The Prevalence of Negative Incentives in Contracts and Non-Expected Utility

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Abstract

Loss aversion has become the dominant alternative to rational theory. The setting of base wages in production contracts provides an interesting application of referenced based decision theory. The predictions of loss aversion depend critically on whether reservation opportunities are evaluated with respect to the reference point implied in the contract, or in a way independent of this reference level of pay. While a few producers use negative incentives prominently, average payouts are above the base wage for the crops we examine on the whole, supporting the notion that reservation opportunities are evaluated independent of reference points. The standard expected utility model is clearly empirically dominated by the loss aversion model.

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In practice, incentive contracts consist typically of a base level of pay, and some schedule of rewards and penalties based upon performance objectives. In fact, it would be difficult to construct a performance based contract without setting some reference level of performance, and payout. While much attention has been focused on the proper structure of marginal incentives, no mention has been made of how principals may set base payouts to maximize their own expected profit (or utility of profit).

There is good reason for ignoring such a topic. Standard contract theory employs expected utility, which has as its foundation that there is a well defined level of utility associated with each possible level of wealth. In this context, reference points should not matter so long as the amount of pay is the same for each level of performance. For example, a piece rate scheme paying 5 cents per piece should, according to standard theory, produce the same work level and profit levels as paying $20 for 400 minus a penalty (premium) of 5 cents for each piece under (over) 400. In this example, the second contract simply draws attention to a specific performance level, without changing the incentive structure. Because expected utility cannot assign different levels of utility to a single level of wealth, it cannot differentiate between these two contract schemes.

More and more, behavioral economic research has found that reference points can be very important in driving individual behavior. For example, Kahneman and Tversky (1979) find that below one's reference level of wealth, individuals are more likely to behave as if risk loving. Due to the structure of production relationships, production contracts may provide a natural field to test the theories relating to reference points, risk and choice. If individual choice is dependent upon reference wealth cues, then firms using contract production should take advantage of this *costless* mechanism to enhance production quality. On the other hand, if there is no evidence of the manipulation of reference points in practice, it may be that such effects are small, and only detectable in special circumstances (such as those found in laboratory experiments).

In this paper we explore the theory of reference points and the implications for principal agent problems. If all outcomes of a contract, and all possible alternative opportunities are evaluated with respect to the reference point implied by the base pay included in the contract, then principals should design contracts that have average payouts below the base pay. Alternatively, if reference points only apply within the context of the contract, allowing alternative opportunities to be evaluated independent of the base pay, the principal should offer positive incentives. Some discussion is given to the presence of multiple incentives. We use existing production contracts to demonstrate evidence of reference manipulation in practice, demonstrating the systematic use of rewards.

Literature Review

The notion of moral hazard, or business relationships involving hidden actions by one party that may affect another, was originally applied to the field of insurance. In the insurance context, possession of insurance policies may induce more risky behavior. More recently the theory has become a popular tool in describing the production of goods (e.g. Hueth and Ligon, 2002).

In the context of production, a worker may be hired to produce some good for sale. However, if it is costly or difficult for the employer (principal) to monitor the effort level of the worker, then the worker (agent) may decide on a level of effort that is less than optimal from the point of view of the principal. In lieu of observing effort level directly, the principal may be able to observe some noisy signal of effort level, such as the number of goods produced, or the quality of those goods. A standard moral hazard contract model using expected utility theory employs a risk neutral or risk-averse principal and a risk-averse agent (see for example Macho-Stadler and Perez Castillo, 1997). The agent's problem is typified by

$$\max_{e} \int U\left(w(\tilde{q})\right) h(\tilde{q} \mid e)\, d\tilde{q} - z(e),$$

where $U(\cdot)$ is the agent's utility of wage, $z(e)$ is the cost of exerting effort e, $\tilde{q}$ is a random signal of effort, in this case quality of production, $h(\cdot \mid \cdot)$ is the probability density of that signal conditional on effort level, and w is the wage awarded by the contract determined by the measured signal. Given that the conditional distribution of q satisfies the monotone likelihood ratio condition and the convexity of the distribution function (Rogerson, 1985), and costs are well behaved, this will be solved where

$$\int U\left(w(\tilde{q})\right) h_e(\tilde{q} \mid e)\, d\tilde{q} - z_e(e) = 0.$$

There are several methods proposed to solve the principal's problem. The simplest solution to the principal's problem (although it requires several caveats) is obtained through the first order approach. This approach supposes the principal simply includes the agent's own decision rule as a constraint in the design of the contract. The principal thus faces the problem

$$\max_{e, \{w(\tilde{q})\}} \int V\left(p(\tilde{q}) - w(\tilde{q})\right) h(\tilde{q} \mid e)\, d\tilde{q},$$

subject to

$$\int U\left(w(\tilde{q})\right)h(\tilde{q}\,|\,e)\,d\tilde{q}-z(e)\geq \underline{U}\,,$$

and

$$\int U\left(w(\tilde{q})\right)h_e(\tilde{q}\,|\,e)\,d\tilde{q}-z_e(e)=0\,,$$

where $V(\cdot)$ is the utility of profit function of the principal, p is the price of the marketable good as a function of quality, and $\underline{U}$ is the reservation utility level of the agent. The solution to this problem is characterized by the following expression

(1) $$\frac{V'\left(p(\tilde{q})-w(\tilde{q})\right)}{U'\left(w(\tilde{q})\right)}=\theta+\mu\frac{h_e(\tilde{q}\,|\,e)}{h(\tilde{q}\,|\,e)}\,,$$

where μ and θ are non-negative.

From (1) we may derive many of the properties of the wage, quality relationship. While this contract is useful in discussing the risk sharing effects of contracts, and the effects of moral hazard on efficiency, some phenomena are not explained by the rational theory. For example, most contracts specify some base pay, several deductions for poor performance, and several premia for good performance. In the context above, the contract may look like

$$w(\tilde{q})=\underline{w}+f\left(\tilde{q}-\underline{q}\right),$$

where f is a non-negative valued function, $\underline{w}$ is the lowest possible wage, and the support of $\tilde{q}$ is given by $\left[\underline{q},\overline{q}\right]$. The standard theory suggests no specific reason to use a premium rather than a deduction, as the same utilities and payoffs can be achieved using either. For example, if the above contract were optimal and represented a premium paid for good performance, then we could define $\overline{w}=\underline{w}+f\left(\overline{q}-\underline{q}\right)$, and the contract

$$w(\tilde{q}) = \overline{w} - \left[\overline{w} - \left(\underline{w} + f\left(\tilde{q} - \underline{q}\right)\right)\right] = \overline{w} - g\left(\overline{q} - \tilde{q}\right),$$

would yield the same payoff to both parties in all cases.

Despite the fact that theory suggests no particular reason for the use of premia or deductions, there appears to be significant thought and gaming involved in choosing the base level of pay on production contracts. Hueth and Ligon (2002) note that while some processing tomato production contracts contain special premia written in processor specific contracts, the boilerplate contracts used for all tomato farmers contain only deductions. Curtis and McCluskey (2003) find a mix of premia and deductions used in production of processing potatoes. Because so much thought and care goes into designing premium/deduction schedules on contracts, we suppose there may be some behavioral phenomena that help determine the structure of contracts. Several behavioral models may lead to the use of specific base rates. The model that has had the greatest impact on the profession, and has been applied most ubiquitously, seems a good starting point to describe such a phenomenon. We propose that loss aversion on the part of the agent may drive the structure of premia and deductions, allowing the principal to obtain greater effort through manipulating the agent's reference payoff.

Loss aversion has become the preferred behavioral model to describe behavior dealing with risk. Kahneman and Tversky first proposed loss aversion as part of their prospect theory (1979). Loss aversion supposes that individuals experience diminishing marginal utility of gains in wealth, but also diminishing marginal pain from losses. Thus, a utility of wealth function must be contingent on a reference point, against which gains and losses are measured. Above this reference point, the utility function is concave, reflecting risk averse behavior. Below this reference point, individuals behave as if risk loving, willing to risk lower returns for a chance at returning to their reference point.

