THE "REVERSE" SUNK COST EFFECT AND EXPLANATIONS RATIONAL AND IRRATIONAL

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Abstract. The all too common "sunk cost effect" is apparent when an investor influenced by what has been spent already persists in a venture, committing further resources or foregoing more profitable opportunities, when the economically rational action is to quit. Less common but arguably just as much a sunk cost effect is the mistake of giving up on a failed or failing venture too readily, sometimes out of nothing but frustration and pique at what has been lost, and otherwise through the more subtle psychological forces posited by Kahneman, Tversky, Thaler and others within "prospect theory" and related work on "mental budgeting". Two case examples are considered, wherein decision makers dissatisfied with the results of their investments, and having lost money, appear to compound their losses by selling out at prices less than their own estimates of the remaining financial worth of the failed assets. These decisions are evaluated from the perspectives of both behavioral and prescriptive economics, and are found to have possible explanations in both. Their prescriptive rationale assumes a "portfolio" theory of investment decisions, and is demonstrated within both expected utility (economics) and mean-variance (finance) frameworks.

Keywords. Sunk cost, escalation, prospect theory, portfolio theory, expected utility.

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1. Introduction.

For decision making purposes, sunk costs are strictly irrelevant. This is a law of economic logic justified by the argument that because no action (current or future) can avert or reduce a sunk cost, no sunk cost can be attributed to or have any relevance to current or future action. It is evident, however, that for many of us, the edict that sunk costs be ignored is hard to accept, if not as a matter of logic then at least in application (Thaler 1980, p.47; Thaler and Johnson 1990, p.643; Shefrin 2000, 24-5). Rather, as individual and group decision makers, we seem prone to "spend good money chasing bad". When the motivation for such persistence is not a rational assessment of the expected marginal costs and benefits of each additional commitment, but rather the thought of what has been spent already, a decision to continue exhibits the so-called "sunk cost effect":

> This effect is manifested in a greater tendency to continue an endeavor once an investment in money, effort, or time has been made. The prior investment, which is motivating the present decision to continue, does so despite the fact that it objectively should not influence the decision. (Arkes and Blumer 1985, p.124)

The same effect exists in our non-economic behavior. I note for instance my own inclination in city driving to press on even when I know I have taken a wrong turn and am well out of my way, a mistake inspired by my innate want to progress rather than "waste time" backtracking. On view here is the apparently instinctive tendency of human decision makers, affected by what has been committed to date, towards deeper or continued involvement ("escalation") rather than rational withdrawal (Staw 1976; Brockner 1992).[1] Beginning with Arkes and Blumer (1985), a succession of experimental studies in psychology and economics has uncovered much about the behavioral forces which prompt decision makers into compounding their losses by hanging on too long. Summaries of these studies' findings are provided in Staw and Ross (1987; 1989) and Heath (1995).

Qualifying much of this previous research, the empirical study of Heath (1995, pp.47, 53) raised the possibility that the siren effect of sunk costs is not as ubiquitous as has

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[1] Instances of decision makers not facing up to sunk costs, and instead letting these sway subsequent decisions, are legion. Arkes and Blumer (1985, pp.125-6) mention that during the Vietnam war commentators argued for continuation of the war so as not to waste those lives lost already. At an everyday level, Thaler (1980, p.48) cites the case of a man who paid a large sum to join the tennis club and then insisted on playing regularly despite developing tennis elbow. Students in my business classes, when asked in an exam for instances of sunk costs affecting their own decisions, had no difficulty obliging. A weekend golfer described how, after playing a bad tee shot, he could not resist trying to play "impossible" recovery shots around trees and the like. Another student complained that without being able to think of an example she had spent so much valuable time on this exam question that she could not bring herself to move on to the other questions. Circumstantial but persuasive evidence of the generality of the sunk cost effect occurs in the observation of trade volumes in stock markets falling when so are prices (Shefrin and Statman 1985; Ferris et al. 1988). The decline in volume with lower prices is attributed in part to the reticence of asset owners to sell at a loss or at a price less than one previously prevailing (Kahneman et al. 1990, p.1345; Thaler 1980; Shefrin 2000,107-17).

been believed. Heath found that the strength of this effect is not general or constant, but in fact depends on two previously unrecognized factors. Specifically, decision makers are prone to wait too long before quitting when they proceed in a venture either (i) without self-imposed "mental budgets" (spending limits), or (ii) without keeping count of aggregate expenditure.

Moreover, according to Heath (1995, pp.39, 53), investors who set "mental budgets" tend to err in the opposite direction. Their inbuilt reaction on recognizing aggregate sunk costs equal to or greater than self-imposed spending limits is to automatically withdraw from further involvement, regardless even of rational (marginal) analysis in favor of continuation:

> Organizations (and general social rules) encourage decision makers to set limits and budgets. In organizations, it is not clear which is the greater evil: giving up too late or giving up too early. There are many situations where escalation is rational. For example, when benefits come from completing a project, investments towards the end of a project produce increasingly high marginal returns. In situations where there is learning, previous investments may decrease marginal costs and increase marginal benefits by moving people down a learning curve. Mental budgeting predicts that in such situations people are more likely to make errors of de-escalating commitment than escalating commitment- they will frequently exceed their budget and quit [at] a time when marginal costs are declining and marginal benefits are increasing. (Heath 1995, p.53)

By hinging the decision to quit on what has been expended to date, rather than on what is to be gained by continuing, decision makers must sometimes, if not generally, withdraw from a venture when the rational action is to continue. This would imply a "reverse" sunk cost effect, since the decision maker is motivated by thoughts of what has been spent already, not into deeper commitment, but in the opposite direction towards premature termination.

By way of definition, the "reverse" sunk cost effect occurs when a decision maker is induced by an awareness of sunk costs into giving up an activity (e.g. investment project) when there remains, or has by that time arisen, reason for continued involvement. This paper contains two case abstracts of financial decisions seeming to epitomize such an effect. In each case, a costly investment not meeting expectations is scrapped despite economic considerations appearing to support retention, thereby leaving the impression of a decision driven more by events to date (sunk costs) than by forward looking rational economic analysis.

