the individual's return to experience is influenced by ability, would render estimates of the return to schooling and experience biased due to simultaneity.

Omitted variable and simultaneity problems would in our case, assuming positive covariances between ability and schooling and experience respectively, result in upward biased OLS estimates of returns to schooling and experience. The estimates of the variance of the OLS residuals would also be biased upwards. As is well known, the magnitude in the bias of a coefficient on a variable m resulting from omitting a variable e.g. ability, would depend positively on the true return to ability in the occupation, negatively on the variance of m and positively on the covariance of m and ability.¹⁷ However, we can safely assume that our estimations suffer also from measurement errors which would attenuate the relation between schooling and earnings and thus bias downward the return to schooling. Furthermore, because we have little reason to believe that the biases in our estimates would systematically bias a comparison of returns across occupations, we will go through with estimating our wage regressions. Hence, we will estimate the following earnings equation:

$$\ln y_{ij} = \varphi_{0j} + \varphi_{1j}s_i + \varphi_{2j}x_i + \varphi_{3j}x_i^2 + \varphi_{4j}u_{ij}. \quad (4.1)$$

¹⁷ $E \left[\hat{\varphi}_m \right] = \varphi_m + \varphi_{4j} \frac{\text{cov}(m, a_i)}{V(m)}$

The estimate of φ_{0j} is used as a measure of the hourly wage rate in the occupation, φ_{1j} measures the return to schooling, φ_{2j} and φ_{3j} capture the return to experience. Although the return to experience would be better described by both φ_{2j} and φ_{3j} , we will only enter φ_{2j} into our occupational choice estimations in order to economize on the number of parameters to estimate in the model. The variance of the regression residuals, φ_{4j}^2 , assuming that u_{ij} is $N(0,1)$, is assumed to capture earnings differences that result from factors other than education and experience, e.g. differences in ability. We use this as a measure of wage dispersion in the occupation. In line with our theoretical model, this measure is assumed to be related to the return to ability in an occupation. s_i is the number of years of schooling of individual i and x_i measures individual i 's experience. Experience is measured as the individual's age, less seven (school starting age), less years of education. Because of the large gender differences in the types of occupations held within our broadly defined occupational categories that became evident in Table 4.1, we estimate separate parameters for men and women. The computed gender specific incentive variables are presented in Table 4.2.

Table 4.2 gives a slightly different picture of the returns associated with choosing an occupation than Table 4.1. The wage rate, i.e. log of the hourly wage of an uneducated person with no experience, for men is highest in production work and lowest in the social medical profession. For women, the occupation with the highest wage rate is transport and communications and the lowest is sales. Men receive the highest return to education if they choose sales and the lowest if they opt for professional or transport and communications. Women also get the highest return to education in sales and the lowest in transport and communications. The occupational choice associated with the highest wage dispersion for men is sales, while the lowest is transport and communications. For women the corresponding occupations are production and transport and communications.

Table 4.2:
Incentive variables for 7 broad occupational categories

	male				female			
	W	Wdisp	Edpr	Expr	W	Wdisp	Edpr	Expr
	φ_0	φ_4	φ_1	φ_2	φ_0	φ_4	φ_1	φ_2
prof	3.87	0.073	0.024	0.025	3.73	0.116	0.035	0.009
soc	3.36	0.068	0.058	0.028	3.86	0.078	0.025	0.005
adm	3.63	0.09	0.038	0.041	3.66	0.048	0.036	0.017
sales	3.38	0.152	0.060	0.037	3.35	0.062	0.058	0.020
trans	3.87	0.044	0.024	0.014	3.93	0.029	0.017	0.013
prod	4.14	0.078	0.036	0.012	3.69	0.202	0.045	0.002
serv	3.49	0.084	0.052	0.018	3.75	0.062	0.023	0.013
mean	3.68	0.084	0.042	0.025	3.71	0.085	0.034	0.011
m+f	3.69	0.084	0.038	0.018				

W=wage rate, Wdisp=wage dispersion, Edpr=return to education
 Expr=return to experience, m=male, f=female.

4.3. Family background variables

In order to capture the various aspects of family background that influence the marginal valuation of incentives discussed in section 3 we have chosen to construct two sets of background dummies and one occupation specific dummy. Throughout we use characteristics of the father.¹⁸

We attempt to capture background effects connected to having rich or poor parents, informational advantages of people with well educated parents, and effects of having well off or poor parents on the cost of educational investments

¹⁸Using both mother and father would probably add to the picture. However, this would result in twice as many background variables apart from causing a problem with missing observations. Many mothers in the sample lack an occupation, probably because housewife is not classified as an occupation.

with a set background dummies based on parental education. Three educational background categories are defined namely, basic education, intermediate education and university education. Basic education corresponds to having attended only compulsory school.¹⁹ Intermediate education corresponds to having attended more than compulsory education, but not at university level.

The second set of background dummies is based on parental occupation. Occupational background groups people who have similar quality of information about their ability for other occupations. In order to keep the estimations numerically tractable, we choose to restrict ourselves to three broad occupational background categories. These categories are based on the pattern found in the transition matrix in Table 1, which identifies three groups of occupations between which intergroup occupational mobility tends to be low. The first occupational background category, which we will refer to as mixed, contains transport and communications and services. The second background category, is referred to as white collar and contains professionals, social sector, administration and sales. The third category, referred to as blue collar, contains production workers and agriculture.

Table 4.3:
Background categories: Father's education (across)
Father's occupation (down)

Father's occ	Father's education			Row total
	Basic	Interm.	Univ.	
Mixed	451 (441)	179 (171)	22 (46)	658
White collar	406 (778)	494 (301)	261 (82)	1161
Blue collar	1870 (1514)	384 (585)	4 (159)	2258
Col. total	2733	1057	287	4077

χ^2 -test of row-column independence: $\chi^2=1013.1$.
Independence rejected at $P=0.00$. Individuals expected in the category if categories were independent in brackets.

Table 4.3 cross-tabulates the number of individuals in the two sets of background categories against each other. The cross-tabulation shows that the two

¹⁹During the 1950's and 1960's compulsory school was extended from seven to nine years.

sets of background dummies are not independent. We can conclude that the occupational background dummies also partly capture aspects of having well off or less well off parents.

