

OPERATIONAL CHALLENGES OF STRATEGY EXECUTION

A Thesis
Presented to
The Academic Faculty

by

Jeremy J. Kovach

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in the
Scheller College of Business

Georgia Institute of Technology
August 2014

Copyright © 2014 by Jeremy J. Kovach

OPERATIONAL CHALLENGES OF STRATEGY EXECUTION

Approved by:

Professor Atalay Atasu
Committee Co-Chair
Scheller College of Business
Georgia Institute of Technology

Professor Stylianos Kavadias
Committee Co-Chair
Judge Business School
University of Cambridge

Professor Manpreet Hora
Scheller College of Business
Georgia Institute of Technology

Professor Cheryl Gaimon
Scheller College of Business
Georgia Institute of Technology

Professor L. Beril Toktay
Scheller College of Business
Georgia Institute of Technology

Date Approved: 10 June 2014

For Renee, Michael, Jill, & Ryan:

Dream up the kind of world you want to live in

and dream out loud.

ACKNOWLEDGEMENTS

I first want to thank the faculty and administration at Scheller College of Business at Georgia Tech for taking a chance and allowing me the opportunity to switch careers midstream. I am grateful to have learned from all of you during this process and look forward to many years of continued interaction. You have taught me not only the nuts and bolts of conducting meaningful research, but additionally through your example, what it takes to succeed in academia. I especially want to thank my committee members for their continued support and feedback, without which this thesis could not have been completed. Additionally, I must recognize the sacrifices made on my behalf by my family during the past five years. Thank you for allowing me the opportunity to pursue this. You have all my love and appreciation.

TABLE OF CONTENTS

DEDICATION	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
SUMMARY	vii
I INTRODUCTION	1
II FIRM PERFORMANCE IN DYNAMIC ENVIRONMENTS: THE ROLE OF OPERATIONAL SLACK AND OPERATIONAL SCOPE	4
2.1 Introduction	4
2.2 Theory and Hypotheses	9
2.2.1 Environmental Dynamism	10
2.2.2 Unpredictability and Instability	10
2.2.3 Operational Scope	12
2.2.4 Operational Slack	18
2.3 Data	21
2.4 Results	28
2.5 Discussion	34
III SALES FORCE COMPENSATION FOR REMANUFACTURED PROD- UCTS	39
3.1 Introduction and Related Literature	39
3.2 Model Setup	44
3.3 Benchmark: A Model without Sales Force Effects	49
3.4 Remanufacturing with a Sales Force	51
3.4.1 Separate Sales Channels for New and Remanufactured Products	52
3.4.2 Joint Sales Channel for New and Remanufactured Products	64
3.4.3 A Comparison of Commissions Across Joint and Separate Sales Channels	67

3.5	Extensions	68
3.5.1	The Effect of Demand Uncertainty and Risk Aversion . . .	69
3.5.2	Sales Effort Cost Interactions	70
3.6	Conclusions	73
IV	FOCUSED OR FLEXIBLE TARGETS? HOW ORGANIZATIONAL DESIGN INFLUENCES THE DEFINITION OF SUCCESS FOR STRATEGIC INITIATIVES	77
4.1	Introduction and Related Literature	77
4.2	Model Setup	82
4.2.1	The Relationship Between Effort and Value	83
4.2.2	Organizational Structure	84
4.2.3	Definition of Success and Stakeholder Incentives	85
4.2.4	Decision Sequence	90
4.3	Model Analysis	91
4.3.1	Functional Organizational Structures	92
4.3.2	Project-Based Organizational Structures	99
4.3.3	Comparing Organizational Structures	105
4.4	Conclusions	108
APPENDIX A	PROOFS FROM CHAPTER III	111
APPENDIX B	PROOFS FROM CHAPTER IV	120
	Bibliography	128

SUMMARY

Operations management studies the process of transforming material, labor, energy, or ideas into goods or services. Operations strategy outlines how firms leverage their capabilities to achieve competitive advantage. While developing or possessing these capabilities is paramount, they must be successfully leveraged to yield competitive advantage. This thesis comprises three essays which consider how firms can successfully implement their operations strategy, specifically within the context of supply chain management, remanufacturing, and project execution. The first essay (Chapter 2) empirically investigates the performance benefits of operational slack and operational scope in dynamic environments. We investigate how contingent investments in operational slack and operational scope moderate the relationship between unstable and unpredictable markets on firm performance. The second essay (Chapter 3) considers how a firm's organizational structure and incentives influence its decision to participate in remanufacturing. Through a principal-agent structure, we determine the optimal sales agent commission structures and product portfolio of new and remanufactured product for the firm. The third essay (Chapter 4) considers the challenges of executing strategic initiatives. We recognize the dual role of performance metrics, they communicate the target outcomes (i.e., what types of project outcomes are sought), and at the same time they incentivize the organizational impetus (i.e., effort commitment) from the stakeholders. Using a game theoretic model, we investigate the implications of the target outcome (focused or flexible definition of success) and project uncertainty, which are dependent on the organizational structure of the firm.

CHAPTER I

INTRODUCTION

Operations management studies the process of transforming material, labor, energy, or ideas into goods or services. Operations strategy outlines how firms leverage their capabilities to achieve competitive advantage. Such capabilities may consist of manufacturing flexibility, operational slack, supply chain structure, production technology, IT infrastructure, organizational structure and incentives, or business processes. While developing or possessing these capabilities is paramount, they must be successfully leveraged to yield competitive advantage. This thesis comprises three essays which consider how firms can successfully implement their operations strategy, specifically within the context of supply chain management, remanufacturing, and project execution. The first essay empirically examines how operational slack and operational scope influence firm performance. The second and third essays utilize normative models to investigate how different organizational structures and incentive plans influence the implementation of strategic initiatives. The second specifically considers conditions unique in the remanufacturing context, while the third investigates how senior management's definition of success influences project execution.

The first essay (Chapter 2) empirically investigates the performance benefits of operational slack (measured as capacity slack, inventory slack, and supply chain slack) and operational scope (measured as product scope, geographic scope, and process scope) in dynamic environments, specifically investigating how operational initiatives moderate the effects of dynamic markets on firm performance. We find that strategic investments in inventory slack improve firm performance in unstable markets; whereas investments in all three forms of operational slack improve firm performance

in unpredictable markets. Further, we find support for lean operations (low operational slack) in stable markets and focused operations (low operational scope) in predictable markets. Investments in operational slack (scope) are found to have no performance benefits for firms in unpredictable (unstable) markets, indicating that the choice of strategic operational investment should be contingent on the specific market conditions of the firm.

The second essay (Chapter 3) considers how a firm's organizational structure and incentives influence their decision to participate in remanufacturing. We specifically investigate the challenges of motivating sales agents to sell remanufactured products that compete in the same market with their new product counterparts. Participation in remanufactured product sales has generally been considered a profitable strategy for firms, provided that the costs of remanufacturing are sufficiently low. This allows for profitable market expansion to price conscious consumers. We find that when sales agents can be utilized to increase sales, conditions exist where it may be optimal to not sell remanufactured products, even if they yield higher profit margins than new products. Additionally, we find that commissions for new products should be higher than those for remanufactured products, which is due to the unique supply constraints on remanufactured products.

The third essay (Chapter 4) considers the challenges of executing strategic initiatives. We recognize the dual role of performance metrics, they communicate the target outcomes (i.e., what types of project outcomes are sought), and at the same time they incentivize the organizational impetus (i.e., effort commitment) from the stakeholders. Using a game theoretic model, we investigate the implications of the target outcome (focused or flexible definition of success) and project uncertainty, which are dependent on the organizational structure of the firm. Specifically, we consider project execution in two archetypical organizational structures, functional and project-based. Functional organizational structures foster skill expertise, but often

suffer from cross-functional coordination challenges. Alternatively, project-based organizations utilize project managers to facilitate cross-functional coordination, but suffer from the loss of stakeholder technical expertise. We find that for incremental projects (i.e., those with low uncertainty), flexible definitions of success should be specified in functional organizations, while focused definitions should be specified in project-based organizations. Flexible targets provide a tolerance for failure to the stakeholders and reduce the incentives required to ensure impetus in functional organizations; yet, such tolerance for failure encourages shirking in project-based organizations.

CHAPTER II

FIRM PERFORMANCE IN DYNAMIC ENVIRONMENTS: THE ROLE OF OPERATIONAL SLACK AND OPERATIONAL SCOPE

2.1 Introduction

In order to remain successful in competitive markets, organizations must maintain a stable operational core under environmental variation (Thompson, 1967). Examples of exogenous variations include pricing and scheduling uncertainties with respect to a firm's upstream supply of materials or the downstream demand uncertainties for a firm's finished goods. These exogenous variations are reflected in the environmental dynamism of an industry, such that firms in more dynamic environments will experience more variations than those in less dynamic environments. Firms can operationally manage such variations through two operational strategies: investing in operational slack and/or broadening operational scope (Boyer & Leong, 1996; Ramdas, 2003). However, the findings on the effects of operational slack and operational scope on performance remain mixed. In this study, we investigate whether two components of environmental dynamism - unpredictability and instability - could help untangle the mixed relationships between operational slack and operational scope with firm performance. Our study aims to address the question: *How do operational slack and operational scope contingently affect firm performance in unpredictable and unstable dynamic environments?* Our empirical setting focuses on 964 publicly traded firms in 23 industries in the manufacturing sector from the years 1998 to 2007, representing 8,473 firm year observations.

Operational slack represents the resources available for the operational activities

of a firm which are in excess of what is required to fulfill expected demand, such as excess plant capacity or inventory. Insufficient operational slack can lead to reduced responsiveness to production disruptions and reduced reliability in product deliveries. For example, the sustained rain and the subsequent flooding in Thailand during the monsoon in 2011 suspended manufacturing operations for various components. This supply disruption resulted in downstream production delays for Intel, Western Digital, Toyota, Honda, Goodyear, Nikon, and Sony (Tibken, 2011). Alternately, Deere and Co., the world's largest producer of tractors and combines, announced in May 2012 that it was investing heavily in capacity expansions and increasing finished goods inventories to better manage anticipated future global demand (Tita, 2012). In addition to buffering potential supply and demand mismatches, operational slack can also be leveraged as a competitive advantage, as exemplified by Hyundai's response to the March 2011 earthquake in Japan. The earthquake and subsequent tsunami led to parts shortages from Japanese suppliers that forced temporary plant shutdowns of most major automobile manufacturers, who maintained tight control over their inventory levels (Terlap & Winterstein, 2011; Terlap, 2011). This shortage resulted in a competitive advantage for Hyundai, whose production facilities were largely unaffected by the supply disruptions since the South Korean automaker sourced only 1% of their subcomponents from Japanese suppliers (Choi, 2011). Hyundai responded to the supply problems of other manufacturers by increasing its production output from its underutilized facilities in an effort to supply product to customers that were unable to purchase cars from Hyundai's competitors (Choi, 2011). In all of these cases, slack resources such as capacity utilization, raw material, and finished goods inventories can be leveraged to better manage supply and demand mismatches.

On the other hand, operational scope represents a firm's breadth of product offering, geographical diversification, and the extent to which a firm's production technologies can operate cost effectively (Tang & Tikoo, 1999; Vokurka & O'Leary-Kelly,

2000; Ramdas, 2003; Boyabatlı & Toktay, 2004; Benito-Osorio *et al.*, 2012). Diverse product offerings allow firms to better manage product specific sales fluctuations while broadening their market reach, as exemplified by Starbucks' recent decision to acquire "a bakery and a fresh juice company, while also launching a line of energy drinks and an espresso brewer" (Gasparro, 2012). Similarly, Samsung, a global leader in consumer electronics, is now exploring diversifying its product portfolio to include LED lighting, mobile networks, set-top boxes, and medical devices to tap into new market opportunities (Huang, 2013). In 2011, Johnson and Johnson, a "maker of products ranging from Band-Aids to the anti-inflammatory drug Remicade flexed its diversification muscles, with sales growth of pharmaceutical and medical-device products helping to offset the sales decline for [highly competitive] OTC drugs" (Loftus, 2011). Additionally, firms can diversify with respect to manufacturing and sales locations, capitalizing on variances in regional or country specific economic conditions (Boyabatlı & Toktay, 2004; Linebaugh & Hagerty, 2011). Chrysler, BMW, Mercedes Benz, and Audi have all recently leveraged higher sales in developing countries to offset the sales declines in Europe for high end automobiles (Bennett, 2011; McGrath & Rauwald, 2012). Further, Volkswagen recently announced global expansion in production capabilities for its core Volkswagen models as well as its higher end Audi division to include Southeast Asia and another North American facility (Lee, 2010; Rauwald, 2012). Firms also have the ability to use their production technology to alter the range of output within their manufacturing facilities. As a benefit from the recent acquisition of Chrysler, Fiat plans to leverage its new production capabilities by producing Chrysler, Fiat, and Maserati automobiles (a subdivision under Fiat) in the same assembly plants (Bennett, 2011).

Studies have separately found mixed support for the effects of operational slack and operational scope on performance, profitability, innovation, and the effectiveness of operational risk management initiatives (Benito-Osorio *et al.*, 2012; Daniel *et al.*,

2004; Vokurka & O’Leary-Kelly, 2000). While Daniel et al. (2004) find that slack resources strengthen firm performance, there is also evidence supporting lean operations (efficient production with minimal inventories), such that slack resources may hinder performance (Modi & Mishra, 2011). Similarly, while Swamidass and Newell (1987) find support for “manufacturing flexibility” (broad product and process scopes) improving performance in uncertain markets, Pagell and Krause (2004) later contradict these findings. Research is ongoing to better understand if and when narrow operational scopes yield higher performance outcomes compared to broad operational scopes (Mukherjee *et al.*, 2000; Ketokivi & Jokinen, 2006; Goyal & Netessine, 2007). Overall, findings relating operational scope and operational slack to firm performance remain mixed.

We attempt to resolve some of these contradictory findings by examining the effects of slack resources and operational scope while explicitly considering components of a firm’s dynamic environment. This research views environmental dynamism as consisting of two distinct components, unpredictability and instability. Unpredictability is the “lack of regularity in the pattern of change in an environment”, while instability is “the extent to which an environment exhibits change” (Miller *et al.*, 2006). Industries could have varying levels of unpredictability and instability. The apparel and consumer electronics industries both experience seasonal demand cycles (thus both industries are unstable), but the apparel industry is much more unpredictable due to the difficulty in forecasting consumer tastes (Abubakar *et al.*, 2010). Consumer electronics sales, however, follow well understood seasonal patterns such that peak holiday season sales can be accurately forecasted, resulting in an unstable but not unpredictable industrial environment. Alternately, the food products industry experiences relatively small seasonal variations on the sales of food products, but the sales do not necessarily follow predictable patterns in the long-run. For example, according to a recent DataMonitor report, product failure rates in the food

industry are as high as 50 percent due to the unpredictability of consumer tastes (Scott-Thomas, 2012). Therefore, the food products industry is stable but unpredictable. We investigate how operational slack and operational scope moderate the effects of unpredictability and instability on industry-adjusted firm performance.

This study contributes to the operations strategy literature by identifying the role of operational slack and operational scope on firm performance in the presence of environmental dynamism. The analyses focus at the firm level and investigate how operational slack (as measured by plant capacity utilization, cash to cash cycles, and inventory level decisions) and operational scope (as measured by the breadth of a firm's product offering, breadth of the geographical regions in which the firm operates, and the extent to which a firm's production technologies can operate cost effectively) influence the performance of firms that operate in unpredictable and unstable environments.

