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Abstract

We extract estimation results on the Mincer earnings function from four earlier studies and add new results from a recent dataset. We analyse differences related to differences in earnings concepts, in sampling frame and differences among studies that cannot be explained. Jointly, the studies show a clear U-shaped development in the rate of return to education from 1962 to 2012, with a bottom in the 1980's. We explain this from Tinbergens's race between suppy and demand (schooling and technology) and suggest this may be a widespread international pattern. Returns to potential experience show no marked time trend.

JEL-codes: I260, J240, J310.

Keywords: returns to education, Mincer earnings equation, race supply and demand.

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1. The Mincer equation

The Mincer earnings equation is a standard summary of the wage structure by education and experience:

$$\ln W = \beta_0 + \beta_1 S + \beta_2 X + \beta_3 X^2 + \varepsilon$$

Ln W is the logarithm of an employee's wage rate per time unit, S is years of schooling, X is years of work experience and ε is a residual for all other variables; some of these other variables may be explicitly specified (e.g. gender or region). The equation has at well defined theoretical basis in the theory of human capital. Under strict conditions, β_1 can be interpreted as the rate of return on investment in schooling: the return on invested foregone wages by going to school rather than going to work. Key conditions are perfect competition in the labour market, stationarity across cohorts, identical aptness among individuals to benefit from schooling (equal "ability"), negligible tuition and other direct cost of schooling, linearity of returns in years of schooling and separabity of log earnings in schooling and experience. β_2 and β_3 measure the returns to continued investment after school, in on-the-job training. Because of easier data availability, X is commonly measured as potential experience: age minus age of graduation from highest level of schooling attended. In standard applications, years of schooling S is measured as the normal, nominal duration of an education. OLS estimates cannot be taken as measures of causal effects, essentially because benefits can only be inferred from individuals who differ in the amount of schooling they have chosen[1]. Without the frame of human capital theory, the equation measures the effect of an extra year of schooling and the average effect of additional experience, from observations on inidividuals that differ in years of schooling and (potential) experience.

In the next two sections we first present the datasets and then the estimation results from the four established studies and from our own new study. Section 4 gives an interpretation of the observed U-shaped time profiles of the Mincer rate of return, section 5 compares the profile to international evidence, section 6 asks the question to what extent other or further explanations than a race between supply and demand are needed, and section 7 discusses the proper econometric interpretation of Mincer returns estimated by OLS. Section 8 concludes.

2. Data

In this paper we present estimation results for The Netherlands from different studies for the period 1962-2012[2]. Unfortunately, not all data have been collected in the same way and we have to face the issue of comparability. We will present published estimates from 4 studies and results from new estimations of our own.

HOT[3], 1962-1989, CBS loonstructuuronderzoeken combined with NPAO and OSA surveys; gross

[1] For discussion and references, see Joop Hartog en Henriette Maassen van den Brink (red), *Human capital, theory and evidence*, Cambridge University Press, 2007. For the host of practical issues in data, variable definitions and specifications, see Harmon, Walker and Westergaard-Nielsen, 2001).

[2] We frequently cite *verbatim* from the source articles, without always specifying the exact location.

[3] HOT: J. Hartog, H. Oosterbeek en C. Teulings, Age, wages and education in the Netherlands, in P. Johnson and K. Zimmermann (eds), *Labour markets in an ageing Europe*, Cambridge University Press, 1993

For the period 1962-1989, data are from 6 samples of 10,000 or more observations, collected from company administrations by CBS (Central Bureau of Statistics, the national statistical agency). In 1962, 1965 and 1972 observations are sampled from male employees working in manufacturing, construction and banking, in 1979, 1985 and 1989 from all full-time working men. Up to 1972, there was a distinction among "employees", with monthly salary, and "labourers", with weekly wage, matching the then internationally common distinction among white-collar and blue-collar workers. The data are available as mean earnings in cross-tables with 5 levels of education and 6 to 10 age groups. .

In addition, for 1982, 1985, 1986 and 1988 HOT present results based on data collected by NPAO and OSA (government subsidised programs for labour market research). The data are from national surveys, each covering some 1200 respondents. Earnings are self-reported, not from administrative sources.

CBS has published separate cross-table data for labourers in 1972; the survey data for 1982 and 1988 allow to distinguish employees and labourers. Availability of these data permits to assess the effect of estimating returns on observations for employees only.

SOH[4]*: OSA, 1986-1996; net*

Estimates for the period 1986-1996 have been made on data from the bi-annual OSA Labour Market Panel. The data for each year cover some 4500 individuals aged 16-64. We present results on net hourly wages, as reported by respondents. Male respondents have a job of 34 hours a week or more, among females, women with part-time jobs are included and the regressions include a dummy for part-time work (less than 35 hours a week).

LO[5]*: IALS 1994, NIPO 1999, gross*

Leuven and Oosterbeek use two different samples, a survey collected in 1999 by NIPO (an opinion research agency) and data from the IALS project in 1994 (International Adult Literacy Survey), both on gross hourly wages for 16-60 year olds. Note that in this case, the data for the two observations of a "time series" are not from the same sampling frame. The samples are rather small.

JW[6]*: Loonstruktuuronderzoeken 1979-2002; gross*

Jacobs and Webbink analyse data from CBS *Loonstructuuronderzoeken* (Wage Structure Surveys) for 1979, 1985, 1989, 1996, 1997 and 2002: gross hourly wages from administrative sources, calculated by dividing gross monthly earnings by hours worked.

GH[7]*: CBS Panel Project, 1999-2012;gross*

[4] SOH: J. Smits, J. Odink en J. Hartog (2000), New results on returns to education in The Netherlands, unpublished note, University of Amsterdam, Department of Economics and Econometrics; results have been published in J.Hartog, J.Odink en J.Smits (1999), Rendement op scholing stabiliseert, *Economisch-Statistische Berichten*, 84 (4215), 13 augustus. 582-584.