It is likely that the "reverse sunk cost effect" is more general in occurrence and antecedents than noted by Heath (1995). There are numerous possible derivations of such an effect within "prospect theory" and the theory of "mental accounting". This is not to say that a superficially unjustifiable cessation of business activity, or “fire sale”, cannot have rational justification, particularly when seen in relation to other (new or existing) investments, as necessitated by a portfolio theory of investments. The purpose of this paper is to develop plausible explanations of such events from the perspectives of both rational and irrational (behavioral) economics.

2. Examples of the “Reverse” Sunk Cost Effect.

The following cases exemplify decisions affected apparently by a “reverse” sunk cost effect, and provide insights on which to base more general analysis.

***Case 1*.** This example of apparent over-reaction to sunk costs occurred in a decision of my own taking and is obscured only by my abilities at introspection. Being a collector of watercolor paintings of a certain inexpensive genre, I purchased for $400 at auction an old and dirty picture. Afterwards I discovered that this picture had long previously undergone botched repairs. Because of these, cleaning and restoration would have been both more expensive and less effective than I had envisaged. All my costly experience of trying to make good out of previous mistakes told me to sell the painting without spending another penny on it, and to put the proceeds towards something “right”. There is, however, a big difference between buying and selling prices at auction, commission being charged on the hammer price against both buyer and seller. Immediate sale, therefore, would certainly provide cash, but significantly less than I had paid, even in the unlikely event of an equal hammer price (another gullible buyer[2]). Furthermore, it occurred to me that I was readily, indeed quite unreservedly, contemplating sale of my picture at a price which in other circumstances I would be more than ready to pay to buy the same painting in the same known state of repair. Put another way, being the owner of a painting and having paid $400 I had become a willing seller at say net (after commission) $200, and yet if I had not previously bought the painting for $400, I would, knowing full well its deficiencies, be eager to purchase (not sell) for $200.

These contradictory sentiments suggest an obvious asymmetry, where as a decision maker I have different views of the same item, at the very same price, all depending on whether or not I have incurred a related sunk cost (i.e. the $400 purchase price). In the presence of that cost I am driven to sell, and yet introspection tells me that otherwise I would be ready and willing to buy at the same price. When seen this way, my reaction seems as much an example of a sunk cost influencing a current decision as, for instance, that of a student refusing to give up on an exam question because of all the valuable time

[2]Where the auction house allows a system of “left” or absentee bids, there need only be a buyer and not an underbidder to lead to an overly high hammer price. This is because the auctioneer, perhaps illegally, is able to start the bidding close to the amount of the left bid, possibly by pretending to have seen another bid in the room, and then knock the lot down to the left bid at or near its limit.

wasted on it already. The difference, however, is that I am apparently too ready, rather than too stubborn, to give up.

Case 2. A corporate department was allocated an annual budget of $100,000 for computer equipment. Two groups within the department submitted expenditure proposals. Group A required a computer costing $75,000 and Group B wanted a similar but higher specification processor at a cost of $95,000. Both proposals were approved in principle, however Group B because of its higher NPV, was given priority in the current budgetary period. Its equipment was purchased at cost $95,000 but was quickly found to be inadequate. The supplier offered to replace the $95,000 machine with a higher capacity $170,000 processor at a discounted price of $150,000. Part of this deal was that the $95,000 processor would be on sold for a price of $40,000, the supplier making no commission on this sale. The market realizable value of the used machine was between $50,000 and $60,000 less commission. Accepting the supplier's terms, the company acquired the $170,000 machine for a price of $150,000 financed in part by the $40,000 sale of its initial purchase.

Although unhappy with these events, Group A conceded that management had no choice but to prop up Group B once its new equipment had failed. The prospect of lost income and compensation payouts greatly altered initial NPV estimates and necessitated, on financial as well as other grounds, continued expenditure on equipment for Group B.[3] Less acceptable to Group A was that the company had sold for, in effect, just $60,000 (i.e. the $40,000 proceeds of onselling plus the $20,000 discount allowed by the supplier as part of this transaction)[4] a processor which exceeded in all relevant specifications the machine required by Group A, a machine the company had previously agreed to buy for $75,000.

The essence of Group A's disaffection was that by selling for only $60,000 the company effectively added to the amount of its loss. After making an unfortunate decision in the first place, the company was left with a processor which was not worth $95,000, at least not for Group B's purposes, but was worth at least $75,000, the price the company had been ready to pay for a lesser equivalent to be used by Group A. By selling for just $60,000, the company contradicted its previous readiness to buy for $75,000, and on its own figures (as contained in the Group A proposal) forfeited more

[3] The very failure of the first investment creates a "new" investment alternative with high NPV, namely that of fixing the mess. Effective corrective has high NPV because its incremental effect is first to restore production and revenue levels and then to raise them to levels intended before the initial failed investment.

[4] Another way to view the effective sale price of $60,000 is as the difference between the $170,000 normal cash price and the amount of $110,000 actually paid. It could be argued that the sale price was really only $40,000 since the $20,000 discount could have been negotiated anyway (which only adds to Department A's grievance).

than $15,000 of NPV, on top of what was lost in the initial purchase, thereby adding insult to injury.

On this interpretation of its financial decision making, the company, shaken by what it had already lost, sold out for less than it should have remained ready to pay. By implication, the effect of the sunk cost, as in the case above, was not in the usual direction in favor of persevering with a failed asset, but in the opposite direction toward underestimating the value of that asset and the potential benefit of its retention. This would imply a "reverse" sunk cost effect, the more common or at least well documented sunk cost effect (Arkes and Blumer, 1985) being one of overvaluing rather than undervaluing retention.

4. Explanations Irrational

How is it possible to explain the behavior of a decision maker who buys an asset for price *P*, realizes that it has deficiencies not anticipated at purchase, and proceeds to sell for a price not only less than *P* but significantly less than would (if he was not already the owner) be paid willingly by the same decision maker for the same asset even given its revealed deficiencies?

The following possible explanations imply economic irrationality and are for the most part built on generalizations established already in positive (behavioral) economics.

Hypersensitivity to sunk costs. There is indication in the empirical literature that prior losses can sensitize decision makers to further losses (Thaler and Johnson, 1990 pp. 649, 656). This might explain a tendency of decision makers hurt by previous episodes of hanging on too long towards the opposite mistake of "getting out" too readily. When the prospect of making the same mistake again, allowing losses to grow out of inaction, is too painful to countenance, immediate termination and realization of whatever is left can become relatively very attractive.