This research also extends the work of Anand and Ward (2004) and Azadegan et al. (2013). Anand and Ward (2004) examine the role of operational flexibility (mobility and range) at the plant level for firms operating under different forms of environmental dynamism (unpredictability and volatility). The current study additionally considers the role of operational slack in dynamic environments, but more importantly, identifies the relative importance of operational slack versus operational scope (related but distinct from operational flexibility) in unpredictable and unstable environments. Azadegan and colleagues (2013) examine how operational slack influences new venture survival under environmental dynamism, complexity, and munificence. Whereas their study focused on the survivability of young and small firms that have limited resources, operational scope was not considered. We not only consider operational scope in addition to operational slack, but focus on larger and established firms to determine how they influence relative firm performance in unstable and unpredictable markets (two components of environmental dynamism). By jointly considering these

factors, we further untangle the relationship between operational scope, operational slack, and environmental dynamism and firm performance.

By considering two distinct components of environmental dynamism, instability and unpredictability, we hypothesize (and find) that increased operational scope enhances firm performance in unpredictable markets, whereas operational slack enhances firm performance in unstable markets. The consideration of a firm's environment along the dimensions of instability and unpredictability bears importance, because it reveals that it is not always beneficial to invest in increased operational scope, operational slack, or both simultaneously¹. This analysis offers guidance to resource-constrained managers in their attempts to effectively manage their operations in dynamic environments.

In the next section, we review the prior literature on slack, scope, and dynamism and present theoretical hypotheses. Next, we describe the data, measures, and methods used to test the hypotheses. Lastly, we present the results from the study and then discuss their theoretical contributions and managerial implications.

2.2 Theory and Hypotheses

Operational scope and operational slack can both be utilized to manage operations in dynamic environments. In this section, we briefly describe the concept of environmental dynamism, classify its unpredictability and instability components, and elaborate on the two operational strategies of scope and slack specifically highlighting their respective roles in the face of environmental dynamism. Next, we conceptualize how the two operational strategies moderate the relationship between these two components

¹Analyses in the robustness section show non-significant effects of squared terms of operational scope or operational slack indicators on performance. The interaction of squared terms of operational scope and unpredictability and operational slack and instability were not significant. Finally, operational scope and instability or operational slack and unpredictability have no significant effect on performance.

of dynamism and firm performance.

2.2.1 Environmental Dynamism

Dess and Beard (1984) succinctly categorized the environment of organizations along three dimensions: munificence, dynamism, and complexity. Through a path analytic model, Keats and Hitt (1988) then attempted to understand how each of these three different dimensions of the environment influenced a firm's decisions and subsequent performance. Their findings indicate that environmental dynamism was the "dominant influence" regarding firm decisions and performance. Dynamism, as defined by Dess and Beard (1984, p.56), is "change that is hard to predict and that heightens uncertainty". In the presence of industry dynamism, the resource allocation decisions of firms can largely influence the ability of firms to outperform competitors and maintain a competitive advantage (Sirmon *et al.*, 2007). As such, it is well documented that it is more challenging to manage firms in highly dynamic environments, and performance is therefore negatively affected by high levels of environmental dynamism (Keats & Hitt, 1988; Goll & Rasheed, 1997; Robert Baum & Wally, 2003).

Recognizing that environmental dynamism is a multidimensional construct, Wholley and Brittain (1989) deconstructed environmental dynamism into four separate dimensions: amplitude, predictability, frequency, and instability. Their findings implied that three of these dimensions were unique, with amplitude and instability highly correlated to one another. These three dimensions were later collapsed into two distinct components, instability and unpredictability (Miller *et al.*, 2006).

2.2.2 Unpredictability and Instability

Unpredictability refers to the "lack of regularity in the pattern of change in an environment" (Miller *et al.*, 2006, p.104). This aspect of dynamism deals with the deviations in the future supply and demand requirements of a firm from their expected patterns, resulting in the inability to accurately forecast production requirements. *Instability*

refers to “the extent to which an environment exhibits change” (Miller *et al.*, 2006, p.101). This aspect of the environment relates to both the frequency of change and the magnitude of change over time and is indicative of the volatility of an industry (Wholey & Brittain, 1989). Each of these dimensions can uniquely influence the benefits of operational slack and operational scope (Ketokivi & Jokinen, 2006; Eisenhardt *et al.*, 2010).

Figure 2.1 graphically illustrates the distinction between instability and unpredictability. Each of the four charts represents the quarterly demand from a firm given either high or low unpredictability or instability; with the x-axes representing sequential time periods (quarters) for a firm and the y-axes the associated product demand for each quarter. For exposition and comparative purposes, each representative demand pattern in the figure has the same historical average and no trend component, such that the specific component of environmental dynamism can be illustrated. The upper left quadrant represents industries which are both unstable and unpredictable, such that the overall demand for products is volatile and does not follow recognizable patterns. General Dynamics, a firm that manufactures aerospace, marine, and combat systems products represents a firm operating in an unstable and unpredictable industry. The upper right quadrant represents unpredictable but stable markets. General Mills, a well-diversified food product manufacturer operates in such markets, where the overall fluctuations in seasonal demand are low, but unpredictable. The lower left quadrant represents predictable, but unstable markets such that the overall market demands may follow expected patterns with high seasonal variations. Sony Corporation operates in such an environment, where the overall demand pattern for consumer electronics is predictable, but highly varied between seasons. Lastly, the lower right quadrant represents industries that are both predictable and stable. Exxon Mobil, the world’s largest publicly traded fossil fuel processor, operates in an environment that experiences low seasonal variations in the demand for fuel which can be accurately

projected by the firm.

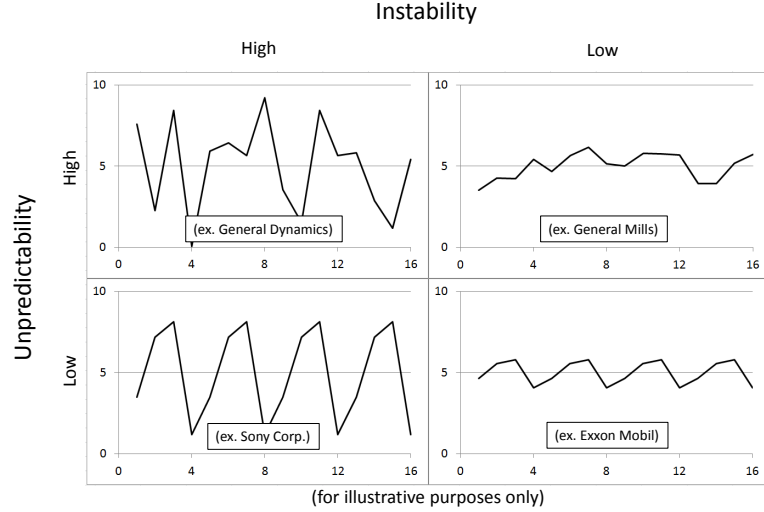


Figure 2.1: Unpredictability and Instability

2.2.3 Operational Scope

Porter (1985) describes how managing the scope of a firm’s activities (operational scope) is a crucial determinant in achieving a competitive advantage over rivals. Specifically, we investigate three forms of operational scope: product scope, geographic scope, and process scope. Considering these three aspects, firms with larger product portfolios, higher levels of geographical diversification and the ability to utilize production technologies to cost effectively alter production output are considered firms with broad operational scope. Conversely, narrow scoped firms focus on a limited set of products, lower levels of geographical diversification and limited production capabilities (Skinner, 1969, 1974; Hayes & Wheelwright, 1984; Porter, 1985). These dimensions of operational scope have been extensively studied, both analytically and empirically, in operations management, strategy, marketing, and economics literature, with excellent literature reviews published on the topic (Pesch & Schroeder, 1996; Palich *et al.*, 2000; Kirca *et al.*, 2011; Nippa *et al.*, 2011). Therefore, our intent

is to study the broader role of operational scope in dynamic environments with respect to firm performance. Figure 2 portrays the conceptual framework of the proposed model and the associated hypotheses.

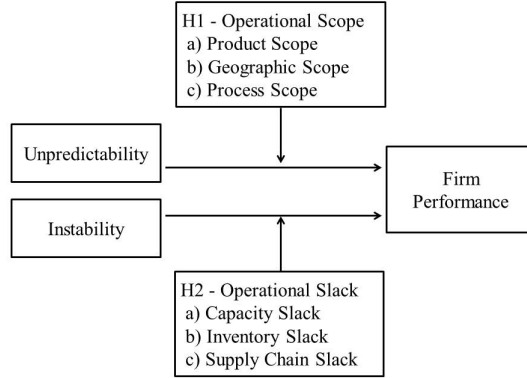


Figure 2.2: Proposed Model

2.2.3.1 Product Scope

The breadth of a firm’s product portfolio reflects the firm’s product scope, such that firms with a larger portfolio have a broader product scope. The potential benefits from a broader product scope are documented in the industrial organization economics and strategy literature (Palepu, 1985). However, this stream of research, when viewed in entirety, indicates there is no “universally valid nature of the diversification-performance linkage” (Bausch & Pils, 2009, p.179). Benito-Osorio et al. (2012, p.335) provide some potential rationale for the historically inconsistent conclusions, suggesting that that the performance benefits accruing from product diversification may indeed be “environment dependent”.

Product scope has also been examined from the perspective of both operations management and marketing. Kekre and Srinivasan (1990) focused on consumer and industrial goods firms (both classified as unpredictable environments in our data) and proposed that increased product breadth would increase costs and market share,

and that the incremental sales in turn would translate into increased profits. However, they do not find support for increased costs. Morgan and Rego (2009) find that broad product scopes improve market share, but hinder cash flows. Randall and Ulrich (2001) provide a more nuanced view of the incremental costs associated with broad product lines, separating the costs into production and market mediation costs. Production costs deal directly with the tooling and establishment of manufacturing capability, as well as the incremental operating and maintenance costs incurred. Market mediating costs involve the additional transportation and inventory holding costs as well as potential mark-downs on product pricing resulting from supply and demand mismatches. The authors suggest that the market mediation costs will generally increase with demand uncertainty. While there is evidence that these costs do increase with uncertainty, prior literature suggests that increased product breadth is an effective means to deal with increased uncertainty, as the risks of supply and demand mismatches can be spread over a greater number of products. This view is consistent with Ramdas (2003, p.81), that “variety creation and variety implementation decisions determine a firm’s responsiveness to demand uncertainty”.

We synthesize these differing perspectives from economics, strategy and operations literature and posit that the benefits from broad product scopes dominate the market mediation costs when demand is unpredictable. However, when demand is predictable, the additional production costs associated with a broad product scope hinder firm performance; i.e., the portfolio benefits and market mediation costs associated with a diverse product are both muted when demand is predictable, but the incremental production costs remain. For predictable environments, this hypothesis supports the concept of focused factory (Skinner, 1974), and provides performance related empirical testing of the conclusions from Ketokivi and Jokinen (2006, p.261), who find that “firms tend to be more focused if demand is predictable”.

Hypothesis 1a - A broader Product Scope strengthens (weakens) firm performance in unpredictable (predictable) markets.

2.2.3.2 Geographic Scope

A second aspect of operational scope, geographic scope, considers the operational implications of the locations in which firms can produce and sell their products; i.e., their geographic diversification (Boyabatlı & Toktay, 2004). Considering geographical diversification as an aspect of operational scope used to manage dynamic environments is succinctly described by Kogut and Kulatilaka (1994, p.124); “the economic merits of the international firm as a network are derived from the option value of multinational operating flexibility under the critical condition of uncertainty”. Geographically diversified production capabilities increase a firm’s scope by allowing the firm to exploit market imperfections in the pricing, availability, and transportation of materials (Hitt *et al.*, 1997). Geographic diversification also allows firms to globally reallocate production based on geographic differences in supply and transportation costs to fulfill their overall demands. Additionally, by locating production facilities close to end customers, firms can better ensure that their production costs and sales revenues are exposed to the same geographical and/or country specific risks and exchange rate uncertainties (Boyabatlı & Toktay, 2004; Kim *et al.*, 2006).

While several studies have found that geographical diversification improves firm performance due to the ability to shift production requirements and/or align costs and revenues to the same currency (Kim *et al.*, 1993; Tang & Tikoo, 1999; Goerzen & Beamish, 2003; Kim *et al.*, 2006; Kumar, 2009; Kirca *et al.*, 2011), some additionally find an inverted U-shaped relationship similar to the relationship sometimes found from broad product scopes (Hitt *et al.*, 1997; Qian *et al.*, 2010; Lampel & Giachetti, 2013), and others find a strictly negative relationship between geographical diversification and firm value (Berger & Ofek, 1995; Denis *et al.*, 2002; Kim & Mathur,

2008). The arguments for (and against) geographical diversification are theoretically analogous to those for product diversification.

When production facilities are located far from customers, the distance creates longer forecast horizons and replenishment lead times, which are exacerbated by demand uncertainty (Randall & Ulrich, 2001). This implies that when demand is unpredictable, then having geographically dispersed operations capabilities can minimize the associated market mediation costs (Randall & Ulrich, 2001). But, if demand were predictable, then the benefits from operating a globally distributed production network may not be sufficient to warrant their operations and maintenance costs. We hypothesize that broad geographic scopes are performance enhancing in unpredictable markets, but not so in predictable markets.

Hypothesis 1b - A broader Geographic Scope strengthens (weakens) firm performance in unpredictable (predictable) markets.

2.2.3.3 Process Scope

The third aspect of operational scope, process scope, considers the extent to which a firm can utilize its production technology to profitably alter its output. Said differently, process scope embodies attributes of both mix flexibility and volume flexibility, previously considered in the literature as two components of “Flexible Manufacturing Capability” (Zhang *et al.*, 2003). Mix flexibility has been generally defined as “the ability of a manufacturing system to effectively produce a wide variety of different products” (Pagell & Krause, 2004, p.635)(Pagell and Krause, 2004, p.635), or more specifically as “being able to handle a range of products or variants with fast set-ups” (Gerwin, 1993, p.398). Volume flexibility has been defined as “the ability to operate economically at different production volumes” (da Silveira, 2006, p.934) or “the ability to effectively increase or decrease aggregate production in response to customers” (Pagell & Krause, 2004, p.635). Each of these definitions implies a dimension

of flexibility that is independent from the other, which is conceptually distinct, but practically impossible to separate, as each of these two dimensions are highly dependent on one another when firms produce a variety of products. To our knowledge, the only plausible way these could be measured independently is if a firm ran a constant production volume but with different products (thus allowing an accurate measure of mix flexibility), or only produced a singular, perfectly homogenous product at varying production volumes (thus allowing an accurate measure of volume flexibility). Moreover, this sentiment was initially described by Mukherjee et al. (2000) who noted that “volume heterogeneity” between different products in a firm may result in stable aggregate demand, yet the proportion of demand for each product the firm produces may change unpredictably. Mukherjee et al. (2000) found that narrow process scopes did not improve firm performance when volume heterogeneity (a combination of mix flexibility and volume flexibility) increased with unpredictability.

Our conceptualization of process scope is similar to the notion of “volume heterogeneity” proposed by Mukherjee et al. (2000), which incorporates attributes of mix and volume flexibility by recognizing that firms produce a variety of products with different production volumes, and this variety and volume change over time. Firms have the ability to invest in resources that allow a broader process scope, thus allowing for a greater variety of production mix and volume with minimal cost penalties. Alternatively, firms can focus on a narrow process scope which attempts to “reduce costs by relying on the benefits of task specialization” (Gerwin, 1993). If firms are able to shift production from one product type to another more cost effectively than their competitors, they will have a competitive advantage in dynamic markets. Consider for instance two firms that each produces two products of differing volumes, each product for a different market. If the demands for the two products are negatively correlated, then the firm that can shift production levels between the two products more efficiently will have a strategic competitive cost advantage (Goyal &

Netessine, 2011). Alternatively, if there is little demand uncertainty, then the costs associated with the ability to efficiently shift production levels may not be justified, as the demand forecasts can be perfectly planned and managed through more focused production methods (Skinner, 1974). Such scenarios have been previously modeled normatively, where increased scope with respect to volume or production mix is proposed to increase in performance with demand uncertainty (Lee & Tang, 1997; Van Mieghem, 1998; Chod & Rudi, 2005). Process scope allows for a larger range of profitable production that can be used to mitigate the negative consequences from unpredictable environments. Therefore, we hypothesize:

Hypothesis 1c - A broader Process Scope strengthens (weakens) firm performance in unpredictable (predictable) markets.

