Assets Stranded by Unanticipatable Regulatory Change.

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I. Stranded assets—a definition and the conditions under which compensation may be claimed.

From time to time a firm finds that changes in its market make it impossible to earn an economic return on previously sunk investments. Such investments are commonly called stranded assets. While the realization of such losses will concern the firm's owners, it is of no concern to the community at large. Such losses are a potential cost of doing business, the risk of which the firm freely undertook in making its investments. It matters not whether the firm was unlucky or ineffectual. However, sometimes stranded assets are generated by legal or regulatory changes made by governments or their agencies. If such changes could not have been reasonably anticipated when the investment was made then fairness suggests compensating the firm for its losses.[1] This note is concerned with when and how a firm with assets stranded by regulatory change should be compensated.

Two primary conditions for claims of compensation are implicit in the definition of a stranded asset. First, the assets for which compensation is to be claimed must be sunk—otherwise the firm's investment costs may be recovered by sale or alternative use. Second, the firm under the new regulatory regime must have not yet recovered, and be unlikely to ever recover, the cost of its investment. Otherwise there is no loss for which compensation can be claimed. This requires a global calculation which

[1] Sometimes this principle is inscribed in law, for example, in the fifth amendment to the U.S. Constitution, commonly referred to as the Bill of Rights, 1791.

estimates not only the losses the firm has made so far due to the regulatory change (subject to the discussion below), but also accounts for any monopoly rents the firm will be able to claim in the future as a result of the status it obtained under the earlier regulatory regime. For example, a firm protected from entry under the original regulatory scheme will have gained an established market presence, which provides market recognition, share, and—because of its sunk assets, the very thing compensation is being claimed for!—the ability to make strong credible threats to competitors.[2] The market valuation of these assets granted to the firm claiming compensation by the previous regime must be off-set against the losses it claims.

The mere existence of a stranded asset, however, is not enough. It must be additionally be shown that the firm claiming compensation made its investments without having any reason to suspect a subsequent change in the regulatory environment—that is, the investments must have been made in good faith under the existing regulatory regime. Put another way, the investment must be shown to have been economic—that is profit maximizing given the original regulatory regime (something which, of course, will not be easy to determine). Further, it must be shown that the losses made on the stranded assets would not have occurred except for the regulatory change. If other events rendered the assets worthless there is no loss to be recovered. Thus, if a new invention rendered the market inviable

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[2] Given an efficient market for the incumbent's operations, or free access by the incumbent to capital markets, sunk assets are a competitive strength, being inputs available to the firm at zero price. Thus it can credibly threaten to drop price to marginal cost on entry making entry unprofitable if this requires sunk investment.

prior to the change in regulation the regulator would not be responsible for any costs born by the firm. Similarly, compensation cannot not be claimed for investments (e.g. copper wire in telephony) which the firm itself has "duplicated" (by laying optic fibre).[3]

Finally, the baseline for estimating losses is a fair rate of return on the firm's initial investment, not its *ex ante* anticipated gains. While governments may allow extra-normal profits, they do not guarantee them (unless an explicit contract to the contrary exists). Thus a regulatory change which does not force negative economic profit (as opposed to a loss of anticipated rents) cannot sustain a claim for compensation. As regulated firms are well aware, legal and regulatory regimes change from time to time, e.g. as new regulatory technologies become available, or politically feasible. Indeed regulated firms generally spend a great deal of money seeking to change existing rules in their favor. If regulators are effective such changes will often reduce monopoly profits increasing welfare overall. However, no question of compensation arises unless negative economic profits are forced on a firm.[4]

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[3] Of course, compensation might still be claimed for any new investments made prior to, and stranded by, the unanticipated regulatory change.

[4] The sense of this is vividly illustrated by the various occasions when a regulator has increased the "x" of a price cap. This lowers the regulated firm's allowed average price increase, and hence future profits—yet to my knowledge this as never generated shareholder demands for compensation, let alone an actual payment of the same. In fact, such regulatory changes occur exactly because the existing cap allows the firm too much profit, and even though such a regulatory change undermines the very rationale of the price cap—which is to allow a firm