Staw and Ross (1987, p.69) envisage a "withdrawal prototype" as essentially a situation where "the objective situation increasingly worsens over time, making it economically clear that persistence is more costly than withdrawal" (cf. Garland et al. 1990, p.726). Experienced decision makers appreciate that the costs of not withdrawing are not just additional out-of-pocket costs (e.g. recurrent operating expenses) but, often much more tellingly, the opportunity cost of not having shifted investment funds away from the failing asset into a more profitable alternative. Having often enough made this mistake at lasting financial and emotional cost, the decision maker's psychology can shift from an immature tendency to persist with a failing activity to a tortured over-readiness to give up.

Minimizing Expected Regret Also relevant is the notion of "regret" whereupon decision outcomes are evaluated against "what could have been". In economics, regret is the emotion or feeling of loss which arises "with the ex post knowledge that a different decision [e.g. terminating a losing venture] would have fared better than the one chosen" (Shefrin and Statman 1985, p.781). It may be that regret is amplified when losses are effectively of "one's own making", as when the decision maker, by not acting, lets losses spiral. To minimize expected regret, decision makers must look into the future and compare possible best case and actual outcomes. If this comparison shows that holding on may (with even low probability) mean a very bad outcome relative to the amount lost thus far, the potential for regret is great, and the inclination is to take today's loss rather than risk tomorrow's self-recrimination.

Reduced Risk Aversion After Losses. Prospect theory (Kahneman and Tversky, 1979) presumes a convex "value" function in the domain of losses. By corollary, typically risk averse decision makers are expected to become risk takers when they perceive themselves as being behind or having lost thus far on a venture:

> The convex shape of the loss function in prospect theory predicts that people will generally be risk seeking in the domain of losses... . This prediction is repeatedly found in the empirical work reported by Kahneman and Tversky and others.... . (Thaler and Johnson 1990, p.656)

Risk taking subsequent to losses ("playing catch-up"), especially when there is the prospect of recovering in full the amount lost (Thaler and Johnson 1990, p.658-9), is according to prospect theory and casual observation a characteristic and widely evident trait of human decision makers:

> ...a person who has not made peace with his losses is likely to accept gambles that would be unacceptable to him otherwise. The well known observation [McGlothlin, 1956] that the tendency to bet on long shots increases in the course of the betting day provides some support for the hypothesis that a failure to adapt to losses or to attain an expected gain induces risk taking. (Kahneman and Tversky, 1979 p.287)

An urge to gamble in ways which can result in loss recovery may explain the liquidation of low return assets at ridiculously low prices. By raising cash, even just small amounts, an investor (gambler) betting on long shots has more to play with. That is, rather than being satisfied to leave whatever value an asset retains (its market realizable value) in that asset earning a relatively low rate of return, the gambler might prefer to sell out at a liquidation price so as to back a long shot with the proceeds. Then there is the potential (albeit low probability) of full loss recovery, something not achievable by merely hanging onto the already "failed" lower return, lower risk asset.[5]

Mental accounting (coding gains and losses). Thaler (1980; 1985) proposed a theory of how human decision makers mentally "code" or "frame" gains and losses in ways which make them most pleasurable or least painful. This theoretical framework, built on prospect theory and the value function of Kahneman and Tversky (1979), explains and predicts behavior (decision) patterns which although common have no possible rationalization in normative economics.

[5] As a rule, stock market investors do not often settle for selling a losing stock and holding the proceeds in cash, they prefer to "have another bet" even in a falling market (Shefrin and Statman 1985, p.781).

The assumed value function $v(x)$ is concave for gains (positive x) and convex for losses (negative x) and is steeper for losses than gains. Because $v(x)$ has these properties there are many situations where a pair or other combination of gains and losses has higher value when considered as a package ("integrated") than when viewed as distinct ("segregated") entities or "accounts" (e.g. the psychological "value" or acceptability of two losses $-y$ and $-z$ is greater when coded as $v(-y-z)$ than as $v(-y)+v(-z)$; Thaler 1985, p.202).

The inclination of decision makers to psychologically "integrate" what are manifestly separate transactions, thereby reducing the effective marginal hurt of a given monetary or other loss, might explain a decision to trade-in an unsatisfactory acquisition against something apparently offering appreciable gain. By trading-in the failed asset, even for less than its true worth, rather than say selling it to another party in a separate transaction, the decision maker is more able to conjure a mental picture of a gain and loss occurring as one, rather than of a gain on one account and a loss on another.[6]

Take for example the purchase of Group B's second computer in the example above. This investment offers a significant increase in cash flows given their much reduced levels after the first unsuccessful purchase, and thus a large gain. When set off against (integrated with) this gain, the loss on sale of the first unsuccessful purchase causes relatively little pain. If the gain g earned by replacing the failed acquisition is high relative to the loss $-l$ attached to the sale of the defective asset, then $v(g-l)$, apart from being higher than $v(g)+v(-l)$, can be positive.

Furthermore, the trade-in decision is likely to be framed using the sunk cost (loss on purchase of the first machine), say $-k$, rather than the origin, as its reference point, in which case, because of the convexity of the loss function, the loss recovery aspect of the second investment is enhanced and the pain of the added loss $-l$ on trade-in is further reduced. This can be seen in Figure 1. After making a loss of $-k$ on the initial purchase, the decision maker trades-in this item for a figure even less than it is worth, thereby adding a second loss of $-l$ to the first loss of $-k$. When framed with reference to the first loss, the marginal pain of the second loss is not $v(-l)$ but merely $v(-k-l)-v(-k)$. Moreover, integrating the gain g coming from the new purchase with the trade-in loss $-l$,

[6] Shefrin and Statman (1985, p.781) observe how stockbrokers found that by using the phrase "transfer your assets" in their advice to clients, they were able to encourage investors who had lost on one share investment to sell this and buy into another. The image of continuation rather than termination promoted by this phrase seems to aid an unhappy investor to merge one "mental account" with another and thus to avoid any psychological acceptance (scoring) of a loss on the first account.

the net effect is an increase in the decision maker's feeling of well being from the reference point $v(-k)$ all the way up to $v(-k-l+g)$, a very soothing prospect.

Insert Figure 1 about here.