2.2.4 Operational Slack

Slack resources allow firms to “adjust to gross shifts in the external environment with minimal trauma” (Bourgeois III, 1981, p.31). Slack resources were historically viewed from the perspective of the organization, and operationalized by investigating factors such as: general and administrative expenses, debt to equity ratios, credit ratings, working capital, R&D expenditures, and the number of employees in a firm (Bourgeois III, 1981; Daniel *et al.*, 2004; Mishina *et al.*, 2004; Voss *et al.*, 2008). Several studies have found that slack resources, at least to some extent, enhance firm performance (Daniel *et al.*, 2004; George, 2005; Tseng *et al.*, 2007; Wefald *et al.*, 2010; Goldstein & Iossifova, 2012).

George (2005) studied the impact of slack resources in privately held firms and found that some slack was beneficial for firms, but too much was detrimental to performance, implying a curvilinear relationship between slack and performance. Although, this study investigated slack resources as they relate to performance, it did not consider the influence of a firm’s environment. Tseng *et al.* (2007) find a similar

curvilinear relationship between organizational slack and multinational growth, such that some slack was beneficial but too much was detrimental. Wefald et al. (2010) recognized that the performance enhancing benefits of slack resources are dependent on the specific industry for which a firm operates. A meta-analysis by Daniel et al. (2004) that documents the relationship between slack resources and firm performance echoes the sentiment that these resources are beneficial for firms, and the results are more significant if the analysis includes industry-specific differentiation. Thus, a consistent theme underlying the previous literature is that slack resources, to some extent, increase performance, and these benefits are highlighted when a firm's industry affiliation is incorporated into the study. However, less is known on how the underlying dynamic aspects of industries influence the slack to performance relationship.

Bourgeois (1981, p.34) proposed that "raw materials and finished-goods inventories represent slack resources used as technical core buffers, work-in-process inventories represent interdepartment buffers another measure would be excess capacity". Sharfman et al. (1988, p.603) later proposes that "slack resources are physical entities such as cash, people, nonobsolete inventory, machine capacity and so forth". Hendricks et al. (2009) additionally consider the overall slack in a firm's supply chain, as measured by the firm's cash-to-cash cycle (also referred to as trade cycle). This measure includes not only the physical inventory of the focal firm, but also the accounts payables owed to the firm's suppliers and the accounts receivables owed from the firm's customers. All else being equal, a firm with a larger cash-to-cash cycle will have more operational slack in their supply chain; i.e., a lower cash-to-cash cycle is an indicator of a firm's supply chain leanness (Hendricks *et al.*, 2009). We will adopt these definitions, and focus on the operations specific slack resources mentioned. Specifically, we will investigate three different aspects of operational slack: inventory slack, capacity slack, and supply chain slack. It is important to distinctly separate operational slack from operational scope, recognizing that investing in inventory or

lower capacity utilization does not necessarily increase a firm's scope (Jack & Raturi, 2003). These definitions of operational slack are widely adopted and consistent with those from prior studies (Chopra & Sodhi, 2004; Kleindorfer & Saad, 2005; Tang, 2006; Hendricks *et al.*, 2009; Azadegan *et al.*, 2013).

We view capacity utilization, inventory levels, and cash-to-cash cycles as decisions firms make in order to have the ability to tactically manage the supply and demand mismatches that may occur in dynamic environments. Although firms with high capacity utilizations for their production capabilities may be more efficient than firms with lower capacity utilizations, firms with lower capacity utilizations may be better able to respond to changes in supply and demand by utilizing their excess capacity. Similarly, firms with smaller inventories or cash-to-cash cycles that employ just-in-time production techniques may not be able to adjust to dynamic markets as well as those with larger inventories that can buffer supply and demand variability. In this respect, this research will contribute to the lean operations literature, which investigates the benefits of efficient inventory and production practices (low slack). While several studies indicate that lean/efficient operations enhance profitability (Capon *et al.*, 1990; Shah & Ward, 2003; Eroglu & Hofer, 2011; Modi & Mishra, 2011), others have found that slack resources improve firm performance (Daniel *et al.*, 2004; George, 2005; Goldstein & Iossifova, 2012). We hope to provide insights into these conflicting findings by additionally considering the industry specific dynamic environments of firms that invest in operational slack.

Since slack resources allow a firm to tactically deploy assets needed to manage supply and demand mismatches, this operational strategy of investing in slack resources could lead to a competitive advantage in unstable industries. The unstable aspect of environmental dynamism as it relates to operational slack leads to the next set of hypotheses. Hypothesis 2a, 2b, and 2c propose that each aspect of a firm's operational slack will enhance firm performance in unstable environments more so

than those in stable environments.

Hypothesis 2 - Operational Slack [represented as: (a) capacity slack, (b) inventory slack, and (c) supply chain slack] strengthens (weakens) firm performance in unstable (stable) markets.

2.3 Data

Since the conceptualization and the measures of operational scope and operational slack focus on various aspects related to product manufacturing (and not provision of services), our sampling criteria considers firms in the manufacturing sector (SIC code: 20 to 39) and we collect data on these firms from COMPUSTAT between 1998 and 2007. To reliably draw panel data estimates, we use the following filters: (a) at least five years of continuous financial information is available in COMPUSTAT; (b) as more than 100 percent growth rate is less likely in large publicly traded firms and such firms must have likely acquired other firms we drop these firms; and finally (c) to avoid firms under financial distress, firms must have an average yearly stock price of at least \$3. Firms with distressed assets are more likely to adopt operational strategies less geared towards increasing competitive advantage and more geared towards firm survival (Khanna & Poulsen, 1995), and as such are not included. Based on these selection criteria, we identified 964 firms representing 8,473 firm-years from 1998 to 2007. Table 2.1 shows the distribution of firms and firm-years across different industry categories.

Dependent Variable - Industry-median adjusted ROA (t). From an operations management perspective, return on assets (ROA) proxies for both profitability and efficiency in utilization of assets. Therefore, to measure firm performance, we operationalize ROA for each firm year (t) and subtract the median industry (2-digit SIC) ROA in year (t) from firm's ROA in year (t).

Independent Variables. Based on Miller et al. (2006), *instability* is measured using

Table 2.1: Sample Composition and Distribution
Sample Composition

	Number of firm years	Percent	Number of Firms	Percent
Full Sample	8,473	100%	964	100%
<i>Composition by S&P Index</i>				
S&P 500	3,575	42.19%	323	33.48%
S&P 400 Mid Cap	2,528	29.84%	258	26.79%
S&P 600 Small Cap	2,370	27.97%	383	39.73%

Distribution of Firm-year observations by firm type

	Firm Year Frequency	% Firms	Instability	Unpredictability	t-test difference
Food Products	326	3.85%	0.169	0.425	6.726
Recreational products	92	1.09%	0.617	0.603	0.205
Printing and Publishing	269	3.17%	0.065	0.203	2.305
Consumer Goods	320	3.78%	0.480	0.570	2.761
Apparel	272	3.21%	0.580	0.563	0.966
Medical Equipment	281	3.32%	0.263	0.198	0.813
Pharmaceutical products	486	5.74%	0.149	0.058	1.954
Chemicals	432	5.10%	0.544	0.565	3.908
Rubber and Plastic Products	102	1.20%	0.115	0.151	1.245
Construction Materials	263	3.10%	0.135	0.207	2.175
Construction	272	3.21%	0.142	0.209	2.306
Steel works etc.	288	3.40%	0.090	0.211	2.496
Machinery	581	6.86%	0.525	0.602	1.185
Electrical Equipment	228	2.69%	0.613	0.282	7.076
Automobile and trucks	323	3.81%	0.138	0.212	0.217
Petroleum and Gas	354	4.18%	0.066	0.121	0.618
Telecommunications	170	2.01%	0.601	0.368	5.609
Computers	502	5.92%	0.516	0.301	6.424
Electronic Equipment	947	11.18%	0.527	0.313	5.739
Measuring and Control Equipment	291	3.43%	0.604	0.469	3.837
Business Supplies	297	3.51%	0.113	0.116	0.467
Transportation	574	6.77%	0.132	0.197	2.587
Other*	803	9.48%	0.615	0.684	0.215

*Other industries include those industries that have less than 20 observations: Agriculture, Aircraft, Alcoholic beverages, Candy and soda, Defense, Entertainment, Fabricated products, Miscellaneous, Nonmetallic mining, Precious metals, Real estate, Ship building and railroad equipment, Shipping containers, Textiles, and Tobacco products.

three indicators: (i) amplitude of change; (ii) average magnitude of instability; and (iii) frequency of changes in fortune. We measure *unpredictability* using two indicators: (i) magnitude of unpredictability and (ii) proportional unpredictability (Miller *et al.*, 2006). We collect quarterly industry sales information of all COMPUSTAT firms listed by 2-digit SIC codes, and use 20 quarters of time series industry sales data to establish a rolling five-year window of quarterly sales for all the indicators.

Instability - For amplitude of change, the natural log of sales for each firm are first adjusted by the industry specific natural log of total industry assets. Next, a seasonal adjustment index for sales is created, which accounts for growth trends, decline trends, and cyclical trends (Brocklebank & Dickey, 2003; Hylleberg, 1992). This seasonal adjustment index is the ratio of the observed sales over the seasonally and growth adjusted quarter-specific moving average (Wholey & Brittain, 1989). *Amplitude of change* is the difference between the largest and smallest values of the seasonal adjustment index in the five-year rolling window, where higher values indicate increased deviation from the average adjusted industry sales trends. The *average magnitude of instability* is the standard error derived by regressing quarterly industry sales over 20 quarters. Higher values indicate increased instability in industry sales. The *frequency of changes in fortune* relates to changes in industry trends from positive to negative or from negative to positive. The slopes of the industry sales data between each quarter are chronologically tabulated. When the slope remains positive or negative between two consecutive quarters, the latter quarter is coded as 1, whereas the quarter is coded as 0 if there is a change in trend (positive to negative slope or negative to positive slope) between quarters. We then count the total number of slope reversals (change from 1 to 0) and divide it by 20. Higher values indicate a higher frequency of change in fortune.

The item loadings for amplitude of change ($= 0.905, t = 12.138, p < 0.001$), average magnitude of instability ($= 0.872, t = 9.317, p < 0.001$), and frequency of

changes in fortune ($= 0.942, t = 15.409, p < 0.001$) on instability ($\alpha = 0.806$) were significant.

Unpredictability - The *magnitude of unpredictability* is the “average size of fluctuations after controlling for systematic change involving growth, decline, and cyclical” (Miller *et al.*, 2006). It is measured as the standard error from a linear regression of the amplitudes derived from the amplitude of change measure. Standard errors indicate the average fluctuation in the seasonally adjusted sales data such that higher values indicate higher magnitudes of unpredictability. *Proportional unpredictability* is the degree to which the environment does not follow a consistent pattern over time. Unpredictability is greater if the ratio of irregular or unsystematic change to total change is higher (Wholey & Brittain, 1989). Controlling for growth, cyclical, and declining trends in X-11-ARIMA, industry wide current quarter sales are regressed on prior quarter sales (Brocklebank & Dickey, 2003; Hylleberg, 1992). The adjusted-R² indicates the degree to which prior quarter’s sales predict the current quarter sales. Higher values indicate higher proportional unpredictability whereas lower values indicate lower proportional unpredictability.

The two indicators for unpredictability, magnitude of unpredictability ($= 0.864, t = 11.906, p < 0.001$) and proportional unpredictability ($= 0.923, t = 13.062, p < 0.001$), also exhibited significant loadings and acceptable inter-item correlation ($r = 0.665; p < 0.001$, two-tailed).

Moderator Variables. We define three measures of operational scope: (a) *product scope*, (b) *geographic scope*, and (3) *process scope*. Based on Hendricks et al. (2009), we define three measures of operational slack: (a) *capacity slack*, (b) *inventory slack*, and (c) *supply chain slack*. All moderator variables are adjusted for the industry-median at the 2-digit SIC code level.

Operational Scope ($t - 1$) - *Product scope* is measured as one minus the Herfindahl index of sales concentrations across product segments, as reported on Form SFAS

131, which began reporting in 1997 (Hendricks *et al.*, 2009; Kumar, 2009). Form SFAS 131 (Statement of Financial Accounting Standards No. 131) is an accounting standard requiring firms to disclose financial and descriptive information pertaining to the products and services, major customers, and geographic areas for which firms participate (FASB, 1997). The Herfindahl index for the product scope of firm k (PS_{Herf}^k) is calculated as the summation of the square of the ratios of the annual sales in each product segment i to the annual total sales of the firm for the prior year ($t - 1$) for all product segments N subtracted by the industry median PS_{Herf} :

$$PS_{Herf}^k = \left(\sum_{i=1}^N \left(\frac{S(i)_{t-1}}{S_{t-1}} \right)^2 \right)_k - \left(\sum_{i=1}^N \left(\frac{S(i)_{t-1}}{S_{t-1}} \right)^2 \right)_{industry}$$

where $S(i)$ are the sales in product segment i and S are the total sales across all segments. We measure the product scope for firm k as $PS_k = 1 - PS_{Herf}^k$, where a higher value indicates a larger breadth of product scope than a lower value.

Geographic scope is measured similarly to product scope, which is measured as one minus the Herfindahl index of sales concentrations across geographic regions, as reported on Form SFAS 131 (Hendricks *et al.*, 2009; Kumar, 2009). The Herfindahl index for the geographic scope of firm k (GS_{Herf}^k) is calculated as the summation of the square of the ratios of the annual sales in each geographic region j to the annual total sales of the firm for the prior year ($t - 1$) for all geographic regions M , subtracted by the industry median GS_{Herf} :

$$GS_{Herf}^k = \left(\sum_{j=1}^M \left(\frac{S(j)_{t-1}}{S_{t-1}} \right)^2 \right)_k - \left(\sum_{j=1}^M \left(\frac{S(j)_{t-1}}{S_{t-1}} \right)^2 \right)_{industry}$$

where $S(j)$ are the sales in geographic segment j and S are the total sales across all segments. We measure the geographic scope for firm k as $GS_k = 1 - GS_{Herf}^k$, where a higher value indicates a larger breadth of product scope than a lower value.

Process scope is measured as the firm's ability to cost effectively manage variations in demand, which is proxied by variations in sales. Specifically, we measure the process

scope of firm k (RS_k) as the past five year's ratio of the variance in total sales (S) to the variance in the firm's cost of goods ($COGS$):

$$RS_k = \left(\frac{\text{variance}(S)_{(t-5)to(t-1)}}{\text{variance}(COGS)_{(t-5)to(t-1)}} \right)_k - \left(\frac{\text{variance}(S)_{(t-5)to(t-1)}}{\text{variance}(COGS)_{(t-5)to(t-1)}} \right)_{industry}$$

This measure for process scope was additionally proposed by Jack and Raturi (2003) as a means to measure volume flexibility considering the effective use of a firm's production technology (and not inventory). Additionally, this measure is the inverse of the amplification ratio used by Cachon et al. (2007), which was used to measure the bullwhip effect faced by firms in response to demand variations. From our measure, a higher process scope ratio (RS) indicates that the firm is better able to cost effectively manage its sales variations than a lower ratio.

