

Information-System Investment: An IS-Commons Market-Failure

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ABSTRACT

While investment in Information Systems (IS) is an area of vital strategic concern to most organizations, there is little understanding of how to measure real returns of IS to business. This measurement problem has persisted from the 1990s to the present -- where managers are under increasing pressure to adopt new technology or face being left behind. In the current competitive climate, senior managers seek practical techniques to manage their current IS investments and to help them to decide where best to allocate uncommitted company resources. The model in this paper should help firms understand and respond to the process behind the persistent underperformance of IS investments. Specifically, the responses of other market participants must be factored into estimates of IS-investment returns -- cooperation and coordination may yield higher long-term returns for all.

INTRODUCTION

For nearly half a century, the vast majority of IS investments have failed to attain their expected returns (Morrison and Brendt, 1990; Barua, 1991; Loveman, 1994; Dagupta, et al, 1999; Economist, 2001a and 2001b).

As investment and organizational differences emerge between “new- and old-economy” business, it becomes increasingly vital to understand IS investment behaviour. Literature on this aspect of business is sparse. However, earlier work on the impact of IS investments on expected returns gives helpful insights into what we might expect to find (Steinfeld *et al.*, 1996).

Over a decade and a half ago, Keen (1980) bemoaned the lack of a “cumulative tradition” in the MIS field of the kind that exists in more established fields such as microeconomics or the behaviour sciences. One such effort is the fairly extensive body of work performed to resolve the infamous “productivity paradox”, although not with the consistent patterns/results anticipated in a cumulative tradition (Sircar *et al.*, 2000). Some of the studies led to the coining of the term “IT productivity paradox” and initiated a long stream of imperial work focused on describing the paradox, denying the paradox, solving the paradox, and burying the paradox (Thacher and Oliver 2001). Some other studies concluded that earlier IT models were often incorrectly specified and/ or incomplete.

Researchers and practitioners (Ryan and Harrison 2000; Holden and Wilhelmij, 1995; Simms, 1997) suggest that traditional analysis, focusing only on the financial or technological aspects of the decision, is not complete. This leads directly to incorrect anticipation of IT payoffs. Hitt and Brynjofsson (1996) called for new approach to identify ‘costs and benefits’ that they are typically not included in IT value analysis.

Recent theoretical and empirical research has begun to provide normative guidance to IT executive by arguing that IS investment is an area of strategic concern to most organizations. Enabled by new net-worked technology, IS has rapidly become an integrated part of the many and various ways people and organizations do business and manage information. Through the information technology (IT) revolution of recent decades, there was much study, but little understanding of how to measure real IS returns to business (Strassman, 1999). This continued

to be the case in the 1990s to the present, where managers perceive they are under increasing pressure to adopt the new technology or be left behind (Myers, 1997). In the current, competitive climate, senior managers seek practical techniques to spur their management of IS investments and to help them to decide where best to allocate costly company resources (OECD, 1997).

It is difficult to discern clear a pattern emerging from the flux of activity that has surrounded IS ventures over the past while. For example, new entrants flourished in the early vacuum created by relatively low levels of IS activity from traditional business -- they had near exclusive access to the rhetoric, enthusiastic investors, unoccupied niches in the IS and e-market place. Those “pure-play” operations that survived cash-flow or general-management problems have demonstrated beyond any reasonable doubt that there are both new kinds of markets to be assembled and exploited and new kinds of business – both of which will be difficult, expensive, or impossible for established business to exploit via conventional market channels (Reynolds, 2000).

An extended era of rapid expansion, prosperity, and enthusiasm in IS investment ended badly for all concerned as the IS-Investment “bubble” burst in 2000 and the industry slid into a major slump in 2001. The result is confusion in the markets with some arguing that the slump will reverse and correct itself and yet others claiming that the IS bubble was an aberration of substantial and unrealistic expectations -- the IS threat to the old economy is seen as being over and a return to historical stability is expected (Reynolds 2000). However, any belief the IS game is over is at best premature (Christiansen and Tedlow, 2000). Castells observed: instability may now be the norm in the financial markets of the new economy and burst bubbles may not necessarily lead to a return to stability (Castells, 2000; Giddens and Hutton, 2000).

