Kim Massey Heide[1]
Latest update 27th April 2006.

The declining skill-premium in Norway:
How skill-biased technical change is compatible with a declining wage premium.

Abstract:

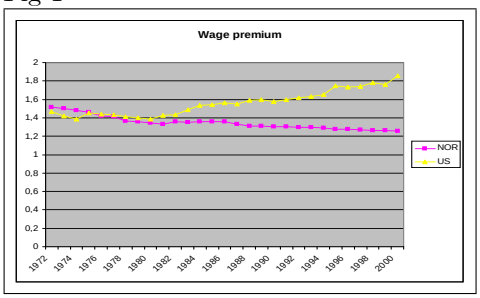
Why is the level of education rising in most western countries but the wage premium following divergent paths? I investigate the case of Norway using the model of capital skill complementarity proposed by Krusell, Ohanian, Rios-Rull and Violante (2000), hereafter KORV, and compare the findings with those in the U.S. I find that skill-biased technical change (SBTC) manifest in capital-skill complementarity (CSC) is quite compatible with a declining wage premium in Norway but a rising one in the U.S.

[1]Preliminary version subject to revision. I am grateful to Kjetil Storesletten, Arvid Raknerud, Hilde Madsen and others for help and encouragement. Does not necessarily represent opinions of affiliated institution. Contact: kmh@ssb.no, +47 21094824, Affiliations: Statistics Norway Research Dept. & The University of Oslo, Economics Dept.

Introduction:

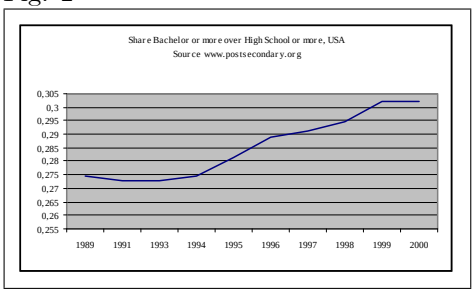
The level of investment in human capital in Norway has been increasing over time. Both the scale and scope of education has augmented the average years of education the population holds. In 1991 27 percent of the Norwegian population 25-34 had finished a university level education. In 2001 this share had risen to 38 percent[2], roughly the same level as the U.S. Though new generations are almost as well educated, the level of education if measured by the share of bachelor or more to high school or more of the *working age population* had reached 38% in the US, whereas it has reached just over 31% in Norway in 2002 (OECD, 2004)[3]. In the U.S. the hourly wage premium of college education over high-school started increasing in the early 1980s and has continued to do so since, whilst in Norway the wage premium associated with College education has been falling during the previous three decades.[4]

Fig 1



This increase in the US wage premium took place at the same time as a rapid growth in the share of the population with tertiary education.

Fig. 2



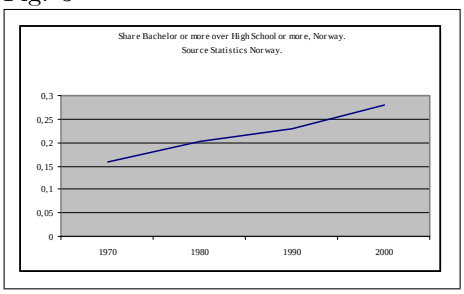
[2] Hægeland (2002a)

[3] In terms of hours the difference is greater as the US is more specialised, with a relatively higher number of hours supplied by higher educated labour. This study will focus primarily on the difference in hourly pay, based on the assumption a higher aggregate income is based on contracting out services and thus overstates the wage premium *per se*. Thus the wage premium will refer to the increase in hourly pay a skilled individual receives over an unskilled individual according to a definition of skilled as having completed 13 years or more of schooling and unskilled as the as having completed 12 years or less. It should be noted that this definition is not a college completion premium. However, individuals cluster primarily in completed secondary school (unskilled), 2 year university level degree and 4 year university degree (both skilled).

[4] US data; KORV style calculated and extendended by Polgreen et. al. 2004.
Norwegian Data; National Accounts, see Appendix One for data description.

In Norway nevertheless, the relative share of College graduates has been rising steadily over the last three decades.