Operational Slack ($t - 1$) - *Capacity Slack* is measured by the ratio of yearly net property, plant, and equipment (PPE) to annual sales in the prior year ($t - 1$) of firm k , which is adjusted by the median value for the industry as determined by the 2-digit SIC code to account for inter-industry differences:

$$CS_k = \left(\frac{PPE_{t-1}}{S_{t-1}} \right)_k - \left(\frac{PPE_{t-1}}{S_{t-1}} \right)_{industry}$$

Firms with a lower capacity slack ratio (CS) are utilizing their production capabilities (capacity) much more efficiently than those with higher capacity slack ratios; but, this additionally implies that they may not be able to respond to extreme variations in demand as cost effectively as those with more excess capacity. A higher ratio of PPE to sales indicates higher slack.

Inventory slack is measured as the days of inventory for the firm in the prior year, which is calculated by dividing the firm's average inventory (INV) in the prior year by their annual cost of goods (COGS) in the prior year, multiplied by 365 days and adjusted by the median value for the industry as determined by the 2-digit SIC code to account for inter-industry differences:

$$IS_k = 365 \left(\frac{INV_{t-1}}{COGS_{t-1}} \right)_k - 365 \left(\frac{INV_{t-1}}{COGS_{t-1}} \right)_{industry}$$

Firms with higher inventory slack (IS) are better able to respond to variations in demand by utilizing finished goods inventory as opposed to altering production processes than firms with lower inventory slack.

Supply chain slack (SS) is measured by the industry adjusted cash-to-cash cycle of the firm in the prior year, which is the days of inventory plus days of accounts receivables (DAR_k) minus days of accounts payables (DAP_k) for firm k , which are defined as:

$$DAR_k = 365 \left(\frac{accounts\ receivable_{t-1}}{S_{t-1}} \right)_k; DAP_k = 365 \left(\frac{accounts\ payable_{t-1}}{COGS_{t-1}} \right)_k$$

The industry adjusted supply chain slack for firm k (SS_k) is calculated by subtracting the median industry cash to cash cycle from the firm's cash to cash cycle:

$$SS_k = 365 \left(\frac{INV_{t-1}}{COGS_{t-1}} \right)_k + DAR_k - DAP_k - \left(365 \left(\frac{INV_{t-1}}{COGS_{t-1}} \right) + DAR - DAP \right)_{ind.}$$

A higher SS value indicates more slack in the supply chain, which includes the inventory of the focal firm as well as the accounts receivables from the firm's customers and account's payables to the firm's suppliers.

Controls. Larger firms are more likely to absorb the impacts of instability and unpredictability than smaller firms, and therefore could experience less deterioration in firm performance when facing unstable or unpredictable environments. Similarly, older firms face lower liabilities of newness, and have well developed operational routines and capabilities to manage environmental changes. Industry-adjusted *firm size* is measured as the natural log of assets minus the median natural log of assets at the 4-digit SIC industry level, and *firm age* as the number of years since the firm was established.

We also control for two additional environmental conditions: *environmental complexity* and *environmental munificence*. Environmental complexity at the industry

Table 2.2: Summary Statistics

Mean, SD, and Correlation Table															
	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Industry-adjusted Firm Size [ln(Assets)]	6.07	5.34	1												
2. Firm Age	28.44	21.72	0.089	1											
3. Environmental Complexity	-0.87	0.22	-0.202	0.035	1										
4. Environmental Munificence	0.34	0.18	0.367	0.292	0.157	1									
5. Instability	0.53	0.12	-0.238	-0.134	0.392	0.155	1								
6. Unpredictability	0.42	0.10	-0.346	-0.202	0.292	0.279	0.375	1							
7. Capacity Slack	0.13	0.21	0.083	0.167	0.109	0.156	0.038	0.062	1						
8. Inventory Slack	0.09	0.28	0.149	0.045	0.153	0.089	0.168	0.190	0.128	1					
9. Supply Chain Slack	0.03	0.05	0.123	0.100	0.076	0.031	0.044	0.115	0.113	0.256	1				
10. Process Scope	0.82	1.13	0.197	0.158	0.163	0.073	0.016	0.145	0.047	0.050	0.186	1			
11. Product Scope	0.11	0.53	0.115	0.149	0.016	0.101	0.137	0.128	0.043	0.161	0.038	0.129	1		
12. Geographic Scope	0.22	0.08	0.198	0.049	0.022	0.163	0.144	0.140	0.162	0.139	0.052	0.132	0.168	1	
13. Industry-adjusted ROA	0.04	0.17	0.110	0.071	-0.217	0.118	-0.146	-0.268	0.094	0.121	0.096	0.103	0.125	0.079	0.249

Notes.

$N=964$ firms representing 8,473 firm-years from 1998 to 2007.

All correlations above |0.086| are significant at 0.05 or below (two-tailed)

All correlations above |0.121| are significant at 0.01 or below (two-tailed)

level is the concentration of market share among industry participants. Based on Heeley, King, and Covin (2006), we regress the market shares of firms in year $t - 5$ on the market shares of firms in year t . A positive beta indicates increasing market share and therefore increasing concentration over time. To facilitate interpretation, we multiply beta by -1 , so that higher values indicate decreasing concentration and therefore increasing complexity. Environmental munificence at the industry level is the beta of regression of yearly sales from $t - 5$ to t on time (Heeley *et al.*, 2006). Higher betas indicate increasing sales over time and therefore increasing environmental munificence. Table 2.2 shows the summary statistics and correlations of the variables in the model.

2.4 Results

Our data consists of firm panels with continuous information for at least five continuous years. We begin by assessing the relevance of pooled OLS regression, fixed-effects, or random-effects regressions. To identify the correct model for our estimation, we start with an OLS model with robust standard errors and compare the estimates with the estimates from firm fixed effects (F-test = 11.629, $p < 0.001$). Therefore, panel

data estimates are required. Next, using the Hausman test, we compare whether a fixed effects or random effects model better corresponds to the data ($p = 0.001$; H0: no difference in estimates between fixed and random effects). As the null hypothesis is rejected random effects are not present, and therefore fixed effects estimations are used. Next, we investigated whether the data exhibited heteroskedasticity or autocorrelation. The autocorrelation component at AR(1), or dependent variable lagged at $t - 1$, is significant ($= 0.398, p = 0.000$), however, AR(2) is not significant ($= 0.113, p = 0.186$); therefore, the AR(1) lag structure is used to model the data. Furthermore, the Cook-Weisberg heteroskedasticity test was significant ($= 111.439, p = 0.000$). To account for autocorrelation and heteroskedasticity in our fixed effects model we use a Feasible Generalized Least Squares (FGLS) approach. The estimators generated from FGLS approach have been shown to be consistent and efficient (Woolridge, 2002). Specifically, we use the *xtgls* command in Stata 11, and include *corr(ar1)* to specify panel specific AR(1) correlation structure, and *panels(hetero)* to specify the heteroskedastic error structure across panels.

Tables 2.3 and 2.4 show the 16 models used to test the hypotheses. Model 1 only considers the effects of the control variables on firm performance. This model indicates that firm size is positively related to ROA, indicating possible economies of scope and scale available in large firms. Environmental complexity is negatively related to performance, whereas firm age and environmental munificence are insignificantly related to performance. Models 2 and 3 individually investigate the effects of instability ($\beta = -0.0139, p < 0.01$) and unpredictability ($\beta = -0.0189, p < 0.01$), indicating that each are associated with lower firm performance. Similarly, each of the six moderating factors positively affect ROA (Models 4-9). All three measures of operational scope (Models 4-6), and two of three measures of operational slack (Models 7 and 8) are statistically significant at the 95% confidence level, whereas

Table 2.3: Fixed Effects Regression

Fixed FGLS Effects Regression with AR(1) structure									
	Model 1 Control	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
<i>Direct Effects (t-1)</i>									
Operational Scope									
Product Scope				0.0142* (0.0057)					
Geographic Scope					0.0099* (0.0041)				
Process Scope						0.0126* (0.0049)			
Operational Slack									
Capacity Slack							0.0146* (0.0062)		
Inventory Slack								0.0105* (0.0046)	
Supply Chain Slack									0.0085^ (0.0046)
Instability		-0.0139** (0.0052)	-0.0137* (0.0054)	-0.0159** (0.0052)	-0.0161** (0.0057)	-0.0142* (0.0058)	-0.0163** (0.0059)	-0.0172** (0.0059)	-0.0176*** (0.0052)
Unpredictability			-0.0189** (0.0066)	-0.0193** (0.0069)	-0.0193** (0.0069)	-0.0193** (0.0069)	-0.0193** (0.0069)	-0.0190** (0.0072)	-0.0195** (0.0066)
<i>Two-way Moderation Effects</i>									
Product Scope × Unpredictability [H1a]									
Geographic Scope × Unpredictability [H1b]									
Process Scope × Unpredictability [H1c]									
Capacity Slack × Instability [H2a]									
Inventory Slack × Instability [H2b]									
Supply Chain Slack × Instability [H2c]									
<i>Controls (t-1)</i>									
Firm Size [ln(Assets)]	0.0518*** (0.0137)	0.0507*** (0.0135)	0.0511*** (0.0138)	0.0520*** (0.0136)	0.0522*** (0.0149)	0.0513*** (0.0131)	0.0536*** (0.0145)	0.0518*** (0.0141)	0.0522*** (0.0146)
Firm Age	0.0009 (0.0007)	0.0008 (0.0007)	0.0007 (0.0008)	0.0008 (0.0008)	0.0006 (0.0006)	0.0008 (0.0008)	0.0007 (0.0006)	0.0008 (0.0008)	0.0007 (0.0009)
Environmental Complexity	-0.0188** (0.0072)	-0.0172* (0.0074)	-0.0168* (0.0076)	-0.0184* (0.0076)	-0.0171* (0.0078)	-0.0174* (0.0073)	-0.0170* (0.0077)	-0.0189** (0.0072)	-0.0183* (0.0076)
Environmental Munificence	0.0019 (0.0017)	0.0022 (0.0022)	0.0020 (0.0020)	0.0024 (0.0027)	0.0020 (0.0021)	0.0023 (0.0020)	0.0020 (0.0021)	0.0028 (0.0028)	0.0031 (0.0029)
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	0.009*** (0.002)	0.009*** (0.002)	0.009*** (0.002)	0.010*** (0.002)	0.010*** (0.002)	0.009*** (0.002)	0.010*** (0.002)	0.011*** (0.002)	0.008*** (0.002)
Wald Chi-Square	375.959	380.297	384.412	389.845	389.118	388.613	390.174	388.508	388.472
Chi-Square change in model		4.338 (1) *	5.115 (1) *	5.433 (1) *	4.706 (1) *	4.201 (1) *	5.762 (1) *	4.096(1) *	4.060 (1) *
Model difference for Chi-square change		(2) minus (1)	(3) minus (2)	(4) minus (3)	(5) minus (3)	(6) minus (3)	(7) minus (3)	(8) minus (3)	(9) minus (3)

Notes. AR(1) structure, or lagged ROA modeled in the fixed effects regression.

N=964 firms representing 8,473 firm-years from 1997 to 2007. ^ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

industry-adjusted cash-to-cash cycle (Model 9) is positively but only marginally related to ROA ($\beta = 0.0085, p < 0.10$). With significant effects of independent and moderator variables established, we now move to interpret the main effects.

Hypothesis 1a proposes that broad product scope strengthens firm performance in unpredictable markets and weakens firm performance in predictable markets, and is supported in Model 10 ($\beta = 0.0289, p < 0.05$). The interactions in Figure 3 are based on the effects of independent variables at one standard deviation above and below the mean values of moderating variables. Figure 2.3(a) shows that with increasing

Table 2.4: Fixed Effects Regression

Fixed FGLS Effects Regression with AR(1) structure

	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
<i>Direct Effects (t-1)</i>							
Operational Scope							
Product Scope	0.0143* (0.0058)						0.0138* (0.0060)
Geographic Scope		0.0097* (0.0040)					0.0086^ (0.0044)
Process Scope			0.0125** (0.0047)				0.0122* (0.0051)
Operational Slack							0.0127* (0.0059)
Capacity Slack				0.0140* (0.0064)			0.0141* (0.0065)
Inventory Slack					0.0107* (0.0045)		0.0098^ (0.0052)
Supply Chain Slack						0.0083^ (0.0048)	0.0081^ (0.0049)
Instability	-0.0174** (0.0061)	-0.0177* (0.0062)	-0.00178** (0.00060)	-0.0181** (0.0066)	-0.0187** (0.0069)	-0.0185* (0.0072)	-0.0147* (0.0063)
Unpredictability	-0.0193** (0.0069)	-0.0195** (0.0070)	-0.0197** (0.0068)	-0.0191** (0.0072)	-0.0194** (0.0074)	-0.0194** (0.0074)	-0.0176* (0.0079)
<i>Two-way Moderation Effects</i>							
Product Scope × Unpredictability [H1a]	0.0289* (0.0117)						0.0274* (0.0119)
Geographic Scope × Unpredictability [H1b]		0.0186* (0.0075)					0.0174^ (0.0079)
Process Scope × Unpredictability [H1c]			0.0249* (0.0107)				0.0246* (0.0109)
Capacity Slack × Instability [H2a]				0.0179* (0.0082)			0.01688 (0.0085)
Inventory Slack × Instability [H2b]					0.0092* (0.0037)		0.0088* (0.0041)
Supply Chain Slack × Instability [H2c]						0.0077 (0.0059)	0.0074 (0.0066)
<i>Controls (t-1)</i>							
Firm Size [ln(Assets)]	0.0536*** (0.0139)	0.0539*** (0.0147)	0.0527*** (0.0138)	0.0518*** (0.0152)	0.0527*** (0.0144)	0.0520*** (0.0156)	0.0490** (0.0179)
Firm Age	0.0008 (0.0007)	0.0004 (0.0007)	0.0007 (0.0009)	0.0008 (0.0007)	0.0005 (0.0007)	0.0006 (0.0007)	0.0006 (0.0009)
Environmental Complexity	-0.0176* (0.0074)	-0.0175* (0.0071)	-0.0182* (0.0077)	-0.0176* (0.0074)	-0.0177* (0.0075)	-0.0172* (0.0077)	-0.0171* (0.0084)
Environmental Munificence	0.0022 (0.0022)	0.0023 (0.0022)	0.0028 (0.0041)	0.0022 (0.0022)	0.0021 (0.0022)	0.0023 (0.0025)	0.0016 (0.0037)
Firm Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	0.011*** (0.002)	0.010*** (0.002)	0.009*** (0.002)	0.011*** (0.002)	0.010*** (0.002)	0.013*** (0.003)	0.007* (0.003)
Wald Chi-Square	394.17	394.874	394.23	394.229	392.585	394.425	407.077
Chi-Square change in model	4.325 (1) *	5.756 (1) *	5.617 (1) *	4.055 (1) *	4.077 (1) *	5.953(1) *	22.665 (12)*
Model difference for Chi-square change	(10) minus (4)	(11) minus (5)	(12) minus (6)	(13) minus (7)	(14) minus (8)	(15) minus (9)	(16) minus (3)

Notes. AR(1) structure, or lagged ROA modeled in the fixed effects regression.

N=964 firms representing 8,473 firm-years from 1997 to 2007. ^ $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

unpredictability, broader product scope increases firm performance, whereas narrower product scope lowers firm performance. Similarly, Hypotheses 1(b) (Model 11: $\beta = 0.0186, p < 0.05$) and 1(c) are also supported (Model 12: $\beta = 0.0249, p < 0.05$). The predictions are supported in Figure 2.3(b) for H1b and Figure 2.3(c) for H1c.