In order to investigate the third aspect of family background, which relates to the distance between occupations, we construct an occupation specific distance dummy which classifies an occupation in terms of familiar or unfamiliar. An occupation is familiar if it belongs to the same occupational category as the father's occupation and unfamiliar if it belongs to a different occupational category. We have used the same occupational categories as for the definition of occupational background.

5. Results

This section presents the results of estimations of the following model:

$$\begin{aligned}
 V_{ij} = & (\bar{\Phi}_1 + \bar{\mu}_{1i})W_j + (\bar{\Phi}_2 + \bar{\mu}_{2i})Wdisp_j + (\bar{\Phi}_3 + \bar{\mu}_{3i})Edpr_j + \\
 & (\bar{\Phi}_4 + \bar{\mu}_{4i})Expr_j + (\bar{\Phi}_5 + \bar{\mu}_{5i})Ed_j + \\
 & (\Phi_{1f} + \mu_{1if})D_fW_j + (\Phi_{2f} + \mu_{2if})D_fWdisp_j + (\Phi_{3f} + \mu_{3if})D_fEdpr_j + \\
 & (\Phi_{4f} + \mu_{4if})D_fExpr_j + (\Phi_{5f} + \mu_{5if})D_fEd_j + \varepsilon_{ij}.
 \end{aligned} \tag{5.1}$$

The incentive variables included are the wage rate, W , i.e. our φ_0 -estimate, wage dispersion, $Wdisp$ (φ_4), return to education, $Edpr$ (φ_1), return to experience, $Expr$ (φ_2). We also include the average years of education required in the occupation, Ed , as a proxy for the costs of choosing the occupation. However, the length of education required in the occupation also gives information about the level of earnings in the occupation.

D_f is a set of dummy variables measuring background. The dummies included in our models are presented in Table 5. $\bar{\Phi}$ and $\bar{\mu}$ are the marginal valuations of the background category for which there is no dummy included. Φ_f and μ_f are the deviations from $\bar{\Phi}$ and $\bar{\mu}$ of background category f .

Table 5:
**Estimated models of occupational choice
as a function of incentives**

Model	D_f
1	None
2	Father has intermediate/university education
3	Father's occupation is white collar/blue collar
4	Occupation is unfamiliar

5.1. Model selection

Each model is estimated unrestricted (MMNL) and restricted (MNL) such that the random coefficients are restricted to be zero in order to test the random coefficient specification. The value of the log-likelihood function for each estimation is presented in Table 5.1:

Table 5.1:
The value of the log-likelihood function

D	MNL	MMNL
None	-7501	-7776
Father's education	-7441	-7424
Father's occupation	-7408	-7393
Occupational distance	-7406	-7394

Evaluation of the estimated models on the basis of likelihood ratio tests selects the models with background effects over the models without background effects and MMNL estimation over MNL estimation in all three models with background effects on the 5 per cent significance level.²⁰ The log-likelihood function values further indicate that out of the models with background effects, occupational background effects produces the best estimation results. However, because we see the models as complementary rather than competing, a best fit measure is not our only criterium. It would, however, be interesting to estimate a nested

²⁰We can note that the results of the MNL estimation of the model without background effects conform qualitatively with the results presented by Orazem and Mattila (1991). However, it should also be noted that the MNL estimations with or without background effects fail to satisfy tests of the independence of irrelevant alternatives assumption. The reason for failure may well be the presence of unaccounted for unobserved heterogeneity.

version of the three models with background effects. This is, unfortunately far from numerically tractable if random coefficients are allowed for all explanatory variables. Since we are interested in comparing the results of the different aspects of family background captured by the three background effects models we will present the results from these estimations.

5.2. Estimation results

The results from the estimations of occupational choice models with background effects are presented in Tables 5.2.1, 5.2.2 and 5.2.3. In Table 5.2.1 we present the results of estimations allowing coefficients to depend on father's education. The first third of Table 5.2.1 reports the estimates for people whose fathers have only basic education. The middle section of the table reports how the reactions of people whose fathers have intermediate education *differ* from the reactions of people whose fathers have basic education. The third part of the table reports how the reactions of people whose fathers have university education *differ* from the reactions of those whose fathers have basic education.

In order to obtain the point estimate of the coefficients for those with educated fathers, we simply sum the basic education coefficient estimates of the marginal valuation of an incentive variable and the difference estimates for the corresponding incentive variable for the categories with educated fathers. Significant difference estimates imply that the background category's valuation of the particular incentive variable differs significantly from valuation of the basic education background people. Estimates significant at the 10 per cent level are shown in bold face letters.

The results of the coefficient estimates are very much in line with the predictions of our theoretical model. As expected, the results show that people value the wage rate positively. The positive valuation of the average years of education indicates that the positive effect of high level of income associated with lengthy education is stronger than the negative aspect of high costs of education.

It is interesting to note that the return to education is less important the more educated the father, but that average length of education is regarded as more positive the more educated the father. This indicates that if the father is well educated the child will also want a long education, caring less about the actual return and cost of this education and more about that education can be regarded as a "ticket" to high wage, high status occupation.

Table 5.2.1:

Occupational choice with educational background effects

Father's Education	Explanatory variable		beta	stdev	t-value	prob
Basic	W	$\bar{\Phi}_1$	3.04	0.21	14.77	0.00
		$s(\bar{\mu}_1)$	0.04	1.06	0.04	0.48
	Wdisp	$\bar{\Phi}_2$	-3.41	0.76	-4.46	0.00
		$s(\bar{\mu}_2)$	0.18	6.26	0.03	0.49
	Edpr	$\bar{\Phi}_3$	26.92	3.11	8.64	0.00
		$s(\bar{\mu}_3)$	0.27	18.56	0.01	0.49
	Expr	$\bar{\Phi}_4$	-11.24	6.16	-1.83	0.03
		$s(\bar{\mu}_4)$	64.83	10.12	6.40	0.00
	Ed	$\bar{\Phi}_5$	0.06	0.02	3.81	0.00
		$s(\bar{\mu}_5)$	0.01	0.16	0.04	0.48
Intermediate	W	Φ_1	-0.42	0.44	-0.97	0.17
		$s(\mu_1)$	0.03	2.15	0.02	0.49
	Wdisp	Φ_2	1.67	1.51	1.11	0.13
		$s(\mu_2)$	0.11	13.19	0.01	0.50
	Edpr	Φ_3	-18.46	6.79	-2.72	0.00
		$s(\mu_3)$	0.07	35.73	0.00	0.50
	Expr	Φ_4	9.32	11.14	0.84	0.20
		$s(\mu_4)$	79.94	23.28	3.43	0.00
	Ed	Φ_5	0.18	0.03	5.39	0.00
		$s(\mu_5)$	0.00	0.31	0.00	0.50
University	W	Φ_1	-1.74	1.06	-1.65	0.05
		$s(\mu_1)$	0.71	3.17	0.22	0.41
	Wdisp	Φ_2	3.90	3.11	1.25	0.10
		$s(\mu_2)$	0.33	26.77	0.01	0.50
	Edpr	Φ_3	-31.34	19.60	-1.60	0.05
		$s(\mu_3)$	0.36	62.54	0.01	0.50
	Expr	Φ_4	8.68	18.44	0.47	0.32
		$s(\mu_4)$	73.40	50.81	1.44	0.07
	Ed	Φ_5	0.28	0.06	4.92	0.00
		$s(\mu_5)$	0.00	0.53	0.00	0.50
LogL-fn		-7424.32				

4077 observations, 200 draws. $s(\mu)$ =standard deviation of μ ,
W=wage rate, Wdisp=wage dispersion, Edpr= return to education
Expr=return to experience, Ed=average years of education

The result regarding wage dispersion is also interesting. Wage dispersion is regarded as negative all, except by the university background people. It supports the idea that people from well off background can afford to take chances, either because their future income is diversified enough or because they have better information about where in the wage distribution they will end up, or in fact because their average ability is high enough to make the positively disposed toward wage dispersion.

The valuation of return to experience is negative which we can interpret as indicating that people are impatient. People with educated fathers are, however, much less negative about return to experience, indicating that they can afford to wait for pay off on their occupational choice. Furthermore, the only variable with significant variation in its coefficient is return to experience. An interpretation of that the unobserved heterogeneity present is captured as variation in the coefficient on return to experience is that the actual return to experience an individual can expect will be highly dependent on the ability to learn on the job and to climb up the career ladder. An alternative interpretation of the negative coefficient estimate on return to experience is thus that return to experience is viewed as uncertain. Moreover, there are background effects in the variation in the coefficient on return to experience, indicating that the presence of unobserved heterogeneity is background dependent.

Table 5.2.2 presents the results of our estimations of occupational choice when we allow separate coefficients for people whose fathers have different occupations. The first third of Table 5.2.2 presents the results for people whose fathers are mixed occupation category. The second third of the table presents how the coefficients for those whose fathers are white collar workers, i.e. professional, soc/medical, administrative or sales, *differ* from the mixed background coefficients. A significant estimate, thus, implies that the valuation of the white collar background people significantly differs from the valuation of the mixed background people. The last third of the table presents the results for individuals whose fathers are production workers or working in agriculture. We call this background category blue collar. To obtain the point estimates of the coefficients for those with white and blue collar fathers we simply add up the mixed occupation coefficients and the difference estimates.

Table 5.2.2:

Occupational choice with occupational background effects

Father's Occupation	Explanatory variable	beta	stdev	t-value	prob	
Mixed	W	$\bar{\Phi}_1$	1.67	0.37	4.46	0.00
		$s(\bar{\mu}_1)$	0.02	1.06	0.01	0.49
	Wdisp	$\bar{\Phi}_2$	-5.45	1.55	-3.53	0.00
		$s(\bar{\mu}_2)$	0.18	6.24	0.03	0.49
	Edpr	$\bar{\Phi}_3$	10.66	6.17	1.73	0.04
		$s(\bar{\mu}_3)$	0.14	18.34	0.01	0.50
	Expr	$\bar{\Phi}_4$	-26.89	9.43	-2.85	0.00
		$s(\bar{\mu}_4)$	72.72	10.92	6.66	0.00
	Ed	$\bar{\Phi}_5$	0.08	0.03	2.65	0.00
		$s(\bar{\mu}_5)$	0.01	0.15	0.05	0.48
White collar	W	Φ_1	1.17	0.51	2.31	0.01
		$s(\mu_1)$	0.03	2.00	0.01	0.49
	Wdisp	Φ_2	5.19	1.92	2.70	0.00
		$s(\mu_2)$	0.15	13.30	0.01	0.50
	Edpr	Φ_3	7.90	8.22	0.96	0.17
		$s(\mu_3)$	2.06	31.25	0.07	0.47
	Expr	Φ_4	49.96	10.80	4.62	0.00
		$s(\mu_4)$	7.22	59.06	0.12	0.45
	Ed	Φ_5	0.17	0.04	4.39	0.00
		$s(\mu_5)$	0.01	0.29	0.05	0.48
Blue collar	W	Φ_1	1.56	0.43	3.66	0.00
		$s(\mu_1)$	0.10	1.43	0.07	0.47
	Wdisp	Φ_2	2.07	1.75	1.18	0.12
		$s(\mu_2)$	0.14	8.47	0.02	0.49
	Edpr	Φ_3	14.55	7.06	2.06	0.02
		$s(\mu_3)$	0.55	25.58	0.02	0.49
	Expr	Φ_4	6.95	10.91	0.64	0.26
		$s(\mu_4)$	24.63	32.64	0.75	0.23
	Ed	Φ_5	-0.01	0.04	-0.30	0.38
		$s(\mu_5)$	0.01	0.21	0.03	0.49
LogL-fn		-7393.21				

4077 observations, 200 draws. $s(\mu)$ =standard deviation of μ ,
W=wage rate, Wdisp=wage dispersion, Edpr= return to education
Expr=return to experience, Ed=average years of education

The results of our estimations with occupational background effects show the same general pattern as the results with educational background effects. People like the wage rate, dislike wage dispersion, like return to education, dislike return to experience and like average years of education. With the exception of the reaction to the wage rate and the return to education, the reactions of blue collar background people do not significantly differ from the reactions of the mixed background people. Blue collar background people care significantly more about the wage rate and the return to education. The high sensitivity to return to education and moderate interest for long educations is interesting and indicates that blue collar background people are interested in education only to the extent that it pays off. White collar background people, however, differ significantly from the others in that they are positive towards return to experience, prefer occupations requiring longer education and are much less negative towards wage dispersion.