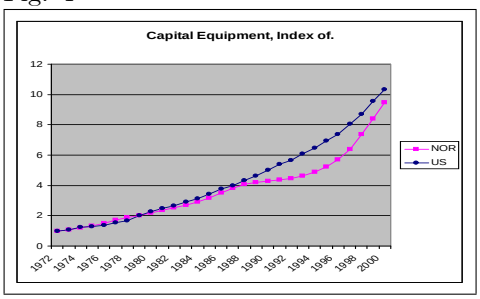
Fig. 3



Assuming agents' preferences are homogenous across countries this raises the question; Why is the level of education rising in most western countries but the wage premium following divergent paths? I will try to shed quantitative light on this issue by taking quantities of students as fixed and trying to explain the price of education (wage premium[5]).

Between 1972 and 2000 the stock of quality adjusted capital equipment rose almost as fast in Norway as in the U.S.

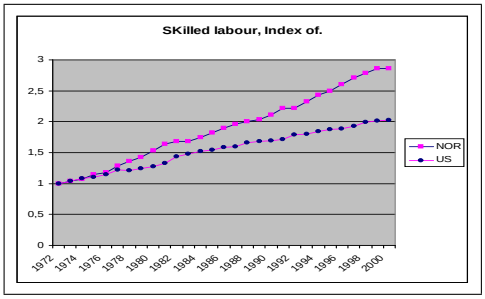
Fig. 4



However, skilled labour rose faster, reaching almost triple the 1972 level, whereas the US saw a doubling.

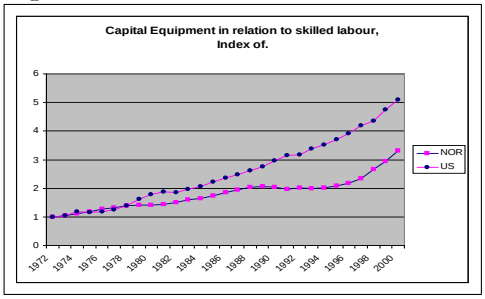
Fig 5

[5] There is an argument to be made that wages are not prices. Heckman, Lochner and Taber (1998) state "[..] wages are not the same as prices [...]" due to "[...] on-the-job-investment[...]". However, this necessitates estimating both job-specific and general on-the-job training. The purpose here is to test the far more parsimonious KORV model and see if a simple theory can be compatible with two such diverse economies as Norway and the US.



The result was that capital equipment in relation to skilled labour rose at a lesser rate. Thus, from casual observation of the data, it would not seem unreasonable to think a theory of skill biased technical change manifest in capital-skill complementarity could be compatible with a the divergence in the skill premium between Norway and the U.S.

Fig. 6



Seeing if the same basic theory that fitted U.S. data can explain the development of the wage premium in Norway is a real test of the theory's validity since it shows that the theory's basic premise, capital-skill complementarity being able to account for most of the development in the wage premium, is quite robust[6]

This paper attempts to answer the question: "Can skill-biased technical change explain the development of wages in Norway?" In section one I will deal with capital skill complementarity. Section two sets out the model, while section three presents the data. Section 4 presents the result and section 5 concludes.

[6] There are major differences in the market for higher education in Norway compared to the US. At the supply side, the direct cost is almost zero. Furthermore, a public institutions gives a combination of grants and loans for living costs, which is neither means tested to parental income, nor linked to academic performance (There used to be a small completion premium for longer courses, above 5 years in length. This was recently (and not in the period the data covers) removed and replaced by a rule where all living cost support is given as loans, but is partially converted to grants if one passes individual courses.). At the Demand side of the labour market a highly centralised wage bargaining structure exists and a very large share (50 percent at end 2003, data from Statistics Norway) of the population with higher education works for the public sector with rigid, primarily seniority based pay scales. It would thus seem that it is not at all obvious apriori that a slightly expanded neo-classical model would be a good representation of the Norwegian market.