[5] LO: E. Leuven en H. Oosterbeek (2000), Rendement van onderwijs stijgt, *Economisch-Statistische Berichten*,85 (4262). 23 juni, 523-524

[6] JW: B. Jacobs en D. Webbink (2006), Rendement onderwijs blijft stijgen, *Economisch-Statistische Berichten*, 91 (4492), 25 augustus, 406-407; we are grateful to Dinand Webbink for supplying is with his estimation results.

[7] GH refers to our own estmates. Earlier estimations on the CBS panel project data were made by D. Webbink, S. Gerritsen and M. van der Steeg, Financiële opbrengsten onderwijs verder omhoog, *ESB* 98 (4651). 11 januari 2013. They used annual rather than hourly wages, leading to rates of return also determined by hours worked. Moreover, years of education was incorrectly defined: the year of highest education level attained was not not measured in the same year as wages were observed. Wiljan van den Berge (CPB) kindly provided the data.

We present newly estimated returns covering 1999-2012 on data from the CBS Labour Market Panel Project. We do not use panel observations, but a match of data in the EBB (*Enquete Beroepsbevolking*, Labour Force survey) and data in the SSB (*Sociaal Statistisch Bestand*[8], Social Statistical Datasurce). Earnings are fiscal earnings, taken from the income tax returns and hours worked have been obtained from EBB. Fiscal earnings are defined as *Bruto Loon Sociale Verzekeringen* (Gross Earnings Social Security, BLSV). Earnings have been divided by days worked as applied for Social Security purposes (*SV-dagen*) and then divided by daily hours, to arrive at gross hourly wages. Respondents are 16-64 years old, the annual number of observations is between 25 and 30 thousand for men, and between 20 and 25 thousand for women.

3. Results

3.1 Effects of different datasources

Estimates of rates of return on data from different sources, with different definitions and different sampling frames, cannot be combined at face value in a single time series. Hence, we will first try to assess effects of these differences. One effect has already been assessed by the original authors themselves. As noted above, the earliest estimates can be corrected fort he restriction to employees only. By estimating the Mincer equation on data for employees only and for all workers, from the same data source in the same year, HOT conclude that estimates on employees only underestimate returns by 2 percentage points. Experience profiles are not systematically under- or overestimated.

In Table 1 we present estimation results from different data source in the same year. We also estimated several specifications on the data set used by Webbink, Gerritsen and Van der Steeg (see footnote 7); we do not present these results, but they have been taken into account in our conclusions.

Age restrictions on the sample have the same effect in all estimations: excluding respondents aged 15-25 reduces estimated rates of return. The exclusion eliminates in particular early working years of the low educated, when their earnings increase rapidly. Excluding their low earnings years reduces the gap with the higher educated, thus depressing the rate of return. The effect of exclusion is larger for women than for men.

Estimation on net wages generates lower rates of return than estimates on gross wages. This is plausible from progressive taxation. Yet, caution is warranted as all comparisons between net and gross are based on self-reported data and not on administrative data. Peculiarities of survey data may also play a role.

Comparing results from OSA data and CBS Wage Structure Survey data, both for 1996, both on gross hourly wages, exposes a gap in estimated returns of 1.4 points for men and 0.6 points for women. This may be due to all kinds of systematic differences in sampling, but it might also simply be due to random sampling variation. Without further research we have no way to tell them apart.

With our CBS Panel Project data 1999-2012 we have made three estimates, both for men and for women: no conditions on hours worked, 35 hours a week or more, or all hours but with a dummy for full-time (35 hours or more). Among men, estimation with a full-time dummy has no effect on the

[8] For details on the data, see CBS Centrum voor Beleidsstatistiek, Documentatierapport Arbeidsmarktpanel 1999-2009V1, 30 maart 2012.

estimated return to years in school, estimation for full-time workers only increases the schooling coefficient by 0.005 to 0.006, ie half a percent point. Among women, including a full-time dummy raises the returns by about one percentage point. Estimation on full-time workers only leads to higher returns: a difference that gradually increases from 2 to 3 percentage points. Thus, full-time and part-time workers will not always enjoy identical rates of returns, but intertemporal comparisons are influenced only slightly for women and not at all for men. Among women, the difference among estimates without sample constraints on weekly hours and a sample with weekly hours above 34 increases by just more than half a percentage point between 1999 and 2012. We have chosen to present our results on CBS panel project data from estimation on the sample without restriction on weekly hours worked.

The Mincer model distinguishes investment in formal schooling and in on-the-job training. To get a handle on changes in the experience profiles of earnings, we use the estimates to calculate earnings growth over the first 10 years: $10\beta_2 + 100\beta_3$. Results are presented in Table 3.

Restricting the sample to workers over 25 years of age flattens estimated profiles, which comes as no surprise. The effect is visible in the OSA data 1982 and 1988 as analysed in the HOT study. It is also visible from the LS data for 1979, 1985 and 1989, but here, the comparison is based on different studies (HOT and JW). The profiles are also flatter for net earnings as compared to gross earnings (OSA 1982, 1988 and 1996), which again, given income tax rate progression, comes as no surprise, but the effect is mostly modest. Remarkably, profiles for women are mostly flatter for women than for men before 1999, and mostly steeper after 1999 (in the GH study). This may be a composition effect on hours worked, as in the GH study women's profiles are flatter than men's if only full-time workers are compared. The profiles estimated by JW are remarkably steeper than in other studies, but this is due to specification: JW estimate on age rather than potential experience. Smits, Odink and Hartog (2001, Table 10.7 and Table 10.8)[9] estimate on age and on potential experience (age minus schooling years minus 6) on the same data set (OSA 1996) and find much higher growth rate on age than on potential experience. For men, the linear terms are 0.081 versus 0.052, for women 0.078 versus 0.041.