Again, we can see that return to experience is the only variable which has significant variation in its coefficient. There are, however, no background effects in the variation of the coefficient on return to experience. Hence, the unobserved heterogeneity present in the data is not qualitatively different across occupational backgrounds. This can be interpreted as support for the idea that sharing occupational background also implies sharing quality of information about ability for other occupations.

Table 5.2.3 presents the results of our estimations when we allow people to have a different marginal valuation of incentives when they consider familiar occupations and unfamiliar occupations. The first half of the table presents the estimates when considering a familiar occupation and the second half presents how marginal valuation *differs* when considering an unfamiliar occupation.

The same general pattern appears if we consider the result for familiar occupations. However, there is one exception. When considering a familiar occupation, people like a high wage, dislike wage dispersion, like return to education, like average years of schooling, but they *like* return to experience. This, again, supports the idea that return to experience should be connected to uncertainty about ability and about the future. When considering a familiar occupation, our model hypothesizes that the uncertainty involved is smaller.

Table 5.2.3:

Occupational choice with distance to occupation effects

Father's occupation	Explanatory variable	beta	stdev	t-value	prob	
Familiar	W	$\bar{\Phi}_1$	2.51	0.19	13.33	0.00
		$s(\bar{\mu}_1)$	0.01	1.11	0.01	0.50
	Wdisp	$\bar{\Phi}_2$	-1.54	0.98	-1.57	0.06
		$s(\bar{\mu}_2)$	0.37	6.11	0.06	0.48
	Edpr	$\bar{\Phi}_3$	10.66	3.97	2.68	0.00
		$s(\bar{\mu}_3)$	0.88	19.17	0.05	0.48
	Expr	$\bar{\Phi}_4$	15.36	6.13	2.50	0.01
		$s(\bar{\mu}_4)$	69.21	8.80	7.86	0.00
	Ed	$\bar{\Phi}_5$	0.17	0.02	6.86	0.00
		$s(\bar{\mu}_5)$	0.00	0.15	-0.01	0.49
Unfamiliar	W	Φ_1	0.15	0.08	1.82	0.03
		$s(\mu_1)$	0.00	0.14	0.02	0.49
	Wdisp	Φ_2	-1.70	1.35	-1.26	0.10
		$s(\mu_2)$	0.14	5.80	0.02	0.49
	Edpr	Φ_3	9.67	4.26	2.27	0.01
		$s(\mu_3)$	0.60	13.22	0.05	0.48
	Expr	Φ_4	-33.53	7.26	-4.62	0.00
		$s(\mu_4)$	11.56	20.97	0.55	0.29
	Ed	Φ_5	-0.07	0.03	-2.36	0.01
		$s(\mu_5)$	0.00	0.05	0.01	0.49
LogL-fn		-7393.67				

4077 observations, 200 draws. $s(\mu)$ =standard deviation of μ ,
W=wage rate, Wdisp=wage dispersion, Edpr=return to education,
Expr=return to experience, Ed=average years of education

As predicted by our theoretical model, people are more sensitive to incentives when they consider unfamiliar occupations. People are more positive towards the wage rate, the dislike wage dispersion more strongly, they are more interested in return to education, they dislike return to experience and they are less willing to go for a long education.

As in the previous models, return to experience is the only variable with significant variation in its coefficient. There is, however, no significant difference in this heterogeneity when familiar or unfamiliar occupations are considered.

6. Conclusions

The empirical results obtained in this study suggest that socio-economic background influences how people react to economic incentives when they make occupational choices. In particular, we find that people from low skilled background are more sensitive to economic incentives since they to a greater extent are attracted to occupations with high wage rates and high returns to education. We also find evidence that this group is more risk averse in their occupational choices since they are more negative towards wage dispersion and returns to experience than are people from high skilled background. Furthermore, the results show that people are more sensitive to economic incentives when considering unfamiliar occupations than when considering familiar occupations.

These empirical results support the predictions generated by the theoretical model when risk aversion is strong presented in this paper. The results, thus, show that the idea of family background related ability uncertainty raised in this paper is indeed complementary to the human capital approach to intergenerational mobility, which stresses the importance of educational costs and differences in access to capital.

We find that there is a significant presence of individual heterogeneity in the estimated marginal valuations of return to experience. We interpret this as resulting from unobserved ability heterogeneity and that return to experience is linked to occupation specific ability. The presence of individual heterogeneity supports the use of MMNL estimations.

The absence of background effects in the estimates of individual heterogeneity when occupational background is controlled for and the presence of background effects when controlling for educational background, indicate that these background concepts are indeed complementary. The result could be interpreted as supporting the idea that the degree of ability uncertainty facing the individual is linked to occupational background. In particular, it could be a result of that sharing occupational background implies that people also have the same quality of information about their ability for other occupations. An alternative interpretation is that educational background is correlated with some general measure of ability and, hence, that sharing educational background implies being drawn from the same part of the ability distribution such that the ability distributions would be different across educational backgrounds.

The results of our theoretical and empirical analyses lead to the conclusion that policies affecting the incentive structure on the labor market are far from

neutral in terms of their effect on people from different family background. Poor return to education due to high taxes or costly education financing will deter children from less well situated background to a higher extent than it will affect well off children. Unstable rules regarding education financing or income taxation creating uncertainty about future income or costs of education will also have a greater impact on the occupational choices of the less well situated than on the choices of the well off.