There are many reasons why a principal may desire to manipulate the reference level of wealth for an agent. First, by doing so, he may manipulate the marginal utility of income, thus making his marginal incentive more effective. Secondly, Sandmo's classic result (1971) suggests that risk attitude can affect input efficiency, and expected profit. Thus the principal may be able to enhance profits by manipulating the risk attitude of the agent via the reference payout level.

We can write the loss averse value function as

$$u(x \mid w) = \begin{cases} v^{+}(x-w) & \text{if} \quad x > w \\ v^{-}(x-w) & \text{if} \quad x \le w \end{cases}$$

where $v^{+}(0) = v^{-}(0) = 0$, so that utility is continuous, and $v^{+}"(s) < 0, v^{-}"(s) > 0$. Figure 1 displays an example of what the referenced based utility function may look like. Note that the function is not differentiable at the reference point, and declines steeply when moving into the loss domain. The loss aversion paradigm has found support in many contexts, including experimental (Tversky and Kahneman, 1992; Camerer, 1995) and non-experimental (Benartzi and Thaler, 1995) contexts, and even in contexts that do not involve risk (Kahneman Knetsch and Thaler, 1991). A common criticism of prospect theory is the problem of determining the reference point. Contracts eliminate this problem by providing a clear reference point at the base level of wage. Despite this, it is unclear whether reservation activities are viewed with respect to the base pay reference point, or viewed outside of the reference point framework. We will illustrate the importance of this point in subsequent discussions.

Figure 1 Here

Contracts and Reference Points

If loss aversion is important in risky behavior, then principals should have a strong interest in manipulating reference points. In order to illustrate this principal, we propose the following model of agent behavior, based on the prospect theory value function

(2) $$\int U\left(w \mid \overline{w}\right) h\left(\tilde{q} \mid e\right) d\tilde{q} - e ,$$

where, as before, U is a measure of utility of wealth, w, only now it is also function of the level of base pay, $\overline{w}$, $h\left(\tilde{q} \mid e\right)$ is the distribution of attribute quality given effort level, and e is the effort level, measured in utils expended. We assume that $U_{ww}\left(w \mid \overline{w}\right) < 0$ for $w > \overline{w}$, $U_{ww}\left(w \mid \overline{w}\right) > 0$ for $w < \overline{w}$. Further, $\lim_{w \uparrow \overline{w}} U\left(w \mid \overline{w}\right) = \lim_{w \downarrow \overline{w}} U\left(w \mid \overline{w}\right) = 0$, and $\lim_{w \uparrow \overline{w}} U_w\left(w \mid \overline{w}\right) > \lim_{w \downarrow \overline{w}} U_w\left(w \mid \overline{w}\right)$, thus the function is continuous, but not differentiable at the reference level of wealth. Lastly, we suppose that $\frac{\partial E\left(\tilde{q} \mid e\right)}{\partial e} > 0$, or that increasing effort increases quality on average. Thus increasing effort will increase the average quality of the good produced.

We suppose that the principal is risk neutral and behaves rationally (in accordance with expected utility theory). This is intended to reflect the risk attitudes of larger companies that have resources to use complicated statistical and strategic analysis in their firm decisions. Further, these large firms have diverse interests that eliminate sensitivity to risk. The agent may represent agricultural producers or individuals working under contract that do not have access to the same decision resources. Thus, the agent's behavior may be more heavily influenced by risk attitudes and behavioral anomalies. Following the contract theory literature, we suppose the principal designs the contract and the agent may simply accept or reject. Inherent in this design is the assumption that the principal exercises some monopsony power over the agent. Other sales options may exist, but for the agent to have so little power over negotiations, these options must be limited.

Reservation in Reference

If the agent compares their reservation activities to the reference point given by the contract, the principal must solve the following problem in designing the contract

(3) $$\max_{e^*,\{w(\tilde{q})\},\bar{q}} \int \left(\tilde{q} - w(\tilde{q})\right) h\left(\tilde{q} \mid e^*\right) d\tilde{q},$$

subject to

(4) $$e^* \in \arg\max_{e} \int U\left(w(\tilde{q}) \mid w(\bar{q})\right) h\left(\tilde{q} \mid e\right) d\tilde{q} - e,$$

(5) $$\int U\left(w(\tilde{q}) \mid w(\bar{q})\right) h\left(\tilde{q} \mid e^*\right) d\tilde{q} - e^* \geq U\left(w_R \mid w(\bar{q})\right).$$

Here w_R is the reservation wage. Because this is a particularly difficult problem to solve, we will first examine the optimal contract in the absence of uncertainty. In this case, the above model reduces to

$$\max_{e^*,\{w(\tilde{q})\},\bar{q}} \left(\tilde{q}\left(e^*\right) - w\left(\tilde{q}\left(e^*\right)\right)\right),$$

subject to

$$e^* \in \arg\max_{e} U\left(w\left(\tilde{q}(e)\right) \mid w(\bar{q})\right) - e,$$

$$U\left(w\left(\tilde{q}(e)\right) \mid w(\overline{q})\right) - e^{*} > U\left(w_{R} \mid w(\overline{q})\right).$$

Given that the agent has signed the contract, she will optimize by exerting effort e, where $U_{w}\left(w \mid w(\overline{q})\right) = \frac{1}{w_{q}\tilde{q}_{e}}$, if $q(e) \neq \overline{q}$.

Proposition 1. Let U be such that for any Δ we can find $w_{l} < \overline{w}$ such that $U\left(w_{l} \mid \overline{w}\right) - U\left(w_{l} - \Delta \mid \overline{w}\right) > U\left(w \mid \overline{w}\right) - U\left(w - \Delta \mid \overline{w}\right)$ for any $w > \overline{w}$. Then under the optimal contract without uncertainty, $w\left(\tilde{q}\left(e^{*}\right)\right) = w(\overline{q})$.

Proof: Suppose that under the optimal contract $w\left(\tilde{q}\left(e^{*}\right)\right) \geq w(\overline{q})$, with $U_{w}\left(w \mid w(\overline{q})\right) = \frac{1}{w_{q}\tilde{q}_{e}}$. Consider an alternative reference wealth $\overline{q}_{a} = \tilde{q}_{e}$, Because, $\lim_{w \uparrow \overline{w}} U_{w}\left(w \mid \overline{w}\right) > \lim_{w \downarrow \overline{w}} U_{w}\left(w \mid \overline{w}\right)$, the maximum of the first derivative occurs as one approaches the reference point from the left. Because $\lim_{w \uparrow \overline{w}} U_{w}\left(w \mid w(\overline{q}_{a})\right) > \frac{1}{w_{q}\tilde{q}_{e}}$, the optimal level of effort for the agent must be larger under the new reference level of wealth, if the optimal level of effort is not 0. This latter possibility is excluded if $U\left(w\left(\tilde{q}\left(e^{*}\right)\right) \mid w(\overline{q}_{a})\right) - U\left(w_{r} \mid w(\overline{q}_{a})\right) > U\left(w\left(\tilde{q}\left(e^{*}\right)\right) \mid w(\overline{q})\right) - U\left(w_{r} \mid w(\overline{q})\right)$. Because, the value function is convex to the left of the reference point, this condition and all conditions of the proof can be met if $\varepsilon > 0$ is small enough. ∎

Proposition 1 tells us that if the convexity of the loss portion of the value function falls within a reasonable bound, then the optimal payout will be the base pay. The constraint placed on the convexity of the loss function is a very minimal requirement that is met by all value functions currently used in the literature (see for example Tversky and Kahneman, 1992). This restriction simply requires that the pain from any loss be larger than the pleasure from an equivalent gain. This is of course one of the two main hypotheses behind loss aversion. Thus if agents are loss averse, the principal will optimize by stating the intended effort as resulting in exactly the base pay, this being the point with the greatest marginal utility of wealth.