A persistent widespread failure of a class of investments to earn expected returns should lead rational investors to drastically reduce their holdings of that investment. Exceptions to this dictum tend to involve mental illness (chronic excessive gambling, hubris) or major common-property-resource issues (e.g. grazing on a commons, fisheries, advertising for market share). Harden (1968, 1977, and 1986) examined the later problem in detail and called it the tragedy of the commons.

In sectors of the economy dominated by common-property issues, an investment bubble (i.e. expanding investment fuelled by unsustainable expectations) is initiated by aggressive parties seeking to appropriate a greater share of rents and quasi-rents. This initial investment is first emulated by less aggressive investors seeking what they see as a proven opportunity for higher returns and then followed by defensive catch-up investors seeking to minimize losses imposed on them by the earlier investments. Ultimately, the investment bubble bursts when all investors start making negative returns.

John Dawson (1996) suggested that there were three particular types of IT investment, which had led retailers to more profitability:

- Knowledge-based investments provide more creative ways to run an enterprise;
- Alliances-based investments between businesses work to generate new or reinforce existing competitive positions;
- Productivity-based investments seek to achieve cost reductions or substitutions in particular business units or processes.

(Sharif and Irani 1999) proposed a systematic approach to justify IT based on an exploration of limitations in traditional appraisal techniques. They developed a functional model, which identifies the various issues involved in justifying IT. They suggest that the functional model goes some way to conceptualising the phenomena of IT investment justification. The investment justification process can be succinctly encapsulated within the following expression: $JC = f(V, FA, RR)$, Where: JC is the justification criteria; V is the project value; FA is the financial appraisal of project; and RR is the post-implementation risk review of the project.

Dawood and Wright (2002) developed a model that virtualizes these aspects. Each equation in the model (value-possibilities, achievable-value and efficient-cost) represents a limit on information’s net return. That model looks at IS in terms of three dimensions:

- System Power – ability to store, move, and present information,
- Message Quality – single fraction that is information vs. noise, and
- Information Handling – cognitive ability of the organization.

In summary, the reviewed literature indicates a primary objective of investment in IS is to out-invest the other market participants in IS power. As this paper will demonstrate, this goal is based on a harmful illusion -- As long as out-investing is seen as being a viable goal, an IS-investment bubble gathers momentum until ultimately reality is forced upon the market by exhaustion and the IS-investment bubble bursts.

This paper proposes a mathematical model to understand the persistent under-performance of IS. Further, the model is used to look for solutions to this problem. Specifically, if the responses of the other market participants can be factored into estimates of IS investment returns, co-operation and coordination may create an opportunity for higher long-term returns.

MODEL DEVELOPMENT

This section starts with the Dawood and Wright (2002) general model. The focus in this paper is on what happens when the assumption of perfect information is relaxed so that firms have the illusion that they can out-invest other firms in information system power.

Basic Assumptions

Assumption One -- The model in this paper is predicated on the Dawood and Wright (2002) model where three equations represent limits on the net return in IS. These equations (plus the profit function) are:

The value-possibilities frontier -- value achieved if the organization has an infinite, instantaneous capacity to assimilate information:

$$V = aI^b \tag{1}$$

V = value from improved decision making; where $V \rightarrow \infty$, as $I \rightarrow \infty$, I = Private information flow/unit time, a,b = parameters where $b \leq 0$

The achievable-value frontier -- value achievable, given the current cognitive capacity of the organization:

$$V\sim = ahI^b e^{-(nI/q)} \tag{2}$$

h = organization opportunities; $h \leq 1.00$, n = slope parameter, q = information quality reflecting the message load in the organization.

The efficient-cost frontier -- efficient cost to achieve a given level of information flow:

$$C = rj e^{Ik/qj} \tag{3}$$

j = fixed cost, r = scale parameter, k = slope parameter -- $k < 1.00$

The profit function (eqn (2) less (3)):

$$\pi = ahI^b e^{-(n/q)I} - rj e^{Ik/qj} \tag{4}$$

Assumption Two -- The complex, interrelated, multiple effects of investment in IS are assumed away to focus solely on the effects of investing in IS power (i.e. ability to gather, handle, move, and store information).

Assumption Three – the market participants are identical and operate in free, perfectly competitive markets. However, in this variant of the Dawood and Wright model, the perfect information assumption is partially relaxed so that each participant suffers the illusion they can out-invest others in IS.