This does not invalidate claims made for coverage of the *cost* of stranded investments which were intended to, legitimately under the original regulatory scheme, earn monopoly profits. While lost monopoly rents cannot be recovered, the cost of stranded investments can be, regardless of whether they would have maximized welfare. The investments remain the result of legitimate activity made in good faith. The law does not and cannot require good Samaritanism (welfare maximizing behavior). It is well-known that profit maximization does not in general coincide with welfare maximization. This is particularly so for regulated industries, not just because regulation is likely to occur where this divergence between private and public interest is sharp, but also because regulation is itself distorting. But if a firm maximizes profits subject to the law, it should not subsequently be punished because profit was not synonymous with social welfare. For example, under rate-of-return regulation, profit maximization can, from the perspective of efficiency, lead to over-investment in capital—the Averch-Johnson effect (Gasmi and Sharkey 1995 provide a more general exposition). Such investment, profit-maximizing, but Pareto inefficient, may legitimately be subject to a claim for compensation if it is subsequently stranded by an unsignalled change of regulatory regime.

In Section II these points are illustrated by several variations on a simple formal model. Stranded assets in this case are generated by the unanticipated deregulation of a franchise monopoly initially subject to a universal service requirement over two markets at a regulated price. Operations overall are profitable, but losses are made in one market. A

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increased profit if it reduces costs.

case for compensation can arise due to the unexpected deregulation, but this is entirely dependent on history and the model's parameters. In particular, history may reduce asset values ahead of regulatory change eroding or eliminating any loss by regulation, and hence the amount of compensation that may be claimed. Similarly, losses generated by the regulatory change may be less than the monopoly profits earned under the original regulatory scheme, and/or earned after the change because of the first mover advantage granted the incumbent by the earlier regime.

While Section II serves to clarify the issues associated with compensation, its simple examples give little guidance for practical estimation of due compensation. Section III generalizes the results in a manner that, at least for companies which are traded and which publish their accounts, makes estimation of owed compensation operational.

II. An illustration with a formal model.

Consider a system, with exogenous interest rate i ($0 < i < 1$), two customer groups, r and b, perhaps for residential and business,[5] with respective costs of supply requiring a once-and-for-all outlay of $C_r = c_r/i > 0$ and $C_b = c_b/i > 0$.[6] (It is assumed for simplicity that these assets do not depreciate and that there are no operating expenses. Alternatively respective expenditures of $0 < \delta_r < C_r$ and $0 < \delta_b < C_b$ could be required at the end of each period to maintain the asset as well as operating expenses, $0 < o_r$ and $0 < o_b$. Assume standard in-period demands, $d_r(.)$ and $d_b(.)$, and no trade between customers or periods. Investments can be made immediately, and income from servicing demand is collected at the start of the following period. Grant, at time $t = 0$ ($t \quad [0, \infty)$), a firm, hereafter called the incumbent, i, sole rights to both markets in perpetuity, subject to the constraint that it must provide universal service at a price no more than p^R in each period, with the following characteristics: Define $p_j^M = \arg\max_p pd_j(p)$, and $m_j = p_j^M d_j(p_j^M)$. Then p^R is such that:

$$p^R d_r(p^R) + p^R d_b(p^R) \geq c_r + c_b$$

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5 The example is readily extendable to an arbitrarily large number of customer groups. Each group can be thought of as containing customers (maybe only one) which supplying firms are unable to distinguish between. Such a cost function is not a bad approximation for a local telecommunications network, though it abstracts from up-front fixed costs.

6 Stocks are indicated by uppercase letters, with time subscripted ($t = x$), and flows by lower case letters.

(+ $\delta_r + \delta_b + o_r + o_b$ if depreciation and/or operating expenses are allowed);

$$p^R d_r(p^R) < c_r \ (+ \delta_r + o_r);$$

$$p^R < p_r^M; \text{ and}$$

$$p^R < p_b^M.$$

A profit maximizing incumbent will make the investments C_r and C_b and charge p^R in both markets. In the long run customers in r do not cover their incremental cost, C_r, and so are subsidized by the customers in b, who pay more than their stand alone costs, C_b.[7] Depending on the parameters of the model the firm earns at least zero, and possibly positive economic profits, that is a rate of return that at least compensates the firm's investors for the risks associated with their investment.

Now consider an unexpected regulatory change: at time t = n > 0 (i.e. after the incumbent has made the sunk investments C_r and C_b) the market is deregulated, i.e. the restrictions on entry, coverage, and the incumbent's prices are suddenly relaxed.

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[7] This is the standard definition of cross-subsidy—see e.g. Ralph 1992 Ralph, EK 1989 Cross-subsidy: A novice's guide to the arcane, *Telecommunications Costing in a Dynamic Environment*, Bellcore and Bell Canada Industry Forum, 4-7 April, San Diego CA. Revised version available directly from the author.