Section One: Capital-Skill Complementarity:

In the U.S. the wage premium associated with College education rose substantially from around 1980. At the same time the relative supply of College graduates increased. An explanation in the literature is SBTC. KORV (2000) use a neoclassical growth framework to show that equipment specific technical change fits the U.S. data well in a model with a capital-skill complementarity mechanism. Further it has been shown by Lindquist (2004) that the same model can also explain well the development of the wage premium in the manufacturing sector in Sweden. Jacobs (2003) uses the same formulation to study skill-biased technical change in the Netherlands and the corresponding possibilities for affecting the wage premium. However, this study focuses on the aggregate shifts in relative demand for skilled labour (incidentally finding little effect), without considering the causes of these shifts. Batista (unpublished manuscript) considers the capital-skill complementarity hypothesis in Portugal, using the period 1985 to 1999, a period with several shocks, many linked to its entry into the European Economic Community (EEC) in 1986. The share of higher educated labour in Portugal was low (between 2 and 7 percent of unskilled hours worked in the period under consideration). This is likely to affect the outcome since the very small proportion of higher educated labour is likely to be caused by factors also important in determining the wage premium. However, the results strongly support the capital-skill complementarity mechanism. With the large inflow of physical capital associated with EEC entry the skill premium rose. With the subsequent increase in investment in human capital the skill premium fell. It would seem difficult to generalise from the results of the study as the magnitude of the relative effects is of importance and this is influenced by the level of capital. The conclusion that investment in education of the workforce reduces inequality would seem likely to hold during the stage of development where higher education moves from being the privilege of the top strata of society to being generally available. Moreover, when higher education is relatively generally available evidence from the US suggest that the skill premium can increase with increased supply of higher educated labour (KORV), that is the capital-skill complementarity, or embodied technical change, dominates[7]. In

[7] Given difference in ability, the cost of education is heterogeneous over individuals (Heckman et al. 1998). This suggest that overinvestment in education is just as possible since ability (to learn) is a scarce good. Thus it may be beneficial to compensate those with low ability for not taking education with a negative NPV. Since there is a significant incentive to take (subsidised) education, particularly if its function is partly signalling, reducing barriers to higher education is not necessarily the best way to reduce inequality. It would seem far more likely that equality of opportunity is likely to result in a new stratification based on ability, where the mating of ability rather than financial resources to education will increase potential productivity differences between agents and therefore the potential skill premium. To some extent this is what the US is seeing manifest. Apriori one would assume that as individuals are transferred from the low skill to the high skill category those individuals with the highest level of innate ability in the low skill category will move first, increasing wage differentials.

Norway this seems[8] not to be happening[9] which offers insight by counterexample into why it does happen in the US. In a later paper this topic will be explored further by taking into account heterogenous ability.

Section Two: The Model:

The KORV model is a two sector model of the production side of the economy with four factors. Capital is split into structures (k_{st}) and equipment (k_{et}), labour into skilled (s_t) and unskilled (u_t). One sector produces new capital equipment (x_{et}), the other new capital structures (x_{st}) and consumption goods. There is a common constant returns to scale level of technology (a_t), but a factor specific scalar for equipment (q_t). The relative price of capital equipment is equal to $1/q_t$ Capital depreciation is given by δ_s, δ_e.

The individual production functions are:
$x_{et} = q_t A_t G(k^e_{st}, k^e_{et}, u^e_t, s^e_t)$
$c_t + x_{st} = A_t G(k^c_{st}, k^c_{et}, u^c_t, s^c_t)$

Giving an aggregate function for output:
$y_t = c_t + x_{st} + \frac{x_{et}}{q_t} = A_t G(k_{st}, k_{et}, u_t, s_t)$.
Capital evolves by:
$k_{s,t+1} = (1-\delta_s)k_{st} + x_{st}$
$k_{e,t+1} = (1-\delta_e)k_{st} + x_{et}$
The production function is given by:
$G(k_{st}, k_{et}, u_t, , s_t) = k^\alpha_{st}[\mu u^\sigma_t + (1-\mu)(\lambda k^\rho_{et} + (1-\lambda)s^\rho_t)^{\sigma/\rho}]^{(1-\alpha)/\sigma}$

μ and λ are parameters that govern income shares whilst σ and ρ ($\sigma, \rho < 1$) govern the elasticity of substitution between unskilled labour, capital equipment and skilled labour. The elasticity of substitution between equipment (or skilled labour) and unskilled labour is $1/(1-\sigma)$ while the elasticity of substitution between equipment and skilled labour is $1/(1-\rho)$. Capital skill complementarity requires that $\sigma > \rho$. If either equals zero the nesting is Cobb-Douglas.

Labour is measured in efficiency units, so that $s_t \equiv \psi_{st} h_{st}$ and $u_t \equiv \psi_{ut} h_{ut}$, where h_{it} is the number or hours worked and ψ_{it} is the (unmeasured) quality per hour of type i at date t. This gives a measure (ψ_i) that can be interpreted as human capital or skill specific technology.

