ISSN 1011-8888

INSTITUTE OF ECONOMIC STUDIES

WORKING PAPER SERIES

W10:01 May 2010

Life-Cycle, Effort and Academic Deadwood

Yu-Fu Chen and Gylfi Zoega

Addresses: Yu-Fu Chen
Economic Studies
University of Dundee
Perth Road
Dundee DD1 4HN
Email: y.f.chen@dundee.ac.uk

Gylfi Zoega
Faculty of Economics
University of Iceland
Oddi, at Sturlugata,
101 Reykjavik, Iceland
Iceland
Email: gz@hi.is

Life-Cycle, Effort and Academic Deadwood

Yu-Fu Chen [a] and Gylfi Zoega [b, c]

[a] Economic Studies, University of Dundee, 3 Perth Road, Dundee, UK
[b] Department of Economics, University of Iceland, 101 Reykjavik, Iceland
[c] Department of Economics, Birkbeck College, Malet Street, London, UK

31 May 2010

Abstract

It has been observed that university professors sometimes become less research active in their later years. This paper models the decision to become inactive as a utility maximising problem under conditions of uncertainty and derives an age-dependent activity condition for the level of research productivity. The model implies that professors who are close to retirement age are more likely to become inactive when faced with setbacks in their research while those who continue research do not lower their activity levels. Using data from the University of Iceland, we confirm the model's predictions. The model suggests that universities should induce their older faculty to remain research active by striving to make their research more productive and enjoyable, maintaining peer pressure, reducing job security and offering higher performance related pay.

Keywords: Deadwood, aging, optimal stopping.
JEL Classification: J44, J22

We would like to thank Baldvin Zarioh at the University of Iceland for assistance.

1. Introduction

Young university lecturers frequently complain about colleagues who are not engaged in research, who have become "deadwood" in common parlance. The reasons why university teachers may end up as deadwood are seldom explained. Sometimes one might conclude from the complaints that they were infected by unexpected spells of slothfulness. Workers in other professions may also gradually reduce their effort as they get older and become less active at work. Some workers may also choose to move to professions where opportunities for on-the-job leisure are greater: Politicians sometimes end up as diplomats; football players as celebrities and movie stars may take on fewer roles and end up enjoying leisure and sometimes fame. In some cases the decision is driven by physical deterioration, such as in sports, but in other cases it is for other less well-defined reasons such as when an academic stops spending his time doing research.[1] The question that then arises is whether this is due to declining mental abilities or results from changing incentives. The objective of this paper is to show how older intertemporal-utility-maximising workers may face incentives to stop doing research in spite of undiminished physical and mental strength.

We will explain our argument using the university workplace as an example but it applies also to other professions where workers' level of exertion is at least partly up to their own discretion and can only be imperfectly observed by employers. Our model shows why academics may face reduced incentives to do research as they get closer to retirement. One insight coming from our model is that older workers are less threatened by the possibility of being dismissed and future research successes are also less important for them when compared to current sacrifices brought about by strenuous research effort.[2] The model also helps distinguish those individuals who are more likely to become inactive. Those who remain research active are the ones who enjoy research and those whose productivity is sufficiently great to offset any incentives to slow down. It follows that while there are many inactive older professors, the active professors tend to be quite productive.

[1] Even in the case of athletes, the retirement decision is to some extent up to the individual's discretion because the rate of deterioration of physical ability has been shown to be quite small, see Fair (1994, 2007) who fails to find a strong effect of aging on physical abilities.

[2] The model resembles the model of Lazear and Rosen (1981) on rank-order tournaments. In their model workers exert effort in the hope of being promoted in the future while in our model they exert effort in the hope of enjoying an unexpected productivity surge.

2. Causes of inactivity in late career

To our knowledge, not much has been written on the causes of inactivity in late career. There is however statistical evidence showing that research productivity is declining in age. Oster and Hamermesh (1998) find that economists' productivity measured by publications in leading journals declines with age, although the probability of acceptance, once an article has been submitted to a leading journal, is independent of age. Moreover they find that the median age of authors of articles in leading economics journals was 36 in the 1980s and the 1990s and that a very small minority of authors are over 50 in spite of a substantial percentage of AEA members being over the age of 50.[3] However, they cannot discriminate between the two possible reasons for this observation; whether the falling frequency of publications is due to deteriorating mental faculties or, alternatively, reflects rational decisions to devote less time to research. In a recent paper, Jones (2010) analyses the age of individuals at the time of their greatest achievements in science using data on research that leads to the Nobel Prize in physics, chemistry, medicine and economics and also data on research that leads to great technological achievements as shown in the almanacs of the history of technology. He finds that the greatest concentration of innovations in the life of a scientist comes in his 30s but a substantial amount also comes in the 40s, while scientists in their 50s, and even more so in the 60, generate far fewer discoveries.

Standard human capital models can be used to explain why research effort may be declining in age. Using the Mincer (1958) framework, workers have to choose between working to earn wages and investing in human capital. In the Ben-Porath (1967) model, we can think of "academic human capital" as having a particularly high depreciation rate – a lot of work is required just to keep up to date – and that as people get close to retirement they have a smaller incentive to invest in human capital since there are few years left to reap the return from this investment. The empirical prediction of the human capital approach is that human capital and research activity is declining in age and eventually declines to zero just before retirement. We will refer to this as the "human capital effect."

In our model output is partly stochastic – sometimes an editor or a referee likes a paper because he happens to be working on something similar; clearly the choice of referees has a

[3] Similar results are reached by Lehman (1953), Diamond (1986), McDowell (1982) and Levin and Stephan (1992) for other disciplines. However, Jan van Ours (2009) finds no relationship between the quality-adjusted rate of publication and age among his colleagues at Tilburg University.

random element; co-authors may be active or not; and we have family issues that can distract us and so forth. Faced with disappointments, the young may decide to stay research active because they can hope for future successes knowing that they have a long future ahead. In contrast, the older professors may think that they are not likely to be lucky in the short remaining span of their tenure and become inactive. Remaining research active allows a professor to hope for future (publication) success, the more years he has left the more time he has to realize these hopes. Hence a young lecturer may stay research active in spite of setbacks while the older one may turn to admin/teaching/consulting. It follows that the old professors are either very good or inactive while the mediocre younger ones decide to stay research active in the hope of future successes. We will refer to this as the "option value effect."

3. A Model of Academic Deadwood

In this section we model the decision by a professor whether to remain research active. The representative professor devotes his time to teaching, administration and research. Of these tasks, his efforts at teaching and administration are observable by the university and justify paying him a fixed salary w_0. In contrast, there is asymmetric information about research effort. Low observable output in the form of published papers and books can have many possible explanations, such as excessive attention to detail by the professor, the research projects being very ambitious and time consuming, bad luck when it comes to the choice of journals and publishers for submitting research results or simply that the professor is engaged in the type of research that the profession does not value at the moment due to fads and fashions. There is also, of course the possibility that the professor is simply not devoting enough time to doing research.

We first explore the case when it is impossible to monitor research effort but then extend the analysis in Section 4 to the case of imperfect monitoring of effort and finally to include tenure effects in Section 5. Empirical predictions are presented in Section 6 before the concluding Section 7.

3.1 Assumptions

We assume that a representative professor faces a one-off decision whether or not to continue doing research in the future. The level of effort, *f*, has two possible values, zero and one as in Shapiro and Stiglitz (1984); when *f* is equal to one the professor is doing research while *f* takes the value zero when he is inactive in research although still teaching and performing administrative duties. When doing research the professor suffers disutility γ – caused by the constant exertion needed to get results – but generates measurable research output *g* which the university uses to calculate his performance-related pay. The variable γ can take a negative value if the professor enjoys doing research – in which case he will never choose to become inactive. When a professor decides to become inactive in research, that is *f* becomes zero, he faces the one-off wrath of his colleagues which we measure by the variable *W*.[4] However, continuing research effort gives an uncertain return in the form of research output that is used to calculate performance-related pay.

The professor's pay is a linear function of observable research output *g*;

(1) $w = w_0 + w_b g_t f \ , \quad w_0, w_b > 0$

It follows that a worker not doing research would receive the basic professorial pay w_0 and a worker engaged in research would receive $w_0 + w_b g$, while having disutility γ from doing the work.[5]

Future research output is uncertain because of the possibility that research effort will not generate sufficiently interesting and innovative research results, because of uncertainty about how quickly results will be achieved and also because of uncertainty about the reception by editors of professional journals whose preferences are difficult to predict. Each individual can also expect his productivity to change in the future, depending on the environment in which he finds himself, the extent of learning by doing, personal circumstances, the productivity of colleagues and collaborators and so forth. To capture these dynamics, it is assumed that the level of *g* follows a geometric drifted Brownian motion,

(2) $dg = \eta g dt + \sigma g dz \ ,$

[4] One can also model part of the reaction of colleagues as a constant expression of disapproval when not doing research. In this case one can define the variable γ as the disutility of effort net of the approval of colleagues when doing research.