(1) Compensation for stranded assets due to regulatory hardship can only apply to investments which were economic, that is profit-maximizing given expected market development.

In the example, only the costs C_r and C_b (net of any degradation which may have occurred) are relevant. Any larger amounts invested would not be considered. If the firm had invested more than C_r and C_b then it was either poorly managed, or it foresaw the regulatory change and viewed the additional investment as strategic in that light. In any case, the additional investment cannot be attributed to the original regulatory regime.

(2) Further compensation can only be paid out on assets which are sunk.

That is compensation should be paid for assets that cannot be recovered, but except for the regulatory change, were useful in the production process. In the example, if each asset was not sunk then respectively the r (b) asset could be sold for at least C_r (C_b) at $t = n$, or rented out period-by-period for c_r (c_b). The firm therefore experiences no loss, and has no grounds for claiming compensation.

Assume for $0 < \rho \leq 1$ and $0 \leq \beta \leq 1$ that ρC_r and βC_b is sunk (and respectively ρ and β of any amount spent on capital maintenance if depreciation is allowed for).

(3) Compensation can only apply to losses which not have been incurred except for the unanticipated regulatory change.

Thus any depreciation due to technological advance lowering the replacement cost of the assets in question should be deducted. An extreme case of this occurs when a new technology becomes available, say dial-tone video, which subsumes the old. Then the regulator can no longer be held responsible for losses incurred on the sunk asset.

To illustrate let at time $t = N$, where $0 < N \leq n$, a new technology emerge with cost N_r to service Market r, generating (standard) demand $d_r^N(p) > d_r(p)$; assume the regulated price ceiling, p^R, applies to supply of the new service, the incumbent has right of first refusal to supply the market using the new technology, and:

$$p^R d_r^N(p^R) - iN_r > p^R d_r(p^R) - i(1 - \rho)C_r;$$

and similarly for market b. This says that investing in supplying the new product is profitable even when only fixed costs are considered. That is, in-period revenues for the new product at the regulated price, $p^R d_r^N(p^R)$, less in-period costs, iN_r, exceed forward-looking in-period profits under the old technology, where only costs which are *not already sunk*, $i(1 - \rho)C_r$, are relevant to a decision about continuation of production.

Given this, and if no further developments are expected to occur in this market, the incumbent will abandon its investments, ρC_r and βC_b, at N <

n, by making investments N_r and N_b supplying the new service.[8] Further, this abandonment will occur regardless of whether the incumbent covered its costs on its original investments C_r and C_b (e.g. it would incur a loss of $\rho C_r + \beta C_b$ if it had previously earned zero in-period economic profits under the regulated price, p^R).[9] In a nutshell, the new technology renders the firm's sunk assets, ρC_r and βC_b, worthless *before* the regulatory change, thereby absolving the regulator of any need to pay compensation for them. This may be seen by showing the *market* value of the firm's investments to be $C_r + C_r$ prior to the development of the new technology, and zero subsequently. The market value of an asset is the lowest price which leads to a sale of the asset. A firm values its own assets at the higher of the price a third party would pay for the asset (i.e. the asset's resale value) and the minimum of the earnings expected from utilization of the asset and the cost of replacing the asset, that is a firm's valuation of an asset is

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[8] If entry is allowed, and the entry game is similar to that illustrated below where deregulation occurs. Entry could only occur if an entrant could profitably supply at least one of the new markets while granting consumers more surplus than that gained from the incumbent providing the old service at prices which just cover, respectively in each market, $(1 - \rho)C_r$ and $(1 - \beta)C_b$.

[9] If losses were incurred, either the firm made a poor investment decision to start with, or the invention was probabilistically expected, with an adverse realization, or the invention was not anticipated and could not have reasonably been so. The regulator, however, is responsible for none of these things.

max[resale price, min(expected earnings, replacement cost)][10] (*).

This boils down to saying firms value assets at the highest present value cash flow the asset can generate.