Assumption Four -- An increase in IS power leads to superior knowledge and, as one’s knowledge improves/deteriorates, relative to that of the market, one becomes more likely to receive/yield a net transfer of wealth from/to other players in the market.

Modeling The IS-Investment Paradox

The new equations of the model (perceived private value and perceived private profit) drive the IS investment behaviour:

Perceived Private Value:

$$V\sim = ah(I^b + g\tau^b((I/\tau)^\phi - 1)e^{-(nI/q)}) \tag{5}$$

\tilde{V} V^- = Perceived short-run value possibilities frontier, g = market relevance factor, ϕ = scale expansion-factor for (I/τ) , (I/τ) = index of relative information, τ = the IS power of the average participant in the market.

Perceived Private Profit:

Equation (5) less eqn (3):

$$\pi = ah(I^b + g\tau^b((I/\tau)^\phi - 1))e^{-(nI/q)} - r_j e^{lk/q/j} \tag{6}$$

Having an IS that is more powerful than average, gives an IS investor more knowledge than average, allowing for better decisions, allowing for an increased share of both normal rents (implied by the profit function) and quasi-rents (from "eating someone-else's lunch").

It is reasonable to assert that better decisions result from a more powerful than average IS, which yields both social gains and a wealth transfer of quasi-rents from the less informed decision makers. Further, second- and n^{th} -order effects can lever a small initial advantage to a major competitive advantage. For example, a retailer with better knowledge about bad-debt risk incurs less bad debt costs by refusing high-credit-risk customers. If the declined, credit-problem, customers go to the competition, the more informed retailer gains a further competitive advantage or his/her less informed competition -- leading to lower prices and scale-economies that may yield even more competitive advantage in the form of lower costs, lower prices, and higher sales volume that may yield... and so forth.

A firm’s knowledge, relative to the market average, is subsumed in the model by adding an index "I/τ" to the *achievable-value frontier*. As I/τ , rises more quasi-rents are available but scale and efficiency problems increasingly interfere with their capture -- this interference is included in the model by modifying the index to $(I/\tau)^\phi$, where: $0 < \phi < 1.00$. The availability of quasi-rents to a firm is mostly determined by the relative size of its product and/or factor markets and by the absolute information development of those markets. Thus, in defining available quasi-rents, the IS power of the average market participant ($ah\tau^b e^{-(nI/q)}$) is likely more important than the firm’s IS power ($ahI^b e^{-(nI/q)}$). These considerations change the *achievable-value frontier* (eqn (2)) to:

$$V\sim = ah(I^b + g\tau^b((I/\tau)^\phi - 1)e^{-(nI/q)}) \tag{5}$$

In total, the Perceived Private value can, in the short-run, exceed the total achievable value. Specifically, eqn (5), unlike eqn (2), includes quasi-rents and, in the short run, the perceived private value can exceed the *value-possibilities frontier* (eqn (1)). Deducting eqn (3) from eqn (5) generates the perceived private profit equation:

$$\pi = ah(I^b + g\tau^b((I/\tau)^\phi - 1))e^{-(n/I/q)} - rje^{lk/q/j} \tag{6}$$

Differentiating eqn (6) with respect to information flow (I) yields a relation but not a function (i.e. "I" is on both sides of the equation). Given that this difficulty, analysis yields little of value and, accordingly, it is not done. Instead, the optimum value of "I" is defined by specifying model parameters (Table 1) and using iteration to solve for the highest value of eqn (6).

Table 1: Parameters (Assumed Values)

Parameter description	Eqn.	Symbol	Value
Value -- Scale	(2)	a	1.000
-- Slope	(2)	b	0.900
I/τ Expansion Factor	(5)	φ	0.750
Market Relevance Factor	(5)	g	10.000
Learning -- Opportunity	(2)	h	1.000
-- Slope	(2)	n	0.030
Cost -- Fixed Portion	(3)	j	6.000
-- Scale	(3)	r	0.030
-- Slope	(3)	k	0.500
Avg. Information Flow	(5)	τ	Variable
Information Quality	(2)	q	0.29636

When eqn (6) is differentiated with respect to τ, the result (after being set equal to nil) can be reorganized to:

$$\tau^\phi = I(1 - \phi/b)^{1/\phi} \tag{7}$$

τ^φ = average market IS power yielding the highest perceived private profit for a given I.