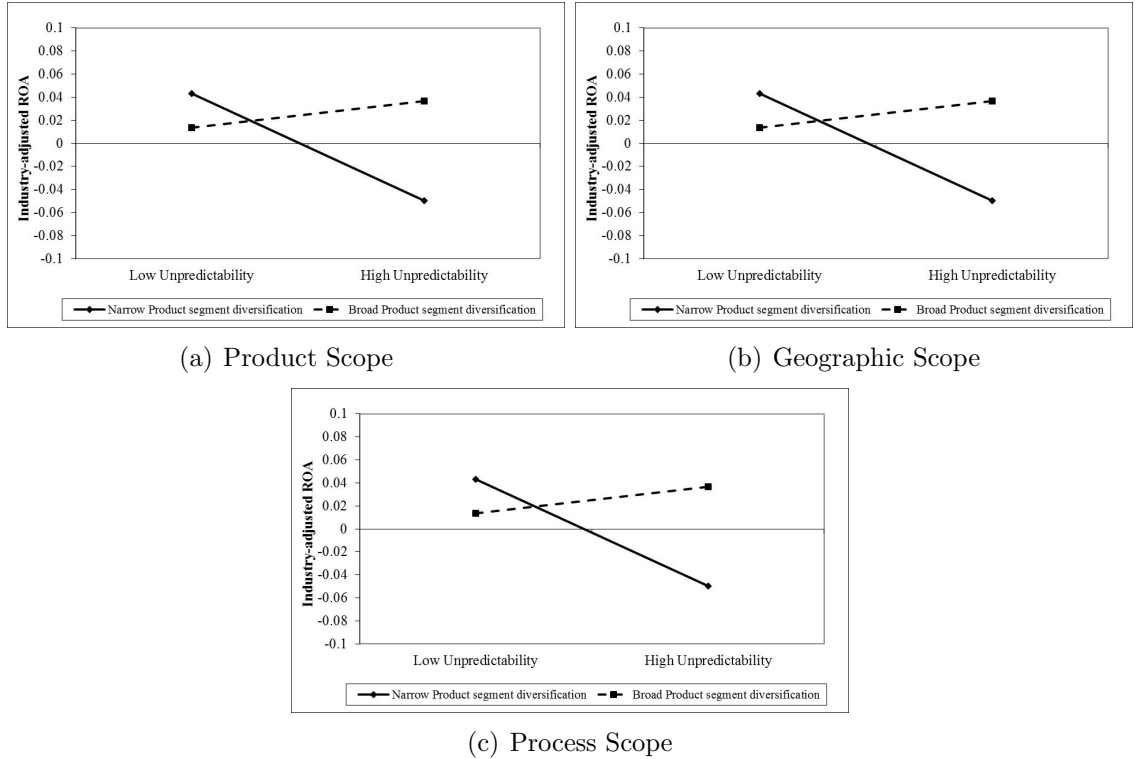


Figure 2.3: Moderation Effects of Operational Scope on Unpredictability

Hypothesis 2a, proposes that increased capacity slack in unstable markets improves performance and higher capacity slack in stable markets lowers performance, and is supported in Model 13 ($\beta = 0.0179, p < 0.05$). Figure 2.4(a) shows that with increasing instability, more capacity slack improves performance. Similarly, Hypothesis 2b concerning the role of inventory slack in unstable markets is supported (Model 14: $\beta = 0.092, p < 0.05$). Figure 2.4(b) indicates that high inventory slack under increasing instability does not significantly impact performance, but having low inventory slack in unstable environment lowers performance. Finally, Hypothesis 3c concerning the moderation effects of supply chain slack on performance under

increasing instability are not supported (Model 15: $\beta = 0.0077, p > 0.10$).

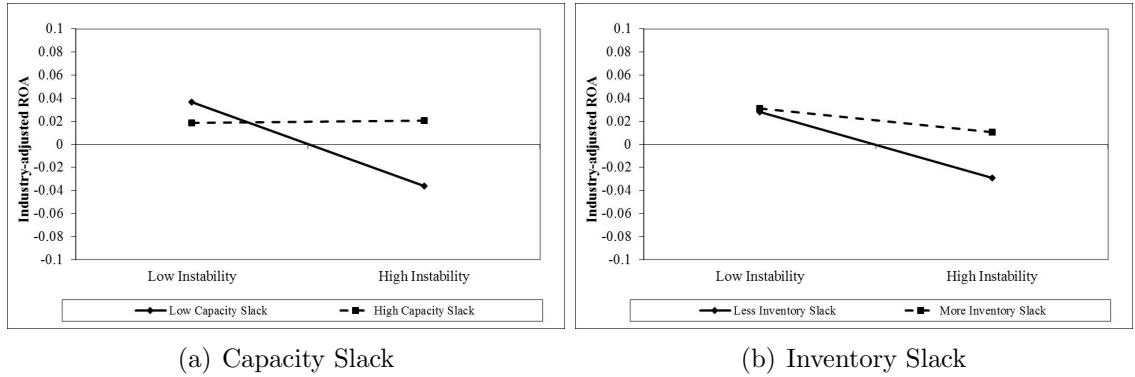


Figure 2.4: Moderation Effects of Operational Slack on instability

Robustness tests.

We conduct two sets of robustness tests. First, we assess whether non-linear relationships are present between the moderator variables and firm performance. The relationship between the squared terms of product ($\beta = -0.0007, p > 0.10$), geographic ($\beta = -0.0004, p > 0.10$), or process scope ($\beta = -0.0004, p > 0.10$) on firm performance are not significant. The interaction effects between the squared terms of product ($\beta = -0.0002, p > 0.10$), geographic ($\beta = -0.0000, p > 0.10$), or process scope ($\beta = -0.0001, p > 0.10$) and unpredictability on firm performance are not significant either.

The squared terms of capacity slack ($\beta = -0.0003, p > 0.10$), inventory slack ($\beta = -0.0007, p > 0.10$), or supply chain slack ($\beta = -0.0010, p > 0.10$) are not related to firm performance. Furthermore, the interaction effects of the squared terms of capacity slack ($\beta = -0.0000, p > 0.10$), inventory slack ($\beta = -0.0002, p > 0.10$), or supply chain slack ($\beta = -0.0004, p > 0.10$) and instability are not significant.

Second, we test for the alternate moderation effects of operational scope on instability and operational slack on unpredictability. The effects of operational scope and instability (product scope: $\beta = 0.0008, p > 0.10$; geographic scope: $\beta = 0.0007, p > 0.10$; process scope: $\beta = 0.0002, p > 0.10$) or operational slack and unpredictability

(capacity slack: $\beta = 0.0003, p > 0.10$; inventory slack: $\beta = 0.0001, p > 0.10$; supply chain slack: $\beta = 0.0000, p > 0.10$) on performance are not significant.

2.5 Discussion

This paper investigates the role of operational levers (operational slack and operational scope) utilized by firms to manage their operations in dynamic business environments. By separately considering the effects of these two operational levers, we can better understand their distinct roles in influencing the performance of firms in unstable and unpredictable markets. When measured independently, we confirm that increased operational slack and operational scope are both positively associated with firm performance, whereas instability and unpredictability are both negatively associated with firm performance. More importantly though, we find that broad operational scope (operationalized as product scope, geographic scope, and process scope) strengthens firm performance in unpredictable markets, whereas operational slack (operationalized as capacity slack, inventory slack and supply chain slack) shows mixed results for enhancing performance in unstable markets. Capacity and inventory slack strengthen firm performance in unstable markets; however, these benefits are not found from supply chain slack. This finding suggests that supply chain slack does not accrue additional performance benefits in unstable compared to stable environments. Additionally, our findings could not support the claims that “too much” slack or “too broad” of a scope was detrimental.

The lack of support for these inverted U-shaped relationships could be attributed to two factors. As noted by Daniel et al. (2004, p.572), “firms could be operating only on the positively sloped portion of the relationship”, implying that firms in our study effectively manage the potentially detrimental consequences from excess slack or scope. Additionally, our study compares a firm’s relative performance in its industry while considering industry specific environmental conditions with respect to its

relative amount of slack resources and breadth of scope (compared to other firms in its industry). Dess et al. (1990, p.14) noted that “research concerned with relationships between diversification strategy and performance demonstrates the potential for misleading interpretations and alternative plausible explanations that can result if researchers do not control for possible industry influences”, yet unfortunately “only a small portion of diversification-performance studies [from prior literature] controlled for such effects” (Palich *et al.*, 2000, p.168). Lastly, through mis-specification tests, our findings indicate that operational slack is ineffective in improving firm performance in unpredictable markets and operational scope is ineffective in improving firm performance in unstable markets. Overall, these findings imply that decisions on investing in operational slack and broadening operational scope should be made recognizing the environmental conditions of the firm.

These findings support prior research on the benefits of operational slack and operational scope, but find industry specific environmental conditions for which these benefits exist. Specifically, the arguments for lean operations are supported (Modi and Mishra 2011), but only for firms in stable industries. We find that low levels of slack resources (lean) are more beneficial than high levels of slack resources (not lean) when firms participate in stable markets, indicating that lean operations for firms in these markets may be a performance enhancing strategy. Conversely, low levels of operational slack (lean) severely weaken firm performance in unstable markets compared to high levels of operational slack. This supports the safety stock formulation from the EOQ model and provides additional insight into the industry specific conditions influencing the performance benefits from lean operations. These findings additionally support the beneficial role that operational slack plays in dynamic markets. While Azadegan and colleagues (2013) find that under increased environmental dynamism, slack resources lower the likelihood of venture failure, we extend their work by specifically examining operational slack resources’ association

with firm performance in unstable and unpredictable markets, two components of environmental dynamism, while additionally controlling for environmental munificence and complexity. Our study finds that operational slack is beneficial in unstable but not unpredictable markets.

In examining the role of operational scope, our findings provide support that focused factories enhance firm performance, but only in predictable markets. When markets are predictable, we find that firms that employ narrow operational scopes outperform those with broader operational scopes. These findings extend the findings of Anand and Ward (2004), with a main key difference in regards to product scope. Whereas their study found no support for range flexibility (similar to product scope) improving performance in unpredictable environments, we find that broad product scopes enhance performance in unpredictable markets. We believe this difference may be due to three possible, yet interrelated factors. First, the level of analyses in Anand and Ward (2004) was at the plant level and focused on three industries (determined by SIC codes), whereas this study is at the firm level including 23 different industries over a ten year period. Second, the measures for unpredictable markets and range flexibility (product scope) are different between the studies. Anand and Ward (2004) followed Bourgeois' (1980) argument and used "managers' perceptions" in determining unpredictable markets and the importance of the plant's ability to enhance product scope. Thus, these perceived measures can differ between plants in the same industry. In this study, the firm-level objective measure of unpredictable markets does not vary across firms belonging to the same industry. Similarly, we examine firms' product portfolios to determine their product scope, which is measured as the firm's industry- adjusted product segment sales concentrations. Lastly, while Anand and Ward investigate sales growth and increased market share as benefits from an increased product scope in unpredictable markets, our performance measure (ROA) considers the additional revenues as well as costs and assets required to establish and

maintain a diverse product scope.

Findings from our study also suggest that if environmental instability and unpredictability are not separately considered, the benefits from operational slack and operational scope can be potentially overstated. Specifically, this study provides cues for resource constrained managers who must determine how to best mitigate the potentially negative consequences from unstable and unpredictable markets. Investments in broadening operational scope for firms in stable markets or increasing operational slack for firms in predictable markets may be misguided, as these costly investments may actually diminish firm performance. Firms should pursue broader operational scopes if they participate in unpredictable markets and increased operational slack if they participate in unstable markets. These strategies mitigate the potentially negative consequences of not having enough slack or operational breadth as instability or unpredictability increases. This stance implies managers should focus on broadening their product offerings, geographical markets served, and ability to cost effectively adjust production output if their anticipated future demand is difficult to predict, as represented by the food and kindred products manufacturing industry (SIC 20) in this analysis. Alternately, managers should attempt to ensure sufficient inventory levels and excess production capacity to manage highly volatile demand, as represented by the electrical equipment manufacturing industry (SIC 36). Firms operating in low instability and low unpredictability industries are found to benefit from low levels of slack (lean) and narrow operational scopes, respectively. The printing and publishing and the petroleum and gas industries (SIC 27 & 29) were each classified as low instability and low unpredictability industries in this study. Investments into the inappropriate operational strategy may place the firm at a competitive disadvantage in their industry.

Limitations and Future Research

We acknowledge the limitations of our study. First, this study was focused on

two operationally specific levers firms can utilize to manage dynamic environments (breadth of operational scope and amount of operational slack), and was not concerned with other organizational (staffing, sales expenditures, etc.) or financial (leveraging, debt structuring, etc.) strategies. Future work which considers these additional strategies could provide managers with further guidance on how to best manage dynamic environments. Second, with respect to operational slack, this study indicates that although lean operations are positively associated with firm performance in stable markets, being too lean may be ineffective in unpredictable markets. However, we also recognize that this inference may be limited to the measures used to operationalize slack. We believe this study can serve as a starting point for future research to further explore different conditions when certain measures of lean operations are beneficial and vice-versa. Third, this paper identified environmental conditions that support the concept of a focused factory as a contrasting operational strategy from broad scopes. Further studies are required to determine what other firm, industry, or environmentally specific attributes lead to the differences as to whether narrow or broad operational scopes yields competitive advantage. Lastly, this study was focused on the performance of publicly traded US firms, and as such these findings may not generalize to foreign or privately managed firms. Future work is necessary to verify that the relationships between operational strategies and dynamic environments of non-US or privately held firms is consistent with those found in this study.

CHAPTER III

SALES FORCE COMPENSATION FOR REMANUFACTURED PRODUCTS

3.1 Introduction and Related Literature

Used goods find their way back into Original Equipment Manufacturer (OEM) facilities for a variety of reasons, including strategic product recovery (Guide *et al.*, 2003), convenient return policies (Guide *et al.*, 2006), false failure returns (Ferguson *et al.*, 2006), product demo returns (Guide *et al.*, 2005), trade-ins (Ray *et al.*, 2005), or warranty requirements (Pince *et al.*, 2012). Motivated by the residual value embedded in these products, many firms from consumer goods manufacturers (e.g., Bosch Tools, HP, and Apple) to industrial equipment manufacturers (e.g., Xerox, Cisco, and Caterpillar) remanufacture¹ and remarket used product returns.

Remanufacturing is prevalent in many industries and for a variety of products, including disposable cameras (Kodak, 2008), ink cartridges (Kittell & Page, 2008), motor vehicle components, aerospace equipment, and retreaded tires to name a few. It is estimated that sales of remanufactured products increased by 15 percent between 2009 and 2011, which is twice the rate of nominal US GDP growth, to \$43 billion in the US (Treat *et al.*, 2012). What makes remanufacturing an attractive business opportunity is the relatively low cost of remanufacturing used products compared to producing new ones. The lower costs associated with remanufacturing provide firms with the opportunity to sell remanufactured products at lower prices, facilitating

¹In this paper, remanufacturing is used in a broader sense to denote other forms of product recovery activities such as refurbishing and reconditioning, which involve the process of repairing or replacing portions of a used product in order to restore it to a like new condition.

market expansion to lower budget consumers while generating relatively higher profit margins from these products.

A firm's decision to offer remanufactured products is essentially a product portfolio problem: the firm needs to strategically price new and remanufactured products so that profits can be maximized by enlarging the customer base with minimal cannibalization of new product sales while benefiting from the lower costs associated with remanufacturing. At the same time, the addition of remanufactured products into a firm's portfolio requires strategic choices regarding sales force management and compensation practices. While there is substantial research investigating the pricing and market segmentation aspects of remanufacturing (Majumder & Groenevelt, 2001; Ferrer & Swaminathan, 2006; Debo *et al.*, 2005, 2006; Ferguson *et al.*, 2006; Atasu *et al.*, 2008; Souza, 2013), this literature implicitly assumes that remanufactured products need only to be redistributed into the supply chain, thereby ignoring the fact that many products require active sales efforts to generate sales. We attempt to "close the loop" by explicitly considering the implications of sales force incentives on the practice of remanufacturing.