[5] The model can be easily modified to take into account wage compression – differences in productivity between two workers exceeding differences in wages – as in Frank (1984) by raising *g* in equation (1) to a power which is less than one. See also Booth and Zoega (2004) on the effect of wage compression for human capital investment.

where η is the drift parameter of research output, σ is the uncertainty parameter about future research output and z is the standard Wiener process – a normalised Gaussian process with independent increments.

The professor has to make up his mind whether to do research or not, keeping in mind that although not doing research yields utility in the form of leisure at work, it also reduces the level of research output and hence also the amount of performance-related pay. The professor thus faces an optimal stopping problem when he decides whether to shirk his research duties. We make the assumption that the professor cannot resume researching once he has decided to shirk. [6]

3.2 The research decision

The professor has utility which is linear in wages and the disutility of doing research; $w_0 + w_b g_t - \gamma$ when doing research and w_0 when not doing research. This gives the following intertemporal utility function;

$$(3) \qquad V = E\left[\int_t^T \left(w_0 + w_b g_s f - \gamma f\right) e^{-\rho(s-t)} ds\right],$$

subject to (2), where $E[\ ]$ is the expectation operator, ρ is the discount rate of the professor and $T - t$ is the time remaining until the professor retires. If the professor chooses not to do research, the intertemporal utility for not being research active V^{S} is

$$(4) \qquad V^{\mathrm{S}} = E\left[\int_t^T w_0 e^{-\rho(s-t)} ds\right] = \frac{w_0\left(1 - e^{-\rho(T-t)}\right)}{\rho},$$

which is obtained by integrating the integral directly as there is no way back to research in the future. In contrast, if he chooses to do research the professor has the following intertemporal utility V^{R}

$$(5) \qquad V^{\mathrm{R}} = E\left[\int_t^T \left(w_0 + w_b g_s - \gamma\right) e^{-\rho(s-t)} dt\right],$$

where the difference between (4) and (5) lies in the research-active professor expecting performance-related pay but also enduring the disutility of more effort γ, which can be either

[6] Implicitly, it means that there are large sunk costs involved in resuming research such that the option to resume research approaches null value for the decision not to do research; for example, the laboratory is gone forever or the human capital has depreciated.

positive or negative, negative if the professor enjoys the effort and challenges of research effort, otherwise positive.

The decision by the professor whether to discontinue research depends on whether the discounted utility from not being research active for the remainder of his tenure V^S exceeds the sum of the discounted utility from being research active V^R and the expected discomfort from the wrath of colleagues when stopping research W. The equality of the two generates what we call the *activity condition*

(6) $$V^{\mathrm{S}} = V^{\mathrm{R}} + W \,.$$

Equation (6) is analogous to the non-shirking condition of Shapiro and Stiglitz (1984). It captures both the *human capital effect* described by Ben-Porath (1967) and *the option value effect*, described earlier. The condition determines the research productivity level g – hence the wages w_0+w_bg – that is needed to convince the professor to continue doing research for a given performance-related pay w_b, a system of measuring performance g, the disutility from doing research γ, peer pressure W and, as we will show, age.

3.3 The activity condition

We need to solve the activity condition. While the solution for V^S is given by equation (4), we still need to solve for V^R. The Bellman equation for equation (5) is the following,

(7) $$\rho V^{\mathrm{R}} = w_0 + w_b g - \gamma + \eta g V_g^{\mathrm{R}} + \frac{1}{2}\sigma^2 g^2 V_{gg}^{\mathrm{R}} + V_t^{\mathrm{R}},$$

where $w_0 + w_b g - \gamma$ represents the net utility from working at the university, $\eta g V_g$ shows changes in V^R due to a drift in research productivity, and the last two terms denote changes in V^R due to diffusion.

The solution to equation (7) comprises a particular solution, representing the net benefits from doing research for the rest of one's career – the human capital effect of Ben-Porath – and a homogenous solution, which is equivalent to the value of the real option to discontinue research later. Therefore, we have the following solutions for V^{R} (see Appendix I for details),

(8) $$V^{\mathrm{R}} = \frac{(w_0 - \gamma)\left(1 - e^{-\rho(T-t)}\right)}{\rho} + \frac{w_b g\left(1 - e^{-(\rho-\eta)(T-t)}\right)}{\rho - \eta} + A_2 g^{\beta_2} N(-d_2),$$

where the first two terms of the right-hand side are obtained from directly integrating the intertemporal utility; the last term on the right-hand side denotes the real option to discontinue research and A_2 is an unknown parameter to be determined by the value-matching condition of the optimal stopping problem.[7] The parameter β_2 is the negative root of the following characteristic equation

$$(9) \qquad \frac{1}{2}\sigma^2\beta(\beta-1)+\eta\beta-\rho=0,$$

$$\text{and } d_2=\frac{\ln g-\sigma^2(T-t)\sqrt{\left(\frac{\eta}{\sigma^2}-\frac{1}{2}\right)^2+\frac{2\rho}{\sigma^2}}}{\sigma\sqrt{T-t}}, \qquad N(-d_2)=\left(1/\sqrt{2\pi}\right)\int_{-\infty}^{-d_2}e^{-\varpi^2/2}d\varpi$$

and $0 \leq N(d) \leq 1$ is the cumulative normal distribution function. Note that as T approaches infinity, $N(-d_2) = 1$ and the option to discontinue research becomes a perpetual option case; however, as T approaches zero, $N(-d_2) = 0$ if $g > 1$. As the professor is near retirement, the value of the option to discontinue research approaches zero because he is going to retire soon.[8]

We can now write an equation for the activity condition $V^S - V^R = W$ where $\underline{g}$ is the productivity threshold at which the professor decides to discontinue research:

$$(10) \qquad \frac{\gamma\left(1-e^{-\rho(T-t)}\right)}{\rho}=\frac{w_b\underline{g}\left(1-e^{-(\rho-\eta)(T-t)}\right)}{\rho-\eta}+A_2\underline{g}^{\beta_2}N\left(-d_2\left(\underline{g}\right)\right)+W,$$

where $\rho > \eta$. The left-hand side of equation (10) shows the benefits of discontinuing research – becoming a deadwood – and the right-hand side the cost. The benefits consist of the expected discounted disutility of doing research, which the professor avoids by not doing research. The costs consist of the sum of the sacrificed expected discounted utility of the performance-related pay, the value of the real option to discontinue research in the future, and the one-off no-pecuniary penalty W – or peer pressure – imposed by colleagues when a professor stops doing research.[9]

A professor may continue doing research even when the performance-related pay no longer compensates for the disutility from doing research. For someone who either dislikes

[7] For readers who would like to study the rapidly developing literature of real options and optimal stopping applications in economics for the past two decades, see Dixit and Pindyck (1994) and Stokey (2008).
[8] Note that the A_2 parameter is also a function of $(1\text{-}e^{-(\rho-\eta)(T-t)})$ and comes from the value-matching/smooth-pasting conditions. The option therefore also approaches zero as $T \rightarrow t$. See equation (13) for details.
[9] See footnote 4 on the case of a constant peer pressure.

doing research – γ is positive and high – or is not very productive – g is low – or is not paid very much for his research output – w_b is low – or expects his research output to decline – η is negative – it may nevertheless be optimal to continue doing research because of the possibility that productivity may improve in the future, the real option value is large (β_2 is negative so that $g^{\beta 2}$ is higher the lower is the value of g). However, as the professor nears retirement, both the benefits from continuing research and the real option approach zero, as does the discounted disutility of research effort.

Equation (10) has several intuitive implications. Clearly, when productivity g is sufficiently high, the professor will continue doing research. The critical productivity level $\underline{g}$ is higher

a) the lower is the performance-related pay w_b,
b) the greater is the disutility of doing research γ,
c) the weaker is peer pressure from colleagues W,
d) the smaller is the rate of growth of research productivity η , and
e) the lower is the level of uncertainty σ.

More importantly for our purposes, the critical productivity threshold depends on the age of the workers;

f) the older the worker, the higher is the productivity threshold at which he becomes inactive for $\eta > 0$, except for workers who are to retire very soon.

The intuition for the age effect is the following: Due to expected growth in research productivity η the performance-related pay is expected to rise, as well as the real option, while the disutility from doing research stays constant over time. Hence, from the current perspective, the final year's expected performance pay and possible research successes (the real option) count more in the professor's current decision than the expected disutility of work. It follows that as the professor gets older the cost of giving up research declines more rapidly than the benefits and he is more likely to decide to become inactive in research for a given slump in research productivity. The young, in contrast, may decide to continue doing research because they have more time to enjoy the fruits of higher productivity and unexpected successes and this justifies current effort.