3.2 Indications for a time series

Table 2 and Figure 1 show the development of estimated Mincer returns since 1962. In the graph, we only connect estimates that emanate from a single study. For men, the composition of fragments merges into a clear pattern: an asymmetric tulip, starting with a decrease since the early 1960's towards a low in the early 1980's, followed by recovery, after 2007 turnign into a mild decline. The swings are large. Just considering comparable data points, the initial decrease, from over 12% (when we add the correction for considering employees only) to some 7% is quite substantial, and the recovery during the 1990's, from 5% to 7.5% is also strong. For women, with fewer data points, the pattern is not at variance with the U-shape observed for men, and the changes are also substantial. Both for men and for women, the increase from 1999 to the peak in the next decade is some one and a half percentage point. For both there is a decline during the most recent years.

Just as for the returns to schooling we have graphed (in Figure 2) the ten-year profile slopes, connecting only the points that emanate from a single study. There are no unequivocal indications of trend in the profile slopes. Estimates differ among studies, but no single study has a clear trend, and the fragments do not merge into a single direction. At best, there is a very mild indication of a decling slope for women after 2000.

[9] J. Smits, J. Odink and J. Hartog (2001), The Netherlands, in C. Harmon, I Walker and N. Westergaard-Nielsen (eds), *Education and earnings in Europe*, Cheltenham UK: Edward Elgar

4. A simple supply and demand interpretation

The primary goal of this paper has been to document the development of the Mincer rate of return over half a century. But once the data are there, the temptation is irresistable to reflect on an interpretation. We will do so by simply checking whether the Tinbergen view of a race between supply and demand, i.e. between education and technology (Tinbergen, 1975. Chapter 6)[10], can fit the data. The feature we focus on is the U shaped development of returns: a decline followed by an increase. Returns will fall when the relative supply of higher educated labour increases faster than the relative demand is pushed up by increased knowledge intensity of production. In the declining stage, supply must have won, in the increasing stage demand must have won.

As Figure 3 shows, the share of higher educated men and women in the labour force has continuously increased since 1960[11]. It is less straightforward to measure demand for higher educated labour. We started by contructing an index of labour demand based on sectoral composition of employment. We calculated how many higher educated workers would have been hired if demand for higher education within each industry would have been been constant, while the employment share of industries was allowed to follow its observed actual course. Hence, the index measures how demand for higher educated labour increases if employment shifts towards industries with high intensity of higher educated labour[12]. As Figure 3 shows, this cannot explain the upward movement of the rate of return. The shift towards high education industries only starts after 1970 (so, during the 1960's supply growth may have outpaced demand growth) but it tapers off after the early 1980's, when rates of return recover and supply continues to grow. To focus on technological development, we have looked for an index of ICT development. Changes in information and communication technology are generally recognised as the key drivers of structural changes in labour demand. Figure 3 also graphs the index of the number of computer service and information technology agencies[13]. Such firms barely existed during the 1960's and 1970's, but their number exploded after the mid-1990's. This suggests that it is not a shift towards knowledge-intensive industries but a shift towards knowledge-intensive production across the board that explains why a shifting supply curve has been overtaken by an even faster shifting demand curve. The interpretation of an economy-wide increase in knowledge intensity triggered by economy-wide application of new ICT technology matches simple day-to-day observations as well as results in the international literature. It is also in line with results on polarisation in the Dutch labour market as reported by Smits and De Vries (2015)[14]. They find that between 1996 and 2011, polarisation has increased in the sense that the share of low-pay jobs and the share of high-pay jobs have both increased while the share of middle-pay jobs has decreased. The interpretation is that computerisation can take over cognitive routine jobs in the middle segment. Low-pay jobs, often involving non-cognitive manual routine jobs (like personal services) and high pay jobs, involving cognitive non-routine jobs are less easily substituted by computerisation. The polarisation is not due to a shift of employment among four main industrial sectors (agriculture, manufacturing, commercial services and non-commercial serviceses), but operates within each sector. Unfortunately, developments before 1996 have not been measured.

5. International comparison

[10] J. Tinbergen (1975), *Income distribution*, Amsterdam: North Holland
[11] Bron: HOT (1960-1990); CBS Statline (2001, 2010).
[12] Bron: CBS Statline, Werkzame Beroepsbevolking; vergrijzing per bedrijfstak SBI 2008 (dd 17 maart 2014) en Statistisch Zakboek 1964.
[13] Bron: CBS Statline, Bedrijven naar activiteit SBI 93, K 72
[14] W. Smits and J. de Vries (2105), Toenemende polarisatie op de Nederlandse arbeidsmarkt, *Economisch-Statistische Berichten* 100 (4701, January 8, 24-25

Montenegro and Patrinos (2014) estimated rates of return for 139 countries using 819 household surveys standardised for maximum comparability. The international annual mean shows a gradual decline from the early 1980's to around 2000 and stabilisation since then. However, it is hard to tell how important composition effects are, as the means have not been calculated for a constant set of countries[15].

Heckman, Lochner and Todd (2005) present estimates of the same standard Mincer earnings function as we use, on U.S. Census data spanning the years 1940-1990. For white men, the return to education is remarkably constant across five decades: 12.5, 11, 11, 12, 10 and 13 percent. Still, the last three values, relating to 1970, 1980 and 1990, indicate a U-shaped pattern as observed for The Netherlands and the increase between 1980 and 1990, by 30%, is substantial. For black men, the estimated return increases monotonically, from 9 to 15 percent.