References

- [1] Becker, G. S. and N. Tomes (1979), "An Equilibrium Theory of the Distribution of Income and Intergenerational Mobility", *Journal of Political Economy*, vol. 87, no. 6, 1153-1189.
- [2] Becker, G. S. and N. Tomes (1986), "Human Capital and the Rise and Fall of Families", *Journal of Labor Economics*, vol. 4, no. 3, pt. 2, S1-S39.
- [3] Björklund, A. and M. Jäntti (1997), "Intergenerational Income Mobility in Sweden Compared to the United States", *American Economic Review*, vol. 87, no. 5, 1009-1018.
- [4] Boskin, M. J. (1974), "A Conditional Logit Model of Occupational Choice", *Journal of Political Economy*, vol. 82, 389-398.
- [5] Brownstone, D. and K. Train (1996), "Forecasting New product Penetration with Flexible Substitution Patterns", forthcoming in *Journal of Econometrics*.
- [6] Erikson, R. and R. Åberg (1987), *Welfare in Transition - Living Conditions in Sweden 1968-1981*, Clarendon Press, Oxford.
- [7] Flyer, F. A. (1997), "The Influence of Higher Moments of Earnings Distributions on Career Decisions", *Journal of Labor Economics*, vol. 15, no. 4, 689-713.
- [8] Haveman, R. and B. Wolfe (1995), "The Determinants of Children's Attainments: A Review of Methods and Findings", *Journal of Economic Literature*, vol. XXXIII, December, 1829-1878.

- [9] McFadden, D. L. and K. Train (1997), "Mixed Multinomial Logit Models for Discrete Response", working paper, Department of Economics, University of California, Berkeley.
- [10] Mulligan, C. B. (1995), "Economic and Biological Approaches to Inheritance: Some Evidence", manuscript.
- [11] Mulligan, C. B. (1997), *Parental Priorities and Economic Inequality*, The University of Chicago Press.
- [12] Orazem, P. F. and J. P. Mattila (1991), "Human Capital, Uncertain Wage Distributions, and Occupational and Educational Choices", *International Economic Review*, vol. 32, no. 1(Feb), 103-122.
- [13] Robertson, D. and J. Symons (1990), "The Occupational Choice of British Children", *The Economic Journal*, vol. 100, 828-841.
- [14] Roy, A. D. (1951), "Some thoughts on the distribution of earnings", *Oxford Economic Papers*, 3:135-146.
- [15] Sjögren, A. (1998), "The Effect of Redistribution on Intergenerational Mobility: Does wage equality nail the cobbler to his last?", *Working Paper Series in Economics and Finance*, no. 239, Stockholm School of Economics.
- [16] Solon, G. (1998), "Intergenerational Mobility in the Labor Market", forthcoming in *Handbook of Labor Economics*.
- [17] Willis, R. J. (1986), "Wage Determinants: A Survey and Reinterpretation of Human Capital Earnings Functions" in *Handbook of Labor Economics*, vol. 1, ch. 10, 526-602, eds O. Achenfelter and R. Layard.

A. Appendix

A.1. The individual's optimization problem

The individual maximizes the following utility function:

$$\max_{H_j} U(c_1, c_{2j}) = u(c_1) + \gamma E[u(c_{2j})], \quad (\text{A.1})$$

where

$$E[u(c_{2j})] = \int_{-\infty}^{\infty} u(c_{2j})f(a_j)da_j. \quad (\text{A.2})$$

The first order condition is:

$$u'(c_1) = \gamma \int_{-\infty}^{\infty} u'(c_{2j})W_j A_j^{\beta_j} f(a_j)da_j. \quad (\text{A.3})$$

Given the chosen utility function we have:

$$(Y_1 - k_j H_j)^{-\frac{1}{\sigma}} k_j = \gamma \frac{H_j^{-\frac{1}{\sigma}} W_j^{1-\frac{1}{\sigma}}}{\sqrt{2\pi\rho^2}} \int_{-\infty}^{\infty} (A_j^{\beta_j})^{1-\frac{1}{\sigma}} \exp\left\{-\frac{1}{2\rho^2}(a_j - \bar{a}_j)^2\right\} da_j \quad (\text{A.4})$$

Because $(A_j^{\beta_j})^{1-\frac{1}{\sigma}} = \exp\left\{(1 - \frac{1}{\sigma})\beta_j a_j\right\}$ we can write the integral:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{2\rho^2(1 - \frac{1}{\sigma})\beta_j a_j - (a_j - \bar{a}_j)^2}{2\rho^2}\right\} da_j. \quad (\text{A.5})$$

Separating out terms which do not contain the integrand we can write the integral:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{-(\bar{a}_j)^2}{2\rho^2}\right\} \exp\left\{\frac{-a_j^2 + 2[\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j]a_j}{2\rho^2}\right\} da_j. \quad (\text{A.6})$$

We can complete the square in the second exponent by multiplying and dividing by $\exp\left\{\frac{-[\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j]^2}{2\rho^2}\right\}$ in second and first exponent respectively:

$$I = \int_{-\infty}^{\infty} \exp\left\{\frac{[\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j]^2 - (\bar{a}_j)^2}{2\rho^2}\right\} \exp\left\{\frac{-a_j^2 + 2[\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j] - [\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j]^2}{\rho^2}\right\} da_j, \quad (\text{A.7})$$

which we can simplify to:

$$I = \int_{-\infty}^{\infty} \exp \left\{ \frac{[\rho^2(1 - \frac{1}{\sigma})\beta_j]^2 + 2(\bar{a}_j)\rho^2(1 - \frac{1}{\sigma})\beta_j}{2\rho^2} \right\} \exp \left\{ \frac{-(a_j + [\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j])^2}{2\rho^2} \right\}. \quad (\text{A.8})$$

Moving the first exponent out of the integral gives us:

$$(Y_1 - k_j H_j)^{-\frac{1}{\sigma}} k_j = \gamma H_j^{-\frac{1}{\sigma}} W_j^{1-\frac{1}{\sigma}} \exp \left\{ \rho^2(1 - \frac{1}{\sigma})^2 \frac{\beta_j^2}{2} + \bar{a}_j(1 - \frac{1}{\sigma})\beta_j \right\} \frac{1}{2\pi\rho^2} \int_{-\infty}^{\infty} \exp \left\{ \frac{-(a_j + [\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j])^2}{2\rho^2} \right\} da_j. \quad (\text{A.9})$$