In the example considered, the earnings expected from utilization of C_r and C_b prior to the discovery of the new technology were

$$p^R D_r(p^R)/i + p^R D_b(p^R)/i,$$

which exceeds the replacement cost of the assets, $C_r + C_r$ (by assumption, and note if this were not true the firm's initial investments would have been uneconomic). The assets' resale value, however is only $(1 - \rho)C_r + (1 - \beta)C_r < C_r + C_r$ so prior to the technological change the firm values the asset at $C_r + C_r$. All other firms, not having the right to produce in this market, value the assets at $(1 - \rho)C_r + (1 - \beta)C_r$, their resale value. Thus pre-invention the market valuation is $C_r + C_r$, since the incumbent can be induced to sell these assets only at a price equal or higher to this amount. This immediately implies the sunk assets are worth $\rho C_r + \beta C_r$ since the market price of the "unsunk" and total investments are respectively $(1 - \rho)C_r + (1 - \beta)C_r$, and $C_r + C_r$. Subsequent the new invention, however, both the incumbent and other firms value the assets at their resale value, (1

[10] This is not the asset's optimal deprival value, which is min[replacement cost, max(expected earnings, resale price)].

$- \rho)C_r + (1 - \beta)C_r$, and the *sunk* assets, $\rho C_r + \beta C_b$, are now worthless (to see this note the expected earnings of the assets C_r and C_r are now zero, since they are to be replaced in production by $N_r + N_r$, so by (*) the firm values the assets at max[resale, 0]).

(4) Compensation for an unanticipated regulatory change should be reduced by any positive economic profit made prior to the regulatory change.

If the original regulatory regime allowed the firm to earn profits which were more than compensatory for the level of investment and risk undertaken by the firm, these should be off-set against any claims for compensation. The firm can hardly claim compensation against future losses without taking account of the profits previously granted it.[11] Further, only positive prior profits need be considered. Past losses are not the regulator's concern. Entry into the market was not coerced. If losses are incurred by the firm these are either due to poor investment decisions and/or management, and/or or bad luck.[12] In any case, the regulator owes

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[11] This is the most controversial argument of the paper. In some respect this may be considered retrospective taxation. A regulatory change which the firm could not have known about imposes losses on it, yet it is expected to absorb some of these losses because it earned positive economic profits it in the past (even though its owners might have long spent those profits on consumption).

[12] Over a sufficient time frame and/or a large enough operation, even the excuse of bad luck cannot hold, since statistically no losses should occur. Thus over a large enough sample losses can be blamed solely on mismanagement.

no investor compensation.

Let $\prod_t$ indicate profit earned up to time t. The relevant loss against which compensation can be claimed in the example then falls to

$$\max[\rho C_r + \beta C_b - \max(\prod_{t=n}, 0), 0],$$

$$\text{where } \prod_{t=n} = [p^R D_r(p^R) + p^R D_b(p^R) - c_r - c_b]\sum_{t=0}^{n-1}(1 + i)^t,$$

which by assumption is positive since otherwise no firm would have taken on production.

(5) Finally, any compensation must be further off-set by any future economic profit that will be obtained by the incumbent.

To illustrate this last point return to the original model were there is a single technology with initial costs C_r and C_b, and consider the following simple game played between the incumbent and an entrant at the beginning of period n, the time of deregulation:

> In the game's first round, the incumbent announces whether it intends to remain in each market, and the entrant simultaneously chooses whether to enter either or both markets by investing C_{re} and/or C_{be} (of which respectively $\rho_e C_{re}$, $0 < \rho_e \leq 1$, and $\beta_e C_{be}$, $0 < \beta_e \leq 1$, will be sunk).

In the game's second round each player announces a price for each market they have chosen to supply and demand must be satisfied at this price. For simplicity it is assumed that the price chosen will remain fixed for all future periods, and that if losses are incurred players exit selling their fungible assets.[13]

Further assume:

$$\rho C_r + \beta C_b - \prod_{t=n} < 0,$$

that is, at t = n, the incumbent has not yet covered its sunk costs.

In this game the two markets, r and b, are independent, so may be analyzed separately. Begin with Market r. The game may have four outcomes:

Supply by both firms. If the incumbent stays in the market and entry also occurs, then price will fall to marginal cost (zero). Both players will immediately sell off their fungible assets in this situation (which they could reinvest in the following period in a more complex

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[13] More realistically the price would apply to a single period and the game would be repeated in each period. Players would be allowed to withdraw from the market after price announcements and supply settlements, and their strategy sets in the first round of the next game would be adjusted according to whether they chose to remain in the market (if so they could again announce price, if not they must wait until the next round where a reentry decision could be made). The results of this more complex game, however, are not fundamentally different to the simpler version analyzed here.

model). In considering this possibility from the perspective of the decision to remain in the market, the incumbent faces losses (only forward-looking calculations are relevant in this decision—past losses are irrecoverable) of zero. The entrant, however, deciding whether to invest faces a potential present value loss of $\rho_e C_{re}$. This compares with a loss of zero if it does not enter.