3.4 Numerical simulations

In order to further analyse the properties of the activity condition we run some numerical simulations. Before doing so, we need to determine the value of A_2 from the smooth-pasting condition,

$$(11)\quad -\frac{w_b\left(1-e^{-(\rho-\eta)(T-t)}\right)}{\rho-\eta}=A_2\frac{\partial\left(\underline{g}^{\beta_2}N\left(-d_2\right)\right)}{\partial\underline{g}}=A_2\left[\beta_2 g^{\beta_2-1}N\left(-d_2\right)-\frac{1}{\sqrt{2\pi}}\frac{g^{\beta_2-1}}{\sigma\sqrt{T-t}}e^{-d_2{}^2/2}\right].$$

The equation yields a solution for A_2, which is the following equation,

$$(12)\quad A_2=\frac{w_b\left(1-e^{-(\rho-\eta)(T-t)}\right)}{\rho-\eta}\frac{1}{\left[-\beta_2 g^{\beta_2-1}N\left(-d_2\left(\underline{g}\right)\right)+\frac{1}{\sqrt{2\pi}}\frac{g^{\beta_2-1}}{\sigma\sqrt{T-t}}e^{-d_2{}^2/2}\right]}.$$

And the value of the real option to discontinue research is then as follows:

$$(13)\quad A_2\underline{g}^{\beta_2}N\left(-d_2\left(\underline{g}\right)\right)=\frac{w_b\underline{g}\left(1-e^{-(\rho-\eta)(T-t)}\right)N\left(-d_2\left(\underline{g}\right)\right)}{(\rho-\eta)\left(-\beta_2 N\left(-d_2\left(\underline{g}\right)\right)+\frac{1}{\sqrt{2\pi}}\frac{e^{-d_2{}^2/2}}{\sigma\sqrt{T-t}}\right)}.$$

To further analyse the relationship between research effort and age we will perform numerical simulations on equations (10) and (13).

The figures below show the activity threshold derived from simulation results using benchmark values listed at the bottom of the figures. The left-hand panel of Figure 1 shows that the activity productivity threshold is increasing in age when $\eta > 0$ until the professor is just about to retire when it falls abruptly.[10] This implies that as the professor gets older he needs a higher level of research productivity to justify continued research. A slump in research productivity – perhaps a sequence of rejections from academic journals – is hence more likely to convince the older workers to discontinue research and become inactive. The right-hand panel of Figure 1 shows how an increase in peer pressure W lowers the threshold so that it takes a greater slump in research productivity to convince the professor to stop research. Figure 2 shows that increased uncertainty about future research output σ has the same effect of shifting the thresholds downwards, as does an increase in the rate of performance-related pay w_b.

[10] The effect is reversed when growth η is negative, the younger professors may then decide to become inactive at higher levels of productivity than the older ones.

The fall in the threshold close to retirement is caused by the non-zero cost of discontinuing research *W*. A professor will not want to attract the scorn of his colleagues for stopping research for a very short period of time. This is apparent in the right-hand panel of Figure 1.

Figure 1. Productivity growth, peer pressure and the inactivity threshold

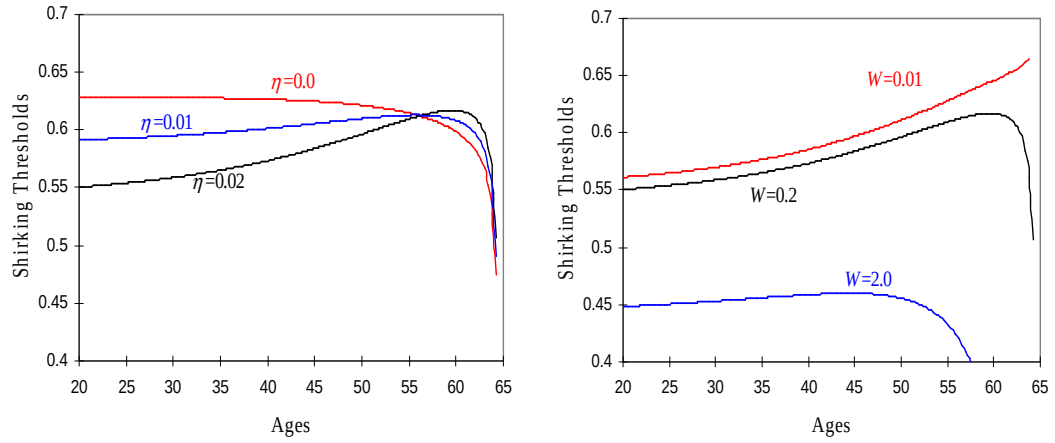
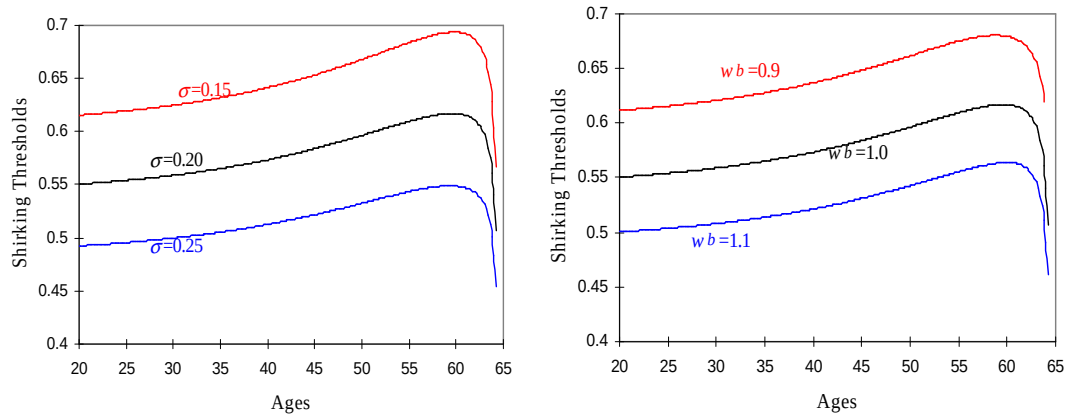


Figure 2. Uncertainty, performance-related pay and the inactivity threshold



Parameter values: $\sigma = 0.2$, $\rho = 0.1$, $\eta = 0.02$, $w_b = 1$, $W = 0.2$, $t = 0$, $\gamma = 1.0$, and age =65-*T*. Note that for a professor with ten years to retirement at the age of 55 the value of *T* is equal to 10.

4. Monitoring

We now change the model in order to allow for monitoring of research effort. As in the efficiency wage literature, we assume that the departmental chair can observe research effort, in addition to research output, but only at a cost. Research effort can thus be checked regularly and the professor gets fired if caught shirking his research duties.

Following Shapiro and Stiglitz (1984) we assume a Poisson detection technology and let professors who do not do research face a constant probability q of being fired. This makes the research inactive professor discount his future wages w_0 at rate $\rho+q$ when not doing research, while the discount rate remains unchanged at ρ when doing research. This addition to the model changes equation (4) to

$$(4') \qquad V^S = E\left[\int_t^T w_0 e^{-(\rho+q)(s-t)} ds\right] = \frac{w_0\left(1-e^{-(\rho+q)(T-t)}\right)}{\rho+q}$$

and we get two new terms on the right-hand side of equation (10);

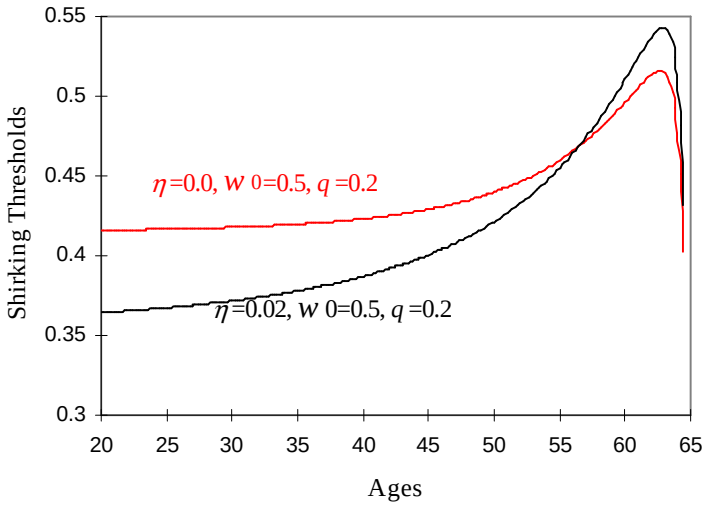
$$(10') \qquad \frac{\gamma\left(1-e^{-\rho(T-t)}\right)}{\rho} = \frac{w_b \underline{g}\left(1-e^{-(\rho-\eta)(T-t)}\right)}{\rho-\eta} + A_2 \underline{g}^{\beta_2} N\left(-d_2\left(\underline{g}\right)\right) + K + \frac{w_0\left(1-e^{-\rho(T-t)}\right)}{\rho} - \frac{w_0\left(1-e^{-(\rho+q)(T-t)}\right)}{\rho+q}.$$

Those who shirk their duties discount future wages w_0 at a higher discount rate because they face the probability q per unit time of being fired by their departmental chair. Hence the difference between the last two terms on the right-hand side of the equation is positive and measures the value of job security, which is reduced when a professor decides to stop doing research. The cost of not doing research now becomes the sum of four terms: The sacrificed performance-related pay; the sacrificed option to stop research at a later time; the negative response of colleagues; and reduced job security. Figure 3 shows the activity thresholds that have become steeper with monitoring and remain upward sloping even for the case of $\eta = 0$. The slope of the threshold is steeper because the value of job security is falling in age – workers close to retirement have less to lose from being fired since they would have quit their job soon anyway.[11]

An older professor who has suffered setbacks in research – experienced a lower level of g – would hence be more likely to become inactive than a younger professor because he has less time left to recover his productivity and enjoy unexpected research results, as described in Section 2, and, moreover, he has less to fear from his employer since he is going to retire soon anyway.