Equation (7) is a constant and (given the assumed parameter values in Table 1) has a value a little over nine percent -- therefore, firms would ideally like to restrict other firms to a small percentage of their own IS power.

Model Simulation Outcomes

Figures 1 through 5 provide an interesting story of what can happen in a near perfectly competitive market when participants in that market have the illusion that they can out invest the others in IS power. In Figure 1, point A is the start where all participants are at an IS power of 1.00. The social optimum investment occurs at point B. However, individual firms perceive their private optimum investment (i.e. maximizing eqn (6)) to occur at point D. When all firms try for point D the market ends up at point C (Figure 2). This occurs because all of the identical firms try in identical ways to out invest each other in IS power.

At point C (Figure 2) the firms are still making a profit on the IS investments but it is not as good as what would have made at point B (the social optimum) and it is nowhere near as good as what was expected at point D. However, point C is not an equilibrium -- the perceived private value curve indicates maximum private returns on IS investment are to be had at point F. When all of the firms try for point F, the result is point E (Figures 2 and 3) where all firms in the market experience losses on their IS investments (i.e. the achievable value is below the efficient cost).

Point G, in Figure 3, looks stable (i.e. the Achievable Value and the Efficient Cost are equal). However, in Figure 4, when the IS market is at point G, the firms perceive an opportunity to make a small positive return (at point H) by trying to out-invest the other firms in IS and this drives the market to an even greater loss position (point I) to the right of point E.

Figure 1: Perceived Benefits and Costs of Expanding an Information System when All Participants Start at an IS Power of 1.0

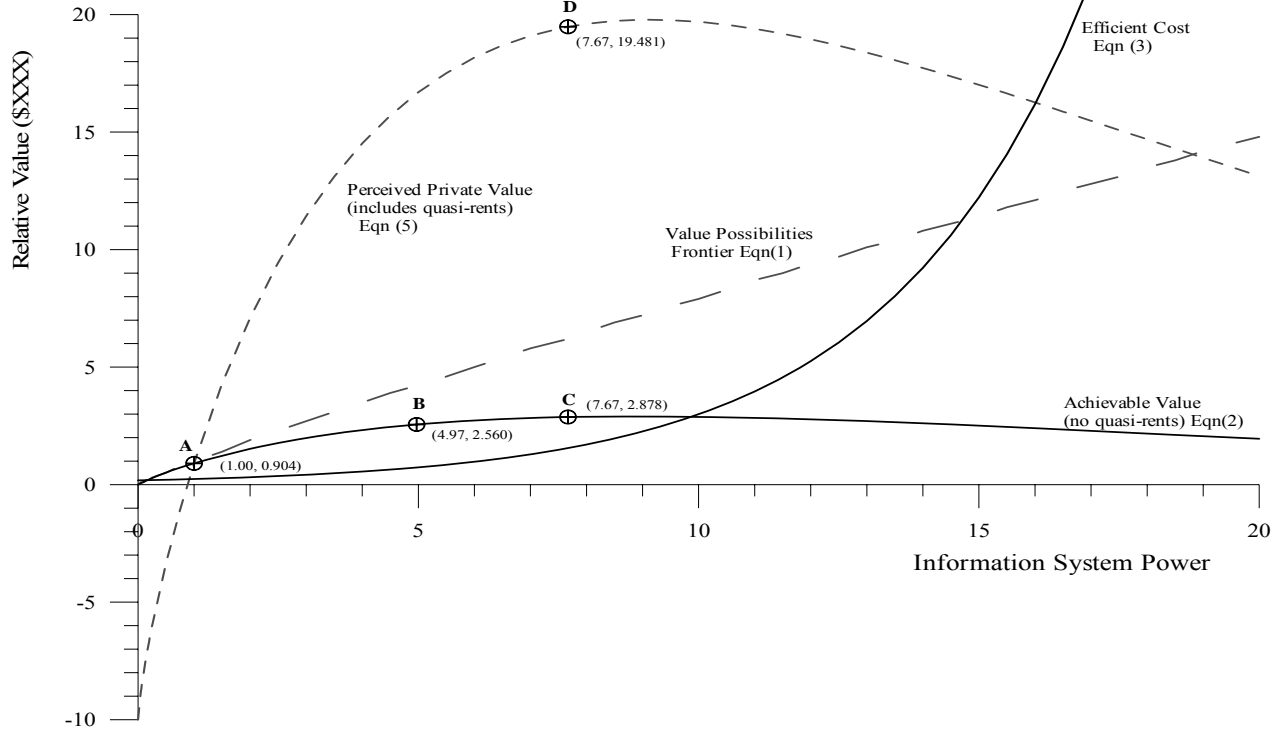


Figure 2: Perceived Benefits and Costs of Expanding an Information System when All Participants Move to the Point C IS Power