Mental budgeting (stop loss orders). As a self-control measure (Thaler 1980, pp.54-7; Brockner and Rubin 1985, pp.196-7) people commonly pre-commit psychologically to withdrawing from a venture if results have not been achieved by some cutoff date or investment limit (e.g. "give it twelve months" or "stop at $100"). The exact amounts of these "mental budgets" are generally quite arbitrary and not derived out of any decision rule from economic theory. For example, stock traders use automated stop loss orders (e.g. "sell if the stock price falls 10%") as mechanical devices to protect them from any psychological tendency to hang on too long in the hope of a turnaround (Shefrin and Statman 1985, p.514). Such self-imposed stopping rules are not intended to be rational in the narrow economic theory sense. To the contrary, they constitute a tacit admission of inherent irrationality (of an innate tendency to "ride losses too long").

In this vein, Heath (1995, p.52) maintains that far from being rational by the standards of normative economics, pre-commitment and adherence to mental budgets sometimes leads investors to quit (e.g. sell out of a capital investment project) when any rational economic (marginal) analysis would call for continued and even heightened commitment. This effect could also explain the phenomenon of a decision maker, who to date has posted a loss, selling his interest for less than he would in other circumstances be prepared to pay for the same investment. Having reached his self-imposed limit (spent his mental budget) the decision maker takes whatever he can get and gets out. He is then relieved of any temptation to risk worse or total loss in pursuit of what has already been lost.

Preference reversal upon purchase (the thrill of the chase). There is no shortage of anecdotal evidence that individuals although acquisitive sometimes value things less after they acquire them than before. This is the "greener pastures" syndrome and is known to dedicated collectors as "the thrill of the chase", as compared with the often lesser thrill of possession. Assuming that there is something of a preference reversal on acquisition, it is feasible that a decision maker might sell something he owns for less than he would otherwise be ready to pay for it. There is a standing joke consistent with a "thrill of the chase" effect among traders who buy and sell chattels at auction. When asked "why do you sell?", the trader's instinctive response is "so that I can buy". This is seen as laughable and yet not irrational. Indeed it is so common as to often pass without comment for a dealer to sell something at auction this week for less than he paid at the same sale two weeks earlier, having carted the item back and forth between times.

Note that the "thrill of the chase" effect runs opposite to what Thaler (1980, p.44) called the endowment effect. The essence of the endowment effect is that an individual who has in his ownership (endowment) a valuable asset will generally want a significantly greater price to sell that asset than he would himself pay to buy it.[7] It is recognized, however, that there are circumstances when no endowment effect is likely, such as when goods are purchased for resale rather than personal consumption or possession (Kahneman et al. 1990, p.1328; 1991, p.200). Transactions where the buyer is immediately unhappy with his purchase may also be exceptional, perhaps because this dissatisfaction precludes any feeling of ownership or acceptance of the purchase into the buyer's psychological endowment. According to the endowment effect, the pain (disutility) of giving something up is greater than the pleasure (utility) of acquiring it (Thaler 1985, p.201; Kahneman et al. 1991, p.194). When, however, the initial anticipation of acquisition turns nearly immediately to dissatisfaction and annoyance, sale may be atypically appealing in that not only is a source of irritation removed but money is received to boot.

Hubris and bad temper. The decision maker might sell at an unduly low price just to be rid of an embarrassment and source of constant irritation. In a corporate environment, managers responsible will find it hard to live down a decision to buy what was found to be a "dud" while that acquisition remains under and on the corporate nose.[8] Management decision making is surely driven at least partly by hubris and dysfunctional ego rather than strictly by the objective of maximizing corporate wealth, a kind of "agency problem".[9] Immediate sale of an investment or interest at a miserably low price ("taking

[7] This effect has been found repeatedly in experimental studies (Kahneman et al. 1991, p.205) and is thought to explain an observed volume reduction in falling markets (Kahneman et al. 1990, p.1345).

[8] Another common reaction to an unhappy purchase is to rid the item from one's sight. Mould (1997, pp.42-46) describes how an apparently over-costly painting met with the immediate dissatisfaction of its purchasers and was deposited out of sight in a cupboard. Only after twenty years of owner "denial" was it sent back to auction (unexpectedly realising a vast sum).

[9] De Bondt and Makhija (1988, p.183) offer essentially the same "agency problem" explanation for instances of managers covering their mistakes by spending more money on unsuccessful ventures. This is the opposite method of "damage control" (i.e. minimizing loss of face etc.) as that of selling out too quickly for too little. A further possibility is that by selling at a sufficiently low price managers can have the buyer agree to, and go to some trouble and cost to ensure strict price confidentiality. This explanation is consistent with the argument of Kanodia et al. (1989, p.60) that business managers are motivated rationally (in their own self interests) to protect their reputations as sound business decision makers by suppressing contrary information. Another self-interest (and thus personally rational) explanation lies in the "market for excuses". Watts and Zimmerman (1979) portray accounting arguments generally as "excuses" taken up by vested interest groups to justify their inherently preferred decisions. The "realization" (according to accounting criteria) of a loss and its

a bath" in management jargon) may be less painful to the ego than a more drawn out period of discredit. At worst, a babyish reaction to an unhappy outcome is to "spit the dummy" in a fit of pique discarding something which remains of obvious value. Even mature decision makers may retain something of this inclination.

Conventional market wisdom. This explanation sources from my discussions with, and observations of, regular auction traders, including seasoned art and antiques dealers. When I confess my reflex and apparently irrational over-reaction to mistaken purchases (see Case 1), most other traders of any experience say either that they do, or wish they had always done, the same thing. More particularly, they suggest that it is always best "in the long run" to cash in a "dog", and put whatever possibly small amount realized toward the purchase of something "right", albeit typically more expensive.

A dealer's commitment to this conventional market wisdom might be understood, of course, by its implication of more, and more expensive, sales. There is, however, another explanation to do with what I will call the "value-for-money" function for collectibles (and possibly other assets including computers), by which is meant a function representing the maximum "value" on offer at auction or on the market for a given dollar outlay.[10] It is hypothesized that this function is (up-to-a-point) convex, meaning increasing marginal returns to the dollar.

The solid line in Figure 2 represents such a function. Although this line entails (increasingly) increasing value-for-money, there is no suggestion that merely by spending more money the buyer will necessarily get better "value". Rather, the value-for-money function represents the *maximum* value on offer at a given price. This value is achievable at any given outlay through highly astute (or lucky) lot selection. The value-for-money function is thus a kind of "efficient frontier". Less "efficient" purchasing is always possible, where the buyer spends amount p and gets value $v<v(p)$ rather than the maximum possible $v(p)$.

