Present-biased preferences and optimal compensation schedules: a note

Battisti, Michele

Ifo Institute at the University of Munich

13 May 2015

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Michele Battisti
ifo Institute
battisti@ifo.de

Friday 5th June, 2015

Abstract

This paper presents a very simple model with present biased agents where optimal compensation schedules may be back-loaded, which is a characteristics of wage contracts we often observe in reality. There is large evidence that workers are often paid less than their marginal productivity early in their careers, and more than their marginal productivity later. In this model, back-loaded wage schedules emerge as a commitment device that allows to prevent sub-optimal consumption and labor supply patterns.

*The author would like to thank David Andolfatto and the participants of the PhD seminar at Simon Fraser University for very helpful comments and discussions. Financial support by the Leibniz Association (SAW-2012-ifo-3) is gratefully acknowledged. All remaining errors are mine.

1 Introduction

In a standard perfectly competitive labor market with full information, workers are paid their marginal productivity at each point in time. However, there is substantial evidence that is not consistent with this: the slope of wage profiles tends to be steeper than that of a worker's productivity. Wages are often lower than productivity early in a job spell and in a worker's career and higher than productivity later. This regularity has been referred to as the *overtaking anomaly* (Smith, 2009). While some explanations for this phenomenon exist in the literature, they do not seem to match the empirical evidence available within a parsimonious and general set of assumptions.

This short paper develops an extremely simple model with imperfect capital markets and where the representative agent has present-biased preferences (Laibson, 1994), and looks at the implication of this type of hyperbolic discounting on equilibrium wage profiles. The goal of the model is the provide a first outline of the basic mechanism at work; future work may generalize and enrich the theoretical environment. The main insight of this paper is that back-loaded wage profiles can appear in equilibrium as a commitment device for time inconsistent agents, who would otherwise choose labor supply patterns that are ex ante sub-optimal. A long-term wage contract that includes deferred wages allow time inconsistent agents to discipline their own future behavior, and in particular labor supply and consumption patterns. Even institutions such as mandatory retirement and actuarially unfair pension plans (Frey and Jegen, 2001) may be seen as optimal commitment devices to prevent the agent to consume 'too much' and work 'too little' (from from an ex ante perspective) early in her career. It is well recognized that time inconsistent agents have a demand for commitment. To the best of my knowledge, however, the consequences of time inconsistency for optimal dynamic wage contracts was not previously analyzed.

There is very solid evidence that wages increase in seniority. This phenomenon however, is likely to be at least partly driven by firm-specific human capital accumulation that affects productivity as well. The overtaking anomaly instead concerns wage increases that go beyond productivity gains. Useful evidence must therefore rely on some measure of productivity. Given the complexity of measuring productivity, this is harder to assess. The evidence may be divided into direct evidence on preferences for increasing wage profiles, and indirect evidence on observed wage and productivity patterns. Loewenstein and Sicherman (1991) present direct survey evidence on preferred wage profiles. The modal choice of the respondents of their survey is a moderately-increasing wage profile, rather than flat or decreasing wage profiles of the same present value. Duffy and Smith (2013) and Smith (2009) summarize the evidence for preferences for increasing wages. While this evidence is largely non experimental, it does suggest that the fact that we observe wages increasing faster than productivity in reality, may not simply depend on informational and incentive considerations.

A number of different studies from separate streams of the literature are useful to understand the empirical relevance of the overtaking anomaly. Earlier studies focus on specific sectors where productivity can be measured. Medoff and Abraham (1980) use data from two major US corporations, and find wages rising faster than productivity, which they proxy with the quality of supervisor's evaluations. Frank and Hutchens (1993) analyze the wage structures in place for commercial airline pilots and intercity bus drivers. In both cases wages are sharply increasing in seniority. These occupations provide very insightful evidence since they represent cases where productivity or incentive considerations are unlikely to be very important. Using US data from two large companies that include weekly output per worker, Lazear (1999) also finds evidence of productivity-unrelated wage increases. Flabbi and Ichino (2001) look at the case of a large Italian commercial bank and find that on-the-job tenure increases wages, while productivity appears to decline.

Some recent papers use rich matched employer-employee datasets to offer additional evidence of the existence of back-loaded wage schemes across the labor market. The advantage of using large matched employer employee datasets is that one can control for unobserved heterogeneity at the individual and firm level because individuals are followed over time across establishments. It is thereby possible to estimate worker productivity without observing it directly. Using US panel data, Hellerstein and Neumark (2007) find evidence of backloaded wage payment schemes estimating productivity from firm-level production functions. Fukao et al. (2006) estimate wage-tenure and productivity-tenure profiles for Japan. They find that the estimated wage-tenure profile has a higher slope than the productivity-tenure profile and that wages are lower than productivity at low levels of tenure, and are higher than productivity at higher levels of tenure. Dostie (2011), using Canadian data, also finds evidence of wage increases that are not consistent with productivity patterns, in particular for older high skilled workers.