[11] This leaves out any reputational effects that could have an offsetting effect and also any adverse effect on pension rights.

Figure 3. Activity thresholds with monitoring



Parameter values the same as in Figures 1 and 2.

It follows from the analysis that older research-active professors either enjoy doing research better than their younger colleagues or are more productive on average. It follows that while there are many inactive older professors the active professors tend to be quite productive. This is in accordance with the empirical results of Oster and Hamermesh (1998) who find that, comparing authors age 36-50 to those over 50, the degree of heterogeneity in terms of research productivity increases with age.

5. Tenure

Finally, we allow for a tenure effect by letting q be declining in age. In this case workers face increased job security – a falling probability of detection and dismissal – the older they get. We assume the time profile for q shown in Figure 4 and captured by the logistic function where job security increases initially at an increasing rate but then stabilizes around the age of 50. The probability of firing, q, is assumed to be highest at age 20 and equal to 0.25, and lowest when the worker approaches retirement and equal to 0.05. The reflection on the second derivative happens at age 40. The time profile is described by the following logistic function:

(14) $$q = 0.25 - \frac{0.2}{1+\exp\left(-0.3\times\left(\text{age}-40\right)\right)}.$$

According to this function, q is near 0.25 for young workers, and 0.05 for old workers who are close to retirement.

Figure 4. The effect of age on job security

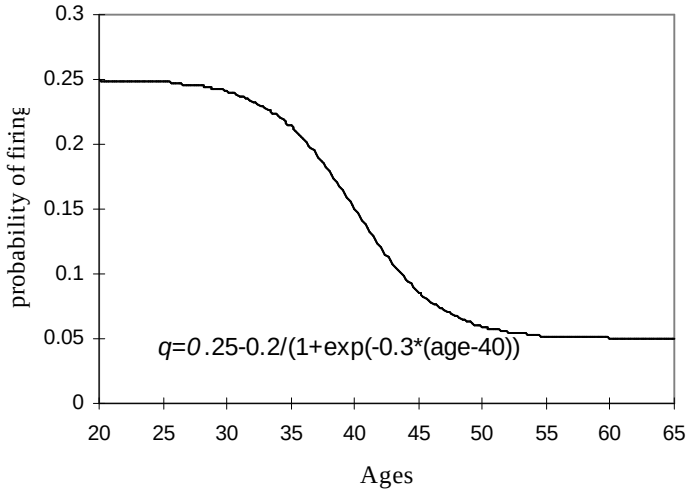
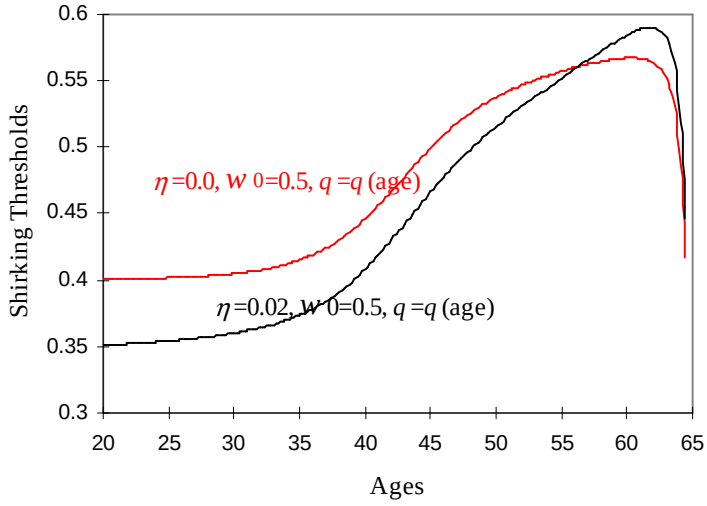


Figure 5 then shows the activity thresholds for both η=0.0 and η=0.02. Note that the threshold is upward-sloping in both cases, more so when η=0.02.

Figure 5. Activity thresholds with a tenure effect



Parameter values the same as in Figures 1 and 2.

Compared to the thresholds in Figure 3, the difference between the value of the new threshold for the young and the old workers is much greater in this case. The tenure effect weakens the incentive for the old workers to continue with research further. The old, unproductive professor may now decide to enjoy leisure on the job by discontinuing research because he has little time left to attain higher productivity; it does not matter much if he is found out and dismissed; and the chances that he be dismissed are low because of his tenured position.

6. Empirical predictions

The empirical prediction coming from our model is that the frequency of inactivity among older university teachers is higher than that for the younger ones because they value the real option to stay research active less. In contrast, the Ben-Porath model would predict that all university teachers slow down as they approach retirement – this is the human capital effect. Our option value effect predicts that the ones who are successful – or really enjoy their work – continue doing research until retirement in spite of the human capital effect.

In this section we use data on research output from the University of Iceland to test the two predictions. The payroll division of the university uses data on research activity to calculate a single measure of activity for each member of staff per year. Activities such as publishing papers in academic journals and books, seminar presentations, conference attendance and so forth each give a fixed number of points each which are then summed up to generate one grand total for each member of staff (see Appendix II). The same point system is used for all departments which enables us to study research activity for the whole university. We use data for the calendar year 2008 when 640 members of staff were assessed. Tables AII-1 and AII-2 in Appendix II summarise the data and Figure AII-1 show the distribution of output for eight age groups. We can see from the distributions in the appendix the large number of inactive university teachers in the older age groups.

In Table 1 we show the number of research inactive member of staff for each age group. We note that this is higher for the oldest three groups than for the younger groups and more than doubles as a proportion of the number of people in each group between the 60-64 and 65-70 years groups. In the 65-70 group we find that 30% are inactive. Since the point system measures not just the number of articles published in academic journals but also

working papers, seminar presentations and so forth, these individuals can be said to be completely inactive when it comes to research.

Table 1. The number of inactive members of staff

Age	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-70
Inactive	1	5	9	6	14	23	12	18
Total	20	45	70	91	130	137	88	60
%	5	11.1	12.9	6.6	10.8	16.8	13.6	30

Of the 18 inactive individuals in the oldest group we find that 14 are men (31% of all men in the age group) and 4 women (26.7% of all women in the age group).

In Table 2 we present results from the estimation of an equation where output (measured in points in year 2008) is regressed on dummy variables for eight age groups. The objective is to map the age profile of research. The results suggest that research output when both sexes are combined is rising until the early forties and then declining. Men slow significantly down in their fifties and sixties, so much that the average number of points drops from around 36 to about 18 per years or by 50%. Women also peak in their early forties at around 25 points but only decline down to 18 in their late sixties. It follows that men tend to produce more in their thirties and forties but lose their edge in their fifties and sixties. However, the null hypothesis that research output remains the same throughout life can only be rejected for men at the 5% level of significance, not for women and not for all workers groups together.[12]

In the second column we include only the research active. For the whole sample research activity is now no longer declining in age – although peaking in the early 40s – and for women it is rising so that output in the 65-70 age group exceeds that in the 30-39 age groups.[13] The equality of coefficients can no longer be rejected for men at the 5% level of significance although it can still be rejected at the 10% level. There is now no longer any significant fall in research output from the late fifties to late sixties for men. This suggests that it is to some extent the research inactive in later working life that pull down average

[12] A Wald test for the equality of all coefficients yields F= 1.64 (probability =0.12) for all members of staff; F= 2.21 (probability of 0.03) for men; and F=0.61 (probability of 0.75) for women. Hence, only in the case of men is the equality rejected.

[13] The Wald test for the equality of all coefficients yields F= 1.04 (probability =0.40) for all teachers; F= 1.99 (probability of 0.06) for men; and F=0.73 (probability of 0.64) for women. We can reject equality for men at the 10% level of significance but we cannot reject equality in the case of women nor the whole sample at all.

research activity in these years. We should note that the results are robust to the exclusion of any one of the academic departments. Finally, the last column has a (censored) Tobit regression on the whole sample which gives similar results to the least squares estimation on the whole sample.