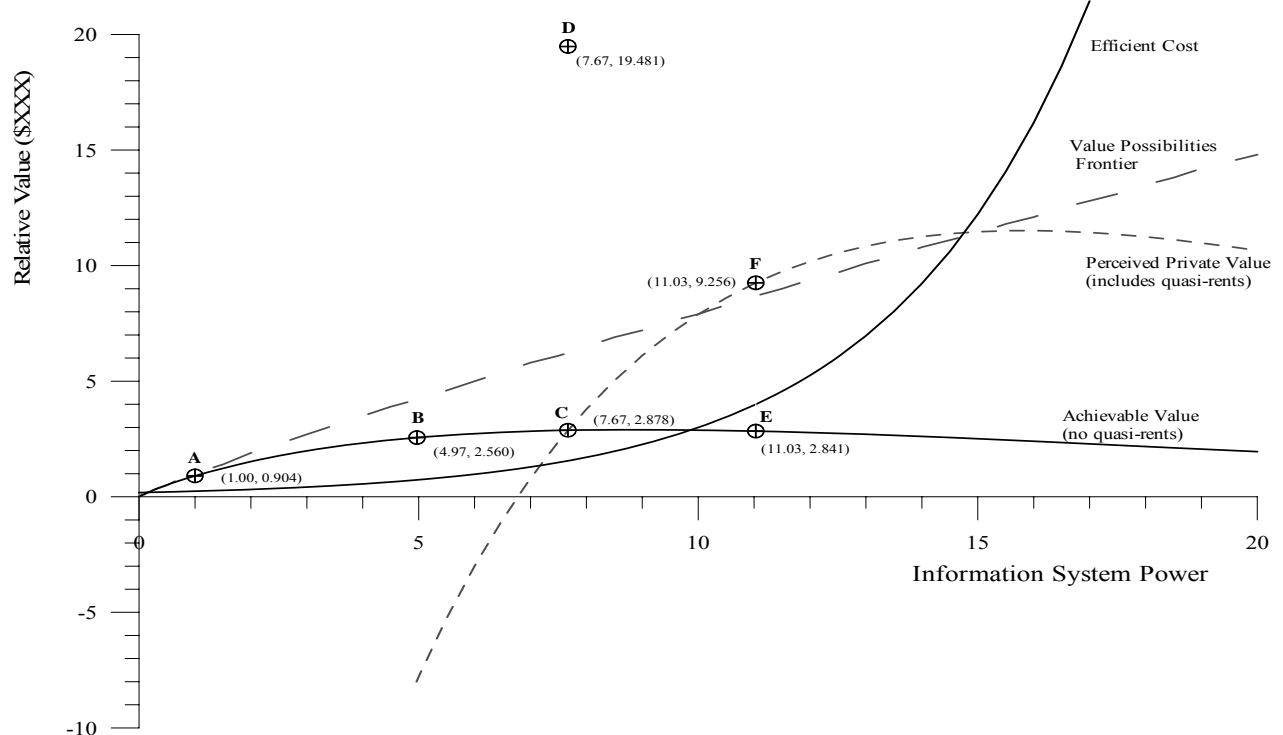


Figure 3: Perceived Benefits and Costs of Expanding an Information System when All Participants Move to the Point E IS Power