Insert Figure 2 about here.

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consequent recognition in company accounts might be used by management as an excuse before staff or shareholders for dismissing the decision maker or curtailing further corporate investment in the area. When an action would otherwise be highly unpalatable or hard to justify, a very public loss on sale of a failed asset, albeit in truth an unnecessarily large loss, can provide the excuse at a superficial level that management needs and would even pay for. A variant of this explanation is one which has senior managers holding back their subordinates by hastily selling out and thus denying them any chance of demonstrating their qualities through corrective or ameliorative measures.

[10] In art, value is often talked about in terms of "desirability", and depends on a range of principal attributes including intrinsic technical quality, rarity, artist "name", condition, and provenance (ownership pedigree). These are the value "constants", other less reliable factors such as current art "fashions" also affecting sale prices but notso much "desirability".

On the above model of value-for-money, it is possible to rationalize the sale for net \$200 of a picture costing net \$400 notwithstanding the seller's acknowledged readiness in "other circumstances" to pay \$200 for the same picture in the same known condition. Based on Figure 1, the argument proceeds as follows. I spend price p_1 buying a picture and unwittingly acquire value of only v_2 when I should ideally have secured value v_1. Upon realizing the weakness of my selection, I sell out for price $p_2<p_1$ and realize amount $(1\text{-}c)\,p_2$ where $0<c<1$ and $100c\%$ is the aggregate (buyer plus seller) percentage commission to the auctioneer on a net price to the purchaser of p_2. I can now spend this money, either in the same amount or as part of a bigger outlay. If I spend it by itself the best value achievable is v_3, an unappealing prospect given both that I should now be at v_1 and that I am already at v_2 before selling out. More attractive is the dealers' wisdom (escalation strategy) of adding an amount p_3 to my previous investment and spending in total $p_3+(1–c)\,p_2$. This outlay offers the prospect of value v_4 far in excess of v_3 and even v_2. Its appeal can be summarized as follows:

(a) By injecting the extra funds p_3 the investor can use the proceeds $(1–c)\,p_2$ from sale of the mistaken purchase to add marginal value $(v_4–v_5)$. This marginal value is much greater than the maximum value v_3 which these proceeds would buy of themselves, and may in some circumstances (as in Figure 2) exceed the value v_1 which could have been acquired at best with the amount p_1 of the initial purchase.

(b) The end result, as measured by value achieved is v_4. This is less than but "approaching" the value v_6 which might optimally have been achieved through total expenditure (p_1+p_3); the larger the funds injection p_3 the more closely the ratio v_4/v_6 approaches one (assuming astute purchasing on the second attempt) and hence the closer the outcome to "full recovery".

In the light of these comparisons, the argument for cashing in and buying a more expensive and much more "desirable" picture, has some appeal. By following this strategy, the investor manages what is in retrospect a very good albeit not ideal outcome, something which cannot be said of his initial purchase. The obvious detraction is the need to commit additional funds, and perhaps a large amount relative to the initial outlay. As a consequence, the investor's total portfolio must include less cash (or more borrowing) and more risky assets (in this case art), with whatever effects this shift has on overall portfolio returns and risk. Because these portfolio effects are not taken into account, the above explanation cannot be considered economically rational.

5. Explanations Rational

There are two well established normative theories of investment under uncertainty, each of which accounts in its own way for portfolio returns and risk. These are expected utility theory (economics) and mean-variance portfolio theory (finance).[11] The decision sequences observed in the two cases described in this paper, being of interest because they typify many business and personal investment histories, have plausible explanations within both expected utility and mean-variance portfolio theories. The curious aspect of these cases is that the decision to sell (terminate) an investment seems to be influenced by the preceding decision to spend so much on its acquisition (a sunk cost). Because of this apparent linkage between decisions, it is instructive to vet each decision in sequence, beginning with the initial investment and culminating in its liquidation and possible re-investment of proceeds.

Decisions occurring at different times are best modeled dynamically. A dynamic model would not only test the rationality of each discrete decision as of the time of its making, it would involve additional criteria regarding the optimal timing of decisions. For example, supposing the decision maker has reason to terminate an investment, when exactly (how soon) should this happen? For the purposes of this paper, however, a "static sequential" rather than dynamic model is sufficient. Apart, for example, from obvious requirements such as that the decision to quit occurs after the decision to invest, such a model is not concerned with the precise timing of each decision, but merely with its rationality in the usual static (temporal) sense. Specifically, the decision maker is required to act optimally (e.g. maximize expected utility) at the instant of each decision according to his state of affairs (e.g. wealth) as at that instant. A current decision can therefore be "affected by a preceding decision" only in the sense that the earlier decision caused a change in the decision maker's circumstances, such as, for example, a loss of wealth and consequent change in risk aversion.

Although simple, this model provides the essential insight that a current investment choice can appear as if influenced by an earlier decision, when in fact it is not that preceding choice but merely its chance outcome (e.g. large wealth loss) which drives current decision making. From this perspective, rational choice means merely that, over time, each new decision is made according to the circumstances of its time. The

[11] Contrary to some misapprehension, both the expected utility and mean-variance models control for the risk (uncertainty) of expected future returns as well as their magnitude. In his Nobel lecture, Markowitz (1991 pp.471-5) made note of the common purpose and subject matter of the mean-variance and expected utility models of portfolio choice, and argued on the basis of simulated stock return data that the two are essentially compatible in that they typically lead to very closely the same optimal portfolios. The suggestion is that mean-variance tools effectively operationalize the more practically troublesome expected utility framework.

previous decision path out of which those circumstances arose is not relevant. Any other investment sequence culminating in the same present circumstances would imply the same present rational investment choices.

Expected Utility Theory. This exposition is based of the following assumptions. An investor has a given amount of wealth spread between cash and risky assets. Wealth is measured by the sum of cash and the market value of assets. Assets are assumed to be durable in the sense that their market value does not diminish until they are either "used" or sold. This means that if an investor with wealth W buys an asset for market value m, his wealth after purchase (including the market value m of the new asset) is still W. At this point, he has the choice of either selling out for m (converting market value back to cash) or holding on. If the asset is held (used), its value reduces to second hand (or scrap) value s, and the investor earns net "operating" revenues r. The overall net effect on wealth is then $(m–s)+r$, where $(m–s)$ is the decline in market value (economic depreciation) of the asset, caused by its use.