Returning to the case of uncertainty given in (3) – (5), only complicates the picture mildly, with the result depending on the precision of the quality signal. To see this, note that, if the first order approach is permitted (see Rogerson, 1985 for the implications), the optimal effort level solves

$$\int U\left(w(\tilde{q}) \mid w(\overline{q})\right) h_e\left(\tilde{q} \mid e\right) d\tilde{q} - 1 = 0 .$$

Totally differentiating the agent's first order condition with respect to e and $w(\overline{q})$ yields

(6)
$$\frac{de}{dw(\overline{q})} = -\frac{\left[\int U_{\overline{w}}\left(w(\tilde{q}) \mid w(\overline{q})\right) h_e\left(\tilde{q} \mid e\right) d\tilde{q}\right]}{\left[\int U\left(w(\tilde{q}) \mid w(\overline{q})\right) h_{ee}\left(\tilde{q} \mid e\right) d\tilde{q}\right]}.$$

Here, the expression in the denominator must be negative for the agent's optimization to hold. Thus, maximizing effort with respect to $w(\overline{q})$ must occur where $\frac{de}{dw(\overline{q})} = 0$. Note that altering the reference wealth exerts no cost to the principal, yet will result in increased mean profits, so long as the wage remains constant. Thus, the principal should maximize effort over the reference level of pay.

The denominator is just the agent's second order condition, which must be negative. Thus, the optimal $\overline{w}$ solves

(7) $$\left[\int U_{\bar{w}}\left(w(\tilde{q})\,|\,\bar{w}\right)h_e\left(\tilde{q}\,|\,e\right)d\tilde{q}\right]\left[\int U\left(w(\tilde{q})\,|\,\bar{w}\right)h\left(\tilde{q}\,|\,e\right)d\tilde{q}-e^*-U\left(w_R\,|\,\bar{w}\right)\right]=0,$$

the corresponding complementary slackness condition (because $\bar{w}$ does not enter directly into the expected profit of the principal). The expression $U_{\bar{w}}\left(w(\tilde{q})\,|\,\bar{w}\right)$ is always negative, as raising the reference point always lowers the value of any gamble.

Proposition 2 Let U be such that for any Δ we can find $w_l<\bar{w}$ such that $U\left(w_l\,|\,\bar{w}\right)-U\left(w_l-\Delta\,|\,\bar{w}\right)>U\left(w\,|\,\bar{w}\right)-U\left(w-\Delta\,|\,\bar{w}\right)$ for any $w>\bar{w}$, and $h\left(\tilde{q}(e)\,|\,e\right)$ be symmetric, with median given by $\hat{q}(e)$. Then there exists $k>0$ such that, under the optimal contract, $E\left(w\,|\,e^*\right)\leq\bar{w}$ if $\left|w''(q)\right|<k$.

Proof: Suppose e^* is such that $\hat{q}\left(e^*\right)=\bar{q}$. Let $g\left(w\,|\,e\right)=h\left(w^{-1}(w)\,|\,e\right)\dfrac{1}{w_q\left(w^{-1}(w)\right)}$. If $w''(q)=0$, then w is also distributed symmetrically, with $E\left(w\,|\,e^*\right)=\bar{w}$. Alternatively, if $w''(q)$ is bounded we can approximate the distribution of w using a symmetric distribution. Then, $h_w\left(w\,|\,e\right)<0$ for $w<\bar{w}$, and $h_w\left(w\,|\,e\right)>0$ for $w>\bar{w}$. By the properties of U, $\left|U_{\bar{w}}\left(\bar{w}-x\,|\,\bar{w}\right)\right|>\left|U_{\bar{w}}\left(\bar{w}+x\,|\,\bar{w}\right)\right|$, for any $x>0$. In addition $U_{\bar{w}}\left(w\,|\,\bar{w}\right)<0$ for any w. Thus, $\int U_{\bar{w}}\left(w\,|\,\bar{w}\right)g_w\left(w\,|\,e\right)dw=\int U_{\bar{w}}\left(w(\tilde{q})\,|\,\bar{w}\right)h_e\left(\tilde{q}\,|\,e\right)d\tilde{q}>0$. By this, we know the expression in (6) must be positive. Thus effort may be increased by raising the reference level of pay, $\bar{w}$, so long as the individual rationality constraint is not already met. This will not alter the expected wage. This result will continue to hold if wages are concave (thus skewing the wage distribution negatively). $\blacksquare$

Proposition 2 tells us that under reasonable conditions we expect the average wage to be below the reference, or base, pay. Note that the restrictions on wage structure required for the proof (namely that it be approximately affine) are commonly assumed in the mechanism design literature. This case will form the base case to which we can compare situations with multiple agents, and multiple quality attributes. There are two primary reasons that penalties should prevail. First, the utility function is steeper over the loss domain, meaning that greater incentives are applied for the same marginal wage. Second, as the mean of the wage is moved to the left of the reference point, the individual becomes less and less risk averse. This means, that the mean incentive starts to matter more than the risk included in the incentives as the reference point is raised. This gives greater leverage to the principal in giving incentives even given a very noisy signal of effort.

Figure 2 Here

Figure 2a and 2b illustrate how the principal can reduce average payout below the reservation wage and obtain the same level of effort. This is accomplished by raising the base level of pay, thus shifting the reference point to the right. When the reservation and reference level of pay are equal (Figure 2a) the function behaves as if concave, yielding utility below that obtained from the average wealth. When instead the reference point is shifted up (Figure 2b) the function behaves as if convex, yielding a higher level of utility for the contract with the same level of pay. The irony of this model is that it uses a loss aversion model and implies that losses are preferred to gains. This irony derives from how the reservation wage is compared to the base level of pay. The principal can take advantage of the risk loving portion of the utility function by inducing losses relative to the base pay.

Reservation Independence

The implications of the reservation in reference model are counterintuitive to say the least. While employing what many would consider the most likely model of loss aversion, it implies a loss loving agent. Alternatively, we examine the case where the reference point is only used to evaluate outcomes within context. Thus, performance in the contract is compared to the base level of pay and evaluated as a loss or a gain. Reservation activities, however, fall outside the context of the contract, and are measured objectively (without exaggeration of gains or losses) with respect to the reference point. Figure 3 depicts the model we propose. Note that the reference based utility is measured in addition to an objective utility function. This model may seem contrary to the traditional loss aversion model proposed by Kahneman and Tversky (1979). However, one of the primary principals behind Kahnman and Tversky's argument is that context matters. Hence, despite its convoluted nature, we suppose this model to mirror more the spirit of the loss aversion phenomenon described in the literature.

If the reservation utility level is independent of the reference wealth, we can rewrite the principal's problem as

$$\max_{e^*,\{w(\tilde{q})\},\bar{q}} \int \left(\tilde{q} - w(\tilde{q})\right) h\left(\tilde{q} \mid e^*\right) d\tilde{q},$$

subject to

(8) $$e^* \in \arg\max_e \int \left[u\left(w(\bar{q})\right) + U\left(w(\tilde{q}) - w(\bar{q})\right) \right] h(\tilde{q} \mid e)\, d\tilde{q} - e,$$

(9) $$\int \left[u\left(w(\bar{q})\right) + U\left(w(\tilde{q}) - w(\bar{q})\right) \right] h\left(\tilde{q} \mid e^*\right) d\tilde{q} - e^* \geq \underline{U},$$

where $u(\bar{w})$ measures the utility of wealth at the reference level of wealth. Thus the reservation utility is measured without respect to a reference point. After signing the contract, the individual compares all outcomes to the base, or reference, pay. This model is consistent with the notion that the individual anticipates that they will behave in a loss averse manner once the contract is signed. The constraints in (8) and (9) can be rewritten as

$$\int \left[U\left(w(\tilde{q})-w(\bar{q})\right)\right] h_e(\tilde{q} \mid e)\, d\tilde{q} - 1 = 0$$

$$\int \left[U\left(w(\tilde{q})-w(\bar{q})\right)\right] h\left(\tilde{q} \mid e^*\right) d\tilde{q} \geq \underline{U} + e^* - u\left(w(\bar{q})\right)$$

The certainty equivalent (to the farmer) of a contract is given by

$$CE = u^{-1}\left(\int \left[U\left(w(\tilde{q})-w(\bar{q})\right)\right] h\left(\tilde{q} \mid e^*\right) d\tilde{q} + u\left(w(\bar{q})\right) - e^*\right)$$

Differentiating with respect to $\bar{w}$ yields

$$\begin{aligned}\frac{dCE}{d\bar{w}} &= u_1^{-1}\left(\int \left[U\left(w(\tilde{q})-w(\bar{q})\right)\right] h\left(\tilde{q} \mid e^*\right) d\tilde{q} + u\left(w(\bar{q})\right) - e^*\right) \\ &\quad \times \left(\int \left[-U'\left(w(\tilde{q})-w(\bar{q})\right)\right] h\left(\tilde{q} \mid e^*\right) d\tilde{q} + u'\left(w(\bar{q})\right) + \left(\int \left[U\left(w(\tilde{q})-w(\bar{q})\right)\right] h_e\left(\tilde{q} \mid e^*\right) d\tilde{q} - 1\right)\frac{de}{d\bar{w}}\right) \\ &= \frac{1}{u'(CE)}\left(\int \left[-U'\left(w(\tilde{q})-w(\bar{q})\right)\right] h\left(\tilde{q} \mid e^*\right) d\tilde{q} + u'\left(w(\bar{q})\right)\right)\end{aligned}$$

We can now examine the optimal contract under a floating reservation utility level.