Table 2. Age, sex and research output

	All			Men			Women		
age	All*	Active*	Tobit**	All*	Active*	Tobit*	All*	Active*	Tobit***
30-34	27.51	28.96	26.77	29.96	32.10	28.86	20.16	20.16	20.16
	(5.71)	(5.97)	(5.26)	(4.98)	(5.30)	(4.44)	(3.48)	(3.48)	(3.54)
35-39	26.61	30.02	24.89	30.84	37.26	27.96	18.43	18.43	18.43
	(5.82)	(6.13)	(5.07)	(4.65)	(5.06)	(3.82)	(5.71)	(5.70)	(5.81)
40-44	31.52	36.17	29.70	35.96	44.68	32.89	25.25	26.15	24.89
	(8.98)	(9.85)	(7.76)	(6.77)	(7.95)	(5.47)	(6.78)	(6.97)	(6.58)
45-49	25.53	27.33	24.53	27.58	29.62	26.41	21.93	23.35	21.25
	(10.13)	(10.55)	(9.19)	(8.17)	(8.54)	(7.36)	(6.06)	(6.29)	(5.69)
50-54	26.40	29.58	24.77	28.73	32.97	26.54	23.68	25.83	22.76
	(11.56)	(12.35)	(10.01)	(8.42)	(9.13)	(7.06)	(8.02)	(8.44)	(7.45)
55-59	22.99	27.67	20.38	23.80	29.19	20.60	21.30	24.68	19.72
	(11.12)	(12.32)	(8.53)	(8.62)	(9.54)	(6.40)	(7.62)	(8.60)	(6.25)
60-64	21.80	25.24	19.96	19.56	23.86	16.37	26.88	27.90	26.88
	(9.94)	(10.96)	(7.98)	(7.58)	(8.51)	(5.12)	(6.65)	(6.86)	(6.77)
65-70	18.53	26.47	13.14	18.57	26.96	12.16	18.39	25.07	15.01
	(6.24)	(7.36)	(3.34)	(5.41)	(6.45)	(2.55)	(3.04)	(3.47)	(2.10)
R-sq.	0.02	0.02	-	0.04	0.04	-	0.01	0.01	-
Obs.	640	552	640	411	342	411	229	210	229

*) White heteroskedasticity-consistent standard errors and covariance, t-statistics in parentheses. **) z-statistics in parentheses.

In Table 3 we redo the estimation of Table 2 but control for academic departments. We find the same age pattern of research as in Table 2. In addition, we find that business administration is weak, as well as several other departments such as nursing, pharmaceutical sciences, medicine, languages and theology. In column (2), we also test for a tenure effect – professors may reduce research output because they have more job security and find that professors at the University of Iceland have almost 17 points more on average than other members of staff. The deadwood phenomenon is hence only associated with age, not rank. In column (3) we only include the research active and find, as before, that the slowdown in output in later years is now smaller, although statistically significant (F=2.73). As in Table 2

the fall in output between the fifties and the sixties is now almost eliminated while the fall from the early forties to late forties and fifties is still there.

Table 3. Research output, academic departments and academic positions

		All (1)*	All (2)*	Active (3)*	Tobit (4)**
Age Group	30-34	30.73 (5.14)	36.67 (5.94)	36.62 (5.92)	38.25 (5.87)
	35-39	28.65 (4.87)	34.81 (5.88)	37.68 (5.87)	35.62 (5.66)
	40-44	36.29 (6.72)	40.12 (7.38)	43.18 (7.55)	40.67 (7.13)
	45-49	29.95 (6.69)	30.71 (6.86)	32.06 (6.79)	30.92 (6.70)
	50-54	30.89 (6.02)	30.48 (5.86)	32.99 (5.96)	29.99 (5.61)
	55-59	28.13 (6.42)	25.05 (5.65)	29.45 (6.22)	23.08 (4.93)
	60-64	26.03 (5.44)	22.19 (4.46)	24.31 (4.51)	20.62 (3.99)
	65-70	22.03 (4.80)	19.19 (4.20)	24.79 (4.87)	14.01 (2.79)
Aca-demic Depart-ments	Social and human sciences	8.73 (1.56)	0.94 (0.12)	-1.31 (0.17)	1.21 (0.15)
	Social work	-6.89 (0.93)	-7.31 (0.88)	-12.11 (1.37)	-5.31 (0.63)
	Economics	3.84 (0.42)	-2.33 (0.28)	1.86 (0.21)	-4.35 (0.48)
	Law	-2.89 (0.44)	-8.34 (1.07)	-7.46 (0.89)	-10.19 (1.20)
	Political science	10.73 (1.09)	-2.32 (0.20)	-6.32 (0.52)	-2.71 (0.23)
	Business Administration	-16.94 (3.26)	-19.47 (2.63)	-24.33 (2.95)	-21.48 (2.69)
	Nursing	-11.66 (1.96)	-14.90 (1.97)	-16.42 (2.04)	-15.31 (1.89)
	Pharmaceutical sciences	-9.95 (1.19)	-22.27 (2.32)	-25.01 (2.59)	-22.99 (2.34)
	Medicine	-11.60 (2.46)	-16.63 (2.50)	-16.64 (2.34)	-19.42 (2.73)
	Food science and nutrition	7.85 (0.63)	1.77 (0.16)	-2.32 (0.20)	2.59 (0.23)
	Psychology	3.67 (0.37)	- 2.12 (0.20)	-6.41(0.59)	-1.24 (0.12)
	Odontology	-12.11 (1.35)	-11.33 (1.16)	-7.91 (0.58)	-16.80 (1.46)
	Languages, literature and linguistics	-13.21 (2.37)	-16.13 (2.13)	-17.00 (2.11)	-17.48 (2.06)
	Theology and religious studies	-11.93 (1.72)	-18.18 (2.14)	-20.50 (2.20)	-20.69 (2.11)
	Icelandic and comparative cultural st.	2.83 (0.40)	-4.18 (0.48)	-8.47 (0.94)	-3.13 (0.35)
	History and philosophy	10.09 (1.49)	0.90 (0.12)	-3.05 (0.39)	1.46 (0.19)
	Sport, leisure st. and social education	-9.89 (1.44)	- 9.78 (1.22)	-11.93 (1.47)	-9.02 (1.04)
	Teacher education	-7.66 (1.57)	-5.52 (0.78)	-9.91 (1.29)	-3.68 (0.49)
	Educational studies	2.21 (0.32)	-2.63 (0.32)	-6.29 (0.73)	-1.20 (0.14)
	Industrial-, mech. eng. and comp.s.	-9.46 (1.66)	-20.74 (2.65)	-18.61 (2.22)	-24.04 (2.76)
	Earth sciences	11.05 (1.74)	-3.69 (0.46)	-8.69 (1.01)	-2.34 (0.29)
	Life and environmental sciences	-2.59 (0.49)	-0.60 (0.07)	-14.24 (1.91)	-11.78 (1.57)
	Electrical and computer engineering	3.20 (0.29)	-5.00 (0.45)	-3.39 (0.27)	-7.73 (0.65)
	Physical sciences	-7.15 (1.29)	-18.74 (2.64)	-16.62 (2.12)	-22.71 (2.93)
	Civil and environmental engineering	8.74 (1.03)	-11.39 (1.61)	-1.93 (0.22)	-1.41 (0.16)
Position	Professor		16.98 (3.26)	17.88 (3.29)	18.69 (3.34)
	Associate professor		3.62 (0.72)	4.43 (0.84)	3.29 (0.60)
	Assistant professor		-5.78 (1.13)	-2.49 (0.46)	-8.92 (1.58)
R-squared		0.11	0.20	0.17	-
Observations		640	640	552	640

*) White heteroskedasticity-consistent standard errors and covariance, t-statistics in parentheses. **) z-statistics in parentheses.

We finally run a probit regression on the binary variable for inactivity (inactivity gives the value one to the variable, otherwise zero), which we explain with age and dummy variables for professors, associate professors and assistant professors. The results in Table 4 confirm that the older workers are at a greater risk of becoming inactive.

Table 4. Inactivity and age

	All		Men		Women	
Age	estimate	z-statistic	Estimate	z-statistic	estimate	z-statistic
Constant	-5.94	6.23	-5.57	-5.31	-7.94	4.18
Age	0.07	4.37	0.06	3.57	0.10	3.34
professor	-0.20	0.42	-0.002	-0.00	-1.00	0.94
assoc. professor	0.65	1.39	1.10	1.91	-0.97	0.93
assist. professor	1.34	2.90	2.02	3.38	0.79	0.96
R-squared	0.14		0.17		0.08	
Observations	641		412		229	

Maximum-likelihood estimation: Logit.

From the coefficient of "age" we can calculate that each additional year raises the probability of being inactive by 0.17% for men and 0.28% for women. However, women are less likely to become inactive from the outset as revealed by the constant term. Somewhat surprisingly, assistant professors are more likely to be inactive than professors.[14] Our results suggest that it is age, not status or job security, which affects the probability that someone becomes research inactive.

We have found that older individuals are more likely to become research inactive than their younger colleagues. We have also found that the high level of inactivity among older workers accounts completely for the observed slowdown in average output of female workers and also for most of the slowdown in research output observed for men in their sixties.

7. Conclusions

Following a string of setbacks in research, it takes a higher level of productivity to convince an older professor to discontinue research than a younger one. The young can look forward to a long career that may generate rising productivity and unexpected successes while the older

[14] We should note that the age profile is similar for the three academic positions; the average age of professors in the sample was 56, the average age of associate professors 52 and the average age of assistant professors was 49.

ones are closer to retirement and have less to lose from discontinuing research. The older professor may also be less threatened by the prospect of being dismissed in the light of low research effort because he has little time left before retirement and because of his tenured position.

Looking at data on research output from the University of Iceland, we find that the risk of becoming inactive is rising in age and the higher proportion of inactive workers in the oldest cohorts explains their lower average research output. We find that a substantial part of the reason why groups of individuals appear to slow down in terms of research when they approach retirement is that some of them become entirely inactive while others continue as before. However, the increased job security of professors does not reduce research; professors tend to be considerably more productive than either associate professors or assistant professors.