Take the case of a diminishingly risk averse investor with initial wealth W_0, all held in cash, and thus implying certain utility $U[W_0]$. Being risk averse but not wanting to hold only cash, the investor identifies a risky asset G from which he expects to make a profit of a dollars with probability ρ and a loss of b dollars with probability (1-ρ). These amounts a and b represent net changes to wealth in the way described above - that is, including both operating costs and revenues and depreciation (loss of market value).

The investor's expected utility given investment G is

$$\rho\, U[W_0+a] + (1–\rho)\, U[W_0–b],$$

which is found to exceed current utility $U[W_0]$, and hence the investment goes ahead.

Although intending to buy G the investor mistakenly buys an inferior asset F. Unfortunately he pays the full market price of G, an amount c, but acquires an asset with lesser market value m ($m<c$). His wealth (cash plus market value of risky assets) is thus immediately reduced from W_0 to $W_1 = W_0–(c–m)$. The amount of W_1 includes the realizable market value m of the mistaken investment F. The investor can now either sell F for price m, thus effectively retreating to *certain* (cash only) wealth $W_1<W_0$, or he can hang on and take whatever profit or loss this unintended acquisition has to offer.

There are arguments both for and against retention of F. In favor of retention is the realization that F is not worth much to sell. Relative to this low market value, the expected profit available from holding on to F may be relatively very good (i.e. F may offer a high expected yield relative to its low market value). On the other hand, holding a risky asset, even one with little market value, can bring about further loss, and having already lost some of his initial wealth, the investor may no longer have the same appetite for risk (i.e. he may be more risk averse).

Suppose that the possible returns (changes in net wealth) from holding on to asset F are a profit of d dollars with probability π and a loss of e dollars with probability $(1-\pi)$. Recognizing that he now has reduced wealth (including m) of only W_1, the investor's expected utility if he retains the failed asset is

$$\pi U[W_1 + d] + (1-\pi) U[W_1 - e]. \tag{1}$$

If this expectation (1) is less than $U[W_1]$, then the investor, having been reduced to wealth W_1, must now "cash in" rather than retain the failed asset F (thereby realizing m dollars). Implicitly, he is sufficiently risk averse at his new wealth W_1, that he is compelled to sell F, notwithstanding its low price. In effect, his risk aversion is such that he has no choice but to settle for certain (all cash) wealth $W_1 < W_0$ rather than risk further loss. The other possibility is that (1) is greater than $U[W_1]$, in which case the investor, if faced with the simple decision of whether to sell or hold risky asset F, should hold. That is, asset F is worth more to the investor than its market value m.

Given that the point of this analysis is to understand decisions exhibiting an apparent "reverse" sunk cost effect - that is, decisions where logic seems to favor retention, rather than sale, of the failed asset - only the latter possibility is relevant. In such cases, the investor might, however unhappily, accept his loss of wealth $(c-m)$ as "spilt milk", contenting himself that in light of its low market value, asset F offers percentage returns more than sufficient to warrant its retention.[12] By selling out he would not get back his initial investment c, but would realize only the lower amount m, an amount which is effectively already "well invested" in asset F, as implied by the premise that expectation (1) exceeds $U[W_1]$.

[12] Without claiming great emotional maturity, my own experience is that in time I have sometimes been able to enjoy a picture for which I paid too much. It is rational but not easy to look at the item's cost not as what was paid for it but as what it could be sold for (Devive and O'Clock 1995, p.29). A good psychological aid is to consider the item for which too much was paid as part of a package including one or more items purchased very cheaply ("mental accounting"). I find it easier to sell a "dud" and take a loss at a sale where there is a highly "desirable" item that I expect to "buy well". Often I have hung on to a previous "mistake", almost in a state of denial, implicitly waiting for a chance to mentally "integrate" a loss on it with a gain on the new item.

Alternatively, heeding the art dealer's maxim of "cash in and buy right", the investor might be motivated to look at investment alternatives beyond just "sell versus keep". Even assuming that sale of F is not of itself optimal, as explained above, it is possible that as part of a more wholesale portfolio overhaul there is something to be gained by converting F into cash. This requires the existence of another investment possibility, such as for example the investor's initial favorite G, with certain specifiable characteristics. In particular, investment in asset G (funded in some part by the proceeds from sale of F) must be preferable not only to simply persisting with the existing investment F, but also to an investment *portfolio*, hereafter denoted by $F \cap G$, containing both F (retained) and G (newly acquired).

As has already been established by the investor (see above), alternative G offers net profit a with probability ρ and net loss of b with probability $(1-\rho)$. Given current wealth W_1 (including the market value of F), the expected utility of investing in G by itself, making use of cash from the sale of F, is

$$\rho\, U[W_1+a] + (1-\rho)\, U[W_1-b], \tag{2}$$

which, depending on the values of ρ, a and b, may exceed the expected utility (1) of simply retaining F, in which case (sale of F and) investment in G is preferable to continued investment in F.

Exploring this possibility, that is assuming (2) > (1), the question remaining is whether, with (1) exceeding $U[W_1]$, the expected utility (2) of the new investment G can exceed that of the portfolio $F \cap G$ achieved by both retaining F and investing in alternative G. If so, then F is not acceptable in conjunction with G and the decision comes down to a choice between F and G, of which G has the higher expected utility (since (2) > (1)).

Before any such possibility can be considered, some assumption is necessary regarding the diversification benefits achieved by combining F with G in portfolio. Because risk averse investors benefit from diversification, any demonstration of the need to sell rather than retain F in portfolio with G is stronger if we assume a high degree of diversification between the outcomes of F and G. The convenient assumption mathematically is independence, which implies strong diversification provided that ρ and π are not both very high. Assuming independence, the expected utility (given wealth W_1) of a portfolio of the retained investment F and the new alternative G is

$$\rho\pi\, U[W_1+a+d]+\rho(1-\pi)\, U[W_1+a-e]+(1-\rho)\pi\, U[W_1-b+d]+(1-\rho)(1-\pi)\, U[W_1-b-e]. \quad (3)$$

If this expectation is less than the comparable expectation (2) of investment in G alone, then G is preferable to $F \cap G$, and thus the investor must sell (trade-in) F, investing only in G. The following mathematical argument based on the diminishingly risk averse utility curve of Figure 3 reveals such a possibility.