Proposition 3 Let U be such that for any Δ we can find $w_l < \bar{w}$ such that $U(w_l - \bar{w}) - U(w_l - \Delta - \bar{w}) > U(w - \bar{w}) - U(w - \Delta - \bar{w})$ for any $w > \bar{w}$, $u'(\bar{w}) < 2\int_{\bar{q}}^{\infty}\left[U'\left(w(\tilde{q}) - \bar{w}\right)\right] h\left(\tilde{q} \mid e^*\right) d\tilde{q}$ and $h\left(\tilde{q}(e) \mid e\right)$ be symmetric, with median given by

$\hat{q}(e)$. Then there exists $k>0$ such that, under the optimal contract, $E(w|e^*)\geq \bar{w}$ if $|w''(q)|<k$.

Proof: Suppose e^* is such that $\hat{q}(e^*)=\bar{q}$. Let $g(w|e)=h\left(w^{-1}(w)|e\right)\frac{1}{w_q\left(w^{-1}(w)\right)}$. If $w''(q)=0$, then w is also distributed symmetrically, with $E(w|e^*)=\bar{w}$. Alternatively, if $w''(q)$ is bounded we can approximate the distribution of w using a symmetric distribution. If $\frac{dCE}{d\bar{w}}<0$, then the individual rationality constraint can be relaxed by lowering the reference wealth $\bar{w}$. Then, by increasing the marginal wage, effort can be increased. Because $h(w|e)$ is symmetric, and because $U(w_l-\bar{w})-U(w_l-\Delta-\bar{w})>U(w-\bar{w})-U(w-\Delta-\bar{w})$, we find $\frac{dCE}{d\bar{w}}<\frac{1}{u'(CE)}\left(-2\int_{\bar{q}}^{\infty}\left[U'\left(w(\tilde{q})-w(\bar{q})\right)\right]h(w|e^*)\,dw+u'(\bar{w})\right)$. Thus, $\frac{dCE}{d\bar{w}}<0$ if $u'\left(w(\bar{q})\right)<2\int_{\bar{q}}^{\infty}\left[U'(w-\bar{w})\right]h(w|e^*)\,dw$. Thus a higher profit obtains by offering $\bar{w}<E(w|e^*)$ ∎

Proposition 3 states that under the most reasonable circumstances, the principal should offer rewards on average if agents behave loss averse in accordance with the reservation independence model, and if both gains and losses are exaggerated in context. Figure 4 depicts this situation, illustrating if the reference point is set equal to average pay, the certainty equivalent will be lower than if the reference point is set below mean pay. Because the individual exaggerates gains as well as losses, the principal is induced to put the agent in the gain domain, where utility is cheapest.

The Case of Multiple Quality Attributes

In the majority of production contract cases, there are a number of quality attributes that are targeted for incentives. If the production of these attributes is non-trivially related, the incentive structure may become extremely complicated. However, the design of contracts typically provides for no interaction between the reward for one quality and another. This is ostensibly due to the complication involved in designing joint incentives. We will treat this as a constraint in the contract. For the sake of simplicity, consider the case of two quality attributes, without uncertainty. Under reservation in reference, we can represent the principal's decision as solving

$$\max_{e_1^*, e_2^*, \{w_1(q_1)\}, \{w_2(q_2)\}, \bar{w}} p\left(q_1\left(e_1^*\right), q_2\left(e_2^*\right)\right) - w_1\left(q_1\left(e_1^*\right)\right) + w_2\left(q_2\left(e_2^*\right)\right),$$

subject to

$$\left(e_1^*, e_2^*\right) \in \arg\max_{e_1, e_2} U\left(w_1\left(q_1\left(e_1\right)\right) + w_2\left(q_2\left(e_2\right)\right) \mid \bar{w}\right) - e_1 - e_2,$$

$$U\left(w_1\left(q_1\left(e_1^*\right)\right) + w_2\left(q_2\left(e_2^*\right)\right) \mid \bar{w}\right) - e_1^* - e_2^* > U\left(w_R \mid w(\bar{q})\right).$$

In this case, the agent's first order condition will be given by

$$V_1 = U_w\left(w_1 + w_2 \mid \bar{w}\right)\left(w'_1\, q_{11}\right) - 1 = 0$$

and

$$V_2 = U_w\left(w_1 + w_2 \mid \bar{w}\right)\left(w'_2\, q_{22}\right) - 1 = 0.$$

Total differentiation obtains

$$\frac{de_1}{d\bar{w}} = \frac{U_{w\bar{w}}\left(w_1 + w_2 \mid \bar{w}\right)}{V_{12}^2 - V_{11}V_{22}}\left[V_{22}\left(w'_1\, q_{11}\right) - V_{12}\left(w'_2\, q_{22}\right)\right]$$

$$\frac{de_2}{d\bar{w}} = \frac{U_{w\bar{w}}\left(w_1 + w_2 \mid \bar{w}\right)}{V_{12}^2 - V_{11}V_{22}}\left[V_{11}\left(w'_2\, q_{22}\right) - V_{12}\left(w'_1\, q_{11}\right)\right]$$

Negative semi-definiteness of the second order matrix requires that the denominator of the first multiplicative term be negative. Due to the concavity conditions on the value function, $U_{w\bar{w}} < 0$ for $w < \bar{w}$, but $U_{w\bar{w}} > 0$ for $w > \bar{w}$. In addition, $V_{12} > 0$ if $w < \bar{w}$, while $V_{12} < 0$ if $w > \bar{w}$. Finally, it must be the case that either $|V_{11}| > |V_{12}|$, or $|V_{22}| > |V_{12}|$. In order to examine the relationship of rewards and penalties to the production properties, we will derive the direction of steepest ascent in profits to the principal for a change in $\bar{w}$.

Now the principal's problem can be described as

$$\max_{e_1^*, e_2^*, \{w_1(q_1)\}, \{w_2(q_2)\}, \bar{w}} \iint \left[p(q_1, q_2) - w_1(q_1) + w_2(q_2) \right] h(q_1, q_2 \mid e_1, e_2) dq_1 dq_2,$$

subject to

$$\left(e_1^*, e_2^*\right) \in \arg\max_{e_1, e_2} \iint U\left(w_1(q_1) + w_2(q_2) \mid \bar{w}\right) h(q_1, q_2 \mid e_1, e_2) dq_1 dq_2 - e_1 - e_2,$$

$$\iint U\left(w_1(q_1) + w_2(q_2) \mid \bar{w}\right) h(q_1, q_2 \mid e_1, e_2) dq_1 dq_2 - e_1^* - e_2^* > U\left(w_R \mid w(\bar{q})\right).$$

The agent's first order conditions can be written as

$$\begin{bmatrix} \iint U\left(w_1(q_1) + w_2(q_2) \mid \bar{w}\right) h_{e_1}(q_1, q_2 \mid e_1, e_2) dq_1 dq_2 - 1 \\ \iint U\left(w_1(q_1) + w_2(q_2) \mid \bar{w}\right) h_{e_2}(q_1, q_2 \mid e_1, e_2) dq_1 dq_2 - 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

Proposition 4. Let U be such that for any Δ we can find $w_l < \bar{w}$ such that $U(w_l \mid \bar{w}) - U(w_l - \Delta \mid \bar{w}) > U(w \mid \bar{w}) - U(w - \Delta \mid \bar{w})$ for any $w > \bar{w}$, and $h\left(q_1(e_1), q_2(e_2) \mid e_1, e_2\right)$ be symmetric in both qualities. Then there exists $k > 0$ such that, under the optimal contract, $E\left(w \mid e^*\right) \leq \bar{w}$ if $\left|w_i''(q_i)\right| < k$, and $EU_{12} > 0$.