A natural starting point for an investigation of this problem is the marketing literature on sales force compensation, starting with Basu *et al.* (1985) who investigate the optimal sales force compensation plan of a firm using a principal agent model. However, optimal product pricing and sales force incentives for selling multiple products, whose demands and cost of selling effort may interact, have not been adequately analyzed (Coughlan, 1993). Although there is some research on sales force incentives for selling multiple products (Holmstrom & Milgrom, 1991; Lal & Srinivasan, 1993), these papers do not consider optimal pricing and sales agent effort decisions simultaneously. Instead, they consider pricing to be exogenous and focus solely on the effort allocation problem. Additionally, prior research does not consider the interaction between demands or costs of effort on each product; i.e., Lal and Srinivasan

(1993) consider how to manage sales agents responsible for products that are sold in different markets whose demands are independent. A notable exception to this point is the analysis of substitutable and complementary products by Zhang and Mahajan (1995). Zhang and Mahajan find that sales force incentives should be based on the total sales of two products if they are substitutes, but only for the product which has a higher productivity of selling effort if the two products are complements. None of these prior approaches, however, adequately describe the product portfolio problem faced in the remanufacturing context. This is due to the unique supply and demand characteristics of remanufactured products.

Modeling demand for remanufactured products differs from traditional sales force compensation models in two significant ways. First, new and remanufactured products are substitutes at the time of purchase, yet complements across time (Debo *et al.*, 2005). The availability of remanufactured products is limited by the quantity of previously sold new products that are subsequently returned to the firm, implying that new product sales are complements to remanufactured product sales. Yet, at any point in time, customers may choose between new and remanufactured products, thus making them also substitutes. Second, the perceived quality of remanufactured products is typically discounted by consumers (Guide & Li, 2010; Michaud & Llerena, 2011; Subramanian & Subramanyam, 2012; Hazen *et al.*, 2012; Agrawal *et al.*, 2012). Accordingly, the existing literature that investigates sales force compensation for multiple products (e.g., Holmstrom and Milgrom 1991, Lal and Srinivasan 1993, and Zhang and Mahajan 1995) cannot adequately represent these unique characteristics of the remanufacturing problem, because they neither capture the vertical differentiation between new and remanufactured products, nor the supply dynamics faced in this context.

Another key departure from prior literature is the possible variation in channel configuration for remanufactured products. For this analysis, the terms *sales channel*

and *sales agent* are used interchangeably, each representing the parties responsible for dedicating sales effort to promote product valuations, thus increasing demand. Two types of sales channel configurations are observed in the remanufacturing practice. Some firms utilize a joint sales channel to sell both new and remanufactured products. For example, new and remanufactured products are available from Apple's website or from Sony's physical stores or website. Other firms utilize separate channels for new and remanufactured products, as exemplified by Caterpillar creating the Cat Reman division in 2005 to separately manage the remanufacturing and remarketing activities for Caterpillar. This variation can even be observed within a firm across product categories. For example, while Bosch USA's Automotive Technology division remanufactures and actively promotes both new and remanufactured Bosch automotive parts, its Consumer Goods division remanufactures power tools but does not actively promote them. Instead it relies on its distribution partners to manage the promotion and sales of remanufactured products (Bosch, 2012a,b). Similarly, Hewlett-Packard (HP) supports its B2B customers with remanufactured IT equipment (enterprise servers) through its HP Renew program, but remanufactured products for B2C customers (such as personal computers) are rarely offered by HP (HP, 2012; Guide *et al.*, 2005). Consequently, the pricing of and sales force compensation plans for new and remanufactured products should be analyzed under both of these channel configurations.

Another factor that requires attention is whether sales force efforts are as effective in promoting remanufactured products as they are in promoting new products, for which prior research does not provide any empirical evidence. Although new and remanufactured products share the same functionality and product architecture, sales force efforts may or may not have the same effectiveness in their promotions. The ability to influence the demand for a product can be product dependent (Bagwell, 2007; Caves & Greene, 1996) or independent (Tremblay & Polasky, 2002; Colombo &

Lambertini, 2003; Reichfeld & Teal, 1996). As such, sales force compensation plans should be examined taking into consideration whether the effectiveness of the sales force differs between new and remanufactured products.

Consequently, the main questions we address in this paper are: (i) How should firms manage sales force incentives for new and remanufactured products? (ii) How do these decisions differ under joint and separate channel configurations? (iii) How does the sales person's effectiveness in selling remanufactured products impact these decisions? and (iv) How do sales force incentives influence a firm's decision to offer remanufactured products?

Our analysis indicates that firms should always offer higher commissions for the sales of new products compared to remanufactured products, even when remanufactured products offer higher profit margins, which contradicts some of the established results in the existing literature; e.g., Lal and Srinivasan (1993). This relation holds under both joint and separate sales channels, irrespective of the effectiveness of sales efforts for remanufactured products as compared to new products. Lastly, sales force incentives may create situations where seemingly optimal remanufacturing practices should actually not be undertaken, since the costs associated with promoting both new and remanufactured products in the market may exceed the benefits from remanufactured products' cost savings, even when the costs of remanufacturing are negligible.

In what follows, an analytical model that builds on traditional sales force compensation and remanufacturing literature is described in §3.2. In §3.3, we analyze a scenario without sales force incentives to benchmark our results with those in the existing literature. In §3.4, we provide a detailed analysis of our model. In §3.5, we provide some extensions to the model to verify the robustness of the results. We conclude in §3.6 by summarizing our managerial insights and contributions to literature, and discussing additional avenues for research.

3.2 Model Setup

We consider a principal (the firm) who decides on the prices and compensation schemes for new and remanufactured products. Sales agents hired by the firm are responsible for promoting and selling new and remanufactured products. Based on the product pricing and compensation scheme, sales agents determine how much effort (t_i) to devote specifically to product type i 's selling activity, where $i \in \{N, R\}$ denotes the product type as new (N) or remanufactured (R). The customers then make their purchasing decisions based on the product price and effort exerted by the salesperson in promoting the product.

The Demand: To model the demand in the remanufacturing context, we combine the multi-product model of Lal and Srinivasan (1993) with the established supply and demand assumptions in the remanufacturing literature (Majumder & Groenvelt, 2001; Ferrer & Swaminathan, 2006; Debo *et al.*, 2005, 2006; Ferguson *et al.*, 2006; Atasu *et al.*, 2008), which borrow traditional assumptions from the durable goods literature (Stokey, 1981; Bulow, 1982; Desai & Purohit, 1998; Waldman, 1993). We model the demand for new and remanufactured products considering a vertically differentiated market with heterogeneous customers who have lower valuations for remanufactured products. The customer's utility is assumed to be of the form $u(\nu_i, t_i, p_i) = \theta\nu_i + \gamma_i t_i - p_i$ from purchasing and using product i , where p_i is the product price, t_i the effort exerted by the salesperson on selling activities for product i , γ_i the effectiveness of the salesperson's activities in promoting product i , and $\theta\nu_i$ the heterogeneous customer's valuation for product i absent a sales force where $\theta \sim U[0, 1]$. While previous literature has considered the effects from sales agent effort to have either multiplicative (Rao, 1990; Taylor, 2002) or additive (Chen, 2000; Cachon & Lariviere, 2005; Caldieraro & Coughlan, 2007) influence on customer utility, we specifically consider an additive model, as this is a more manageable approach when considering the demands for multiple products (Joseph & Thevaranjan, 1998;

Tsay & Agrawal, 2000). The salesperson's efforts effectively improve the customer's perceived valuation of a product, which thereby increases their overall utility should they choose to purchase the product.

We normalize the valuation of new products ν_N to 1 and assume that customers discount the value of remanufactured products by a discount factor δ ; i.e., $\nu_R = \delta\nu_N = \delta$ which represents the perceived quality difference between new and remanufactured products (Guide & Li, 2010; Michaud & Llerena, 2011; Subramanian & Subramanyam, 2012; Hazen *et al.*, 2012; Agrawal *et al.*, 2012). Hence, a customer's utility for new and remanufactured products can be written as $u_N = \theta + \gamma_N t_N - p_N$ and $u_R = \delta\theta + \gamma_R t_R - p_R$, respectively. The demands for new and remanufactured products are obtained by the aggregation of all customers satisfying two conditions: 1) customers receive a non-negative utility from the product, i.e., $u(\nu_i, p_i, t_i) \geq 0$; and 2) the utility from one product exceeds that from the other product $u(\nu_i, p_i, t_i) \geq u(\nu_{-i}, p_{-i}, t_{-i})$. The demand for new products is given by $1 - \hat{\theta}_u$ where $\hat{\theta}_u$ solves for the marginal customer $u(\nu_N, p_N, t_N) = u(\nu_R, p_R, t_R)$, i.e., $\hat{\theta}_u = \frac{(p_N - p_R) - (\gamma_N t_N - \gamma_R t_R)}{1 - \delta}$. Hence, the quantity of new products sold is given by $q_N = 1 - \frac{(p_N - p_R) - (\gamma_N t_N - \gamma_R t_R)}{1 - \delta}$. The quantity of remanufactured products sold is given by $q_R = \hat{\theta}_u - \hat{\theta}_l$ where $\hat{\theta}_l$ solves $u(p_R, t_R) = 0$. Simplifying, we get $\hat{\theta}_l = \frac{p_R - \gamma_R t_R}{\delta}$, which results in $q_R = \frac{\delta p_N - p_R - (\delta \gamma_N t_N - \gamma_R t_R)}{\delta(1 - \delta)}$.

The Agents: The firm designs a compensation plan that incentivizes the sales agents to dedicate time to selling activities in such a way as to maximize firm profits. We restrict our attention to linear contracts following Holmstrom and Milgrom (1987) who show that when an agent chooses efforts continuously over time and can observe her cumulative performance before acting, the efficient wage contract is linear in the total output (sales) over the accounting period, even if the firm can base the sales agent's compensation on the sales history over the entire accounting period. We define this linear wage contract as $s_i(q_i) = A_i + B_i q_i$ for sales agents in separate channels and $s_{\{N,R\}}(q_N, q_R) = A + B_N q_N + B_R q_R$ for sales agents in a joint channel, where A_i is the

fixed wage component of the compensation and B_i the sales commission on product $i \in \{N, R\}$. The sales agent's utility can therefore be represented by the combination of her wage contract and disutility from effort of the form: $U(t_i) = s_i(q_i) - V(t_i) \geq w_0$; where $V(t_i)$ and w_0 represent the agent's disutility from effort and reservation wage, respectively.

We assume that the sales agents have homogeneous capabilities (they have identical costs of effort and are equally effective in promoting identical products) (Rao, 1990; Misra *et al.*, 2013), but consider the possibility that the salesperson's influence on a customer's purchasing decision for a remanufactured product may be different than that for a new product. Specifically, we consider that the sales efforts' effectiveness in increasing a customer's valuation of a product may be either dependent or independent of the product type. Additionally, without loss of generality, we set $\gamma_N = 1$, such that differences in γ_R represent the differences in sales effort effectiveness between the two products. Along these lines, we consider two distinct interpretations for the relationships between γ_i and ν_i , which are theoretically grounded and highlight the influence that sales effort effectiveness has on the sales agent's actions, and subsequently, the firm's remanufacturing strategy.

First, the effectiveness of a sales agent's selling activities can be independent of the product type and increase customer's valuation (thus utility) the same way for both new and remanufactured products. This overall increase in utility can be attributed to customer specific activities such as relationship building or maintenance that the salesperson is able to cultivate. In this context, the salesperson performs a more general function than the one specifically attributed to the product by providing services that help the customer in ways independent from the specific valuation of the product (Reichfeld & Teal, 1996; Tsay & Agrawal, 2000; Tremblay & Polasky, 2002). We represent this interpretation in our utility model by setting $\gamma_N = \gamma_R = 1$, while noting that for any $\gamma_R > 0$ which is independent from the product valuation,

the insights from this analysis remain unchanged². We refer to this interpretation as *product independent* sales efforts.

With the second interpretation, the effectiveness of sales agents' selling activities can be dependent on the product type. This would be the case when the sales agent's selling activities could be "value enhancing", such that selling activities persuade the customer to purchase specific products (Bagwell, 2007; Caves & Greene, 1996). This interpretation can be modeled by assuming that a customer's valuation of a product is given by $\psi_i = (\theta + t_i)\nu_i$ translating into a utility of $u(\psi_i, p_i) = \psi_i - p_i$, which indicates that the effectiveness of the sales effort depends on the product type. This interpretation can be represented in our utility model by setting $\gamma_N = 1$, and $\gamma_R = \delta$. We refer to this interpretation as *product dependent* sales efforts.

Costs: The salesperson decides on the amount of effort (t_N, t_R) to dedicate to the selling activities for new and remanufactured products. Following Holmstrom and Milgrom (1987), we assume the sales agent's cost of effort for selling activities is $V(t) = V(t_i) = \frac{1}{2}t_i^2$ for $i \in \{N, R\}$ for sales agents in separate channels and $V(t) = V(t_N, t_R) = \frac{1}{2}(t_N^2 + t_R^2) - \mu t_N t_R$ for sales agents in joint sales channels, where μ represents the synergy in sales effort between the two products. We initially assume there is no synergy in sales effort ($\mu = 0$), but relax this assumption in §5. Furthermore, we assume a constant marginal production cost for new products $c_N > 0$, while the cost of remanufacturing c_R is negligible and set to 0; i.e., c_N can be interpreted as the cost savings from remanufacturing. This assumption allows us to focus on instances where remanufacturing is profitable for a firm in the absence of a sales force.

Supply Dynamics: Following a well established stream in the remanufacturing literature (Majumder and Groenevelt 2001, Debo et al. 2005, Ferguson and Toktay 2006,

²Results available from the authors but omitted for brevity.

Ferrer and Swaminathan 2006, Atasu et al. 2008b), we assume that new and remanufactured products have a useful lifetime of one period. Previously sold products can be recovered and remanufactured, but only once. Furthermore, in every period, the quantity of remanufactured products that can be sold is constrained by the supply of used products, which is equal to some fraction of the quantity of new products sold in the previous period. It can be shown that an infinite horizon dynamic formulation setting of this problem reduces to a steady state model if the compensation plan is established first and pricing is optimized every period (see Agrawal et. al 2011). Accordingly, we focus our analysis on a steady-state, single-period model such that $q_R \leq \alpha q_N$, where $\alpha \in (0, 1)$ represents the fraction of used products available to the firm for remanufacturing. In other words, if q_N new products are sold in steady state, a maximum of αq_N products can be remanufactured and sold. Without loss of generality, for the subsequent analysis we set $\alpha = 1$, indicating that all previously sold product can be returned to the firm for remanufacturing³. We denote this as the remanufacturing supply constraint (*RS*), which allows us to maintain the dependence between new and remanufactured product sales in a single-period, steady-state formulation.