Insert Figure 3 about here.

Figure 3 shows the possible utility effects of holding F of itself and in combination with G. When retained by itself, without investment in G, and assuming wealth W_1 (including the market value of F itself), the possible utility changes are a gain of u with probability π and a loss of v with probability $(1-\pi)$. The indifference probability $\pi=\pi_1$ for retention of F is given by $\pi u = (1-\pi)v$, and equals $v/(u+v)$. This is the minimum value of π at which it is rational to retain F when the alternative is to simply sell F and "do nothing" (hold only cash).

Figure 3 also shows the utility effects of retaining F in portfolio with G. Here we look at the marginal effects of F in conjunction with G. When G yields a profit of a, as occurs with probability ρ, the marginal utility effects of F are a gain of w with probability π and a loss of x with probability $(1-\pi)$. And when, with probability $(1-\rho)$, G returns a loss of b, the marginal utility effects of F are a gain of y with probability π and a loss of z with probability $(1-\pi)$. Rewriting (3) as

$$\rho\pi\,(U[W_1+a]+w) + \rho(1-\pi)\,(U[W_1+a]-x) + (1-\rho)\pi\,(U[W_1-b]+y) + (1-\rho)(1-\pi)\,(U[W_1-b]-z)$$

and setting this expression equal to (2), the indifference probability $\pi=\pi_2$ for retention of F in portfolio with G is found to be

$$\frac{(1-r)\, z + r\, x}{(1-r)\,(y+z) + r\,(w+x)}\,.$$

This is the minimum value of π at which retention of F adds positive marginal expected utility over and above an investment in G alone. Hence, for $\pi>\pi_2$, $F\cap G \phi\ G$, or put the other way, for $\pi<\pi_2$, $G \phi\ F\cap G$ (where "ϕ " signifies strict preference).

Given the diminishing slope (risk averseness) of the investor's utility function, it is possible with sufficiently low ρ (or sufficiently high a/b) that π_2 exceeds π_1. There is then an interval of π values $\pi_1<\pi<\pi_2$ within which retention of F by itself is better than "doing nothing" (i.e. better than selling F off and holding only cash) and yet G by itself is a better investment than G with F in portfolio. It can also occur even with ρ low enough to ensure $\pi_2>\pi_1$ that G alone is a better investment than is F alone. This requires large a/b (as is consistent with $\pi_2>\pi_1$). In the event of these various conditions being met, $F \phi$ "doing nothing", $G \phi\ G\cap F$ and $G \phi\ F$, meaning that the logical investment is G by itself. Under these conditions, the investor has no choice but to divest from F and put the proceeds of sale towards investment in G. This is despite F's demonstrable acceptability as an investment of itself.

Numerical results illustrating the above argument are as follows. Assuming the sum of exponentials (diminishingly risk averse) utility function of Lindley (1985, p.86),[13] and supposing the values W_1=80, a=150, b=60, d=20, e=18, the class of (π, ρ) values jointly satisfying all three preference conditions above is shown by the shaded area in Figure 4.

Insert Figure 4 about here.

Note that the conclusion that G is a better investment than $F\cap G$ (allowing for F's acceptability of itself) is reached more easily if the outcomes of G and F are not independent but dependent and positively correlated. In the extreme case when the returns of G and F are always good or bad together (perfect positive correlation), the marginal expected utility of F when combined with G is $\rho w-(1-\rho)z$, and exceeds zero only for $\rho > z/(z+w)$. Because of the diminishing slope of the utility function, this critical value of ρ is very high (approaching one with increasing a, all else constant). More generally, under conditions of strong positive correlation between G and F, $G \phi\ F\cap G$ except in cases of very high ρ. This suggests that sale of one asset to fund another of the same type (e.g. sale of one painting to help pay for another painting) is supported by the fact that the two assets involved are likely to offer strongly correlated

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[13] The utility attached to wealth x is given by $1-0.5\,\text{Exp}[-x/200]-0.5\,\text{Exp}[-x/20]$. Any function of the form $1-\text{Exp}[-ax]-b\,\text{Exp}[-cx]$ with parameters a, b, $c > 0$ is diminishingly risk averse (Pratt et al. 1995, p.807).

returns (both being subject to general trends in art prices), and thus little if any diversification benefit.

Portfolio Theory. In corporate finance, the subject of risk and return, and more generally portfolio management, is understood in terms of mean-variance portfolio theory. Just as expected utility theory can explain the behavior of an investor cashing in an asset which relative to its market value (and risk) is not under-performing, and using the proceeds to fund a portfolio of higher expected utility, portfolio theory offers an essentially analogous rationale.

The fundamental assumption of mean-variance portfolio theory is that the investor wishes to achieve an optimal expected (mean) return versus risk (variance) compromise (μ, σ), as determined by the shape of his utility indifference curves. Assuming that he is risk averse, utility is a convex function $f(\sigma, \mu)$ of risk σ and return μ.[14] Each possible investment portfolio presents a mean-variance (μ, σ) combination, and can be compared with its alternatives according solely to these two parameters. The various possible portfolios are mixtures of cash (risk-free) securities and risky assets.

Mean-variance portfolio theory offers the following explanation of an investor's reaction to an investment which results in a loss. The overall effect of the investment and subsequent loss is to (i) reduce the cash or cash securities component of his portfolio by the cost c of the investment, and (ii) add to the risky assets portion of his portfolio a lesser amount m equal to the market realizable value of the unsuccessful acquisition (meaning a wealth loss of $(c–m)$). Both changes increase the proportion of risky (non-cash) assets within his portfolio, thus increasing portfolio risk (variance).

Because of this increase in risk, retention of the failed asset can be untenable, even when that asset offers high expected returns relative to its diminished market value (i.e. a high "dividend yield"). Contributing to this effect, the investor's indifference curves may be steeper (more risk averse) at reduced wealth levels. In these circumstances, the investor is obliged to take refuge in cash, and thus to sell off the risky asset, possibly at a price much lower than cost, so as to constrain overall portfolio risk. On the other hand, the returns offered by the failed asset may be high enough relative to its possibly much reduced market value that, in the absence of other investment opportunities, it should be

[14]Note that although it is usual in finance to talk of mean-variance (μ, σ) in that order, explanations of portfolio theory all but always have σ positioned on the horizontal axis and μ on the vertical. Pratt et al. (1995) label their axes the other, more mathematically conventional way, which unfortunately makes their otherwise unfaultable exposition a little difficult to relate to other references.

retained rather than cashed in. That is, its high yield (measured correctly against market price) warrants persistence even allowing for an increase in the investor's risk aversion since its initial mistaken acquisition.