Proof: If conditions analogous to those in Proposition 2 hold, we may transform the problem to deal specifically with wage. In this case, totally differentiating with respect to effort and the reference wage yields

$$\begin{bmatrix} \frac{de_1}{d\overline{w}} \\ \frac{de_2}{d\overline{w}} \end{bmatrix} = -\frac{1}{EU_{11}EU_{22} - EU_{12}^2} \begin{bmatrix} EU_{22}\iint U_{\overline{w}}\left(w \mid \overline{w}\right) g_{e_1}\left(w \mid e_1, e_2\right) dq_1 dq_2 - EU_{12}\iint U_{\overline{w}}\left(w \mid \overline{w}\right) g_{e_2}\left(w \mid e_1, e_2\right) dq_1 dq_2 \\ EU_{11}\iint U_{\overline{w}}\left(w \mid \overline{w}\right) g_{e_2}\left(w \mid e_1, e_2\right) dq_1 dq_2 - EU_{12}\iint U_{\overline{w}}\left(w \mid \overline{w}\right) g_{e_1}\left(w \mid e_1, e_2\right) dq_1 dq_2 \end{bmatrix}$$

.

Given the conditions on wage, $g\left(w \mid e_1, e_2\right)$ is approximately symmetric, if $w = \overline{w}$, then $\iint U_{\overline{w}}\left(w \mid \overline{w}\right) g_{e_1}\left(w \mid e_1, e_2\right) dq_1 dq_2 > 0$. In order for second order conditions to be met, it must be that either $\left|EU_{11}\right| > \left|EU_{12}\right|$, or $\left|EU_{22}\right| > \left|EU_{12}\right|$. If both $\left|EU_{11}\right|, \left|EU_{22}\right| > \left|EU_{12}\right|$, or if $EU_{12} > 0$, then both derivatives must be positive.■

Thus, if the production activities are weak complements then the average wage will be below the reference wage. In this case, penalties need not be ubiquitous, but will on average outweigh any reward. Alternatively, if EU_{12} is negative enough, then rewards may prevail on average. In this case, if effort in one activity may negate effort in another activity, penalizing both activities will be counterproductive. A reward may be offered on average in what should be a very rare case of severe substitution.

Alternatively, using the reservation independence, the principal's problem becomes

$$\max_{e_1^*, e_2^*, \{w_1(q_1)\}, \{w_2(q_2)\}, \overline{w}} \iint \left[p\left(q_1, q_2\right) - w_1\left(q_1\right) + w_2\left(q_2\right) \right] h\left(q_1, q_2 \mid e_1, e_2\right) dq_1 dq_2,$$

subject to

$$\left(e_1^*, e_2^*\right) \in \arg\max_{e_1, e_2} \iint U\left(w_1\left(q_1\right) + w_2\left(q_2\right) \mid \overline{w}\right) h\left(q_1, q_2 \mid e_1, e_2\right) dq_1 dq_2 + u\left(\overline{w}\right) - e_1 - e_2,$$

$$\iint U\left(w_1\left(q_1\right)+w_2\left(q_2\right)\mid \overline{w}\right)h\left(q_1,q_2\mid e_1,e_2\right)dq_1dq_2+u\left(\overline{w}\right)-e_1^*-e_2^*>\underline{U}\ .$$

.

Thus, the agent's first order conditions can be written as

$$\begin{bmatrix}\iint U\left(w_1\left(q_1\right)+w_2\left(q_2\right)\mid \overline{w}\right)h_{e_1}\left(q_1,q_2\mid e_1,e_2\right)dq_1dq_2-1\\ \iint U\left(w_1\left(q_1\right)+w_2\left(q_2\right)\mid \overline{w}\right)h_{e_2}\left(q_1,q_2\mid e_1,e_2\right)dq_1dq_2-1\end{bmatrix}=\begin{bmatrix}0\\0\end{bmatrix}.$$

Proposition 5 Let U be such that for any Δ we can find $w_l<\overline{w}$ such that $U\left(w_l-\overline{w}\right)-U\left(w_l-\Delta-\overline{w}\right)>U\left(w-\overline{w}\right)-U\left(w-\Delta-\overline{w}\right)$ for any $w>\overline{w}$, $u'\left(\overline{w}\right)<2\int_{\overline{q}}^{\infty}\left[U'\left(w\left(\tilde{q}\right)-\overline{w}\right)\right]h\left(\tilde{q}\mid e^*\right)d\tilde{q}$ and $h\left(q_1\left(e_1\right),q_2\left(e_2\right)\mid e_1,e_2\right)$ be symmetric in both qualities, with median given by $\hat{q}_i\left(e\right)$. Then there exists $k>0$ such that, under the optimal contract, $E\left(w\mid e^*\right)\geq\overline{w}$ if $\left|w_{i=1,2}''\left(q\right)\right|<k$.

Proof: Suppose e_i^* is such that $\hat{q}_i\left(e_i^*\right)=\overline{q}_i$. If $w_1''\left(q\right)=w_2''\left(q\right)=0$, then their sum is also distributed symmetrically, with $E\left(w_1+w_2\mid e_1^*,e_2^*\right)=\overline{w}$. Alternatively, if $w''\left(q\right)$ is bounded we can approximate the distribution of w using a symmetric distribution. By the same arguments as in proposition 3, $\frac{dCE}{d\overline{w}}<0$ if $u'\left(w_1\left(\overline{q}_1\right)+w_2\left(\overline{q}_2\right)\right)<2\int_{\overline{q}}^{\infty}\left[U'\left(w_1+w_2-\overline{w}\right)\right]h\left(w_1+w_2\mid e_1^*,e_2^*\right)dw$. Thus a higher profit obtains by offering $\overline{w}<E\left(w_1+w_2\mid e_1^*,e_2^*\right)$ $\blacksquare$

Evidence from the Field

While it is easy to find anecdotal evidence of reference point manipulation in contracts, a more systematic analysis is difficult. In particular, statistical analysis would require data encompassing a random sampling of signed production contracts, the base pay, penalty and reward provisions, and the average realized pay. This data can be very difficult to come by. In many cases, standard production contracts are designed and then small modifications are made to fit the individual agents. Data on the customized modifications can be particularly difficult to obtain. In searching for evidence of our theory, we will examine broiler-plate contracts for California processing tomatoes, and Washington and Oregon processing potatoes. Our analysis will rely mostly on the reported contracts observed by other researchers. In particular, we make use of the reports of Hueth and Ligon (2002) and Curtis and McCluskey (2003) for results in California and Washington.

General Agricultural Contracts

A general search of the Contracts and Organization Research Institute, and the Iowa Atterney General's databases of contracts generates 28 agricultural fill-in-the-blank contracts including production of soy-beans (10), chicken broilers (4), chicken brooders (1), turkey (1), cattle (1), corn (3), and hogs (8). Hog contracts typically provide incentives for both weight (either live or scalded carcass) and leanness. Each of the hog contracts provides both rewards and penalties. Penalties are offered for hogs that fall outside weight thresholds, yet premia for low fat content. The corn contracts contain incentives for oil content and crop damage. While only penalties are offered for crop damage, incentives for oil content follow a linear scale of both premia and penalties. There is much wider variation in the soybean contracts. Six of the ten offer penalties, while only three offer premia. Penalties are offered for heat damage, contamination, and oleic acid content. Premia are offered for various delivery issues. Of the chicken and turkey contracts, two offer penalties while three offer rewards (three offer no incentives at all). Each of these incentives are offered for holding production costs (paid by the principal) below average.

In each of these cases, while there appear to be some systematic use of penalties and rewards for specific attributes, it is unclear if penalties are more prevalent than rewards. At best, there appears to be some few companies that use penalties exclusively, although there are at least as many that use only premia. In the next two sections, we use data on average payments and base pay for two specific crops to address whether loss aversion is considered in agricultural production contracts.