The intuition of the model is also applicable to other professions where a part of a worker's effort is not observable by the employer and workers require a higher real wage the older they become to deter them from shirking their duties. Our model complements the work of Lazear (1979) by showing how rising wage profiles can be used to increase a worker's effort but for a different reason – in our model rising wages are needed to offset an increasing temptation to shirk one's duties as the day of retirement nears while in Lazear's paper rising wages make workers have higher effort levels throughout their careers in the hope that they will keep their jobs and enjoy rising wages.

Our results suggest that becoming inactive in research can be optimal for university teachers when faced with setbacks given the external environment and salary scheme of the university. For this reason universities can induce their older faculty to remain research active by striving to make their research more productive and enjoyable, maintaining peer pressure, reducing job security and offering higher performance related pay.

References

Ben-Porath, Yoram (1967), "The Production of Human Capital and the Life Cycle of Earnings," *The Journal of Political Economy*, 75 (4), Part 1, 352-365

Booth, Alison L. and Gylfi Zoega (2004), "Is Wage Compression a Necessary Condition for Firm-financed General Training?" *Oxford Economic Papers*, 56 (1), 88-97.

Chen, Yu-Fu and Gylfi Zoega (2010), "An Essay on the Generational Effect of Employment Protection**,"** *Mathematical Social Sciences*, 59 (3), 349-359.

Diamond, Arthur (1986), "The Life-Cycle Research Productivity of Mathematicians and Scientists," *Journal of Gerontology*, 41, 520-525.

Dixit, Avinash K. and Robert. S. Pindyck (1994) *Investment Under Uncertainty*, Princeton: Princeton University Press.

Fair, Ray C. (1994), "How Fast Do Old Men Slow Down?"*The Review of Economics and Statistics*, 76 (1), 103-118.

Fair, Ray (2007), "Estimated Age Effects in Athletic Events and Chess," *Experimental Aging Research*, 33 (1), 37-57.

Frank, Robert (1984), "Are workers paid their marginal products?" *The American Economic Review*, 74 (4), 549-571.

Jones, Benjamin F. (2010), "Age and Great Invention," *The Review of Economics and Statistics*, XCII (1), 1-14.

Lazear, Edward P. (1979), "Why Is There Mandatory Retirement?" *The Journal of Political Economy*, 87 (6), 1261-1284.

Lazear, Edward P. and Sherwin Rosen (1981), "Rank-Order Tournaments as Optimum Labor Contracts," *The Journal of Political Economy*, 89 (5), 841-864.

Lehman, Harvey (1953), *Age and Achievement*, Princeton: Princeton University Press.

Levin, Sharon and Paula Stephan (1992), *Striking the Mother Lode in Science*, New York: Oxford.

McDowell, John (1982), "Obsolescence of Knowledge and Career Publication Profiles," *American Economic Review*, 72, 752-768.

Mincer, Jacob (1958), "Investment in Human Capital and Personal Income Distribution," *The Journal of Political Economy*, 66 (4), 281-302.

Mincer, Jacob and Haim Ofek (1982), "Interrupted Work Careers: Depreciation and Restoration of Human Capital," *The Journal of Human Resources*, 17 (1), 3-24.

Oster, Sharon M. and Daniel S. Hamermesh (1998), "Aging and Productivity Among Economists," *The Review of Economics and Statistics*, 80 (1), 154-156.

Shapiro, Carl and Joseph E. Stiglitz (1984), "Equilibrium Unemployment as a Worker Discipline Device," *American Economic Review*, 74 (3), 433-44.

Stokey, Nancy. L. (2008), *The Economics of Inaction: Stochastic Control Models with Fixed Costs*, Princeton: Princeton University Press.

Van Ours, Jan C. (2010), "Will you still need me – when I'm 64?" unpublished version of van Ours' Presidential Address at the European Society for Population Economics annual conference in Seville, June 12, 2009.

Appendix I: Derivation of Equation (8)

The corresponding integral for equation (7) in the text is denoted by

$$\text{(A1)} \quad V^{\mathrm{R}} = E\left[\int_t^T \left(w_0 + w_b g_s - \gamma\right) e^{-\rho(s-t)} ds\right].$$

Directly integrating (A1) without considering the possibility of shirking in research gives the following particular solution to V^{R}

$$\text{(A2)} \quad V^{\mathrm{R}} = \frac{\left(w_0 - \gamma\right)\left(1 - e^{-\rho(T-t)}\right)}{\rho} + \frac{w_b g\left(1 - e^{-(\rho-\eta)(T-t)}\right)}{\rho - \eta}.$$

Substituting (A2) back into equation (7) in the text shows (A2) is the correct particular solutions. The homogenous part of equation (7) in the text has the following form:

$$\text{(A3)} \quad \rho V^{\mathrm{R}} = \eta g V_g^{\mathrm{R}} + \frac{1}{2}\sigma^2 g^2 V_{gg}^{\mathrm{R}} + V_t^{\mathrm{R}}$$

Chen and Zoega (2010) have shown the detailed derivations of the solution for an equation similar to (A3). We use another way to show how to obtain real options for discontinuing research. It is commonly known that the perpetual real options have the functional form of component g^{β} and the corresponding characteristic equation without considering V^R is as follows,

$$\text{(A4)} \quad \frac{1}{2}\sigma^2 \beta\left(\beta - 1\right) + \eta\beta - \rho = 0.$$

As we only consider the opt-out (shirking) options, we only need to choose the negative root of equation (A4),

$$\text{(A5)} \quad \beta_2 = \frac{1}{2} - \frac{\eta}{\sigma^2} - \sqrt{\left(\frac{\eta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}} < 0.$$

Positive root for beta is not chosen in order for the real options not to approach infinity when productivity becomes very big. It is then natural to guess that real options to equation (A3) have the following functional form

$$\text{(A6)} \quad V^{\mathrm{R}}(g,t;T) = A_2 g^{\beta_2} N(-d_2(g,t;T)),$$

where A_2 is the unknown parameter, and

$$\text{(A7)} \quad d_2 = \frac{\ln g - \sigma^2(T-t)\sqrt{\left(\frac{\eta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}}}{\sigma\sqrt{T-t}},$$

$$\text{(A8)} \quad N(-d_2) = \left(1/\sqrt{2\pi}\right)\int_{-\infty}^{-d_2} e^{-\varpi^2/2} d\varpi.$$

The d_2 function has the components of β_2 from perpetual real options to shirk. We can then prove that (A6) is one of possible solutions to (A3) by plugging (A6) back to (A3). Differentiation $V^R(g,t;T) = A_2\left(1/\sqrt{2\pi}\right)g^{\beta_2}\int_{-\infty}^{-d_2} e^{-\varpi^2/2} d\varpi$ by using Leibnitz rule gives

$$\text{(A9)} \quad \eta g V_g^{\mathrm{R}} = \eta\left[\beta_2 g^{\beta_2}\int_{-\infty}^{-d_2} e^{-\varpi^2/2} d\varpi - g^{\beta_2}\frac{1}{\sigma\sqrt{T-t}} e^{-d_2{}^2/2}\right]\frac{A_2}{\sqrt{2\pi}},$$

$$\text{(A10)} \quad V_t^{\mathrm{R}} = \left[-\frac{\ln g}{2\sigma(T-t)\sqrt{T-t}} - \frac{\sigma}{2\sqrt{T-t}}\sqrt{\left(\frac{\eta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}}\right]\frac{A_2}{\sqrt{2\pi}} g^{\beta_2} e^{-d_2{}^2/2},$$

$$\frac{1}{2}\sigma^2 g^2 V_{gg}^{\mathrm{R}} = -\frac{\sigma}{2\sqrt{T-t}}\beta_2\frac{A_2}{\sqrt{2\pi}} g^{\beta_2} e^{-d_2{}^2/2} + \frac{\sigma^2}{2}\beta_2(\beta_2 - 1)\frac{A_2}{\sqrt{2\pi}} g^{\beta_2}\int_{-\infty}^{-d_2} e^{-\varpi^2/2} d\varpi$$

$$\text{(A11)} \quad + \frac{1}{2(T-t)}\frac{A_2}{\sqrt{2\pi}} g^{\beta_2}\left(\frac{\left[\ln g - \sigma^2(T-t)\sqrt{\left(\frac{\eta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^2}}\right]}{\sigma\sqrt{T-t}}\right) e^{-d_2{}^2/2}$$

$$- \frac{\sigma}{2\sqrt{T-t}}(\beta_2 - 1)\frac{A_2}{\sqrt{2\pi}} Y^{\beta_2} e^{-d_2{}^2/2}.$$

Substituting (A6), (A9) – (A11) back to equation (A3) and collecting terms gives

$$\left[\frac{\sigma^2}{2}\beta_2(\beta_2-1)+\eta\beta_2-\rho\right]\frac{A_1}{\sqrt{2\pi}}Y^{\beta_2}\int_{-\infty}^{-d_2}e^{-\varpi^2/2}d\varpi$$
$$+\left[-\beta_2+\frac{1}{2}-\frac{\eta}{\sigma^2}-\sqrt{\left(\frac{\eta}{\sigma^2}-\frac{1}{2}\right)^2+\frac{2\rho}{\sigma^2}}\right]\frac{\sigma}{\sqrt{T-t}}\frac{A_2}{\sqrt{2\pi}}Y^{\beta_2}e^{-d_2{}^2/2}=0 \quad \text{(A12)}$$

The items in two brackets are equal to zero due to equation (9) in the text (or (A4)) and (A5), which concludes the proof that $V^R(g,t;T)=A_2g^{\beta_2}N(-d_2(g,t;T))$ is the general solutions to equation (7) in the text. Combining the particular solutions and homogenous solutions [A(2) and (A6)] gives equation (8) in the text.