Researchers have put forward a number of explanations for these findings. Existing theories can be roughly divided into those focusing on agency dynamics in the context of asymmetric information and moral hazard, and those postulating that there may be direct preferences for increasing wage profiles. Probably the most commonly-cited explanations for delayed payment contracts is within the early agency theory literature. In the context of costly monitoring of individual effort, Lazear (1981) and Lazear (1999) develop models where a wage contract that entails deferred payments can ensure higher levels of efforts by the agent by increasing the cost of shirking, while making it cheaper for the firm to monitor. In a related contribution, Salop and Salop (1976) present a model where employers face firing costs and workers are of different types, which are private information of the workers and represent different exogenous probability of quitting. An increasing wage profile can emerge as an optimal device for screening workers of different types. A mechanism that is key to this literature is that stochastic monitoring of individual effort is possible and can result in dismissal of the worker. Delayed wages will not occur if workers can be monitored perfectly, or if firing costs are very high.

Behavioral theories, such as Loewenstein and Sicherman (1991), focus on the role of preferences for the emergence of increasing wag contracts. Loewenstein and Sicherman (1991) argue that workers may exhibit a preference for increasing wage profiles even at the cost of a lower present value, discussing a number of possible reasons why that may be the case. Some of the proposed explanations include deriving utility from the feeling of mastery associated with increasing wages, utility from anticipation, irrational "errors". Frank and Hutchens (1993) assume that agents have inherent preferences for increasing consumption streams and thus for increasing payments, i.e. exhibit negative discounting. However, there is very large evidence that this assumptions does not hold empirically in many different contexts. Reference-dependent preferences may result in a preference for wage increases, as in Grund and Sliwka (2007). Cabrales et al. (2008) show that a model in which workers have social preferences may generate “productivity-unrelated wage increase”. Workers experiencing productivity declines will have their wages increased. Smith (2009) postulate workers' costs of effort to be higher when previous wages were lower, driven by individual cognitive dissonance playing a role in their choices.

The model below discusses the consequences of present-biased preferences for optimal wage schedules. This offers a very parsimonious explanation of the *overtaking anomaly*. It does not rely on informational asymmetries, which confines the relevance of the overtaking anomaly to specific contexts, which are hard to reconcile with its broad empirical relevance. It also does not add arguments to the utility function in order to derive the results. I specify preferences similarly to Laibson (1994) and O'Donoghue and Rabin (1999). A present-biased preference structure is a special case of the larger family of preferences exhibits hyperbolic discounting, i.e. preferences by which the agent discounts two subsequent periods different depending on how far in the future they are. There is large empirical support from the lab and the field for non-exponential time discounting. Meier and Sprenger (2010) conduct a large field study to investigate the stability of preferences. They find that over a third of the participants exhibit behavior consistent with hyperbolic discounting. Ashraf et al. (2006) find similar proportions of present-biased individuals, and offer also a detailed review of the relevant literature.

2 The model

This section develops a very simple model in which agents' preferences may not satisfy the assumption of a constant discount factor. The analysis then derives optimal compensation schedules for the time consistent and time inconsistent cases.

2.1 Agent owning and operating

I first consider an economy made up of only one agent. There are three periods $t = 1, 2, 3$. The usual technicality of treating an agent that may have time inconsistent preferences as a series of different time-dated agents is adopted here for simplicity. In other words, the model below can be interpreted as a model where agents live for one period only and have preferences over consumption levels of future agents, as in a standard model with dynasties.

Preferences The goal of the assumption on preferences is to keep the analytics as simple as possible, while isolating the dynamics that are of interest and providing the key insight. A more general model is left for future research. Agent 3 (living at time $t = 3$ has preferences:

$$u(c_3) \tag{1}$$

Agent 2 has preferences:

$$u(c_2) - \alpha n_2 + \delta u(c_3) \tag{2}$$

Agent 1 (alive in period $t = 1$) has preferences:

$$-\alpha n_1 + u(c_2) - \alpha n_2 + u(c_3) \tag{3}$$

where c_j denotes the consumption allocated to agent $j = 1, 2, 3$ and $n_j \in \{0, 1\}$ is the labor expended by agent $j = 1, 2$. This structure is simplified here, its purpose is simply to illustrate the basic insight of the paper in the simplest way. Assume that $0 \leq \delta \leq 1$ and that at $t = 3$ the agent cannot work, so that $n_3 = 0$ by assumption. Assume also that $u'' < 0 < u'$ and that $u(0) = -\infty$. Note that unless $\delta = 1$ these preferences imply that the discount factor between period 2 and period 3 is different according to the preferences of agent 1 and agent 2. Allowing agent 1 to be present biased as well, or including c_1 in the utility function of agent 0 would not qualitatively change any of the results below. Both are assumed purely for convenience.[1]