We can now use the fact that $\frac{1}{\sqrt{2\pi\rho^2}} \int_{-\infty}^{\infty} \exp \left\{ \frac{-(a_j + [\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j])^2}{2\rho^2} \right\} da_j$ is the integral of a normal distribution with mean $[\rho^2(1 - \frac{1}{\sigma})\beta_j + \bar{a}_j]$ and variance ρ^2 . The integral from $-\infty$ to ∞ of a normal distribution is always equal to one. This gives us:

$$(Y_1 - k_j H_j)^{-\frac{1}{\sigma}} k_j = \gamma H_j^{-\frac{1}{\sigma}} W_j^{1-\frac{1}{\sigma}} \exp \left\{ \rho^2(1 - \frac{1}{\sigma})^2 \frac{\beta_j^2}{2} + \bar{a}_j(1 - \frac{1}{\sigma})\beta_j \right\}. \quad (\text{A.10})$$

We can now obtain an expression for the optimal human capital investment given that the individual chooses occupation j :

$$H_j^* = \frac{Y_1}{k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta_j})^{1-\sigma} e^{\frac{\rho^2}{2}\beta_j^2(1-\sigma)(1-\frac{1}{\sigma})}}. \quad (\text{A.11})$$

A.2. Comparative statics on H^*

$$\frac{\partial H^*}{\partial Y} = \left(k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta_j})^{1-\sigma} \xi^{(1-\sigma)} \right)^{-1} > 0, \quad (\text{A.12})$$

$$\frac{\partial H^*}{\partial k} = -Y \frac{1 + \sigma \gamma^{-\sigma} k_j^{\sigma-1} (W_j A_j^{\beta j})^{1-\sigma} \xi^{(1-\sigma)}}{\left(k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta j})^{1-\sigma} \xi^{(1-\sigma)}\right)^2} < 0, \quad (\text{A.13})$$

$$\frac{\partial H^*}{\partial W} = -Y \frac{(1-\sigma) \gamma^{-\sigma} k_j^{\sigma} W_j^{-\sigma} A_j^{\beta j(1-\sigma)} \xi^{(1-\sigma)}}{\left(k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta j})^{1-\sigma} \xi^{(1-\sigma)}\right)^2} \begin{cases} > 0 & \text{if } (1 - \frac{1}{\sigma}) > 0 \\ < 0 & \text{if } (1 - \frac{1}{\sigma}) < 0 \end{cases}, \quad (\text{A.14})$$

$$\begin{aligned} \frac{\partial H^*}{\partial \beta} &= -Y \frac{(1-\sigma) \gamma^{-\sigma} k_j^{\sigma} W_j^{1-\sigma} A_j^{\beta j(1-\sigma)} \xi^{(1-\sigma)} (a + \beta \rho^2 (1 - \frac{1}{\sigma}))}{\left(k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta j})^{1-\sigma} \xi^{(1-\sigma)}\right)^2} \quad (\text{A.15}) \\ &> 0 \quad \text{if } \begin{cases} (1 - \frac{1}{\sigma}) < 0, a \text{ small} \\ (1 - \frac{1}{\sigma}) > 0, a \text{ large} \end{cases} \\ &< 0 \quad \text{if } \begin{cases} (1 - \frac{1}{\sigma}) < 0, a \text{ large} \\ (1 - \frac{1}{\sigma}) > 0, a \text{ small} \end{cases} \end{aligned}$$

$$\frac{\partial H^*}{\partial a} = -Y \frac{\beta(1-\sigma) \gamma^{-\sigma} k_j^{\sigma} W_j^{-\sigma} A_j^{\beta j(1-\sigma)} \xi^{(1-\sigma)}}{\left(k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta j})^{1-\sigma} \xi^{(1-\sigma)}\right)^2} \begin{cases} > 0 & \text{if } (1 - \frac{1}{\sigma}) > 0 \\ < 0 & \text{if } (1 - \frac{1}{\sigma}) < 0 \end{cases}, \quad (\text{A.16})$$

$$\frac{\partial H^*}{\partial \rho} = -Y \frac{(\beta^2 \rho (1 - \frac{1}{\sigma}) (1 - \sigma)) \gamma^{-\sigma} k_j^{\sigma} W_j^{-\sigma} A_j^{\beta j(1-\sigma)} \xi^{(1-\sigma)}}{\left(k + \gamma^{-\sigma} k_j^{\sigma} (W_j A_j^{\beta j})^{1-\sigma} \xi^{(1-\sigma)}\right)^2} > 0. \quad (\text{A.17})$$

A.3. Comparative statics on E(U)

$$\frac{\partial E[U]}{\partial Y} = (Y - kH^*)^{-\frac{1}{\sigma}} > 0, \quad (\text{A.18})$$

$$\frac{\partial E[U]}{\partial k} = -(Y - kH^*)^{-\frac{1}{\sigma}} H^* < 0, \quad (\text{A.19})$$

$$\frac{\partial E[U]}{\partial W} = \gamma W_j^{-\frac{1}{\sigma}} \left(H^* A_j^{\beta_j} \xi \right)^{\left(1 - \frac{1}{\sigma}\right)} > 0, \quad (\text{A.20})$$

$$\begin{aligned} \frac{\partial E[U]}{\partial \beta} &= \gamma \left(W_j H^* A_j^{\beta_j} \xi \right)^{\left(1 - \frac{1}{\sigma}\right)} \left(a + \beta \rho^2 \left(1 - \frac{1}{\sigma}\right) \right) \\ &\geq 0 \quad \text{if} \quad \left(1 - \frac{1}{\sigma}\right) < 0 \quad \begin{array}{l} a \text{ very large} \\ a \text{ small} \end{array} \\ &\geq 0 \quad \text{if} \quad \left(1 - \frac{1}{\sigma}\right) > 0 \quad \begin{array}{l} a \text{ large} \\ a \text{ very small} \end{array}, \end{aligned} \quad (\text{A.21})$$

$$\frac{\partial E[U]}{\partial a} = \gamma \left(W_j H^* A_j^{\beta_j} \xi \right)^{\left(1 - \frac{1}{\sigma}\right)} \beta > 0, \quad (\text{A.22})$$

$$\frac{\partial E[U]}{\partial \rho} = \gamma \left(W_j H^* A_j^{\beta_j} \xi \right)^{\left(1 - \frac{1}{\sigma}\right)} \beta^2 \rho \left(1 - \frac{1}{\sigma}\right) \begin{array}{l} > 0 \quad \text{if} \quad \left(1 - \frac{1}{\sigma}\right) > 0 \\ < 0 \quad \text{if} \quad \left(1 - \frac{1}{\sigma}\right) < 0 \end{array}. \quad (\text{A.23})$$

EFI

The Economic Research Institute

Reports since 1994

Published in the language indicated by the title

1998

Andersson, M., On Testing and Forecasting in Fractionally Integrated Time Series Models.