California Processing Tomatoes

The California Tomato Growers Association (CTGA) negotiates all processing tomato contracts on behalf of the growers, representing more than two thirds of tomato growers. Because of this, we might expect growers to have greater bargaining power than would be implied by the model of contracting presented earlier. In any year, there are 25 to 30 processors contracting for processing tomatoes (Hueth and Ligon, 2002), each with its own individualized contract. Generally these contracts provide a base price per tons of tomatoes delivered, with some adjustment based on various quality measures. These measures usually include color (communition), percent material other than tomatoes (MOT), percent limited use (LU), percent mold, percent infested with worms, and percent soluble solids.

While Hueth and Ligon (2002) report that deductions are more prevalent in written contracts, their later work (2003) suggests there is more variability in contract incentives depending on the processor. In Hueth and Ligon (2002) they report the contract appearing in Table 1. Here it is seen that the particular contract they used specifies premia only for soluble solids, and all other incentives are specified as penalties. Table 2 is reproduced from Hueth and Ligon 2003, containing the average quality measures, as assessed by the Processing Tomato Advisory Board, for a sample of 1.5 million loads of tomatoes delivered under contract, as well as the average difference in base pay and realized pay under the contract in Table 1. Note that each of these average outcomes implies an average penalty of around $2.50 per net ton. In fact, Hueth and Ligon note that penalties are written into the master contracts, while premiums are added on by some processors. This would suggest a systematic use of penalties over rewards.

Table 1 Here

Hueth and Ligon (2003) tell a different story, however. Across all observed contracts, they find an average reward over the base pay of $2.20, $2.95, $4.06 for 1994, 1996 and 1998 respectively. This mean is calculated by summing the mean premium and deduct for each measured characteristic. Figure 2 displays the mean payouts for various realizations of characteristics for a typical contract in 1998. In this year, the base price was $53 per ton. It is clear that the average producer would receive a premium of around $1.00 per ton under this contract.

The results of Hueth and Ligon (2003) suggest that, if there is significant reservation in reference loss aversion among tomato growers, the average processor is not taking advantage of it. The results appear to be consistent with the reservation independence model. However, there is some reason for caution when drawing conclusions from these results. First, it may be that loss aversion does not play a role in contract behavior. Second, as we mentioned previously, contacts are negotiated collectively. Thus the agents have some power in the process beyond what the standard principal agent model suggests. Third, many of the tomato growers sell to multiple processors, with many more having the opportunity to sell to multiple processors. This means that the market for contracts may be more competitive in some areas where multiple processors are located. This sort of competition could drive out contracts attempting to take advantage of loss aversion, as farmers will exaggerate the potential damage from penalties in their decisions. Lastly, it could be that the distributions of characteristics are significantly correlated. In this case, it may be that simply adding mean payouts for each characteristic produces a biased estimate of mean payout. In fact this appears to be the case. The contract in figure 2 shows a mean payout of about $1 over the base pay. While this average is significantly lower than the $4.06 calculated from adding the individual means effects, it is still positive, further confirming the reservation independence model.

Table 2 Here

Figure 5 Here

Washington Processing Potatoes

The base price for Washington processing potatoes is also negotiated by a commodity association, in this case the Potato Growers of Washington. The price is determined by adding penalties and rewards to the base price as dictated by the quality of the potatoes. The primary attributes that are of interest include tube weight, presence of nematodes, hollow heart, specific gravity, internal discoloration, sugar content, surface scab, bruising and tare. Curtis and McCluskey (2003) examine actual Russet Burbank potato contracts and outcomes for two Washington potato processors. Ten sample loads from 1995 and 1996 were chosen for analysis. Table 3 contains the contract structure for the years 1995 to 2000. The contracts show the potential for positive or negative payments. Only the incentive for tare is exclusively a penalty.

Table 3 Here

The two processors report mean variable payments of $14.88 , $14.31 and $13.95, $13.52 for 1995 and 1996 respectively. One processor completely rejected one load of potatoes in 1996, this load being excluded from the average variable payment. Even including this penalty (of $73.00), the processor paid a premium of more than $3 on average. Clearly the bar is set very low with respect to rewards. While, as in the case of processing tomatoes, the negotiating procedure may call into question the assumptions of the model, clearly this is evidence that the processors design their contracts to pay premiums. Thus, if loss aversion is important in contract behavior, we find clear evidence that the reference point is evaluated only in the context of the contract.

Conclusions

We find strong evidence that the base price is manipulated to control producer behavior. The data clearly support the model of reservation independence in loss aversion. As a whole processors in the processing tomato and potato industries offer compensation on average above the base price. Among other agricultural products we do not have enough information to draw conclusions as to the systematic use of penalties and rewards. The reservation in reference model presented here is more consistent with the model of loss aversion used in the literature, however, implies behavior that is decidedly not loss averse. Further, it is not supported by the data.

Given the evidence, it seems that the reservation independence model of loss aversion describes the situation encountered in agricultural production contracts, as we find systematic use of rewards. Importantly, this empirical result is at odds with the standard economic model of contracts. Models based on expected utility would predict no systematic use of penalties or rewards. A systematic use of rewards suggests that either: (1) marginal utility of wealth is greater just above the reference point, contrary to standard models of loss aversion, or (2) that the reservation wage is considered in a way that is independent of the base pay selection. Further data, and experimentation could help determine if the reservation independence model is an adequate predictive model of behavior.

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Table 1. Processing Tomato Contract; Base price $51 (from Hueth and Ligon 2002).

	Deduction(%) (multiply number by percentage in brackets)									
Damage Measures										
MOT	3[0, 100]									
LU	0[0, 5]		1[5.5, 8]		1.5[8.5, 14]		2[14, 100]			
Green	1[0, 2]		2[2.5, 100]							
Mold	1[0, 100]									
Worms	1[0, 100]									
Quality Measure										
Soluble Solids	[0,5.1]	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	[6.0,100]
Premiums	0	0.5	1	1.5	2	2.5	3	3.75	4.5	5.25

Table 2. Summary Statistics: Quality of Processing Tomato Deliveries

	1994		1996		1998	
Measure	Mean	S.D.	Mean	S.D.	Mean	S.D.
Comm	23.27	2.76	25.13	2.79	24.48	2.84
LU	2.58	2.45	2.46	2.51	2.03	2.03
MOT	0.33	0.45	0.30	0.43	0.33	0.51
Solids	5.16	0.55	5.19	0.52	5.28	0.49
Green	0.73	0.75	0.76	0.70	1.00	1.41
Mold	1.34	1.59	1.16	1.23	1.81	2.17
Worms	0.01	0.10	0.02	0.11	0.02	0.12
	Difference between compensation and base pay for the contract in Table 1.					
	-$2.57		-$2.34		-$2.82	

Table 3. Grower Potato Load Payment Schedules 1995 to 2000 (From Curtis and McCluskey, 2003)

Year	1995	1996	1997	1998	1999	2000
Base	$90.40	$96.90	$88.65	$84.65	$84.65	$86.40
Tare	4%(-.50)	4%(-.50)	4%(-.50)	4%(-.50)	4%(-.50)	4%(-.50)
Bruise Free	55%(±.50)	55%(±.50)	55%(±.50)	55%(±.50)	55%(±.50)	55%(±.50)
Specific	1.0780	1.0780	1.0780	1.0780	1.0780	1.0780
Gravity	(±1.25)	(±1.25)	(±1.25)	(±1.25)	(±1.10)	(±.80)

(±) specifies a dollar amount for every percentage increase and/or decrease.