[8] There are reasons for believing this may be happening in Norway but not showing up in the data. In Norway the probability of receiving an invalidity benefit has trippled from 1980 to 2000 for both males and females aged 30-40 (Bratberg et al. 2001). The compensating percentage is capped well below the median income implying highest compensation in the most elastic area of the labour supply curve. Around a seventh of the working age population receives this benefit, and thus do not show up in hourly pay statistics. One would expect this to increase average earnings for the lower education category quite markedly.

[9] Acemoglu (2002) explains this in terms of different technology adoption decisions, developing a theory where "labor market institutions creating wage compression in Europe also encourage more investment in technologies increasing the productivity of less-skilled workers".

The Skill premium (π) is expressed as a function of the input ratios. Using that factor prices are equal to marginal products:

$$\pi_t = \frac{(1-\mu)(1-\lambda)}{\mu}[\lambda(\frac{k_{et}}{s_t})^{\rho} + (1-\lambda)]^{(\sigma-\rho)/\rho}(\frac{h_{ut}}{h_{st}})^{1-\sigma}(\frac{\psi_{st}}{\psi_{ut}})^{\sigma}$$

Log-linearising, differentiating and defining the growth rate of x as g_x and rearranging yields:

$$g_{\pi t} \approx (1-\sigma)(g_{h_{ut}} - g_{h_{st}}) + \sigma(g_{\psi_{st}} - g_{\psi_{ut}}) + (\sigma-\rho)\lambda(\frac{k_{et}}{s_t})^{\rho}(g_{k_{et}} - g_{h_{st}} - g_{\psi_{st}})$$

The interpretation of each of these three components is, respectively, relative quantity effects, relative efficiency effects, capital-skill complementarity effects. Thus the model allows for a meaningful analysis of the quantitative causes of divergence in wage growth between skilled and unskilled labour. KORV find that for the U.S., when allowing for capital-skill complementarity, changes in observed inputs alone can account for most of the variations in the skill premium in the 30 years prior to their study (1963 to 1992).

Section Three: Data:

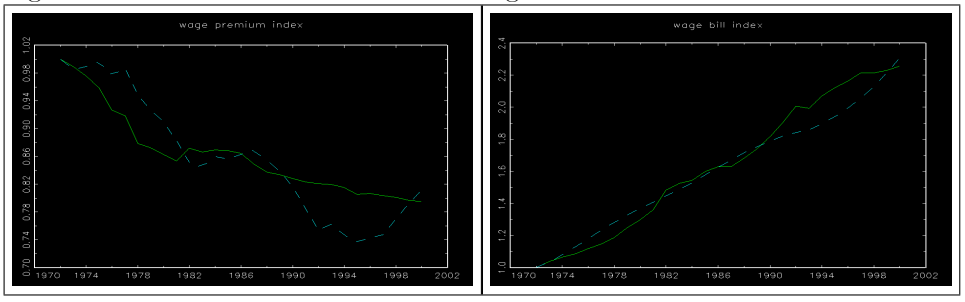
The data used is primarily from the National Accounts, with hourly wages, see appendix one for a description. The data is available from 1972 to 2000.

Parameters are taken from KORV, this implies $1/(1-\sigma) = 1.66$ and $1/(1-\rho) = 0.66$. Appendix one presents the details.

Section 4: Results:

Using the KORV parameterisation results in a path for the wage premium which follows the data quite well. Capital equipment grows rapidly, however skilled labour grows faster, contributing to a decline in the skill premium. The model reproduces the data on the share of wages going to skilled labour reasonably well.