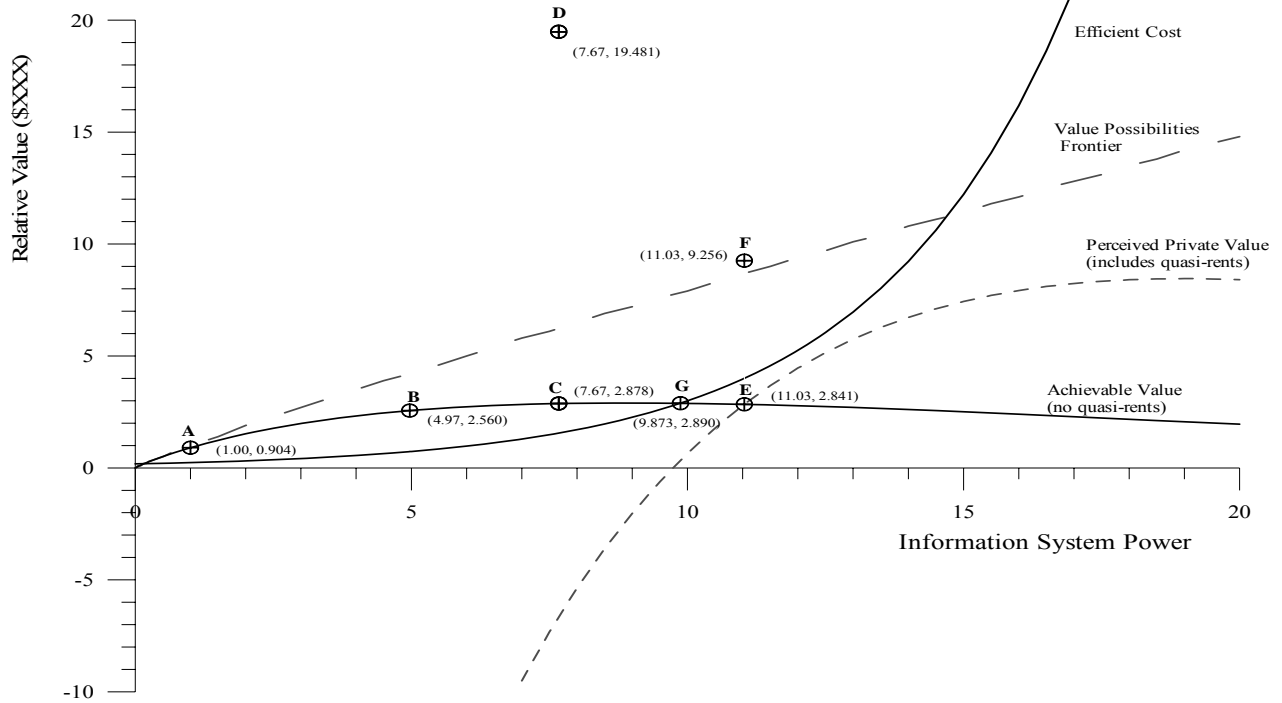


Figure 4: Effect on Perceived Private Value As All Participants Expand Their Information Systems From the IS Power at Points A to D to F to G