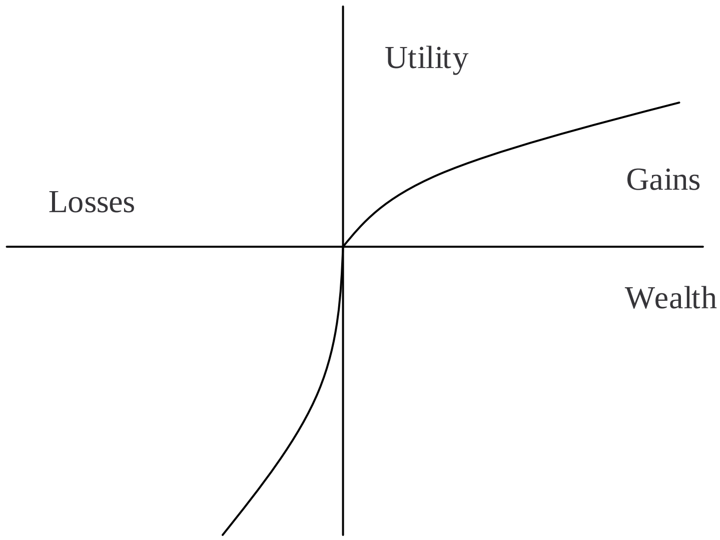

Figure 1. Prospect theoretic value function

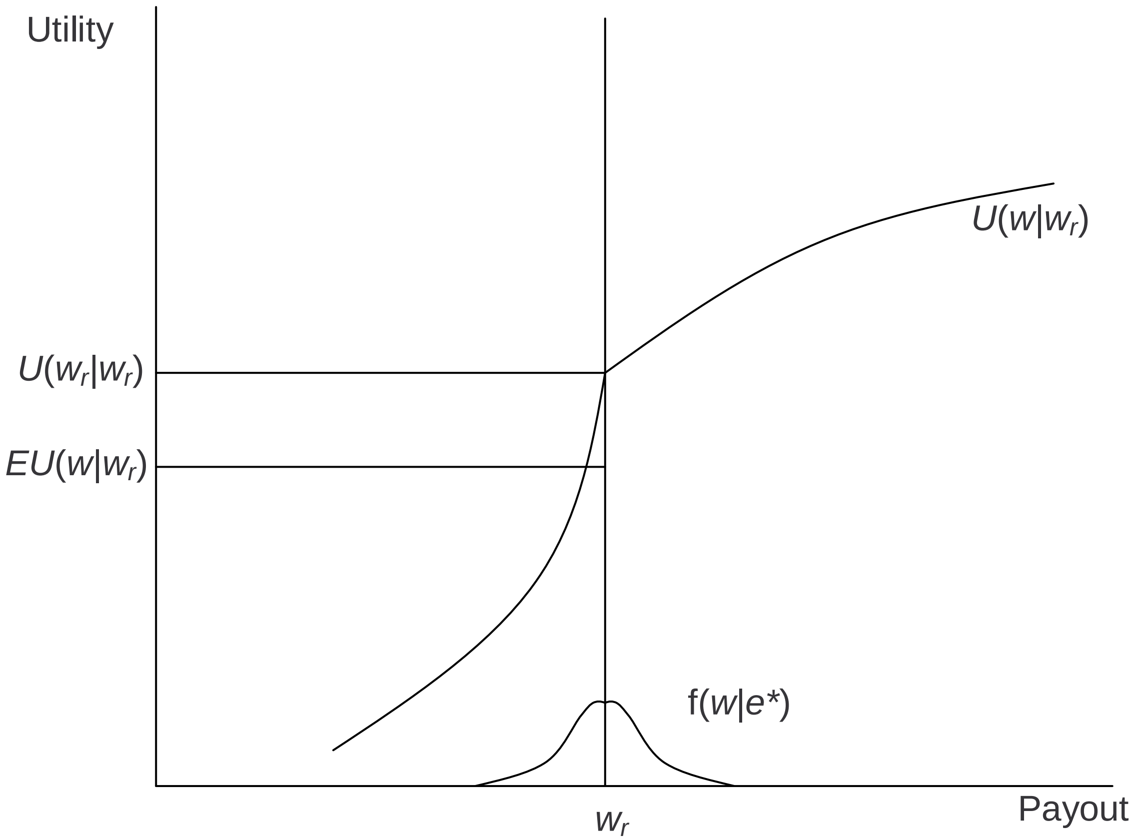

Figure 2a. Loss aversion with reservation equal to reference wage.

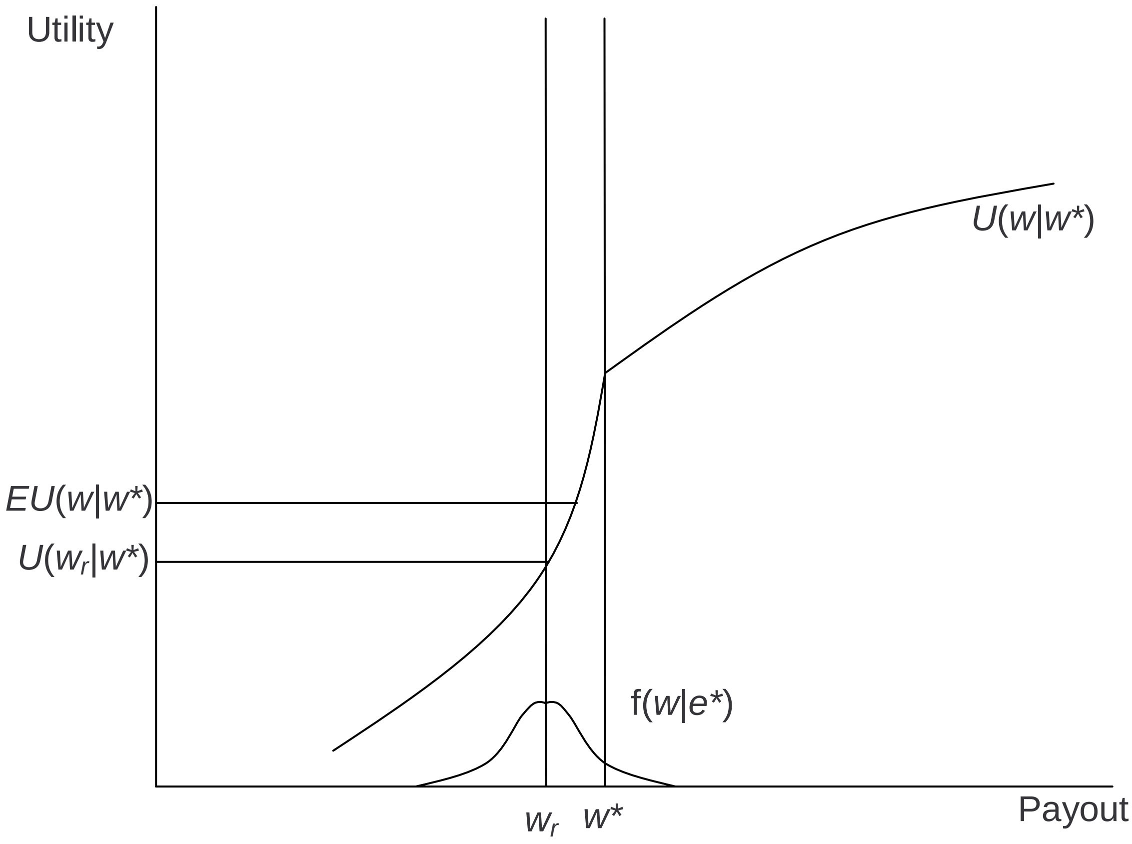

Figure 2b. . Loss aversion with reservation below reference wage.