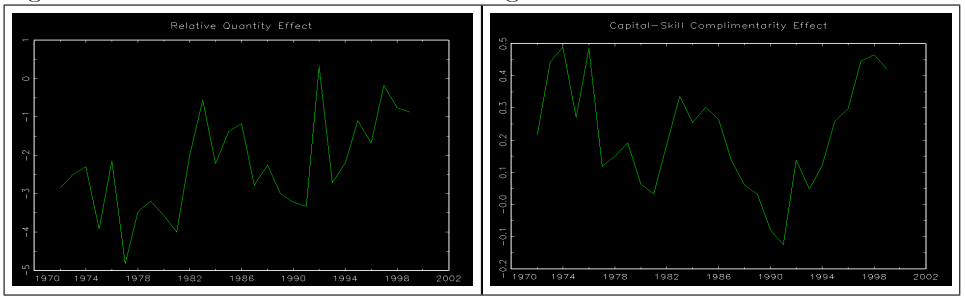
Fig. 7 Fig 8



Decomposing the effect into the relative quantity (RQ) effect and the CSC effect shows that early in the sample period the RQ effect was strong, as higher education was expanded rapidly. The CSC effect initially dampened the very

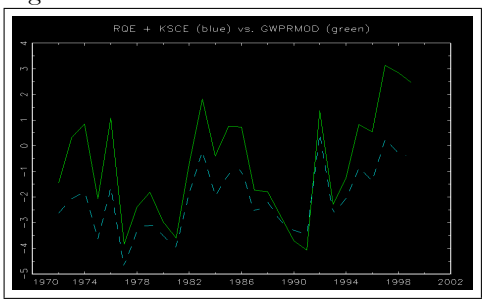
strong downward pressure on skilled wages following. In the 1980s skilled labour expanded less rapidly while the CSC effect counteracted any movement in the skill premium. In the 1990s the skill premium continued its downward trend. The model predicts a fall in the early 1990s, assisted by a reduction in the level of capital equipment per skilled worker and a strong increase towards 2000, again helped by CSC effect, now due to an increase in capital equipment per skilled worker. It should be noted that Norway has tended to follow the Scandinavian Model of Inflation (SMI) with centralised wage bargaining the norm. During the 1970's there was active policy trying to affect wages quite directly. During the 1980's wage setting was fairly decentralised, wheras in the 1990 strong centralisation was introduced again (the policy was known as the 'solidarity alternative'[10]). Thus it is not altogether surprising that during the 1980's the model tracks the data quite well, wheras there is some deviation the earlier and later periods.

Fig. 9 Fig 10



The cumulative result of the CSC and RQ effects is shown below, with the growth in the wage premium.

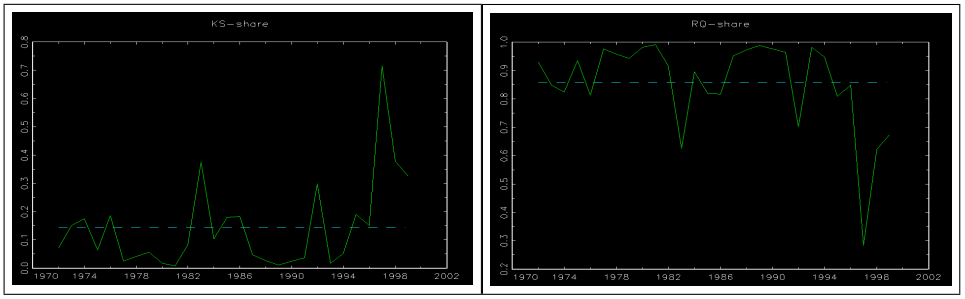
Fig. 11



The contributions of the CSC and RQ to the total (RQ+CSC) effect show how the RQ effect dominates, resulting in the observed reduction in the skill premium. At the end of the sample the CSC effect predicts and upswing in the wage premium.

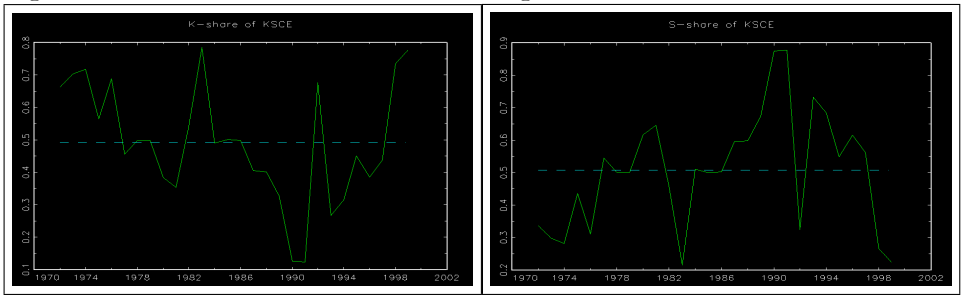
Fig. 12 Fig 13

[10] See NOU 1992:26



Setting the growth rate in skilled labour to zero shows the contribution of the change in capital equipment to the total CSC effect (blue line is average contribution), see fig. 14. In fig 15 the growth of capital equipment is set to zero showing the contribution of skilled labour growth.