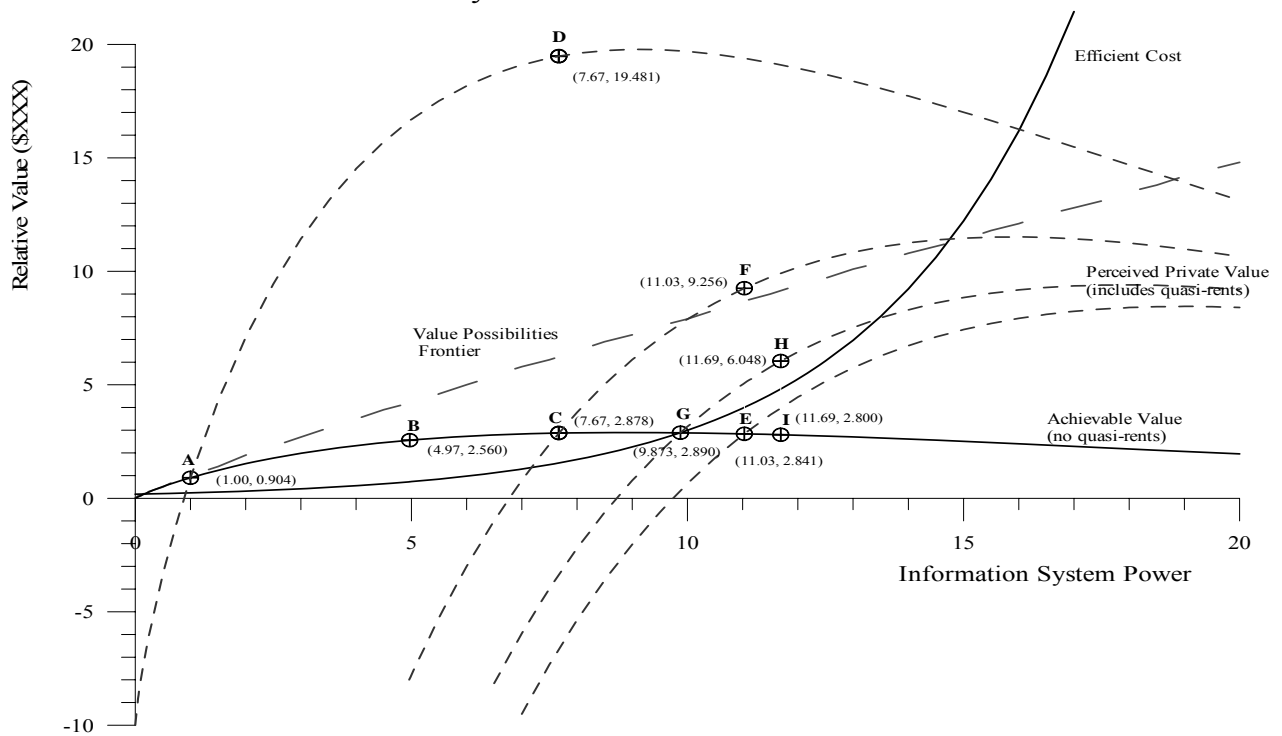


Figure 5: Intersection of the Perceived Private Value and the IS Cost Curves

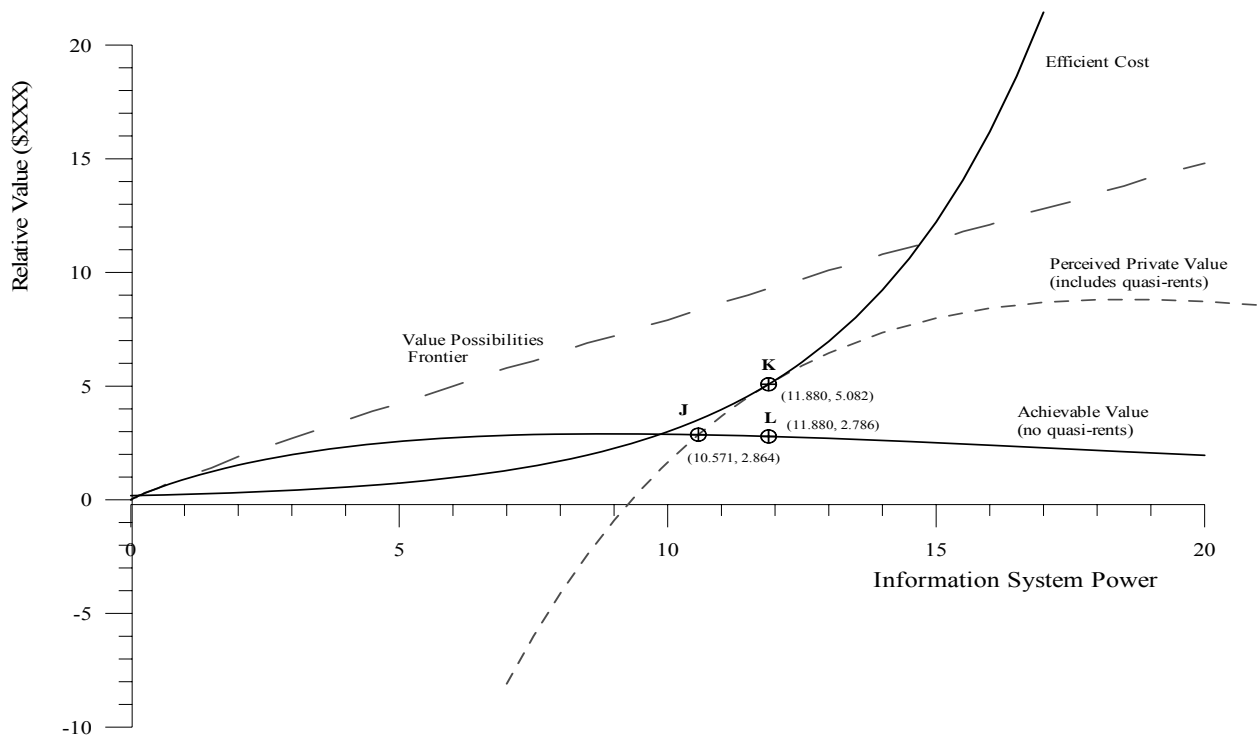


Figure 5 provides very distressing information. Specifically, even where there is no profit available from quasi-rents (point J), there is still the illusion that out-investing other firms will minimize a firm’s IS loses at point K. In the mature IS investment market (i.e. all points to the right of point J, Figure 5) there appears to be no hope for either profit or stability.

CONCLUSIONS

It is widely recognized that the performance of IS investments persistently under-perform expectations. The recent *bust* in IS investment appears to be part of an IS boom-bust cycle where once an investment boom is initiated by IS innovation, a bust is inevitable – although it may be delayed by one or more intervening IS innovations. The bust in IS investment arises when the expectations of fabulous profits are crowded out by the reality of low or negative returns on IS investment.

This paper developed a theoretical model to examine IS-investment behaviour. IS-investment behaviour was modeled by using the *perceived private value* and the *perceived private profit* in conjunction with three equations representing relationships between information flow, knowledge, value and IS investment -- the Value-Possibilities, the Achievable-Value, and the Efficient-Cost Frontiers

The model simulation outcomes show persistent high expectations of profit that tend to generate an investment bubble, followed by a general failure to achieve the expected returns. In most economic sectors, an on-going pattern of poor returns on such “great expectations” would result in rational firms significantly reducing similar investments in the future. Exceptions to this dictum tend to involve mental illness or economic sectors with common-property resource issues. The situation in IS investment is very similar to what economic literature calls “the tragedy of the commons”.

Investment bubbles (e.g. investment frenzies based on unsustainable expected returns) are common in economic sectors dominated by common-property resources – they are initiated when one or more parties invest with the aim of appropriating a greater share of rents and/or quasi-rents. This initial investment is emulated by less aggressive investors seeking what they see as a proven opportunity for higher returns and then by defensive investors playing catch-up to minimize losses imposed on them by earlier investors. Ultimately, the investment bubble bursts when investors realize they are making negative returns on their investments in livestock, fishing vessels/power, or IS.