Berg-Suurwee, U., Styrning av kultur- och fritidsförvaltning innan stadsdelsnämndsreformen

Berg-Suurwee, U., Nyckeltal avseende kultur- och fritidsförvaltning innan stadsdelsnämndsreformen.

Bergström, F., Essays on the Political Economy of Industrial Policy.

Bild, M., Valuation of Takeovers.

Gredenhoff, M., Bootstrap Inference in Time Series Econometrics.

Ioannidis, D., I nationens tjänst? Strategisk handling i politisk miljö – en nationell teleoperatörs interorganisatoriska, strategiska utveckling.

Johansson, S., Savings Investment, and Economic Reforms in Developing Countries.

Levin, J., Essays in Company Valuation.

Ljunggren, U., Styrning av grundskolan i Stockholms stad innan stadsdelsnämndsreformen.

Mattsson, S., Från stat till marknad – effekter på nätverksrelationer vid en bolagiseringsreform.

Nyberg, A., Innovation in Distribution Channels – An Evolutionary Approach.

Olsson, P., Studies in Company Valuation.

Reneby, J., Pricing Corporate Securities.

Roszbach, K., Essays on Banking Credit and Interest Rates.

Runsten, M., The Association Between Accounting Information and Stock Prices. Model development and empirical tests based on Swedish Data.

Segendorff, B., Essays on Bargaining and Delegation.

Sjöberg, L., Bagozzi, R., Ingvar, D.H., Will and Economic Behavior.

Studier i kostnadsintäktanalys, red Jennergren, P.

Thorburn, K., Cash Auction Bankruptcy and Corporate Restructuring

Wijkström, F., Different Faces of Civil Society.

Zethraeus, N., Essays on Economic Evaluation in Health Care. Evaluation of Hormone Replacement Therapy and Uncertainty in Economic Evaluations.

1997

- Alexius, A.**, Essays on Exchange Rates, Prices and Interest Rates.
- Andersson, B.**, Essays on the Swedish Electricity Market.
- Berggren, N.**, Essays in Constitutional Economics.
- Ericsson, J.**, Credit Risk in Corporate Securities and Derivatives. Valuation and Optimal Capital Structure Choice.
- Changli He**, Statistical Properties of Garch Processes.
- Charpentier, C.**, Budgeteringens roller, aktörer och effekter. En studie av budgetprocesserna i en offentlig organisation.
- De Geer, H., Silfverberg, G.**, Citizens' Trust and Authorities' Choices, A Report from The Fourth International Conference on Ethics in the Public Service, Stockholm June 15-18, 1994.
- Friberg, R.**, Prices, Profits and Exchange Rates.
- Från optionsprissättning till konkurslagstiftning.**
red. Bergström, C., Björk, T.
- Hagerud, G.E.**, A New Non-Linear GARCH Model.
- Haksar, A.**, Environmental Effects of Economywide Policies: Case Studies of Costa Rica and Sri Lanka.
- Holmgren, M.**, Datorbaserat kontrollrum inom processindustrin; erfarenheter i ett tidsperspektiv.
- Jennergren, P.**, Tutorial on the McKinsey Model for Valuation of Companies.
- Lagerlöf, J.**, Essays on Political Economy, Information, and Welfare.
- Lange, F., Wahlund, R.**, Planerade och oplanerade köp - Konsumenternas planering och köp av dagligvaror.
- Löthgren, M.**, Essays on Efficiency and Productivity; Contributions on Bootstrap, DEA and Stochastic Frontier Models.
- Nilsson, H.E.**, Using Conceptual Data Modelling in Management Accounting: A Case Study.
- Sjöberg, L., Ramsberg, J.**, En analys av en samhällsekonomisk bedömning av ändrade säkerhetsföreskrifter rörande heta arbeten.
- Säfvenblad, P.**, Price Formation in Multi-Asset Securities Markets.
- Sällström, S.**, On the Dynamics of Price Quality.
- Södergren, B.**, På väg mot en horisontell organisation? Erfarenheter från näringslivet av decentralisering och därefter.
- Tambour, M.**, Essays on Performance Measurement in Health Care.
- Thorén, B., Berg-Surwee, U.**, Områdesarbete i Östra Hökarängen - ett försök att studera effekter av decentralisering.
- Zhang Gang.**, Chinese Rural Enterprises Between Plan and Market.
- Åhlström, P.**, Sequences in the Process of Adopting Lean Production.
- Åkesson, G.**, Företagsledning i strategiskt vakuum. Om aktörer och förändringsprocesser.
- Åsbrink, S.**, Nonlinearities and Regime Shifts in Financial Time Series.

1996

Advancing your Business. People and Information Systems in Concert.
red. Lundeberg, M., Sundgren, B.

Att föra verksamheten framåt. Människor och informationssystem i sam-verkan. red. Lundeberg, M., Sundgren, B.

Andersson, P., Concurrence, Transition and Evolution - Perspectives of Industrial Marketing Change Processes.

Andersson, P., The Emergence and Change of Pharmacia Biotech 1959-1995. The Power of the Slow Flow and the Drama of Great Events.

Asplund, M., Essays in Industrial Economics.

Delmar, F., Entrepreneurial Behavior & Business Performance.

Edlund, L., The Marriage Market: How Do You Compare?

Gunnarsson, J., Three Studies of Financial Behavior. Research Report.

Hedborg, A., Studies of Framing, Judgment and Choice.