Fig. 14 Fig 15



Further, to consider, respectively, the contribution of skilled and unskilled labour the growth rate of the opposite is set to zero and the result shown in relation to the average effect of the labour type.

Fig. 16 Fig 17

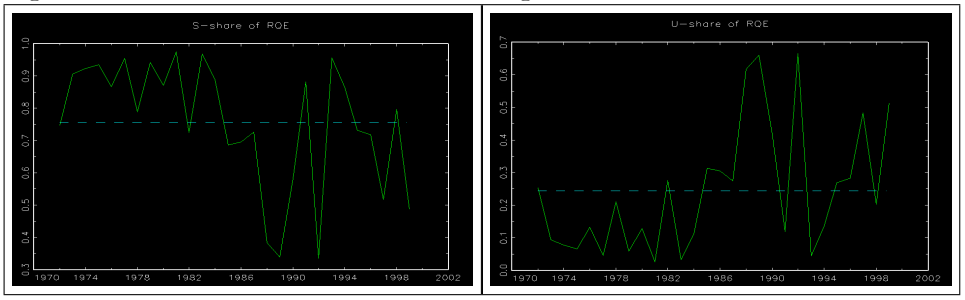
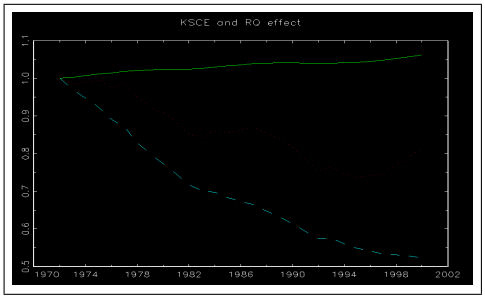


Figure 18 shows the RQ and CSC effect and the resulting model calculated wage premium.

Fig. 18



Considering trends in unmeasured labour quality the model fit does not improve. A reduction of 1% per year in skilled labour quality (fig. 19) reduces the overshooting in the 1970s, but increase the overshooting in the 1990s, while the opposite is the case for a 1% increase (fig. 20). The model does not provide any guidance as to which, if either, would be an improvement.

Fig. 19

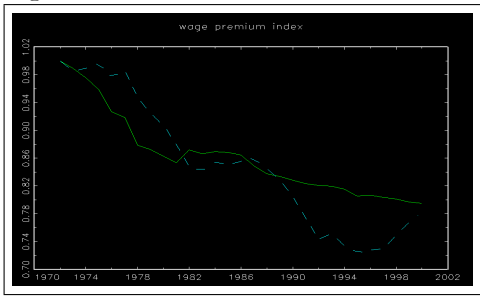
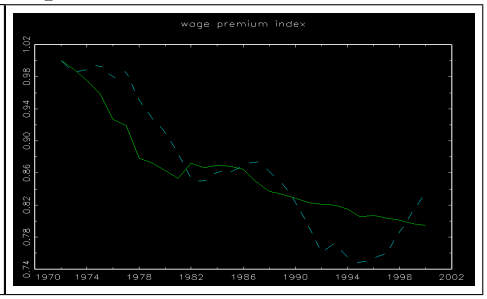


Fig 20



Section 5: Conclusions:

Subsidising education is generally undertaken because of the accepted positive externalities associated with it. In the US this subsidy is lower than in Europe generally and Norway specifically, for tertiary education, see footnote 6. In addition the share of the total amount spent on education allocated to tertiary is just half the U.S. share[11]. KORV argues that "[...] the key to narrowing inequality is better education and training for unskilled workers". The Norwegian experience would support this conclusion, primarily because increased supply of skilled labour reduces the wage premium and thus inequality and this effect has, unlike in the U.S., dominated. A possible reason is that the share of GDP allocated to tertiary education is a better proxy than years of education

[11] Hægeland (2002b) when discussing the premium on younger cohorts irrespective of attributes offers: (translation) "In light of Norwegian education policy this can be an indication of transfer of resources to less able students at lower levels of schooling having manifested itself in higher incomes for these individuals [...]". The magnitude of the diversion of resources is strong. Spending on tertiary education in Norway amounted to 1.28% of GDP in 2001 (total education spending was 6.12%), whereas 2.68% was spent in the US (total education spending 7.22%). Sources: Education spending from the OECD Education database, GDP from Statistics Norway & Bureau of Economic Analysis.

for quality[12]. Why agents would want to continue to invest in (so many years of) human capital with a falling return is another matter. It seems likely that part of the answer lies in the public subsidy to tertiary education, which is larger in Norway, as well as non-pecuniary benefits, such as job satisfaction.