Harmon, Walker and Westergaard-Nielsen (2001, p 16) classify results from more than 1000 studies (!) on Europe and the United States. Their graph shows a similar U- shaped pattern as we report here: a marked decline from the 1960's to the 1970's, a further decline to the 1980's and then recovery in the 1990's.

6. Further explanations

While the supply and demand framework is an obvious start for an economic analysis of changes in the structure of wages, it is equally obvious that we should not be blind to its limitations. Of course, there is a long list of factors that may explain changes in the rate of return to education. However, we have a specific focus on a broad feature of the developments, the U-shaped pattern observed over 5 decades. International evidence seems to confirm that this is a global development and this calls for considering factors that operate worldwide. The simple supply and demand framework seems to match this global development quite well. Growing participation in higher education is a world wide development, interestingly enough precisely in the period we cover. As Shofer and Meyer (2005, p 3)[16] note: :"Participation in higher education has been growing at high rates in virtually every country in the world…..The bulk of the growth occurred after 1960, in just the last four decades." Similarly, the ICT revolution is a global phenomenon. It would be a broad and bold step to suggest that the race between supply and demand, or education and technology, has developed at the same page everywhere. Acemoglu and Autor (2012)[17], in their review of Goldin and Katz's book that squarely adopts the Tinbergen race as their key frame of analysis, agree that that the model does a good job in explaining the development of the college/high school wage premium during the twentieth century. In the US, the increased college premium in recent decades is not ascribed to speeding up of technological develepment, but of slowing down of the growth in college participation. But the key implication is that Tinbergen's race model is a very fruitful approach.

A little reflection suggests that other, specific Dutch potential explanations probably will not carry much weight in undermining our interpretation of the observed time profile. One might think that the business cycle has some influence: the bottom of the U-shape coincides with high unemployment and the modest decline in rates of return in recent years may be related to the recession that developed after 2008. In fact however, the relationship between rate of return and the business cycle is poorly

[15] Inspection of time series for separate countries shows a variety of patterns and certainly no dominant U-shape. But for several countries from EUROSTAT which enter the sample at the end of the period (around 2004), they usually have low returns. This private communication from Harry Patrinos is gratefully acknowledged.

[16] E. Shofer and J. Meyer (2011), The World-Wide Expansion of Higher Education, Stanford Univerity, CDDRL Working 0Papers no 32

[17] D. Acemoglu and D. Autor (2012), What Does Human Capital Do? A Review of Goldin and Katz's The Race between Education and Technology, *Journal of Economic Literature*, 50(2), 426-63.

known[18]. Labour market institutions may have an impact on the wage structure as the relative bargaining power of educational groups may shift over time. However, there have not been significant changes in the system of wage bargaining; union membership rates have fluctuated, but coverage by collective bargaining has been fairly constant. Socio-economic policies may have some effect, as social protection at the bottom (minimum wages, unemployment and disability entitlements and benefits) has weakened after the 1980s[19]: less policy support for the lower wages may increase the rate of return. The schooling system has been restructured, with softening the rigid selection of pupils right after grade school but this was precisely motivated by a desire to facilitate more participation in advanced education: it would merely help to explain the increased supply of higher educated labour. While each of these factors may have an impact on the wage structure by education, whether compressing or elongating, it is unclear a priori how their interaction would precisely generate the observed U-shaped profile of returns.

A deeper analysis would certainly be interesting. Shifting demand curves can be related to changes in the nature of job tasks and in job requirements, adding the dynamic perspective to an analysis as in Hartog (1980)[20], in the vein of Autor, Levy and Murnane (2003)[21]. The notion of shifting supply curves can be backed up by a more detailed analysis of a changing differentiaton of the labour force by abilities, skills and personality, Horizontal differentiaton of job requirements and types of education can also enrich the picture. It would be interesting, for example, to trace the effects of technological change and distinguish primary effects from spill-overs to jbs with less scope for productivity increase (like teaching or live entertainment). But these would all be additional analyses rather than alternative explanations. Essentially, the race between shifting supply and demand curves seems an excellent starting point for understanding the U – shaped time profiles of the Mincerian rate of return to education.

7. Can we trust Mincer rates of return?

In a much more extensive and profound analysis than ours of 50 years of Mincer equations for men in the US, Heckman, Lochner and Todd (2005)[22] quantify limitations of Mincer estimates of the rate of return. Statistical tests show that separability of schooling and experience does not hold: profiles differ by education. Calculations of internal rates of return from estimated earnings functions allowing for these interactions and giving up linearity in the schooling effect show large variations in the rates of return to sequential steps in schooling careers, thus rejecting the imposition of constant marginal returns to years of schooling. Not surprisingly, a single schooling coefficient can hide large variation. In 1940, the single Mincer coefficient for white men is 12.5 percent, while estimating marginal returns for sequential steps of two additional schooling years each, from 6 to 16, leads to the series 12, 14, 24, 8 and 15 percent; in 1990, the linear Mincer return is 13 percent, while the step series is 19, 19, 47, 8 and 12 percent. There are also large and variable gaps among internal rates of return calculated from estimated Mincer equations or from observed mean earning by schooling and experience cells. The effect of including tuition cost and taxes on men's return to schooling is actually rather mild; the largest reductions relate to the highest level of education, in particular for black men.