No new entry. If the incumbent stays in the market, but entry does not occur, the present value of incumbent's future profits are $m_r/i - (1 - \rho)C_r$), which may be negative. The entrant's profits are of course zero.

Exit with new entry. If the incumbent abandons the market and entry occurs the incumbent loses nothing on a forward looking basis (it sells that part of its asset base which it can for $(1 - \rho)C_r$ and writes off the loss off its sunk assets), and the entrant gains $m_r/i - C_{re}$, which also may be negative.

No supply: Exit and no entry. If the incumbent abandons the market, and no entry occurs both parties earn zero.

Given these possible outcomes, the game's second round may be represented by the normal form:

	Entry	No Entry
Incumbent stays in the market	0 $-\rho_e C_{re}$	$m_r/i - (1 - \rho)C_r$ 0
Incumbent exits the market	0 $m_r/i - C_{re}$	0 0

The normal form game summarizes the pay-offs of each player given the game's possible outcomes. The incumbent's (entrant's) pay-offs are to the top left (bottom right) of each box. Thus if the incumbent stays in the market and entry occurs, it earns zero while the entrant makes losses of $-\rho_e C_{re}$. Similarly, if the incumbent exits the market, and entry occurs it earns zero, while the entrant earns $m_r/i - C_{re}$, etc.

An outcome of the game is a (Nash) equilibrium if no player would wish to change its strategy given the other player's. Thus if $m_r/i - (1 - \rho)C_r > 0$ and $m_r/i - C_{re} > 0$, the game has two Nash equilibria—one where the incumbent stays and no entry occurs (given the no entry decision the incumbent would not wish to change its strategy since this would mean forgoing positive profits, $m_r/i - (1 - \rho)C_r$, for zero, while given the incumbent's decision to stay in the market, if the entrant changes its strategy and enters it will lose $\rho_e C_{re}$ instead of nothing); and a second where the incumbent exits and the entry occurs (in this case the incumbent does not care what it does given entry has occurred—it earns zero either way, while given the incumbent has exited, the entrant clearly prefers positive profits, $m_r/i - C_{re}$, to none, so again neither player would wish to change their strategy).

Not all Nash equilibria are equal, however. For example, in the above case where $m_r/i - (1 - \rho)C_r > 0$, it is unlikely that the incumbent would ever exit. The reason for this is that regardless of what the entrant does, the incumbent is guaranteed zero or positive profits by staying in the market, but only zero profits if it exits. Thus it can never do worse by staying, and sometimes will do better. In these circumstances the strategy "staying" is said to weakly dominate "exiting" (or exiting is a weakly dominated strategy).[14] Ruling out the weakly dominated strategy, only one Nash equilibrium remains—the incumbent stays and no entry occurs. For the remainder of this discussion it will be assumed that weakly dominated strategies are never played.

The exit-enter game under analysis can have a number of outcomes depending on the values of its parameters—C_r, C_{re}, m_r, i, ρ and ρ_e. The

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[14] Weakly because in some instances (when entry occurs) staying is not better than exiting. A player's strategy is (strictly) dominant when it is strictly better than all other strategies available to the player regardless of what other players do, and (strictly) dominated when another strategy is always better than it regardless of the actions of the other players. With more than two strategies, a strategy may be (weakly or strictly) dominated by another, but the dominating strategy may not be (respectively weakly or strictly) dominant—a third strategy might lead to better outcomes in some circumstances, and worse in others.

possible cases are now considered, beginning with when the pay-offs of the normal form game are such that:

$$m_r/i \geq C_{re} \textit{ and } m_r/i \leq (1 - \rho)C_r,$$

that is, when

$$C_{re} \leq (1 - \rho)C_r \qquad \text{C1.}$$

This particular parameterization has several strong implications. First it implies the entrant's *total* costs are less than the incumbent's *variable* costs, which may be regarded as empirically unlikely. Further, if C1 held at t = 0 then this implies the government licensed a more expensive firm to supply the market. Finally, and from the perspective of the game, most importantly, C1 is the only circumstance which allows entry as a possible equilibrium after the elimination of weakly dominated strategies. It also ensures that the incumbent will either actively seek to exit Market r, or will be indifferent to remaining in it, as compared with exiting. Under C1 if $m_r/i - C_{re} > 0$ and $m_r/i - (1 - \rho)C_r < 0$ exit by the incumbent with new entry is the unique equilibrium. If $m_r/i - C_{re} = 0$ (so the entrant is indifferent to entry and remaining outside the market) and $m_r/i - (1 - \rho)C_r < 0$, then entry is weakly dominated by no entry (the former guarantees the entrant zero profits, while the latter can result in losses of $\rho_e C_{re}$). The unique equilibrium after elimination of weakly dominated strategies, then, is for no supply, that is exit and no entry (while another equilibrium exists—exit and entry—it is unlikely). When $m_r/i - (1 - \rho)C_r = 0$ the incumbent is indifferent between remaining in Market r and exiting. This creates an additional possible equilibrium—one where the incumbent remains in the market and no entry occurs. Thus if $m_r/i - C_{re} > 0$ and $m_r/i - (1 - \rho)C_r = 0$ there are two equilibria, exit and entry, and supply by the incumbent with no entry. Similarly if $m_r/i - C_{re} = 0$ and $m_r/i - (1 - \rho)C_r = 0$ there are three possible equilibria, exit and entry (which involves the use of a weakly dominated strategy), no supply, and supply by the incumbent with no entry.

In all these cases, including the weakly dominated equilibria, the incumbent earns zero. Thus its net position in Market r, taking account of past profits and sunk investments, is $\prod_{t=n} - \rho C_r$, which may be negative. That is the firm may face a loss in Market r after past profits are accounted for. In effect, the sunk asset, ρC_r, has been rendered worthless, either because it is not profitable for the incumbent to supply Market r, or because the incumbent is indifferent between remaining in that market and exiting from it. However, in this case it was government action, rather than technological development, which made the asset valueless. As a result the firm is due

$$\max[\rho C_r - \prod_{t=n}, 0]$$

in compensation *less* any future economic profits expected in Market b—discussed below (past profit in Marbet b is already contained in $\prod_{t=n}$).

~C1: The case when C1 does not hold is now considered, first for when $m_r/i \leq (1 - \rho)C_r$ and then for the reverse. If $m_r/i \leq (1 - \rho)C_r$ then $m_r/i < C_{re}$ and entry will never occur—entry implies negative profits to the entrant, when zero can be earned by staying out of the market. Thus if $m_r/i < (1 - \rho)C_r$ a unique equilibrium emerges—no supply, i.e. exit and no entry; and for $m_r/i = (1 - \rho)C_r$ there are two equilibria—no supply, or no exit with no entry. Again the incumbent earns zero in all cases. As a result, it should be compensated for the regulatory change by $\max[\rho C_r - \prod_{t=n}, 0]$ plus the firm's net expected position in Market b—again see below.

When C1 does not hold and $m_r/i > (1 - \rho)C_r$ exiting by the incumbent is weakly dominated by staying in the market (exactly as discussed in the explanation of a weakly dominated strategy above). In this case, the only equilibrium which does not involve the use of dominated strategies has the incumbent remaining in the market, and no entry. In this case, the incumbent secures future extranormal profits of $m_r/i - (1 - \rho)C_r > 0$. These profits are earned exactly because of the previous regulatory regime. Under the original rules the incumbent was granted rights to Market r. This lead it to sink $\rho_e C_{re}$ which—ironically—enables it to claim monopoly control of Market r after deregulation. The incumbent's losses at time t = n due to the regulatory change, $\rho C_r - \prod_{t=n}$, then, must be offset by these gains, $m_r/i - (1 - \rho)C_r$. Thus the firm is due for the regulatory change in Market r

$$\max[\rho C_r - \prod_{t=n} - m_r/i + (1 - \rho)C_r, 0] = \max[C_r - \prod_{t=n} - m_r/i, 0]$$

in compensation.

The analysis so far has estimated historical profit, $\prod_{t=n}$, and future profit in Market r due to the unanticipated regulatory change. However, this is not enough. It is necessary to also analyze future profit in Market b. In this case the incumbent will make extra-normal profits. In Market b the elimination of weakly dominated strategies ensures there is no entry. Since $m_b > c_b \geq (1 - \beta)c_b$ by assumption exiting for the incumbent is weakly dominated by staying in the market. This guarantees the unique equilibrium—the incumbent supplies Market b, and no entry occurs. Thus the incumbent will operate as a monopolist in Market b, earning $m_b/i - (1 - \beta)C_b > 0$ in future extranormal profits. This means in Market b the incumbent's net position from an original investor's perspective is $m_b/i - (1 - \beta)C_b - \beta C_b = m_b/i - C_b$, which is positive by assumption.