There is no saying, however, that such an asset should be retained once other investment possibilities are considered. Moreover, it may not be feasible to both retain this asset and at the same time invest in a separate, individually preferable security, without unacceptable increase in overall portfolio variance. This can occur even when the covariance between the two assets' returns is not high (i.e. when there is a diversification benefit from holding them both). The necessity in which case is to sell the individually inferior asset, possibly even for a price less than "it is worth" (i.e. less than would be accepted for it if the choice was only between it and nothing), thereby contributing towards financing the preferred risky asset without unduly running down cash holdings or running up borrowings (negative cash).

7. Conclusion.

Once an investment has failed and is worth little, it need not offer the returns previously expected of it to warrant retention. When measured in relation to its depleted market value, even much lower returns may be attractive. Against this economic inertia, investors sometimes sell a failed asset at a price not only less than cost but less indeed than the failed asset would seem to be worth, even accounting for its defects. Such action may be symptomatic of a psychological "reverse" sunk cost effect (e.g. the investor frustrated by losses "spits the dummy") but can also be explained on more rational grounds.

Rationally, there are just two reasons for why a failed asset might be sold. These are:

(i) Losses incurred to date leave the investor with lower wealth and hence greater need for the certainty of cash (riskless assets) rather than a continued risky investment.
(ii) A further investment alternative G is identified and is preferable to both the existing investment F and to a portfolio of F and G together.

Of these only (ii) is relevant for our purposes, since we are concerned with the sale of an asset which, when considered in isolation, should be held, even allowing for what has been lost to date and any consequent reduction in the investor's capacity to carry risky assets. To summarize what has been found in regard to (ii), assume the following notation; say existing cash (riskless) assets are l, the market realizable value of the failed asset F is m, and the price of the other asset G is p. Under these conditions, the existence of investment possibility G means that the failed asset F should be sold only if the investor prefers a portfolio containing

(a) risky asset G along with an amount $(l+m-p)$ of cash

over either: (b) existing asset F with existing amount l of cash, or

(c) both F and G with $(l-p)$ in cash.

We began this paper with the case of an investor selling a failed asset for less than it was worth, not to the market, but by his own reckoning. In terms of the above three portfolios, the worth of the failed asset F to the investor is the value m which makes him indifferent between portfolio (b) and a portfolio of just $(l+m)$ in cash (certain wealth). It has been shown that even when the proceeds of selling the failed asset are less than this indifference value (i.e. even when the asset of itself is worth keeping) consideration of a further investment alternative can necessitate its rational sale. In effect, the returns offered by this new asset are too good to forego, yet without selling the existing asset there is too little cash available to buy the new asset while containing overall portfolio risk at an acceptable level. This is despite the diversification benefit (risk reduction) which must come with carrying the two (less than perfectly correlated) assets in conjunction. The existing asset must therefore be sacrificed, despite the fact that, of itself, it is worth more to the decision maker than the price obtained for it. The desirable overall effect on portfolio risk and return justifies the apparently overly generous "fire sale" of the failed asset.

The moral here is that by viewing decisions concerning individual assets from an aggregate portfolio perspective, investment (and divestment) choices, which considered individually are apparently irrational, can sometimes be rationalized. More generally, a portfolio level interpretation of investment choices may have significant consequences for how we interpret experimental evidence on sunk cost effects. Take for example the "counter game" experiments of Brockner and Rubin (1985, p.36 Table 4.1). Here subjects were given an amount of \$5 to begin with and were allowed to spend whatever chosen amount (possibly zero) of this money, at \$0.01 per "click", gambling on bringing up the number which carried the jackpot and lump sum prize. Referring to these games, Heath (1995, p.41) wrote:

> In most conditions, the expected value of the game is positive, and the appropriate strategy is to enter and never quit. However, the average amount invested in these games is quite low, indicating that many subjects quit early. Consider, for example, the average of $3.82 invested in the game with a $10 prize. In this game, the average subject quits at a point where expected benefits of a marginal investment are three times what they were when the subject began investing.

A contrary interpretation is that (some) subjects become increasingly conscious of risk as their cash reserves run down, and, on reaching the point where (on average) only $1.18 remains in kitty, make the decision not to chance further loss despite the attraction in expected money value terms of continuing. From a utility theory perspective, their lower capital and accordant higher risk aversion means that a gamble with positive expected money value has negative expected utility.

This explanation assumes that participants look at their initial $5 cash portfolio as more than just play money or "house money".[15] Given that they establish a "mental account" for these funds and treat them in much the same way as they might an actual personal investment holding (e.g. $1000 worth of stocks), any decision to withdraw while there is still something left is understandable (cf. Thaler and Johnson 1990, p.657). Supporting such an assumption, it is interesting that note that each subject was instructed specifically to think of the $5 stake as his or her own money and to invest as little or as much as desired on this understanding (Brockner and Rubin 1985, p.35).

An inherent problem for empirical research into sunk cost effects is to decide between the competing rational and irrational explanations for a given action. The portfolio viewpoint advocated here does not solve this problem but does identify previously unrecognized rational explanations for sunk cost related investment decisions. Such portfolio related explanations will need to be excluded before the observed decisions of laboratory subjects, or real world economic agents, can be attributed to any kind of irrational sunk cost effect. It is essential, therefore, that experimental designs either control or allow for relevant portfolio parameters. Unfortunately, improvements in experimental design devised to serve this purpose must to some extent be self defeating in that the more theoretically refined the decision framework, the more programmed the "correct" or rational choice. When decision problems are posed at a level of analytical formality requiring in effect algorithmic solution, psychological factors have no part to play, thus preventing any insight into their effects in less well articulated decision problems. The contexts within which unambiguous sunk cost effects can be demonstrated experimentally are to this extent inherently limited.

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[15] Thaler and Johnson (1990, p.657) and Keasey and Moon (1996, pp.109-110) have found that investors are risk takers with "house money", exhibiting a kind of "easy come, easy go" abandon with money they have won from the "house" (casino).

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