Technologies There is a production technology $f(n) = yn$ and a storage technology with no depreciation, such that output can be carried from one period to the next at no cost.[2]

Agent 1 in full control In this section, we assume that there is a commitment technology available to agent 1. Agent 1 choice problem involves the maximization of (3) subject to

$$\begin{aligned} c_3 + s_3 &\leq s_2 \\ c_2 + s_2 &\leq yn_2 + s_1 \\ c_1 + s_1 &\leq yn_1 \end{aligned}$$

where $s_j \geq 0$ denotes output stored at date j, $j = 1, 2, 3$. By monotonicity of the utility function, the constraints above will be satisfied with equality in equilibrium. By (1), any solution will have $s_3 = 0$ and $c_1 = 0$, and thus $c_3 = s_2$ and $s_1 = yn_1$.

Using these results and substituting the constraints into the objective function the problem of agent 1 is then equivalent to choosing present and future optimal labor supply:

$$\max_{n_1, n_2} \left[-\alpha n_1 + u(yn_2 + yn_1 - s_2) - \alpha n_2 + u(s_2) \right] \tag{4}$$

Assume that α is sufficiently small so that $(n_1, n_2) = (1, 1)$ is optimal from the perspective of agent 1.[3] Then, the optimal choice for s_2, namely s_2^*, is characterised by $u'(2y - s_2^*) = u'(s_2^*)$ so that

$$s_1^* = s_2^* = y \tag{5}$$

$$c_2^* = c_3^* = y \tag{6}$$

equating consumption between period 2 and period 3.

Sequentially-rational solution Let us now consider the case in which agent 1 cannot commit to an intertemporal plan for consumption and labor supply. The solution thus needs

[1] Equivalent, one could add a fourth initial period in which the contract is signed but no labor is supplied.

[2] One could assume that there is a credit market with zero interest rate and that the agents faces a borrowing constraint.

[3] Welfare statements in a world of time inconsistency depend on the relative weights given to the different time-dated agents.

to be sequentially rational, i.e. needs to be the result of a maximisation program of agent 2 and agent 3, as well as agent 1. We therefore need to apply backward induction. At $t = 3$ agent 3 is in control. She will optimally (and trivially) choose to consume whatever is available, so that $\hat{c}_3 = s_2$, obtaining a payoff of $u(s_2)$. At $t = 2$ agent 2 is in control and takes s_1 as given. Conditionally on n_2, the problem of agent 2 is:

$$v(s_1, n_2) \equiv \max_{s_2} u(s_1 + yn_2 - s_2) - \alpha n_2 + \delta u(s_2) \tag{7}$$

with the solution satisfying $u'(s_1 + yn_2 - \hat{s}_2) = \delta u'(\hat{s}_2)$. Clearly, this solution is different from s_2^* that agent 1 would choose. First of all, even conditional on $n_2 = 1$, $\hat{c}_2 > \hat{c}_3$ insofar as $\delta < 1$. Secondly, the choice of $n_2(s_1)$ need also to be considered. If s_1 is sufficiently large, agent 1 may choose $n_2 = 0$. Assume that for $s_1 = y$ this is the case. Even agent 1 may then decide not to work to elicit $n_2 > 0$. In other words, even if α is sufficiently small so that $(n_1, n_2) = (1, 1)$ is optimal from agent 1 perspective, this need not be the case for agent 2. Irrespective of $\hat{n}_2$, the sequentially optimal solution is

$$\hat{s}_1 = y \tag{8}$$
$$\hat{c}_2 > \hat{c}_3 \tag{9}$$

Therefore, the sequentially-rational solution for this economy is suboptimal from the perspective of agent 1 (and that of agent 3). This in turn implies that agent 1 has a demand for a commitment technology: agent 1 is willing to pay for a technology that distorts agent 2's choices away from the sequentially rational equilibrium towards the equilibrium in equation (6). Below, I provide an example of how such a technology may look like.