The Firm's Problem: The firm determines the optimal pricing and compensation structure to maximize its profits by solving equation (3.1) as follows (assuming separate sales channels):

$$\begin{aligned}
 \max_{p_N, p_R, A_N, A_R, B_N, B_R} \quad & \Pi = (p_N - c_N)q_N + p_R q_R - s_N(q_N) - s_R(q_R) & (3.1) \\
 \text{s.t.} \quad & U(t_i) \geq w_0 \quad \forall i \in \{N, R\} & (IR) \\
 & t_i^* = \underset{t_i}{\operatorname{argmax}} U(t_i) \quad \forall i \in \{N, R\} & (IC) \\
 & q_R \leq q_N & (RS)
 \end{aligned}$$

³For any $\alpha \in (0, 1)$, the insights from this analysis continue to hold, therefore setting $\alpha = 1$ is not a limiting assumption. Results for this analysis are available from the authors but omitted for brevity.

$$q_R + q_N \leq 1 \quad (MC)$$

$$\{t_i, q_i, B_i\} \geq 0 \quad \forall i \in \{N, R\} \quad (NN)$$

Here, the individual rationality constraint (*IR*) ensures that the sales agents will accept the compensation contract offered by the firm only if they are guaranteed a minimum wage (w_0), which we normalize to 0⁴. The incentive compatibility constraint (*IC*) indicates that the sales agents choose their effort level to maximize their utility. The remanufacturing supply constraint (*RS*) ensures the balance between the available supply and demand for remanufactured products. Additionally, we ensure that the total sales of new and remanufactured products does not exceed the overall market demand with the market capacity constraint (*MC*), and that all prices, efforts, quantities, and commissions are non-negative in equilibrium. We normalize the total number of potential customers in the market to one. Since sales agents can increase customers' valuations of products, the *MC* constraint guarantees that the actual number of products sold does not exceed the number of consumers in the market. For the model analysis in §3.3 and §3.4, we consider that the demands for new and remanufactured products are deterministic. This assumption is relaxed in §3.5 to verify that demand uncertainty does not alter our insights.

3.3 Benchmark: A Model without Sales Force Effects

In this section, we provide a benchmark analysis in the absence of a sales force to represent the implications of prior research on remanufacturing, where product pricing has been the only mechanism to drive demand. This benchmark will serve to highlight the implications of sales force incentives on remanufacturing. To exclude the influence of the sales force on demand, we set $B_R = 0$ and $B_N = 0$. In this setting, the firm

⁴It is straightforward to show that the commissions B_N and B_R are independent of w_0 , and w_0 linearly modifies A_N and A_R in a one to one fashion; therefore, setting $w_0 = 0$ does not alter the insights from the model.

solves equation (3.2) as follows:

$$\begin{aligned}
\max_{p_N, p_R} \quad & \Pi = (p_N - c_N)q_N + p_R q_R & (3.2) \\
s.t. \quad & q_R \leq q_N & (RS) \\
& q_R + q_N \leq 1 & (MC) \\
& q_R \geq 0 & (NN)
\end{aligned}$$

The optimal solution in the absence of a sales force consists of two distinct pricing strategies for the firm, depending on the relationship between δ and c_N . We denote these policies as *Full Remanufacturing (FR)* and *Limited Remanufacturing (LR)*. For large c_N , the **FR** policy is optimal such that the remanufacturing supply constraint is binding. In this region, the firm finds it optimal to maximize the sales of remanufactured products, which results in balanced sales of new and remanufactured products (due to the *RS* constraint) such that $q_R^* = q_N^*$. For small c_N , the **LR** policy is optimal, such that $q_R^* < q_N^*$. The firm will not completely cover the market in either of these policies (i.e., the *MC* constraint is never binding). Proposition 3.1 and Table 3.1 define these policies, which are illustrated in Figure 3.1.

Proposition 3.1. *In the absence of a sales force, there exists a unique optimal solution to the the firm's problem. When $c_N > \frac{1-\delta}{2}$ the **FR** policy is optimal, whereas when $c_N \leq \frac{1-\delta}{2}$ the **LR** policy is optimal. The equilibrium solution is characterized in Table 3.1.*

Table 3.1: Optimal Policy Without a Sales Force

	FR	LR
p_R^*	$\frac{\delta(c_N+2\delta)}{1+3\delta}$	$\frac{\delta}{2}$
p_N^*	$\frac{1+c_N+(4+c_N)\delta-\delta^2}{2(1+3\delta)}$	$\frac{1+c_N}{2}$
q_R^*	$\frac{1-c_N+\delta}{2(1+3\delta)}$	$\frac{c_N}{2(1-\delta)}$
q_N^*	$\frac{1-c_N+\delta}{2(1+3\delta)}$	$\frac{1-c_N-\delta}{2(1-\delta)}$

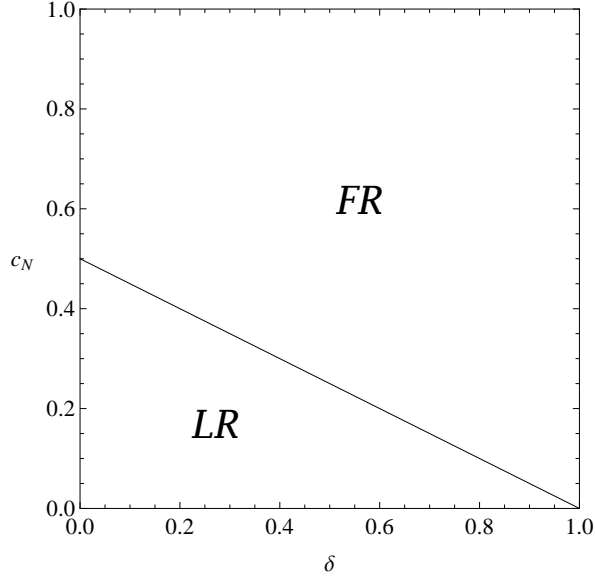


Figure 3.1: Optimal Policy Without a Sales Force

A key observation in this setting is that in the absence of a sales force, the firm always finds it optimal to sell remanufactured products alongside new products in the same market. This result is consistent in principle with previous research in that if the cost for remanufacturing is sufficiently low (note that we assume $c_R = 0$), then it is always optimal for a firm to sell remanufactured products concurrently with new products in the market (Debo *et al.*, 2005; Ferrer & Swaminathan, 2006; Atasu *et al.*, 2008; Majumder & Groenevelt, 2001; Ferguson & Toktay, 2006).

3.4 Remanufacturing with a Sales Force

In this section, we analyze the optimal pricing of new and remanufactured products in the presence of a sales force that is offered an optimal compensation. We first examine the optimal policy for a firm that employs separate sales agents for new and remanufactured products. Then, we explore the optimal policy for a firm that employs a single sales agent to sell both new and remanufactured products in the same market. We then compare these solutions to the benchmark case provided in §3.3 to generate insights.

3.4.1 Separate Sales Channels for New and Remanufactured Products

In this setting, each channel is responsible for the sales activities of either new or remanufactured products, and each sales agent is offered a linear compensation scheme of the form: $s_i(q_i) = A_i + B_i q_i$, where $i \in \{N, R\}$. The firm's decision problem is formally written in equation (3.1).

3.4.1.1 Separate Channels with Product Dependent Sales Effort Effectiveness.

We first examine the optimal policy for a firm when the effectiveness of the sales efforts are dependent on the product type, i.e., when the sales effort to induce demand for the remanufactured product is less effective than the same for the new product ($\gamma_R = \delta$).

In this scenario, the optimal portfolio choice concerning new and remanufactured products takes the form of one of three strategies: *No Remanufacturing* (**NR**), *Full Remanufacturing* (**FR**), and *Limited Remanufacturing* (**LR**). This characterization of the optimal solution is outlined in Proposition 3.2 and Table 3.2, and illustrated in Figure 3.2. The analytical reasoning behind this partitioning of the solution space is driven by the remanufacturing supply and non-negativity constraints. For this scenario, the *MC* constraint is never binding at the optimal solution, i.e., the market is never fully covered. When the *NN* constraint is binding, the **NR** strategy is optimal, and when the *RS* constraint is binding, the **FR** strategy is optimal. Otherwise, i.e., when no constraints are binding, the **LR** strategy is optimal. Similar to Proposition 3.1 from the benchmark case without sales agents, Proposition 3.2 indicates that the **FR** policy is optimal when c_N is high. For intermediate values of c_N and low δ , the **LR** policy is optimal.

Proposition 3.2. *There exists a unique solution to the firm's problem with separate sales channels and product dependent sales effort effectiveness ($\gamma_R = \delta$). When $c_N > \frac{3\delta-3}{\delta-4}$ and $\delta \leq \frac{2}{5}$ or $c_N > \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$ and $\delta > \frac{2}{5}$, the **FR** policy is optimal; when $\frac{1}{2} \leq c_N \leq \frac{3\delta-3}{\delta-4}$ and $\delta \leq \frac{2}{5}$, the **LR** policy is optimal; whereas when $c_N \leq \frac{1}{2}$ and $\delta \leq \frac{2}{5}$*

or $c_N \leq \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$ and $\delta > \frac{2}{5}$, the **NR** policy is optimal. The equilibrium solution is characterized in Table 3.2.

Table 3.2: Optimal Policy with Product Dependent Separate Sales Channel Efforts

	FR	LR	NR
B_R^*	$\frac{(1-c_N+\delta)\delta(1-\delta)}{1+6\delta-\delta^2}$	$\frac{(2c_N-1)\delta(1-\delta)}{2-5\delta}$	—
B_N^*	$\frac{1-c_N+c_N\delta-\delta^2}{1+6\delta-\delta^2}$	$\frac{(2-2c_N-3\delta+c_N\delta)(1-\delta)}{2-5\delta}$	$1 - c_N$
p_R^*	$\frac{\delta(2c_N-1+5\delta-c_N\delta)}{1+6\delta-\delta^2}$	$\frac{\delta(1-3\delta+c_N\delta)}{2-5\delta}$	—
p_N^*	$\frac{1+5\delta+c_N\delta-2\delta^2}{1+6\delta-\delta^2}$	$\frac{2(1-2\delta-c_N\delta)}{2-5\delta}$	1
t_R^*	$\frac{\delta(1-c_N+\delta)}{1+6\delta-\delta^2}$	$\frac{\delta(2c_N-1)}{2-5\delta}$	—
t_N^*	$\frac{1-c_N+c_N\delta-\delta^2}{(1-\delta)(1+6\delta-\delta^2)}$	$\frac{2-2c_N+c_N\delta-3\delta}{2-5\delta}$	$1 - c_N$
q_R^*	$\frac{\delta(1-c_N+\delta)}{1+6\delta-\delta^2}$	$\frac{2-2c_N+c_N\delta-3\delta}{2-5\delta}$	—
q_N^*	$\frac{\delta(1-c_N+\delta)}{1+6\delta-\delta^2}$	$\frac{2c_N-1}{2-5\delta}$	$1 - c_N$

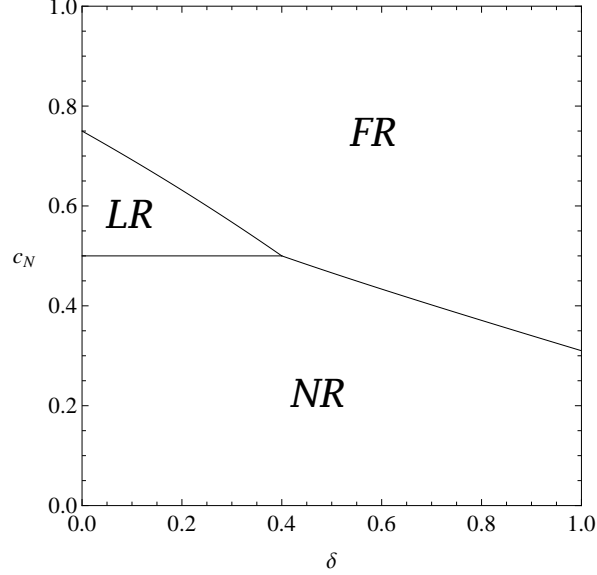


Figure 3.2: Optimal Policy with Product Dependent Separate Sales Channel Efforts

A critical observation in Figure 3.2 is immediate after a comparison with Figure 3.1. While selling remanufactured products is always optimal in the absence of a

sales force, the same is not true with a sales force. The firm now finds that for low c_N , the **NR** strategy is optimal. There are two drivers of this result: (i) when c_N is low, the margin advantage from remanufactured products is low, and (ii) product dependent sales force activities are more effective for new products than for remanufactured products. Accordingly, in this region (where c_N is low), the firm prefers to incentivize sales activities for new products more than those for remanufactured products and may choose not to offer remanufactured products at all. Essentially, inside the **NR** policy region, the sales force incentives required to guarantee that both new and remanufactured products can co-exist in the market results in lower firm profits than can be achieved by focusing all sales efforts on new products (and none on remanufactured products). *An implication of this result is that the existing literature on remanufacturing may overestimate the profitability of remanufacturing; i.e., ignoring sales force incentives may imply profitable remanufacturing even when it is suboptimal to do so.* This indicates that prior research that only considers pricing decisions in the absence of a sales force may overestimate the benefits from remanufacturing. Specifically, Proposition 2 from Debo et al. (2005), Theorem 1 from Ferrer and Swaminathan (2006), Proposition 1 from Ferguson and Toktay (2006), and Propositions 1 & 2 from Atasu et al. (2008) are not robust when a sales force is utilized to promote and sell products.

Corollary 3.1. *For separate sales channels with product dependent sales efforts: $B_N^* > B_R^*$.*

Corollary 3.1 states a key insight: *The new product sales agent should always receive a larger sales commission than the remanufactured product sales agent.* The intuition behind this result is two sided: With low δ , not only is the valuation for remanufactured products discounted, but also the product dependent sales force efforts for remanufactured products are ineffective. Intuition therefore suggests that the firm provide higher incentives for new product sales. This is in line with Lal and

Srinivasan’s (1993) Proposition 3, which indicates that commission rates should be higher for products that have a higher sales-effort effectiveness. Additionally, this result holds for any δ , as the product dependent sales efforts for new products are always more effective than those for remanufactured products.

Surprisingly, this ordering of commissions persists for all values of c_N , which contradicts Lal and Srinivasan’s (1993) Proposition 2, which suggests that higher commission rates should be given for products with lower costs (i.e., higher margins). In this model, $c_R = 0$, such that the profit margins for remanufactured products are always higher than those for new products; $\frac{p_N - c_N}{p_N} < \frac{p_R - c_R}{p_R} = 1$. Therefore, it is surprising that the commissions for new products are always higher, even when they return a significantly lower marginal profit than remanufactured products. This discrepancy can be explained by two factors: the endogenous optimal pricing decisions from the firm, and the implications of the remanufacturing supply constraint.