[18] M. Corliss, P. Lewis and A. Daly (2013), The Rate of Return to Higher Education Over the Business Cycle, *Australian Journal of Labour Economics*, 16 (2), 219 – 236.
[19] ESB Dossier Activerende Sociale Zekerheid, *Economisch-Statistische Berichten*, 2015 (47065), 26 maart
[20] J. Hartog (1980), Earnings and capability requirements, *Review of Economics and Statistics*, LXII (2), pp. 230-240
[21] D. Autor, F. Levy and R. Murnane (2003), The Skill Content of Recent Technological Change: An Empirical Exploration, *The Quarterly Journal of Economics*, 118(4), 1279-1333.
[22] J.Heckman, L. Lochner and P. Todd (2005), Earnings Functions, Rates of Return and Treatment Effects: The Mincer Equation and Beyond, IZA Discussion Paper 1700

As noted, OLS Mincer estimates cannot be taken at face value as measuring causal effects. But in 1999, David Card concluded from a survey of IV studies that "the *average* (or average marginal) return to education in a given population is not much below the estimate that emerges from a simple cross-section regression of earnings on education. The "best avaliable"evidence …..suggest a small upward bias (on the order of 10%) in the simple OLS estimates" (Card, 1999, p 1855)[23]. Card suggests that the ability bias is modest and emphasises that IV corrections are sensitive to the type of instruments used. Rates of return to education are heterogeneous, and through their choice of instruments, IV corrections target different segments of the distribution. Heckman, Lochner and Todd (2005) are very critical on the value of IV estimates, arguing that instruments are mostly very weak.

For our purpose, the key question is to what extent endogeneity bias is constant over time. As far as we know, there is only one study that compares a time series of OLS estimates with a time series of IV estimates using the same instruments in each year. Sousa, Portega and Sa (2015) [24] use quarter of birth as instrument to estimate returns to schooling in Portugal for each year from 1986 to 2009. Not only the level differs among OLS and IV, but trends also differ. Taber (2001)[25] analyses the rise in the college premium in the US from early to late 1980s' and concludes from IV, Heckman two-step and structural dynamic programming modelling that the causal effect of college attendence has not changed but that returns to unobserved ability have increased (the returns to observed ability, i.e. AFQT score, has not changed); estimation (and interpretation) of the dynamic programming model is marred by a problem of multiple optima. Taber's conclusion fits in with the the dominant view of ythe time, but Cawley, Heckman and Vytlacil (1998)[26] do not agree that the increase in the college premium in the US would be due to an increase in the return to ability. They show that the result is not robust and point to two serious identification problems: the effects of time and age cannot be disentangled, and strong sorting of education by ability leaves most education-ability combinations unobserved. They reject the linear models that have been applied and conclude from their own non-parametric estimates that in the mid-80's the college premium has increased for young white males of high ability, but that little can be said for other ability groups.

8. Conclusion

After assessing comparability of a number of studies on the Mincer earnings function in the Netherlands, we can confidently draw two clear conclusions, both for men and for women: over a period of five decades since 1960, the rate of return to education has followed a U shaped pattern with bottom in the mid-1980's, while the slopes of earnings-experience profiles have not changed. The U-shape can be explained with Tinbergen's race between supply and demand: initially the growth of participation in higher education outpaced the growth in demand, while later the ICT revolution pushed out the demand curve faster than the supply curve. This history is similar to international developments.

In spite of its elegant theoretical underpinning, we should not forget that essentially, the Mincer rate of return is a convenient summary statistic of the wage structure by level of education. Log-linearity in

[23] D. Card (1999), The causal effect of education on earnings, in O. Ashenfelter and D. Card, *Handbook of Labor Economics*, volume 3A, Amsterdam: North-Holland

[24] S. Sousa, M. Portela and C. Sa (2015), Characterization of returns to education in Portugal: 1986-2009, Working Paper Catolica Lisbon School of Economics and Business

[25] C. Taber (2001), The Rising College Premium in the Eighties: Return to College or Return to Unobserved Ability? , *The Review of Economic Studies*, 68 (3), 665-691

[26] J. Cawley, J. Heckman and E. Vytlacil (1998), Cognitive ability and the rising return to education, NBER Working Paper 6388

years of schooling is a simplification that hides miuch variation. On changes in the causal effect of education on wages we cannot draw firm conclusions

Data Appendix

1. Supply: Share of tertiary educated in the labour force

	1960	1975	1979	1990	2001	2010
Male	4.0	10.8	13.6	20.0	25.5	33.2
Female	1.0	9.1	11.9	19.8	33.2	35.0

Source: HOT (1960-1990); CBS Statline (2001, 2010)

2. Supply: Aggregate share of tertiary educated if shares within industries were constant

Share of higher educated in the labour force if the share of higher educated within industries is held constant at the level in 2001, and employment across industries shifts over time as observed

1960	1971	1975	1979	1983	1987	1991	1995	1999	2003	2007	2011	2012
18.20	18.69	21.29	22.11	23.75	24.25	24.40	24.97	25.26	26.21	26.66	27.09	27.02

Source 1971-2012
Share higher educated in labour force by industry 2001: CBS Statline, Werkzame Beroepsbevolking; vergrijzing per bedrijfstak SBI 2008 (dd 17 maart 2014), Totaal M/V, 15 +, totaal herkomstgroepering, totaal werkzame beroepsbevolking

Share labour force by industry: 1971-2012: idem, idem, SBI 93

Share labour force by industry 1960: Statistisch Zakboek 1964, H74, p 40
Added: werknemers Gemeente (H78, p 43), Rijk (H77, p 44) voor Sector Overheid, afgezonderd van "Overige dienstverlening"; Restant "Overige dienstverlening" samengevoegd met "Huiselijke diensten".