2.2 One worker, one firm

Agent 1 can pass control of the production technology to another agent (the firm) by making a take-it-or-leave-it offer. The firm then hires agent 1 for a wage schedule $(w_1, w_2(n_2), w_3(n_2))$. Assume that the firm can commit to the offered wage schedule. Agent 1, on the other hand, cannot commit to work in the future, so that the equilibrium wage schedule needs to be sequentially rational. Wage payments are inalienable, and thus that future wage payments cannot be used as collateral. Consider the following *back-loaded* wage schedule:

$$\left\{ \begin{array}{c} w_1 = 0 \\ w_2(n_1 = 1, n_2 = 1) = w_3(n_1 = 1, n_2 = 1) = y \\ w_2(n_1 = 0 \ \vee \ n_2 = 0) = w_3(n_1 = 0 \ \vee \ n_2 = 0) = 0 \end{array} \right\} \tag{10}$$

This wage schedule is feasible, in the sense that it lies within the production possibility set of this economy. Next, I check whether it is desirable from the perspective of agent 1, and sequentially rational. At time $t = 1$, agent 1 faces the same problem as in the scenario of full control analyzed above. He will therefore set $n_1 = 1$ to avoid losing future wage payments.[4]

[4]In case of $n_0 = 0$ we should consider renegotiation of the wage contract at time $t = 1$. This can be ignored by observing that this wage schedule reaches the first best for agent 1, and so deviations cannot be welfare-improving from the perspective of agent 1.

At time $t = 2$, agent 2 works and consumes the received wage y completely. At time $t = 3$, agent 3 receives y as wage (pension) payment, and consumes it all.

The allocation obtained is the same as that obtained as the solution to the problem where agent 1 is in full control, equation (6). It is therefore optimal from the perspective of agent 1. As a consequence, agent 1 will decide to pass control of the production technology to the firm. Note that inalienability of wages is optimal from the perspective of agent 1, as it prevents agent 2 from over-consumption through borrowing.

Time consistent case For $\delta = 1$, the wage schedule analyzed above is feasible and (weakly) optimal. In fact, a *quasi-Ricardian* results hold, by which the "first-best" allocation (from the perspective of agent 1) can be achieved with a wide variety of contracts:

$$\left\{ \begin{array}{c} w_1 + w_2(n_1 = 1, n_2 = 1) + w_3(n_1 = 1, n_2 = 1) = 2y \\ w_1 + w_2(n_1 = 1, n_2 = 1) \geq y \end{array} \right\} \tag{11}$$

Optimal wage schedules in this case can be front-loaded, constant, or back-loaded. The first row of equation (11) represents the usual Ricardian result. The second row of equation (11) adds a second condition, which comes from the inalienability of wages: excessively backloaded wages cannot be optimal. The same allocation can also be achieved with the agent operating the firm directly. Therefore, in the case of $\delta = 1$ at time $t = 1$ agent 1 is just indifferent between passing the control of the production technology to the firm, or operating the technology, having no demand for commitment.

Time inconsistent agent Equation (10) is the unique wage schedule that achieves agent-1's first best in the case of $\delta < 1$. Every other wage schedule that is optimal for $\delta = 1$ results in $c_2 > c_3$, which is sub-optimal from the perspective of agent 1. This uniqueness result holds for any $\delta < 1$, which means that any arbitrarily small degree of time inconsistency results in a back-loaded wage schedule as the unique optimal compensation schedule.

The wage schedule in (10) provides incentive for agent 2 to work, and provides an upper bound on agent 2's consumption. This result is an illustration of the *overtaking anomaly.* Under (10), the worker is paid less than her productivity early in his career, the same as her productivity at some point in her career and more than her productivity in the end of his/her career (one can think of $t = 3$ in the model as retirement). The wage profile presented above relies on the ability by the worker to make a take-it-or-leave-it offer to pass control to the firm at $t = 1$. This is equivalent to assuming that the worker has all of the bargaining power and the firm has none. If this assumption does not hold, the firm will be able to exploit the demand for commitment and can offer a wage contract that has lower life-time wages but will nevertheless be accepted by the worker. Ceteris paribus, for a non-degenerate bargaining share, the larger is the time inconsistency problem of the agent, the larger will be the expected profit of the principal, because the agent is willing to pay more for the commitment device he is offered. Calculating equilibrium wage contracts for different assumptions on the market structure is beyond the scope of this short paper.

3 Concluding Remarks

This paper introduces a very simple model offering an explanation for the *overtaking anomaly*, i.e. the tendency for wages to increase more than productivity during a worker's career. Time inconsistent agents will accept back-loaded wage schedules with lower present value as a commitment device that helps them choose the ex-ante optimal labor supply and consumption levels. This result has been derived for a one-agent economy, and then generalized to a context where the presence of a firm is derived endogenously, as a response to a demand for commitment by agents. The first-best (from the perspective of the initial agent) can then be achieved as a sequential equilibrium. In the scenario analyzed here, even a negligible degree of time inconsistency can generate back-loaded wage profiles, and positive expected profits for the firm. The expected profits of the firm depend positively on the degree of time inconsistency of the agent. Illiquid assets such as publicly managed pension plans and mandatory retirement age may be viewed an extreme example of deferred compensation. Back-loaded wages prevent excessive consumption as well as from insufficient labor supply. The goal of this note was to present the simplest explanation of this mechanism. More rigorous modeling and complex applications are left for future research.

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