Chapter 4

# SYNERGY, QUANTUM PROBABILITIES, AND COST OF CONTROL

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**Abstract**: A standard control problem is analyzed using quantum probabilities. There are some advantages of conducting the analysis using the axiomatic structure of quantum probabilities: (1) there is synergy associated with bundling activities together, and, hence, a demand for the firm; (2) information occupies a central place in the analysis; (3) accounting information questions can be related to other information sciences. The main result is that control costs decline when aggregate performance measures are used; aggregation arises naturally. An implication is that the common practice of acquiring individual measures may be misguided in an environment where synergy is a first order effect. Also, double entry accounting appears well suited for processing information in a synergistic context.

**Key words**: Aggregation, Agency, Quantum Probabilities, Synergy

## 1. INTRODUCTION

Exploiting synergy is a fundamental objective of firms. Synergy exists if it is more efficient to bundle activities than to engage in each separately. In an uncertain environment a definition of synergy invokes expected values: the expected value of the bundled activities strictly exceeds the sum of the expected values if the activities are performed separately. Synergy supplies an explanation for the existence of firms, as, absent synergy, separate activities could be conducted as efficiently purely in a market setting.

In this paper we are interested in the general question of how to process information in a firm. As synergy is a fundamental precursor to firm formation, it seems sensible to address the question in a setting in which synergy is of first order importance. Typical sources of synergy are economies of scale and scope (frequently modeled without uncertainty).

Arya (2002) describes synergistic gains to information in an adverse selection setting where there exists no production synergy. That is, two independent but potentially value-enhancing activities undertaken simultaneously can yield more favorable trade-offs between production and rationing to control the agents' information rents than when the activities are undertaken individually. In this paper we consider an inherently uncertain (quantum) setting in which synergy arises from bundling productive activities. A primary information processing result is reductions in control costs arise from employing aggregate performance measures for agents who supply unobservable inputs.

This paper augments a recurring theme in accounting on the merits of aggregation. A commonly cited reason to aggregate information is bounded rationality: limits on information transmission, reception, and processing can make aggregated information desirable. Benefits to aggregation, even with fully rational participants, include cancellation of errors in product costing (Datar and Gupta 1994), conveying information via choice of aggregation rule (Sunder 1997), protecting proprietary information (Newman and Sansing 1993), and substituting for commitment (Arya, Glover, and Sunder 1998, and Demski and Frimor 2000). By exploiting information processing capacity created via superposition,[10] quantum information adds another avenue for aggregation to be beneficial. A natural accounting response follows: aggregate measurement of bundled activities is more efficient both in terms of synergy and control cost than individual measurement of each activity.

In this paper synergy is modeled using quantum probabilities, the probabilities used to describe Nature in the subatomic realm. One advantage of the approach is that synergy is a first order effect of the uncertain environment. That is, when uncertainty is described by quantum probabilities, synergy is a direct implication. A further advantage is that quantum probabilities follow an axiomatic development with its inherent advantages of abstraction and rigor of analysis.[11] An implication of the axioms is that productive and measurement activities are inextricably linked; it is not possible to talk about productive activities without explicit recognition of the measurement activity.

[10] Superposition, and other quantum physics terms, are defined in the axiomatic development of Appendix 1.

[11] As discussed in Appendix 1, quantum probabilities reflect the superposition principle and are fundamentally different from a mixture of classical probabilities used to describe non-quantum phenomena (Feller, 1950, Zuric, 1991, Tegmark and Wheeler, 2001, Nielsen, 2003, and Davidovich, 2005).