Holgersson, C., Höök, P., Ledarutveckling för kvinnor - Uppföljning av en satsning på Volvo - Research Report.

Holmberg, C., Stores and Consumers - Two Perspectives on Food Purchasing.

Håkansson, P., Wahlund, R., Varumärken. Från teori till praktik.

Karlsson, A., The Family Business as an Heirloom. Research Report.

Linghag, S., Man är handelsstudent. Research Report.

Molin, J., Essays on Corporate Finance and Governance.

Mägi, A., The French Food Retailing Industry - A Descriptive Study.

Mölleryd, B., Så byggdes en världsindustri - Entreprenörskapets betydelse för svensk mobiltelefoni. Research Report.

Nielsen, S., Omkostningskalkulation for avancerede produktionsomgivelser - en sammenligning af stokastiske og deterministiske omkostningskalkulationsmodeller.

Normark, P., Danielsson, L., Larsson, A., Lundblad, P., Kooperativa nyckeltal. Research Report.

Sandin, R., Heterogeneity in Oligopoly: Theories and Tests.

Sandén-Håkansson, U., Från kampanjmål till mediemix - en studie av samarbete mellan annonsörer, reklambyråer och mediebyråer. Research Report.

Stein, J., Söderlund, M., Framgång i arbetet, strategier för att utföra arbetsuppgifterna, arbetsuppgifternas karaktär och utbildningskvalitet. En empirisk studie av civilekonomer. Research Report.

Strömberg, P., Thorburn, K., An Empirical Investigation of Swedish Corporations in Liquidation Bankruptcy. Research Report.

Söderlund, M., Och ge oss den nöjda kunden. En studie av kundtillfredsställelse och dess orsaker och effekter. Research Report.

Thodenius, B., Användningen av ledningsinformationssystem i Sverige: Lägesbild 1995. Research Report.

Ulfsdotter, U., Internationalisering för expansion eller hemmamarknadsförsvar? De nordiska marknaderna för fruktyoghurt 1982-1994.

- Westelius, A.**, A Study of Patterns of Communication in Management Accounting and Control Projects.
- Wijkström, F.**, Den svenska ideella sektorn och pengarna. Research Report.
- Örtendahl, M.**, Health and Time - A Problem of Discounting.

1995

- Becker, T.**, Essays on Stochastic Fiscal Policy, Public Debt and Private Consumption.
- Blomberg, J.**, Ordning och kaos i projektsamarbete - en social-fenomenologisk upplösning av en organisationsteoretisk paradox.
- Brodin, B., Lundkvist, L., Sjöstrand, S-E., Östman, L.**, Styrelsearbete i koncerner
- Brännström, T.**, Bias Approximation and Reduction in Vector Autoregressive Models. Research Report.
- Ekonomisk politik i omvandling.** red. Jonung, L.
- Gunnarsson, J., Wahlund, R.**, Hushållens finansiella strategier. En explorativ studie.
- Höök, P.**, Chefsutveckling ur könsperspektiv - Mentorskap och nätverk på Vattenfall - Research Report.
- Levin, J., Olsson, P.**, Looking Beyond the Horizon and Other Issues in Company Valuation. Research Report.
- Mägi, A.**, Customer Satisfaction in a Store Performance Framework. Research Report.
- Persson, P-G.**, Modeling the Impact of Sales Promotion on Store Profits.
- Roman, L.**, Institutions in Transition. A Study of Vietnamese Banking.
- Sandberg, J.**, Statistisk metod - dess vetenskapliga hemvist, grundläggande principer och möjligheter inom samhällsvetenskapen. Research Report.
- Sandberg, J.**, How Do We Justify Knowledge Produced by Interpretative Approaches? Research Report.
- Schuster, W.**, Redovisning av konvertibla skuldebrev och konvertibla vinstandelsbevis - klassificering och värdering.
- Söderberg, K.**, Farmartjänsten - Ny Kooperation inom lantbruket. Research Report.
- Söderqvist, T.**, Benefit Estimation in the Case of Nonmarket Goods. Four Essays on Reductions of Health Risks Due to Residential Radon Radiation.
- Thorén, B.**, Användning av information vid ekonomisk styrning - månadsrapporter och andra informationskällor.

1994

- Andersson, H.**, Ett industriföretags omvandling. En studie av Hägglunds förändringsprocess 1922-81 med bas i företagets produkter, relationer och resurser.

Andersson, H., En produkthistoria. (*separat publicerad bilaga till ovanstående*)

Cowan, R., Hultén, S., Escaping Lock-in: The Case of the Electric Vehicle. Research Report.

Dahlfors, G., Jansson, P., Essays in Financial Guarantees and Risky Debt.

Företag och marknader i förändring - dynamik i nätverk, red. Mattsson, L-G., Hultén, S.

Helgesson, C-F., Coordination and Change in Telecommunications. earch Report.

Lundström, T., Wijkström, F., The Swedish Nonprofit Sector. Research Report.

Nessén, M., Essays on Exchange Rates and International Finance.

Niemeyer, J., Essays on Market Microstructure -Empirical Evidence from Some Nordic Exchanges.

Nilsson, K., Rapportering i svenska storföretag 1993. Delrapport 1. Faktiska tider och påverkande faktorer för månatlig resultatrapportering. Research Report.

Nilsson, K., Rapportering i svenska storföretag 1993. Delrapport 2. Rapporteringstider för kvartals/tertialsrapporter. Research Report.

Nordenlöw, L., Entreprenörskap i industriella nätverk. Research Report.

Norén, N-E., Om Flexibilitetspåverkande beslut. Research Report.

Normark, P., Medlemsägda företag. Organisering av strategiska förändringar.

Nyman, K., Studier av inkomstfördelningar med hjälp av mikrosimuleringsmodeller. Research Report.

Thodenius, B., Användningen av ledningsinformationssystem i Sverige: Lägesbild 1993. Research Report.

Sjöholm, G., Redovisningsmått vid bolagisering. Utformning och effekter.

Wijkström, F., Det organiserade ideella arbetet i Sverige. Research Report.

Wirsäll, N-E., Holmlöv, PG., Den nyckfulle Svensson. Reflektioner efter ett seminarium om strategier för handeln.