Share higher educated added up to Aggregate 1960, weight of subgroups 1971 :
Handel, Bank Verzekering = G+J
Overig= H+K+M+N+O

Datasources: CBS statline

Labour force by industry: Werkzame beroepsbevolking; vergrijzing per bedrijfstak SBI '93; verslagperiode 1971-2013; 14 maart 2014

Share higher educated: Werkzame beroepsbevolking; vergrijzing per bedrijfstak SBI 2008; 14 maart 2014

3. Demand: ICT firms

Copied from CBS Statline:

72 Computerservice- en informatietechnologiebureaus e.d.

Onderwerpen	**Bedrijven naar activiteit SBI'93**
	K Verhuur
	72 Computerservice, informatietechnol.
Perioden	*Absoluut*
1983	3 830
1984	3 880
1985	4 180
1986	4 100
1987	4 105
1988	4 330
1989	4 725
1990	5 060
1991	5 540
1992	5 970
1993	6 390
1994	6 925
1995	6 885
1996	7 680
1997	8 965
1998	10 180
1999	11 835
2000	14 020
2001	16 770
2002	17 560
2003	17 790
2004	18 495
2005	17 630
2006	21 000

Table 1. Mincer rates of return: effects of differences in data surces

			HOT		SOH		JW		GH	
			m	**m**	**m**	**v**	**m**	**v**	**m**	**v**
1979	LS	gh25+	8.9							
1979	LS	gh					6.4	6.0		
1982	OSA	gh25+		7.3						
1982	OSA	gh		7.8						
1982	OSA	nh		7.4						
1985	LS	gh25+	7.2							
1985	LS	gh					5.2	5.0		
1985	OSA	nh		5.0						
1988	OSA	gh25+		5.9						
1988	OSA	gh		6.1						
1988	OSA	nh		5.5	6.1	6.0				
1989	LS	gh25+	7.3							
1989	LS	gh					5.0	4.5		
1996	OSA	nh			6.3	5.1				
1996	OSA	gh			7.5	5.6				
1996	OSA	ny			6.1	6.8				
1996	OSA	gy			7.3	7.8				
1996	LS	gh					6.1	6.2		
2002	CBSp	gh							8.0	7.2
2002	LS	gh					7.5	7.5		

g=gross, n=net; h=hourly wage, y=annual wage ; 25+=25 years and older; m=men, v=women

LS CBS Loonstruktuuronderzoek (Wage structure Survey)
CBSp CBS Panel Project

Table 2. Mincer rates of return: time series

			HOT		SOH		JW		GH		LO	
			m	m	m	v	m	v	m	v	m	v
1962	LS	ghw25+	11.0									
1965	LS	ghw25+	10.2									
1972	LS	ghw25+	9.3									
1979	LS	gh25+	8.9									
1979	LS	gh					6.4	6.0				
1982	OSA	gh25+		7.3								
1982	OSA	gh		7.8								
1982	OSA	nh		7.4								
1985	LS	gh25+	7.2									
1985	LS	gh					5.2	5.0				
1985	OSA	nh		5.0								
1986	OSA	nh		4.8	5.8	6.2						
1988	OSA	gh25+		5.9								
1988	OSA	gh		6.1								
1988	OSA	nh		5.5	6.1	6.0						
1989	LS	gh25+	7.3									
1989	LS	gh					5.0	4.5				
1990	OSA	nh			5.4	6.0						
1992	OSA	nh			5.6	5.3						
1994	OSA	nh			6.3	5.7						
1994	IALS	gh									5.7	5.7
1996	OSA	nh			6.3	5.1						
1996	OSA	gh			7.5	5.6						
1996	OSA	ny			6.1	6.8						
1996	OSA	gy			7.3	7.8						
1996	LS	gh					6.1	6.2				
1997	LS	gh					6.6	6.6				
1999	NIPO	gh									8.0	9.0
1999	CBSp	gh							7.2	6.5		
2000	CBSp	gh							7.4	6.5		
2001	CBSp	gh							7.9	6.9		
2002	CBSp	gh							8.0	7.2		
2002	LS	gh					7.5	7.5				

2003	CBSp	gh	8.1	7.0
2004	CBSp	gh	8.0	6.6
2005	CBSp	gh	8.3	7.0
2006	CBSp	gh	8.4	7.2
2007	CBSp	gh	8.9	7.3
2008	CBSp	gh	8.8	7.6
2009	CBSp	gh	8.9	7.6
2010	CBSp	gh	8.8	7.9
2011	CBSp	gh	8.7	7.3
2012	CBSp	gh	8.4	7.2

g=gross, n=net; h=hourly wage, y=annual wage; w=employees (white collar); 25+=25 yeas and older; m=male, v=female

LS CBS Loonstruktuuronderzoek
CBSp CBS Panel Project
NIPO, IALS see text on LO

Table 3. Wage growth over the first 10 years ($10\beta_2 + 100\beta_3$).

			HOT		SOH		JW		GH	
			m	**m**	**m**	**v**	**m**	**v**	**m**	**v**
1962	LS	ghw25+	.513							
1965	LS	ghw25+	.490							
1972	LS	ghw25+	.480							
1979	LS	gh25+	.326							
1979	LS	gh					.636	.593		
1982	OSA	gh25+		.299						
1982	OSA	gh		.430						
1982	OSA	nh		.350						
1985	LS	gh25+	.328							
1985	LS	gh					.707	.744		
1985	OSA	nh		.340						
1986	OSA	nh		.280	.393	.367				
1988	OSA	gh25+		.300						
1988	OSA	gh		,370						
1988	OSA	nh		.350	.421	.372				
1989	LS	gh25+	.344							
1989	LS	gh					.727	.731		
1990	OSA	nh			.449	.341				
1992	OSA	nh			.397	.282				
1994	OSA	nh			.448	.313				
1995										
1996	OSA	nh			.443	.344				
1996	OSA	gh			.488	.382				
1996	OSA	ny			.433	.184				
1996	OSA	gy			.477	.226				
1996	LS	gh					.731	.709		
1997	LS	gh					.789	.736		
1999	CBSp	gh							.237	.269
2000	CBSp	gh							.234	.251
2001	CBSp	gh							.220	.255
2002	CBSp	gh							.200	.240
2002	LS	gh					.723	.596		
2003	CBSp	gh							.205	.243
2004	CBSp	gh							.207	.243