Appendix II. University of Iceland point system for research (April, 2000)

Publications	
Dissertations	
Master's thesis	15 points
Doctoral thesis	30 points
Doctoral thesis*	45 points
Books	
Book where new knowledge is presented, generated using scientific methods, which contributes to the state of knowledge in the relevant field.	10-60 points
Journal articles	
Article that is published in an internationally recognized journal (Science Citation Index, Social Science Citation Index and Arts/Humanities Citation Index)	15 points
Article published in a journal not mentioned in SCI, SSCI, AHCI	10 points
Articles published in refereed conference proceedings	
Chapter in a refereed conference volume	10 points
Book chapter	10 points
Other	
A scientific report	0-5 points
Published opinion	0-3 points
Summary chapter, refereed	1 point
Review article	1-2 points
Textbook	5-10 points
Lecture given at a scientific conference	3 points
Poster presented at a conference	2 points
In the case of multiple author articles or books, the points are calculated using the following formulae	
2 authors	1,5 x points / 2
3 authors	1,8 x points / 3
4 authors	2,0 x points / number of authors
Recognitions	
Citations listed in SCI, SSCI or AHCI give points as follows	
First 10 citations	1 point for each citation
Next 20 citations	0,5 points for each citation
Citations in excess of 30	0,2 points for each citation
Lectures	
Plenum lecture at an international conference	10 points
Seminar at a university or other academic institution or a keynote lecture at a conference	5 points
Editorial work for academic journals	
Editor	3 points for each year
Associate editor	2 points for each year

* German universities offer two types of doctoral theses; the more advanced one gives more points.

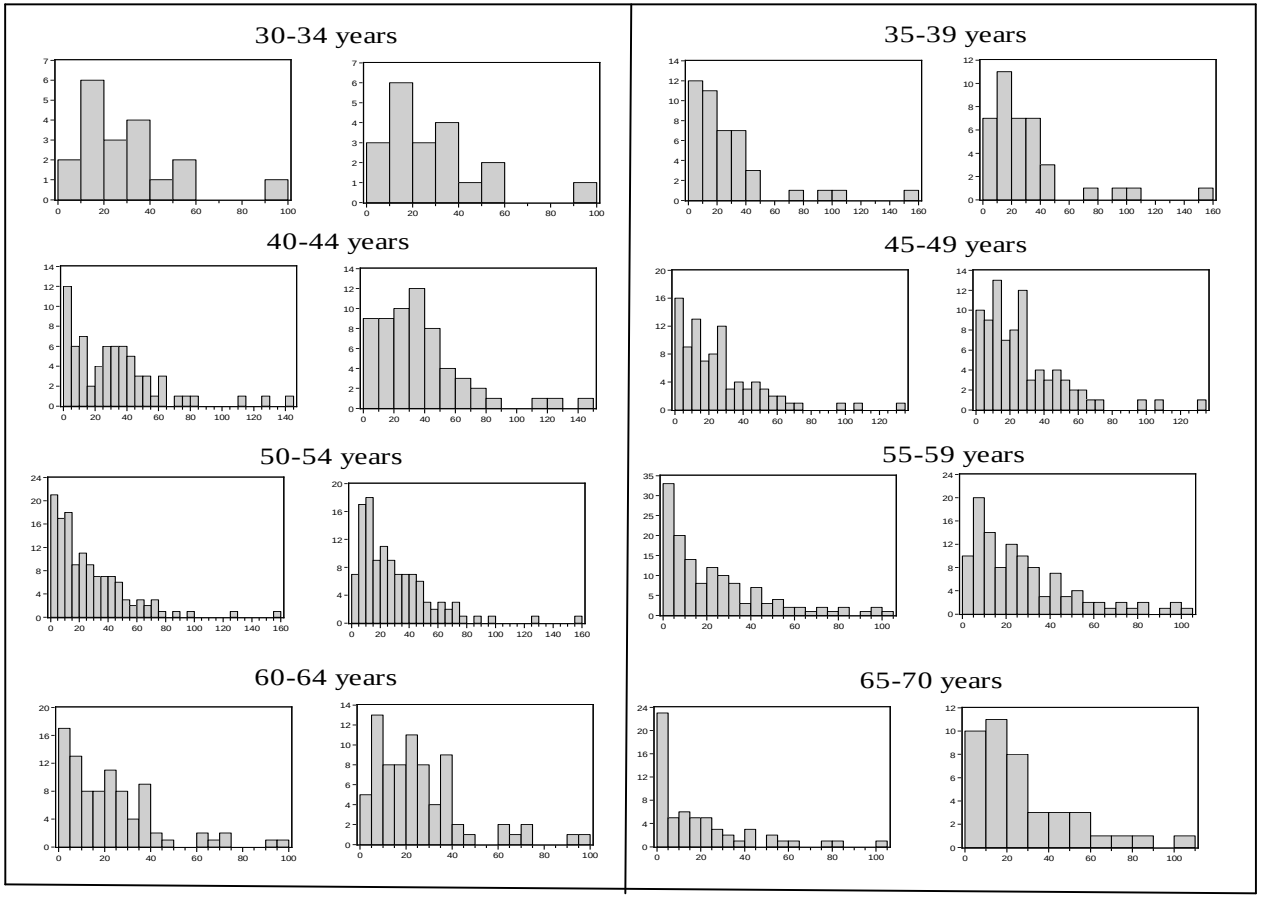
Table AII-1. **Summary of data – Departments**

Schools	Departments	Staff members	Men	Women	Average age	Research output - average points -	Research output - standard deviation -
Social sciences	Social and human sciences	22	10	12	51.7	38.6	17.0
	Social work	7	1	6	51.0	24.2	15.4
	Economics	15	14	1	45.8	33.6	31.6
	Law	25	17	8	46.1	27.7	26.0
	Political science	7	7	0	50.1	40.6	25.1
	Business Administration	18	15	3	50.7	13.1	13.2
Health sciences	Nursing	29	3	26	50.7	18.6	21.8
	Pharmaceutical sciences	9	4	5	46.4	19.6	21.7
	Medicine	110	77	23	54.8	17.1	22.9
	Food science and nutrition	9	6	3	51.6	36.7	36.9
	Psychology	11	9	2	50.7	33.4	30.3
	Odontology	17	15	2	54.6	16.6	34.3
Humanities	Languages, literature and linguistics	19	8	11	50.7	16.7	16.4
	Theology and religious studies	10	8	2	54.4	18.4	16.8
	Icelandic and comparative cultural studies	29	15	14	52.7	31.9	30.7
	History and philosophy	26	20	6	53.5	39.3	25.7
Education	Sport, leisure studies and social education	11	5	6	47.1	21.0	17.3
	Teacher education	70	28	42	56.3	20.4	20.4
	Educational studies	25	18	7	54.9	30.2	26.8
Engineering and Natural Sciences	Industrial-, mechanical engineering and computer science	21	19	2	49.0	21.1	18.8
	Earth sciences	8	7	1	60.3	36.4	17.3
	Life and environmental sciences	31	17	14	51.3	27.1	18.3
	Electrical and computer engineering	10	9	1	49.2	33.6	34.1
	Physical sciences	42	41	1	53.5	20.6	26.2
	Civil and environmental engineering	15	14	1	51.6	37.4	28.1

Table AII-2. Summary of data – Institutes

Institutes	All staff	Men	Women	Average age	Research output - average points -	Research output - standard deviation -
The Árni Magnússon Institute for Icelandic Studies	14	10	4	57.6	29.4	21.3
Institute for Experimental Pathology, University of Iceland	10	3	7	57.7	18.7	13.1
Science Institute	26	19	7	49.2	34.4	36.8
Other institutes	4	4	0	43.5	11.7	4.4

Figure AII-1. The distribution of output for different age groups



The left-hand panel shows the distribution of research output when everyone is included while the right-hand side panel show the distribution when the research inactive have been removed from the sample

INSTITUTE OF ECONOMIC STUDIES WORKING PAPERS 1987-2009
Formerly Iceland Economic Papers Series

Editor Sveinn Agnarsson

A complete list of IoES Working Papers and Reprints can be accessed on our World Wide Web site at http://www.ioes.hi.is

W09:10 Yu-Fu Chen and Gylfi Zoega: Strong hysteresis due to age effects.