Thus if the incumbent subsequent to the regulatory change abandons Market r, or earns zero profits there (which will be true if $m_r/i \leq (1 - \rho)C_r$), it is entitled to compensation:

$$\max[\rho C_r - \prod_{t=n} + C_b - m_b/i, 0],$$

(and for the model used here this can be positive, i.e. can result in compensation being paid). If the incumbent remains in both markets it is entitled to compensation:

$$\max[C_r - \Pi_{t=n} - m_r/i + C_b - m_b/i, 0],$$

which, for this particular model, is necessarily zero (because overall cost coverage at the regulated price, p^R, is assumed, and p^R is less than the monopoly price of either market).

III. Operationalizing compensation estimates.

The preceding discussion may be generalized in a very straight-forward, and in some instances, a readily operational fashion. If a firm's investors incur a loss due to an unexpected regulatory change this will be apparent in a change in the value of the firm due to the regulatory announcement. In certain circumstances—for example for a publicly listed joint stock firm—this change in value will be directly observable. The loss, however, may overstate the amount of compensation owed to the firm's owners for two reasons. First, the firm may have made some monopoly profit under the earlier regulatory regime. This profit should be off-set against any loss incurred due to the unexpected regulatory change. Second, the firm's value *prior* to the change would include a component for any expected future monopoly profits. Thus if the regulatory change eliminated these the firm's value would fall, but as argued earlier, the regulatory pact cannot be construed as protecting monopoly rents.

A firm's value at time t, denoted V_t, (which may be directly observable) is the present value at time t of expected future cash flows which will accrue to the firm's owners less the firm's current liabilities. If an unexpected regulatory change at t = n imposes costs on a firm, this will be reflected by a change in the firm's value. Specifically, the firm's value after the change (i.e. when t = n) will be less than its value just before it (at t = n-),

$$V_{t=n} < V_{t=n-}.$$

The loss the firm's owners incur then is max($V_{t=n-}$ - $V_{t=n}$, 0).

The firm, however, may have made extranormal profits prior to the regulatory change, i.e. $\prod_{t=n} > 0$, $\prod_{t=n}$ defined as above. Such profits, granted to the firm, and hence its owners, under the original regulatory scheme may be off-set against the losses incurred due to the regulatory change (past negative profits are not added in for the reasons outlined under (4) above). Past monopoly profits were either directly passed onto to the firm's owners (e.g. as dividends), so directly benefitted them, or were reinvested in the firm. Reinvestment, however, should be treated as if the profits were directly taken. Reinvestment may be thought of as a payment to the firm's owners, which is then returned to the firm to be invested, so is no different to a dividend which happens to be used to purchase new stock. In fact, if the market agrees with this policy, the reinvestment will be immediately reflected in a capital gain to the firm's owners equal to at least the value of their (re)investment. As with any other investment, reinvestment is undertaken when the firm's owners feel they will earn at least as much on their investment as they could elsewhere (and that this is preferred to current consumption). If this were not the case shareholders would object to the policy and/or sell their stake in the firm. This means the present value of the additional future earnings generated by the reinvestment is expected to at least equal the initial outlay. Thus the firm's owners are expected to benefit by at least the amount of the extranormal profits reinvested. Of course, *ex post* things might not work out like that, but such a loss is not attributable to the regulatory change (this is completely captured by $V_{t=n-}$ - $V_{t=n}$). Just as any new investor could not claim compensation from the government for a poor or unlucky investment decision, the firm's existing investors cannot claim losses for poor or unlucky reinvestment decisions.

Compensation to be paid the firm, then, cannot exceed

$$\max[V_{t=n-} - V_{t=n} - \max(\Pi_{t=n}, 0), 0].$$

The firm's value before the unexpected regulatory change, $V_{t=n-}$, will also include any future monopoly profits expected to be earned, but compensation should not be paid for the loss of these. Let Π^f_t be the present value at time t of expected future profits allowing for a return on past investments. If $\Pi^f_{t=n-}$ is negative it is of no concern to the regulator—the regulator is not responsible for the firm's expected profits prior to the unexpected regulatory change. This means the firm's shareholders should receive total compensation of:

$$\max[V_{t=n-} - V_{t=n} - \max(\Pi_{t=n}, 0) - \max(\Pi^f_{t=n-}, 0), 0] \qquad (*).$$

Compensation looked at in this way need not always be difficult to estimate. Both $V_{t=n}$ and $V_{t=n-}$ are often readily observed, and if $V_{t=n} \leq V_{t=n-}$ no compensation is called for. If the reverse holds, i.e. $V_{t=n} > V_{t=n-}$, then it would seem $\Pi_{t=n}$ and $\Pi^f_{t=n-}$ must both be estimated. However, in some instances only the sign of these need be established. More generally cash flow data allows at least a ceiling on total compensation to be estimated. These points are now explained in detail.