Further work:

This paper is the first of my Ph.D. The second paper considers what was taken as exogenous here; the quantity of students. Using a model with heterogenous skill levels I attempt to analyse what expectations from micro agents would result in the observed increase in human capital investment, and attempt to answer the question: "Why have (Norwegian) high-ability agents continue to increase their investment in Human Capital even though the associated wage premium has been falling?". A better understanding of the incentives facing agents entails a better basis for policy. Again differences in the functioning of the Norwegian economy will provide a good test of the fit of a model developed to analyse U.S. conditions. Taking into account differences in subsidies to higher education this will provide an original and useful test of the model. Norway is small, and in many ways an outlier, but more interesting because of it. A theory that can explain the behaviour of individuals in two such distinct economies as Norway and the U.S. is a much better theory for it.

Literature:

Acemoglu, D. (2002): *Cross-Country Inequality Trends.* NBER Working Paper 8832.

Alstadsæter, A. (2003): *Income Tax, consumption value of education, and the choice of educational type.* Discussion Paper 11/2003. Norwegian School of Economics and Business Administration.

Batista, C. (2002) *Skill Premium in Portugal: Some Evidence on the Capital Skill Complementarity Hypothesis.* Draft, University of Chicago.

Bell, L., R Freeman (2000) *The incentives for hard work: explaining hours worked differences in the US and Germany.* NBER Working Paper 8051.

[12]It may be that capital skill complementarity which determines investment in equipment is most marked in relation to certain kinds of skill. While the share of the working age population with tertiary education is higher in the US than Norway, a situation which remains in 2002 when 38 percent of the U.S. population has completed some tertiary education vs 31 percent in Norway, this, however, masks a marked difference in shorter tertiary education. In the US 9 percentage points of tertiary education (or 31% of the total) is class B, or lower according to OECD definitions, whereas in Norway this share is only 3 percentage points (or 11% of the total). Thus tertiary education of class A (inc. research programmes) is almost identical at 28 and 29 percentage points for respectively Norway and the US. In addition average years of schooling is actually higher in Norway at 13.8 years vs 12.7. (Incidentally the average length of schooling in Norway was the highest in the OECD in 2002). Source: OECD; Education at a Glance 2004: Table A1.1. Educational attainment: adult population (2002) Distribution of the 25-to 64-year-old population, by highest level of education attained

Blundell, R., T. MaCurdy (1998) *Labour Supply: A Review of Alternative Approaches*, Institute for Fiscal Studies Working Paper W98/18.

Bratberg, E. A. E. Risa and K. Vaage (2001): *Sosial utjevning og veksten i uføretrygden.*Tidsskrift for Velferdsforskning, Issue 3, p.169-182.

Epple, D., R. Romano, H. Sieg (2005) *Admission, Tuition and Financial Aid Policies in The Market for Higher Education*, Mimeo, Carnegie Mellon University.

Gottschalk P., T. M. Smeeding (1999) Empirical Evidence on Income inequality in Industrialized Countries, Working Paper No. 154, Luxembourg Income Study.

Heckman, J., L. Lochner and C. Taber (1998): *Explaining rising wage inequality: Explorations with a dynamic general equilibrium model of labour earnings with heterogeneous agents.* NBER Working Paper 6384.

Holmøy, E., K. M. Heide (2005) *Is Norway Immune to Dutch Disease? CGE Estimates of Sustainable Wage Growth and De-industrialisation*, Discussion Paper 413, Statistics Norway.

Hægeland, T. (2002a): *Har det vært et fall i kvaliteten på norsk utdanning?* Økonomiske Analyser, 4/2002.