W09:09 Yu-Fu Chen and Gylfi Zoega: An essay on the generational effect of employment protection.

W09:08 Anna Gunnthorsdottir, Roumen Vragov and Jianfei Shen: Tacit coordination in contribution-based grouping with two endowment levels.

W09:07 Axel Hall and Gylfi Zoega: Working in spite of High Taxes: On the Role of Culture in Explaining High Employment in the Nordic Countries.

W09:06 Gylfi Zoega: Employment and asset prices.

W09:05 Gylfi Zoega: Market forces and the continent's growth problem.

W09:04 Gylfi Zoega: A double-edged sword: High interest rates in capital-control regimes.

W09:03 Jon Danielsson and Gylfi Zoega: The collapse of a country.

W09:02 Manoj Atolia, Tor Einarsson and Milton Marquis: Understanding liquidity shortages during severe economic downturns.

W09:01 Thorolfur Matthiasson: Spinning out of control: Iceland in crisis.

W08:07 Ragnar Arnason: Natural resource rents: Theoretical clarification.

W08:06 Axel Hall and Gylfi Zoega: Feminism and labour supply in the Nordic countries.

W08:05 Gylfi Zoega: Productivity, wages and relationships.

W08:04 Thrainn Eggertsson: Knowledge and economic progress: The role of social technologies.

W08:03 Thrainn Eggertsson: Genetic technology and the evolution of property rights: The case of Decode Genetics.

W08:02 Tinna Laufey Asgeirsdottir and Gylfi Zoega: Sleeping.

W08:01 Thorvaldur Gylfason: Development and growth in mineral-rich countries.

W07:14 Ragnar Arnason: Fisheries enforcement with a stochastic response function.

W07:13 Thorvaldur Gylfason and Eduard Hochreiter: Growing apart? A tale of two republics: Estonia and Georgia.

W07:12 Thorolfur Matthiasson: Economic gain from education in Iceland during the period 1985 to 1999.

W07:11 Alison L. Booth and Gylfi Zoega: Worker heterogeneity, new monopsony and training.

W07:10 Yu-Fu Chen and Gylfi Zoega: Aging and job security.

W07:09 Ron Smith and Gylfi Zoega: Keynes, investment, unemployment and expectations.

W07:08 Thorolfur Matthiasson and Claire W. Armstrong: Effects of foreshortening of transferred quota in an ITQ market.

W07:07 Helgi Tomasson: Likelihood based surveillance of continuous-time processes.

W07:06 Helgi Tomasson: Review of Econometric Modeling Approaches in Finance.

W07:05 Anna Gunnthorsdottir, Roumen Vragov, Kevin McCabe and Stefan Seifert: The meritocracy as a mechanism to overcome social dilemmas.

W07:04 Gylfi Zoega: Endogenous employment cycles in Euroland.

W07:03 Thorvaldur Gylfason: The international economics of natural resources and growth.

W07:02 Helga Kristjansdottir: Talking trade or talking aid? Does investment substitute for aid in the developing countries?

W07:01 Ali Choudhary, Thorlakur Karlsson and Gylfi Zoega: Testing for customer markets using survey data.

W06:13 Brynhildur Davidsdottir: Sustainable energy development.

W06:12 Helga Kristjansdottir: Substitution between inward and outward foreign direct investment.

W06:11 Helga Kristjansdottir: Evaluation of Icelandic trade flows, the gravity model approach.

W06:10 Brynhildur Davidsdottir: Capital constraints and the effectiveness of environmental policy.

W06:09 Gylfi Zoega: Market forces and the continent's growth problem.

W06:08 Fridrik M Baldursson and Nils-Henrik M von der Fehr: Vertical integration and long-term contracts in risky markets.

W06:07 Ragnar Arnason: Conflicting uses of marine resources: Can ITQ's promote an efficient solution?

W06:06 Thorvaldur Gylfason and Gylfi Zoega: A golden rule of depreciation.

W06:05 Ron Smith and Gylfi Zoega: Global factor, capital adjustment and the natural rate.

W06:04 Thorolfur Matthiasson: To whom should the rent accrue?

W06:03 Tryggvi Thor Herbertsson and Gylfi Zoega: Iceland's Currency Dilemma.

W06:02 Thorolfur Matthiasson: Possible stakeholder conflicts in quota regulated fisheries,contribution to the political economics of fisheries.

W06:01: Eyjolfur Sigurdsson, Kristin Siggeirsdottir, Halldor Jonsson jr , Vilmundur Gudnason, Thorolfur Matthiasson, Brynjolfur Y Jonsson:Early discharge and home intervention reduces unit costs after total hip replacement: Results of a cost analysis in a randomized study.

W05:14 Gylfi Zoega and J Michael Orszag: Are Risky Workers More Valuable to Firms?

W05:13 Friðrik Már Baldursson: Fairness and pressure group competition.

W05:12 Marias H. Gestsson and Tryggvi Thor Herbertsson: Fiscal Policy as a Stabilizing Tool.

W05:11 Tryggvi Thor Herbertsson and Gylfi Zoega: On the Adverse Effects of Developement Aid.

W05:10 Thráinn Eggertsson and Tryggvi Thor Herbertsson: Evolution of Financial Institutions: Iceland's Path from Repression to Eruption.

W05:09 Tryggvi Thor Herbertsson: The Icelandic Pension System in 2004.

W05:08 Ron Smith and Gylfi Zoega: Unemployment, investment and global expected returns: A panel FAVAR approach.

W05:07 Gylfi Zoega and Thorlakur Karlsson: Does Wage Compression Explain Rigid Money Wages?

W05:06 Thorvaldur Gylfason: India and China

W05:05 Edmund S. Phelps: Can Capitalism Survive?

W05:04 Thorvaldur Gylfason: Institutions, Human Capital, and Diversification of Rentier Economies

W05:03 Jón Daníelsson and Ásgeir Jónsson: Countercyclical Capital and Currency Dependence

W05:02 Alison L. Booth and Gylfi Zoega: Worker Heterogeneity, Intra-firm Externalities and Wage Compression

W05:01 Tryggvi Thor Herbertsson and Martin Paldam: Does development aid help poor countries catch up?

W04:12 Tryggvi Thor Herbertsson: Personal Pensions and Markets

W04:11 Fridrik M. Baldursson and Sigurdur Johannesson: Countervailing Power in the Icelandic Cement Industry

W04:10 Fridrik M. Baldursson: Property by ultimatum: The case of the Reykjavik Savings Bank

W04:09 Ingólfur Arnarson: Analyzing Behavior of Agents of Economic Processes in Time

W04:08 Otto Biering Ottosson and Thorolfur Matthiasson: Subsidizing the Icelandic Fisheries

W04:07 Niels Vestergaard and Ragnar Arnason: On the Relationship between Greenland's Gross Domestic Product and her Fish Exports: Empirical Estimates

W04:06 Ingolfur Arnarson: Modelling Fishery Management Schemes with an Olympic System Application

W04:05 Ingolfur Arnarson and Pall Jensson: Adding the Sales Markets Dimension to Bio-Economic Models. The Case of Fishery Management

W04:04 Edmund S. Phelps: Changing Prospects, Speculative Swings: Structuralist Links through Real Asset Prices and Exchange Rates

W04:03 Ingolfur Arnarson: Analysing Behavior of Agents of Economic Processes in Time

W04:02 Ron Smith and Gylfi Zoega: Global Shocks and Unemployment Adjustment

W04:01 Fridrik M. Baldursson and Nils-Henrik M von der Fehr: Prices vs. quantities: public finance and the choice of regulatory instruments

W03:07 Sveinn Agnarsson and Ragnar Arnason: The Role of the Fishing Industry in the Icelandic Economy. A historical Examination

W03:06 Thorolfur Matthiasson: Paying paper by paper, the wage system of Icelandic University teachers explained

W03:05 Gur Ofur and Ilana Grau: Bringing the Government hospitals into line: The next step of reform in the healthcare sector

W03:04 Ingolfur Arnarson and Pall Jensson: The Impact of the Cost of the Time Resource on the Efficiency of Economic Processes

W03:03 Torben M. Andersen and Tryggvi Thor Herbertsson: Measuring Globalization

W03:02 Tryggvi Thor Herbertsson and J. Michael Orszag: The Early Retirement Burden: Assessing the Costs of the Continued Prevalence of Early Retirement in OECD Countries

W03:01 Eirik S. Amundsen, Fridrik M. Baldursson and Jørgen Birk Mortensen: Price Volatility and Banking in Green Certificate Markets

W02:10 Tryggvi Thor Herbertsson and Gylfi Zoega: A Microstate with Scale Economies: The Case of Iceland

W02:09 Alison, L. Booth and Gylfi Zoega: Is Wage Compression a Necessary Condition for Firm-Financed General Training

W02:08 Asgeir Jonsson: Exchange rate interventions in centralized labor markets

W02:07 Alison, L. Booth, Marco Francesconi and Gylfi Zoega: Oligopsony, Institutions and the Efficiency of General Training

W02:06 Alison L. Booth and Gylfi Zoega: If you're so smart, why aren't you rich? Wage inequality with heterogeneous workers