An initial estimate of the sign of each of $\prod_t$ and $\prod_t^f$ may lead to an immediate simplification. If $\prod_t$ and/or $\prod_t^f$ non-positive, then respectively max($\prod_{t=n}$, 0) and/or max($\prod^f_{t=n-}$, 0) drop from (*). If both are non-positive no further estimation is required.

If both these terms are positive compensation may be calculated from the firm's valuation pre-regulatory change, $V_{t=n-}$, an estimate of the competitive rate of return for the firm, i, and cash flow data—past dividends and shareholder investments. No estimates of either $\prod_t$ or $\prod_t^f$ need be directly made. This is further explained below.

Finally, if $\prod_t$ and $\prod_t^f$ have different signs, only the positive profit need be estimated. Further, performing the calculation referred to in the previous paragraph defines a ceiling on total compensation owed, providing a check on the profit estimated.

Define P_t as the present value at time t of all past payments by the firm to shareholders ("dividends"); and I_t, as the present value at time t of all past investments made by shareholders in the firm. Implicit in these definitions is an in principle estimateable interest rate, i, which is the best alternative rate of return available to investors in the firm, risk held constant.[15] At time t, investors in aggregate have earned P_t directly, and V_t - I_t in capital gains, for a total return, $\$_t = P_t + V_t - I_t$, which captures past profits, $\prod_t$, and expected future expected profits, $\prod_t^f$ (through V_t). Notice too, estimation of $\$_t$ requires $V_{t=n-}$, knowledge of past dividend payments and shareholder investments including retained earnings, and an estimate of i. With the exception of i, these items are all generally available from public accounts, at least in the case of publicly listed firms.

The rate of return earned by shareholders is $\$_t/I_t$. If $\$_t/I_t > i$ then the firm (and its owners) have made extranormal profits ($\prod_t + \prod_t^f > 0$). The rate of *economic* profit is given by $\$_t/I_t - i$, and total economic profits, $\prod_t + \prod_t^f$, are equal to $(\$_t/I_t - i)*I_t$. By definition,

$$(\$_t/I_t - i)*I_t. \leq \max(\prod_t, 0) + \max(\prod_t^f, 0),$$

so; noting that $\prod_{t=n-} = \prod_{t=n}$, total compensation owed the firm cannot exceed

$$\max[V_{t=n-} - V_{t=n} - \max((\$_{t=n-}/I_{t=n-} - i)*I_{t=n-}, 0), 0] \qquad (**),$$

15 More generally i might be replaced by i_t, a rate which varies by period, a complication unnecessary for the analysis which follows.

and is less than this amount if either

$$\Pi_{t=n-} < 0 \text{ and } \Pi^f_{t=n-} > 0$$

or

$$\Pi_{t=n-} > 0 \text{ and } \Pi^f_{t=n-} < 0.$$[16]

Thus if both $\Pi_{t=n-}$ and $\Pi^f_{t=n-}$ are known to be non-positive no further estimation is necessary. If this is not the case, the competitive interest rate must be estimated and past cash flows (divident payments and investments) uncovered. If both $\Pi_{t=n-}$ and $\Pi^f_{t=n-}$ are known to be positive, then this is enough; otherwise the positive profit term must be additionally estimated, and this estimate must be consistent with the ceiling established by the cash flow analysis (i.e. it must exceed $(\$_t/I_t - i)*I_t$).

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[16] If $\Pi_{t=n-} \leq 0$ *and* $\Pi^f_{t=n-} \leq 0$ then compensation equals $\max[V_{t=n-} - V_{t=n}, 0]$ which equals (**). If $\Pi_{t=n-} > 0$ *and* $\Pi^f_{t=n-} > 0$ compensation equals $\max[V_{t=n-} - V_{t=n} - \Pi_{t=n-} - \Pi^f_{t=n-}, 0]$ which equals (**).