Hægeland, T. (2002b): *Inntektsulikhet og avkastning på humankapital I Norge 1970-97.* Økonomisk Forum, 6/2002.

Hægeland,T., T.J. Klette and K.G. Salvanes (1999): *Declining returns to education in Norway? Comparing estimates across chorts, sectors and over time.* Scandinavian Journal of Economics, 101, p. 555-576.

Jacobs, B (2003) *The Lost Race between Schooling and Technology.* The Netherlands Bureau for Economic Policy Analysis.

Krusell, P., L.E.Ohanian, J. Rios-Rull, G.L.Violante (2000) *Capital-Skill Complementarity and Inequality. A Macroeconomic Analysis.* Econometrica,5, p. 1029-1053.

Lindquist, M. (2004) *Capital-Skill Complementarity and Inequality in Sweden.* Fourthcoming Scandinavian Journal of Economics.

Manning, A. (2003) *Monopsony in Motion: Imperfect Competition in Labor Markets*, Princeton University Press,

Mariano, R., T.Schuermann and M J.Weeks (Editors) (2000) Simulation-based inference in economometris: methods and applications, Cambridge University Press,

NHO (2005) *Utdanning, Kompetanse og FoU; Læring for arbeidslivet . i arbeidslivet*, Posisjonspapirer, Næringslivets Hovedorganisasjon.

Norges offentlige utredninger (NOU 1992:26) *En nasjonal strategi for økt sysselsetting i 1990-årene.*

OECD (2005) *Employment Outlook, Statistical Annex.*

Olovsson, C. (2004) *Why do Europeans Work so Little.* Seminar paper 727, Institute for International Economic Studies, Stockholm University.

Polgreen, L., P Silos (2004) *Capital-Skill Complementarity and Inequality: A Sensistivity Analysis, Working Paper.* Department of Economics, University of Iowa.

Psacharopolous, G (1979) *On the weak vs. strong version of the screening hypothesis.* Economics Letters, 4, p. 181-185.

Statens lånekasse for utdanning, (2004) *Utvikling i kostnadsnorm og stipend siden 1975-76*, www.lanekassen.no

Appendix One:

Documentation of data collection and aggregation for KORV analysis:

o GDP(Y):

National accounts nominal mainland industries gross domestic product minus residential property services deflated by relevant indicies.

o Share Labour national income(Theta)

initially tried tot wage*tot hours+ payroll tax/mainland gdp (measure one). See below. Found very low, instead used National Accounts labour costs minus labour costs in oil and gas sector minus labour costs in residential property services (measure two). Wages subsequently adjusted to fit with the result. See below.

o Pke/Pks

Relative price capital equipment/structures. See below.

o Hours supplied unskilled (U):

Data from Statistics Norway. Hours inc. overtime excl. hours away. Lunchbreak not included. Own companies: Registered hours excl. hours away.

o Hours supplied skilled (S):

See above.

o Capital Structures(Kst)

National accounts data deflated by relevant indicies. See under. Note that residential property is excluded.

o Capital Equipment(Keq)

Defined as national accounts "Transportmidler" plus "Maskiner og utstyr". Machines and equipment + transport equipment. Note that ships&boats are not included in this category. Series given by investment deflated by quality adjusted price indicies using difference in KORV TORN and NIPA price index 1980 to 1992 for quality adjustment. Problematic finding quality adjustment parameter for Norway. The assumption behind using US data being that equipment is a fully tradable good.

o Wages skilled (Ws)

National accounts wages per hour. Problematic data due to changes in the categories for reporting of quarterly data in the period. Work done to align these by national accounts. Includes cash pay incl. overtime pay, holiday pay, sick pay, maternity leave, military service compensation, payment-in-kind: food, housing, car. Adjusted as in appendix 1 in the KORV paper. Skilled defined as University level I+II. In practice schooling of total length above 13years. (All university education categories). Share of output in data marginally too low.

Slight adjustment in line with factor shares in National Accounts proportionate to share of total employment.

o Wages unskilled (Wu)

All categories up to 12 years schooling. See above. Note unreported category excluded. Historically this is presumed to have overweight only basic schooling, but immigrants with higher education tend to end up there too so uncertain interpretation. Note this category amounts to 3 percent of the total in 2003. Share of output in data marginally too low. Slight adjustment in line with factor shares in National Accounts proportionate to share of total employment.