The problem with tying the IS investment bubble to a common-property-resource issue is that the traditional solutions to such issues (e.g. monopoly owner, limited entry, and regulation) are unlikely to work well in the IS investment market. Further, the tragedy in the IS investment market is like a “Greek Tragedy”. Specifically, once any firm starts the competitive-investment process, the tragedy is inevitable and even foreknowledge cannot stave it off.

AREAS FOR FUTURE INQUIRY

This study concludes that prospects in the IS sector are, at best gloomy. However, over most of the last 30 years, the IS industry has been considered to be highly dynamic, profitable, and resilient -- when riding the IS tiger, it is only when you get tired and want to dismount that you find you have a problem. Future studies need to look at the dynamics of IS markets. A number of concepts may generate interesting ideas for future research. A few suggestions and comments follow:

- Investment timing – Relax the assumption of instantaneous response to allow for diffusion over time and space (i.e. the rate of IS investment may vary by firm). This reality may create years or even decades of profitability, for aggressive initiator firms, in a succession of markets.
- Producer Rents – Relax the assumption of identical participants (i.e. some firms are better at business than others and are able to generate profits even when on average there are losses; Copes, 1970 and 1972). These changes can sustain more investment and renew an over mature IS market.
- Increase the complexity of IS investment. Investment can reduce IS costs, improve message quality, and/or reduce message handling. These effects, in combination with improved access to information and communication networks, increased inter- and intra-system compatibility can greatly reduce costs and increase the Achievable Value curve. These changes can renew an over mature IS market and/or stimulate more IS investment.
- Allow for technological change (i.e. technological improvements tend to drive IS Costs down and rotate the Achievable Value curve upward) to sustain/increase investment.

While these inquiries may prove that the messy real world is much more resilient than indicated by simple static-equilibrium-analysis models, the underlying problems identified in this paper will continue to haunt IS markets -- waiting to convert any mere falter into an economy wrecking bust.

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