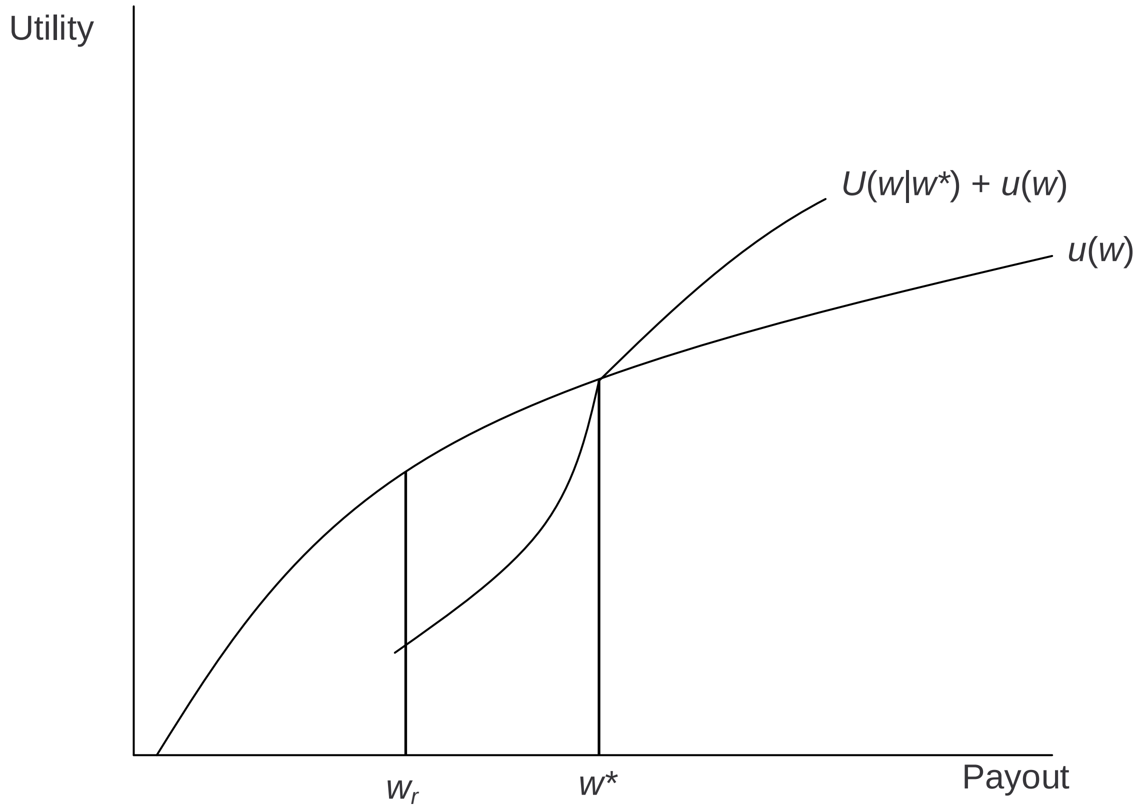

Figure 3. Loss aversion with reservation independence.

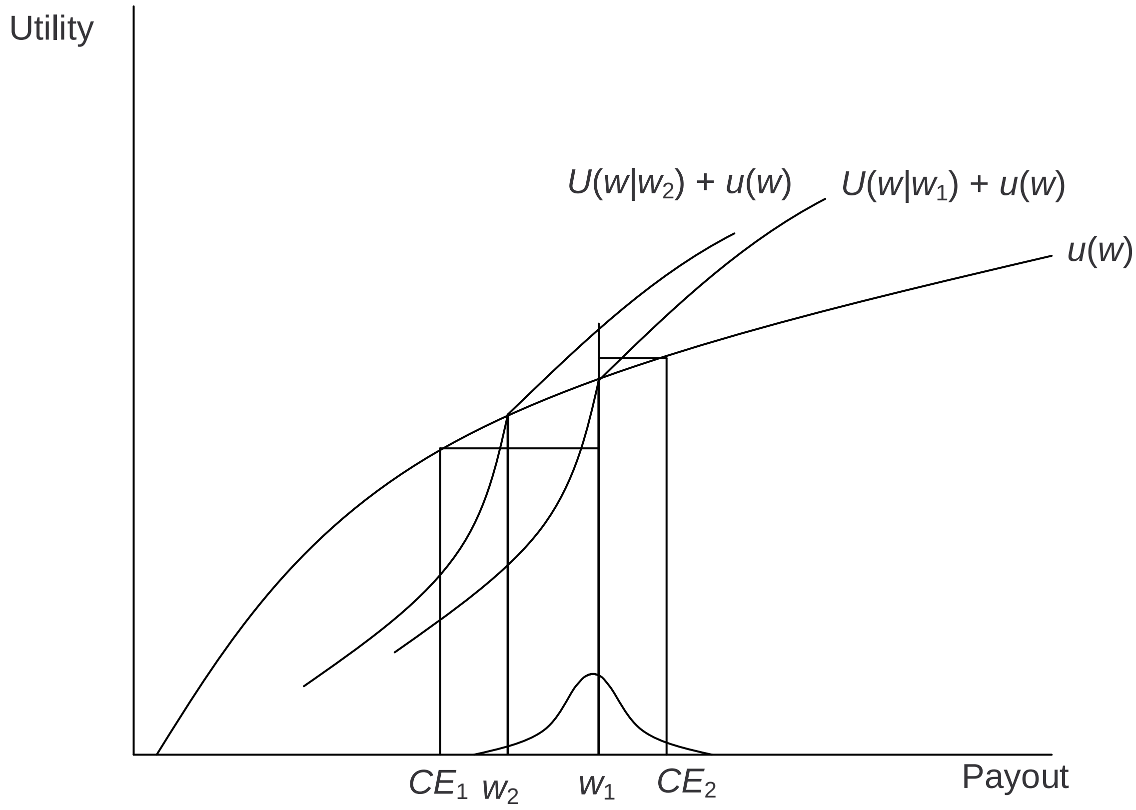

Figure 4. Certainty equivalents for various reference points under reservation independence.

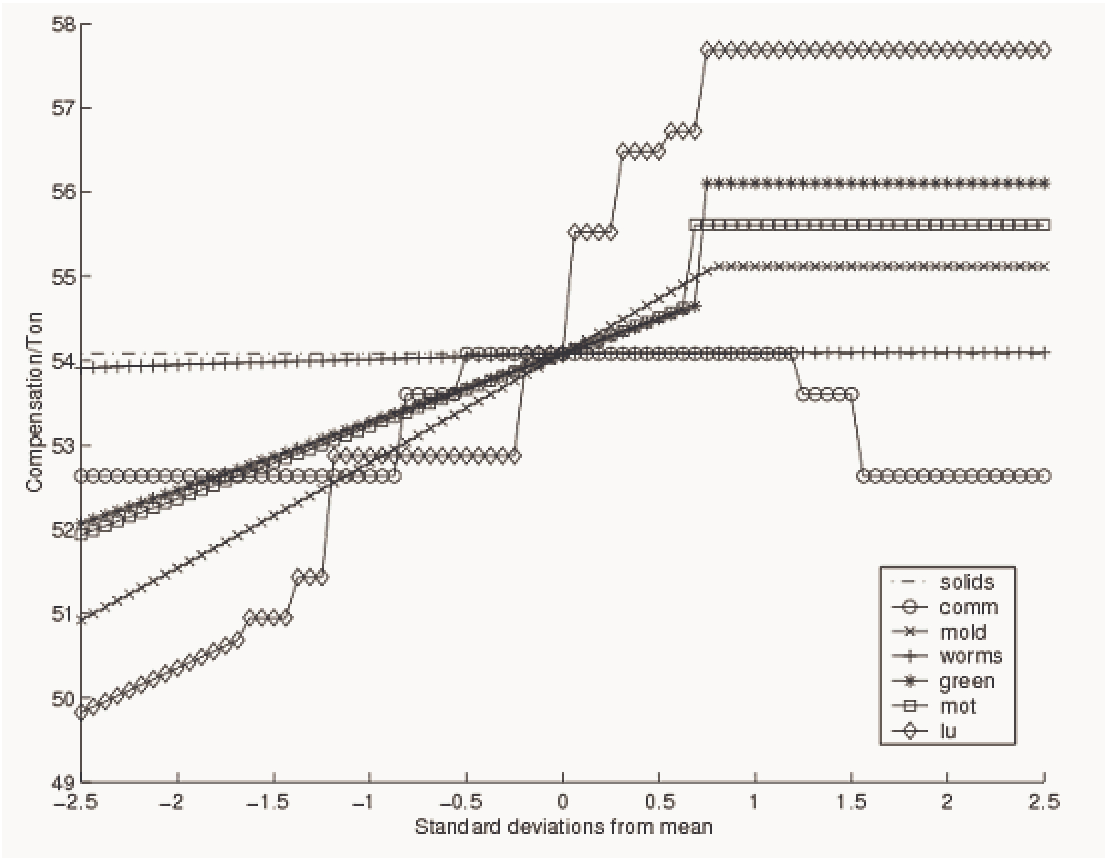

Figure 5. Compensation for an actual contract from 1998 evaluated at the mean of each quality measure (and mode grower, variety, location, and date of harvest). Marginal incentives for each measure are evaluated at standard deviations from the relevant mean holding other measures constant. Reproduced from Hueth and Ligon, 2003.