2005	CBSp	gh	.214	.239
2006	CBSp	gh	.207	.243
2007	CBSp	gh	.207	.245
2008	CBSp	gh	.215	.222
2009	CBSp	gh	.196	.198
2010	CBSp	gh	.193	.199
2011	CBSp	gh	.212	.189
2012	CBSp	gh	.188	.206

g=gross, n=net;h=hourly, y=annual; w=white collar only; 25+=25 and older

LS CBS Loonstruktuuronderzoek
CBSp CBS Panel Project

Figure 1a: Mincer returns to schooling: men

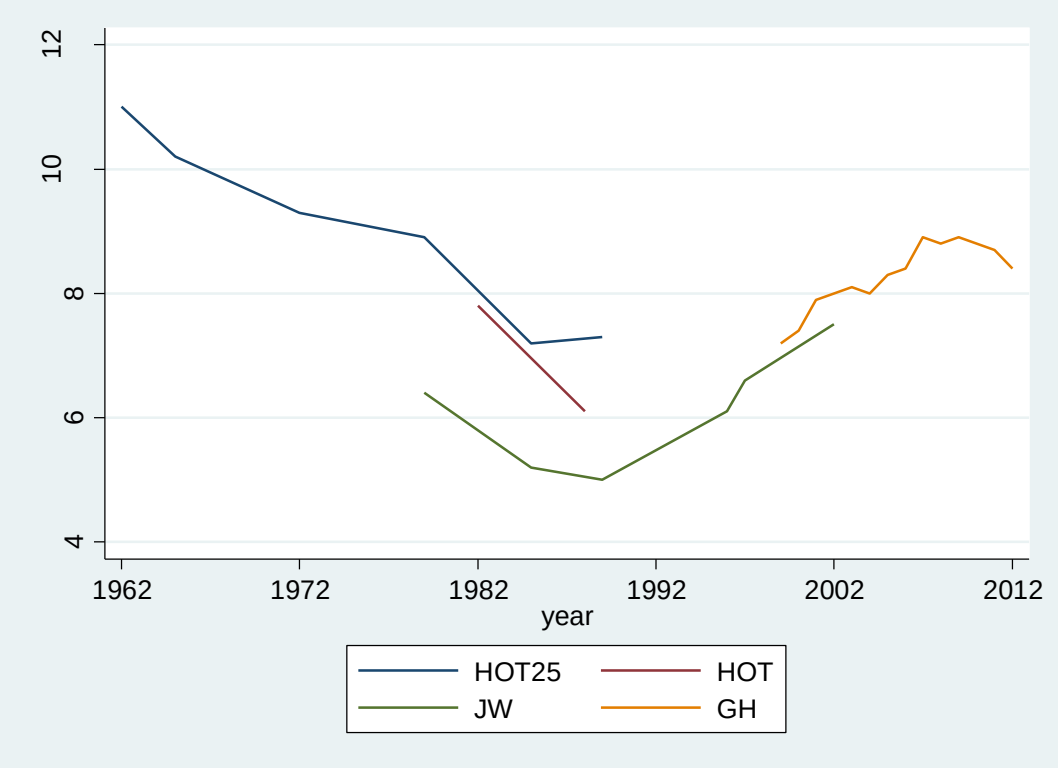

Figure 1b: Mincer returns to schooling: women

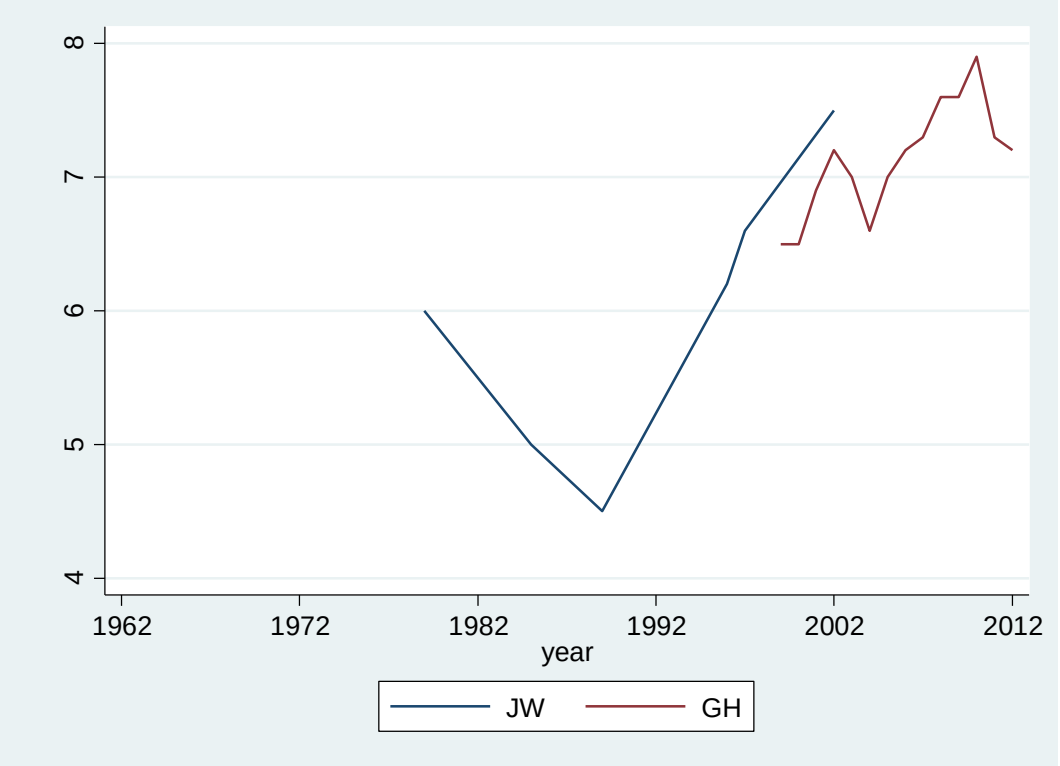

Figure 2a. Predicted wage growth during the first 10 years: men

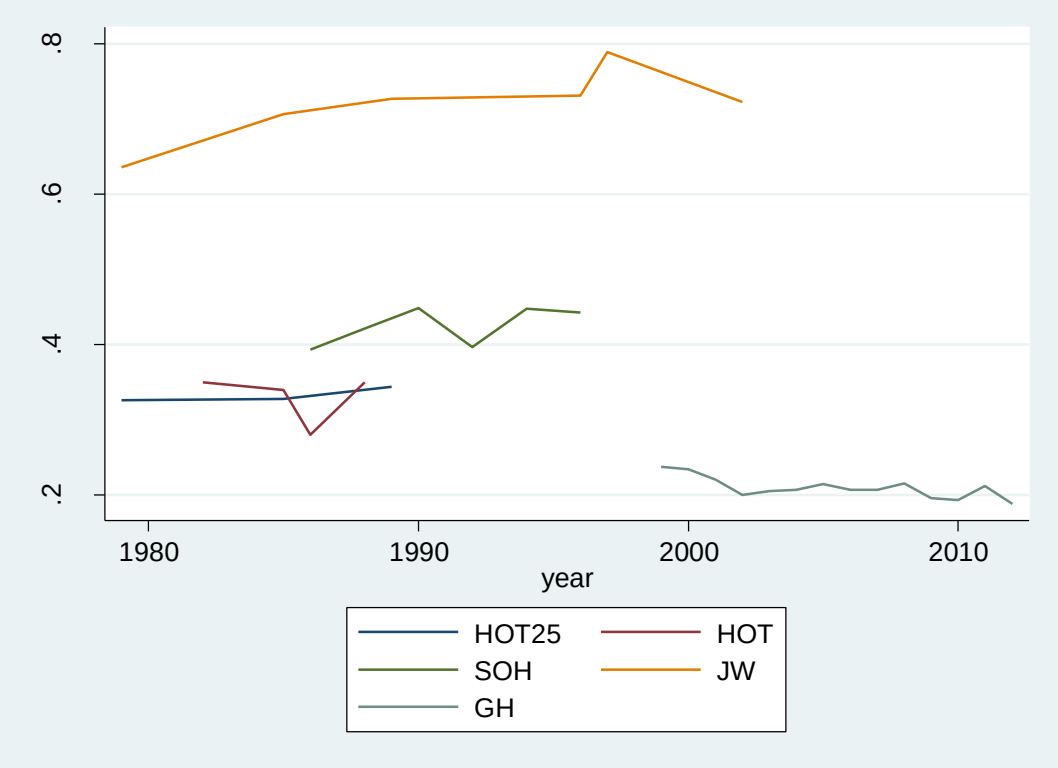

Figure 2b. Predicted wage growth during the first 10 years: women

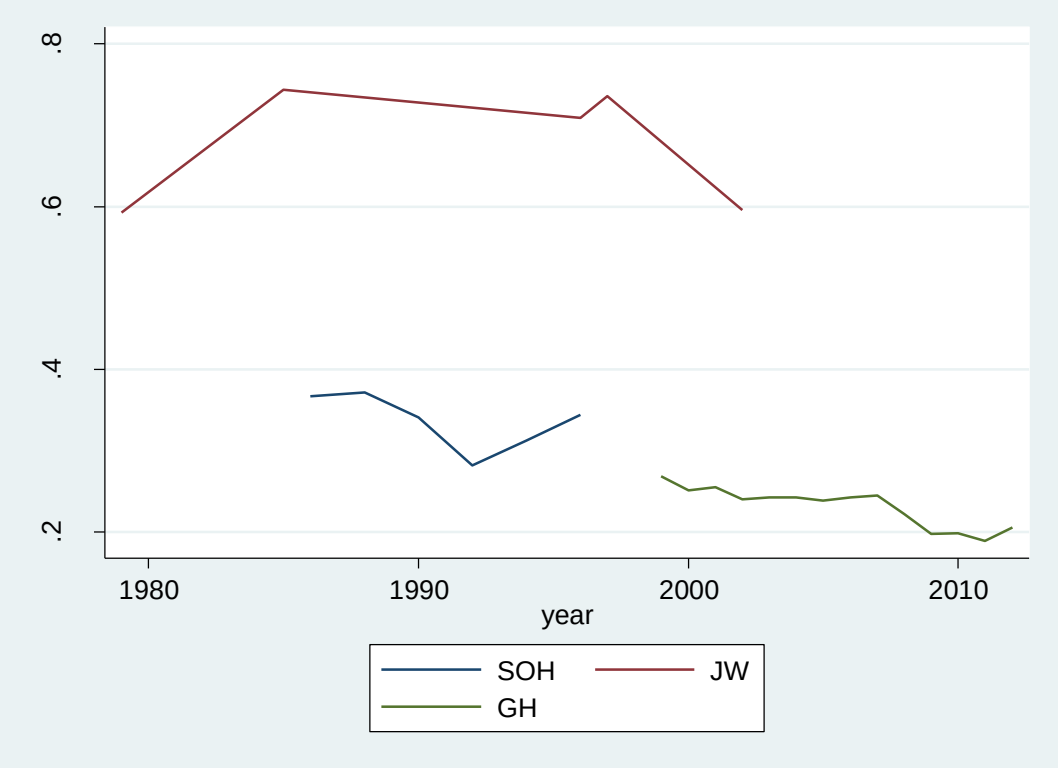

Figure 3: Supply and demand higher educated labour