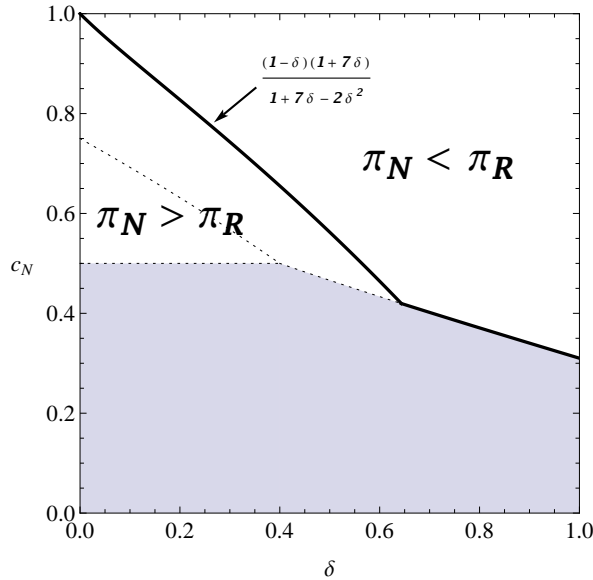


Figure 3.3: Per Unit Product Profits with Product Dependent Separate Sales Channel Efforts

Whereas Lal and Srinivasan (1993) consider exogenous prices such that profit margins for each product are only dependent on costs, we optimize product prices

along with sales agent effort. Here, a mere cost comparison is not sufficient to compare the profitability of the two products in our portfolio. Accordingly, we turn our attention to *per unit profits* to explain the intuition behind our results. Figure 3.3 compares the per unit profits for new and remanufactured products for a firm that utilizes separate sales channels with product dependent sales efforts. We define $\pi_i = p_i^* - c_i$ for $i \in \{N, R\}$ as the per unit profit for new and remanufactured products. As can be seen from Figure 3.3, when a firm finds it optimal to participate in remanufacturing (the non-shaded region where the **FR** or **LR** policy is optimal), if $c_N < \frac{(1-\delta)(1+7\delta)}{1+7\delta-2\delta^2}$ then $\pi_N > \pi_R$. Under these conditions, the firm makes higher per unit profits from the sales of new products than remanufactured products, and therefore having $B_N^* > B_R^*$ is understandable, as the firm wishes to compensate more for the sales of the more profitable product. However, when $c_N \geq \frac{(1-\delta)(1+7\delta)}{1+7\delta-2\delta^2}$ then $\pi_N < \pi_R$, indicating that remanufactured products yield higher per unit profits than new products. Under these conditions, the firm would like to maximize the sales of remanufactured products to capitalize from their higher profits. However, the dependence of the remanufactured product's supply on previously sold new products limits the firm's ability to sell remanufactured products. Increasing the sales commissions for remanufactured products leads to a higher cannibalization of new product demand, thus reducing the supply of remanufactured products to be obtained from previously sold new products. Accordingly, even when remanufactured products provide much higher per unit profits, sales commissions should be higher for new products.

Furthermore, when the firm finds the **FR** or **LR** policy optimal such that it participates in remanufacturing, the per unit profits from remanufactured products are increasing at a faster rate than those from new products in both δ and c_N : $\frac{\partial \pi_R}{\partial \delta} > \frac{\partial \pi_N}{\partial \delta}$ and $\frac{\partial \pi_R}{\partial c_N} > \frac{\partial \pi_N}{\partial c_N}$. This implies that when the firm determines the optimal product pricing and sales agent commissions (thus sales agent effort), as customer's willingness to pay for remanufactured products (δ) or the cost of new products (c_N)

increases, then the per product profits from remanufactured products increases at a faster rate compared to those for new products, thus making remanufacturing even more desirable for the firm; albeit, this opportunity is limited by the availability of supplies.

3.4.1.2 *Separate Channels with Product Independent Sales Effort Effectiveness.*

We next investigate the robustness of the previous insights for separate sales channels with product independent sales efforts; i.e., sales efforts are equally effective in increasing customers' valuations (thus demand) for new and remanufactured products ($\gamma_R = 1$).

Similar to the previous analysis, depending on the relationship between δ and c_N , the optimal portfolio composition of new and remanufactured products involves one of three strategies for the firm in this scenario. These strategies are *No Remanufacturing (NR)*, *Full Remanufacturing with Market Coverage (FC)*, and *Full Remanufacturing (FR)*. This characterization of the optimal solution is outlined in Proposition 3.3 and Table 3.3, and illustrated in Figure 3.4. Similar to the previous scenario, this partitioning of the solution space is driven by the remanufacturing supply and non-negativity constraints. When the *NN* constraint is binding, the **NR** strategy is optimal. When the *RS* constraint is binding, the **FR** strategy is optimal. A critical difference between these results and those with product dependent sales efforts however, is that the *MC* constraint can become binding for product independent sales force efforts, as the benefits from the sales agents' efforts are independent from the product type. In this case, the **FC** policy may become optimal, where the sales agent's efforts (t_R) can mitigate (and overcome) the detrimental consequences from the customer's discounted valuation for remanufactured products (δ) on the utility customer's receive from remanufactured products (and thus demand). The **FC** policy is comparable to the **FR** policy in the sense that the firm wishes to maximize the

sales of remanufactured products and thus balances the sales of remanufactured and new products; i.e. $q_R^* = q_N^*$. However, whereas the **FR** policy results in partial market coverage, the **FC** policy completely covers the market.

Proposition 3.3. *There exists a unique solution to the firm's problem with separate channels with product independent sales effort effectiveness ($\gamma_R = 1$). When $c_N > 1 - 2\delta$ and $\delta \leq \frac{3}{8}$ or $c_N > \frac{1-5\delta+\delta\sqrt{6\delta}}{1-6\delta}$ and $\delta > \frac{3}{8}$, the **FR** policy is optimal; when $\frac{1-\sqrt{1-2\delta}}{2} \leq c_N \leq 1 - 2\delta$ and $\delta \leq \frac{3}{8}$, the **FC** policy is optimal; whereas when $c_N \leq \frac{1-\sqrt{1-2\delta}}{2}$ and $\delta \leq \frac{3}{8}$ or $c_N \leq \frac{1-5\delta+\delta\sqrt{6\delta}}{1-6\delta}$ and $\delta > \frac{3}{8}$, the **NR** policy is optimal. The equilibrium solution is characterized in Table 3.3.*

Table 3.3: Optimal Policy with Product Independent Separate Sales Channel Efforts

	FR	FC	NR
B_R^*	$\frac{(1-c_N+\delta)(1-\delta)}{6}$	$\frac{\delta(1-\delta)}{2}$	—
B_N^*	$\frac{(1-c_N+\delta)(1-\delta)}{6\delta}$	$\frac{1-\delta}{2}$	$1 - c_N$
p_R^*	$\frac{1-c_N-\delta+2c_n\delta+4\delta^2}{6\delta}$	$\frac{1}{2}$	—
p_N^*	$\frac{5+c_N-\delta}{6}$	$1 - \frac{\delta}{2}$	1
t_R^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	—
t_N^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	$1 - c_N$
q_R^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	—
q_N^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	$1 - c_N$

Figure 3.4 illustrates the partitioning of the feasible landscape for this scenario. Similar to the product dependent sales effort scenario, for product independent sales efforts, the **NR** policy is optimal for low c_N . Along with the analysis in §3.4.1.1, this result confirms that *sales force incentives can create situations where a firm finds it optimal to not participate in the remanufactured product market, despite the beneficial cost structure of remanufactured products.*

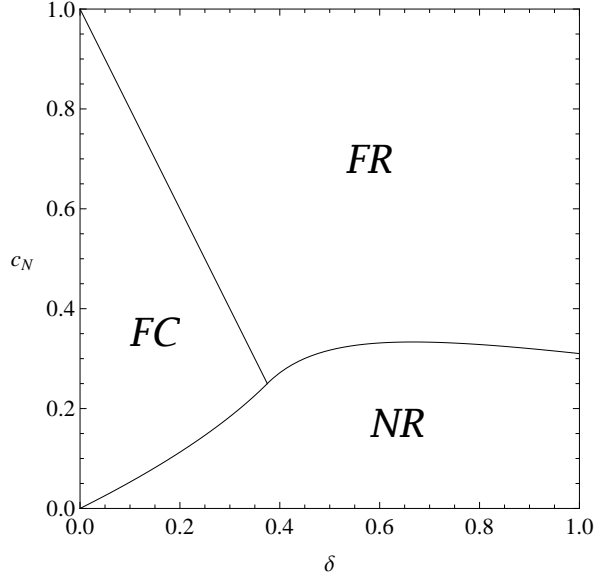


Figure 3.4: Optimal Policy with Product Independent Separate Sales Channel Efforts

In this scenario, when the firm finds it optimal to sell remanufactured products (i.e., inside the **FR** and **FC** policy regions), the commissions are set such that the sales agents dedicate equal effort towards new and remanufactured products and the firm adjusts pricing to maximize remanufactured product sales; i.e., $t_N^* = t_R^*$. Moreover, given any δ or c_N , the new product price under the **FR** policy is higher than the new product price under the **FC** policy, while the sales agents exert more effort for both products in the **FC** policy than the **FR** policy.

Note that the **FC** policy was never optimal with product dependent sales efforts, as the product dependent sales activities for remanufactured products are largely ineffective when δ is low. However, when the sales efforts are product independent ($\gamma_N = \gamma_R = 1$), it is optimal for the firm to induce higher sales efforts to increase the total sales volume. The existence of this region where the **FC** policy is optimal is a key difference between product dependent and product independent sales activities. It is also interesting to note that as δ increases under the **FC** policy, firm profits decrease. This means that if the firm finds it optimal to completely cover the market with a

balance of new and remanufactured product sales, an increase in customers' valuation of remanufactured products diminishes firm profits. This counter-intuitive finding is due to the unique supply constraint faced in the remanufacturing context. The firm cannot sell more remanufactured products than new products and the market is already covered such that no more product can be sold. Therefore, if δ increases while the firm is operating under the **FC** policy, the firm is forced to reduce the pricing of new products to ensure that there is enough supply of remanufactured products. Consequently, this reduction in new product price in an effort to maintain a sufficiently large supply of remanufacturable products results in lower profits from new products, while maintaining constant profits from remanufactured products, thus resulting in lower overall firm profits.

Corollary 3.2. *For separate sales channels with product independent sales efforts: $B_N^* > B_R^*$.*

Corollary 3.2 states that the key insight from Corollary 3.1 continues to hold when sales efforts are independent of the product type. In other words, *the new product sales agent should receive a larger commission for sales than the remanufactured product sales agent, even when the sales force effectiveness is product independent.*

As was the case with product dependent sales efforts, since we assume a negligible cost for remanufacturing ($c_R = 0$), the profit margins for new products are always less than those for remanufactured products. Again though, the per product profits and the *RS* constraint must be considered to understand the ordering of $B_N^* > B_R^*$. Figure 3.5 indicates the ordering of per product profits for new and remanufactured products with product independent separate sales channel efforts ($\gamma_N = \gamma_R = 1$). Similar to Figure 3.3, when the firm determines that it is optimal to participate in remanufacturing and δ and c_N are both low, new products yield a higher per product profit than remanufactured products. This area is indicated by $\pi_N > \pi_R$ in Figure 3.5, where $c_N < \frac{1-\delta}{2}$ inside the **FC** region and $c_N < \frac{1-6\delta+5\delta^2}{1-7\delta}$ inside the **FR** region.

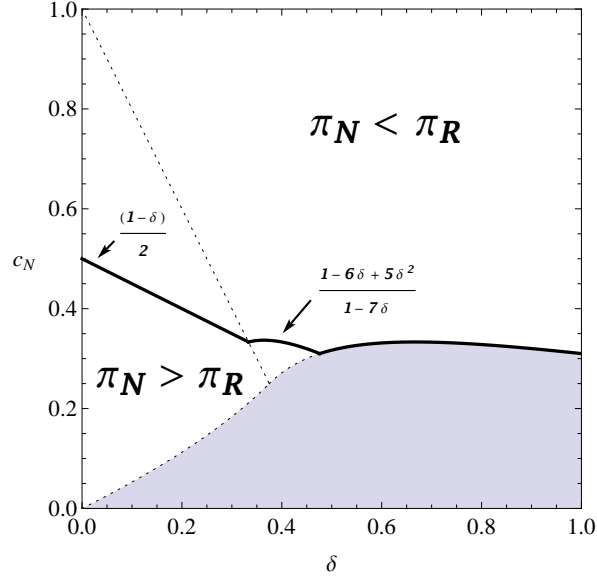


Figure 3.5: Per Unit Product Profits with Product Independent Separate Sales Channel Efforts

Therefore, it makes sense that the commissions for new products should be higher than those for remanufactured products under these conditions. However, when δ and/or c_N are high, remanufactured products yield higher per product profits than new products; i.e., $\pi_N < \pi_R$. This area is indicated by $\pi_N < \pi_R$ in Figure 3.5, where $c_N \geq \frac{1-\delta}{2}$ inside the **FC** region and $c_N \geq \frac{1-6\delta+5\delta^2}{1-7\delta}$ inside the **FR** region. Despite the higher per unit profits for remanufactured products in this region, in order to ensure a sufficient supply of remanufactured products, the commissions for (previously sold) new product sales must be higher than those for remanufactured product sales. The insights from §3.4.1.1 continue to hold as well, when the firm participates in remanufacturing, per unit profits from remanufactured products increase faster than those from new products as δ and c_N increase; i.e., remanufacturing becomes more attractive as δ or c_N increase.

3.4.1.3 *The Impact of Sales Force Effectiveness with Separate Channels.*

Next, we illustrate the impact of the sales force effectiveness (product dependent or product independent) on the firm’s participation in remanufacturing when separate channels are utilized for new and remanufactured products. Figure 3.6 compares the optimal policies between product dependent and product independent sales efforts; i.e., $\gamma_R = \delta$ and $\gamma_R = 1$.

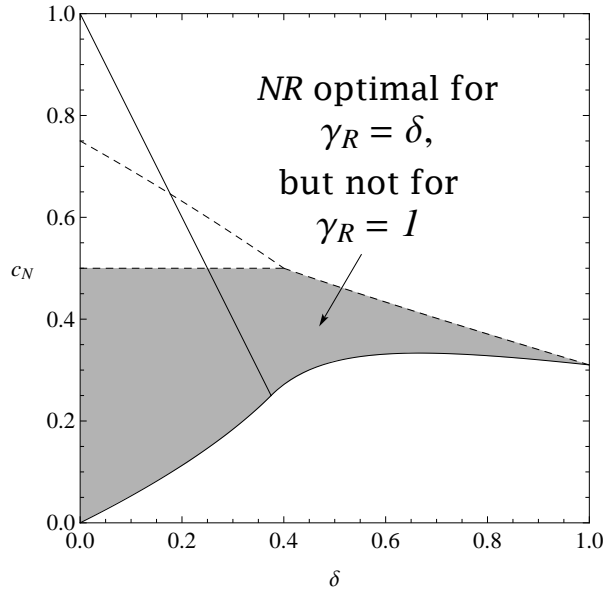


Figure 3.6: Expanded NR Region with Product Dependent Sales Efforts

As can be seen in Figure 3.6, remanufacturing is consistently optimal when c_N is high, such that irrespective of the effectiveness of sales agent’s efforts, when there is a substantial marginal cost benefit from remanufactured products, the firm will always find it optimal to maximize the quantity of remanufactured products it can sell. However, as evident by the regions where the **NR** policy is optimal, for product dependent sales effort effectiveness, the firm is more likely to not participate in the sales of remanufactured products. Irrespective of how sales efforts increase demand, when the marginal benefits from remanufacturing are low (i.e. low c_N), the firm will find it optimal to not participate in remanufactured product sales as their presence

in the market would cannibalize the sales of new products. When sales force effort effectiveness is product dependent instead of product independent, this increases the lower limit on c_N for which the firm would elect to not participate in remanufactured product sales. The influence of sales agents' effort effectiveness on the sub-optimality of remanufacturing is formally stated by Corollary 3.3 and illustrated in Figure 3.6, where the grey area characterizes the parameter range for which product dependent sales efforts ($\gamma_R = \delta$) favor the **NR** policy, but product independent sales efforts ($\gamma_R = 1$) do not. For ease of notation, we will define the set of all $(\delta, c_N) \in \mathbf{NR}|_{\gamma_R=1}$ as $\Omega_{NR}^{\gamma_R=1}$ and the set of all $(\delta, c_N) \in \mathbf{NR}|_{\gamma_R=\delta}$ as $\Omega_{NR}^{\gamma_R=\delta}$. Similarly, we define the set of all $(\delta, c_N) \in \mathbf{FR}|_{\gamma_R=1}$ as $\Omega_{FR}^{\gamma_R=1}$ and the set of all $(\delta, c_N) \in \mathbf{FR}|_{\gamma_R=\delta}$ as $\Omega_{FR}^{\gamma_R=\delta}$. From this notation, the gray area in Figure 3.6 can be stated as $\Omega_{NR}^{\gamma_R=\delta} \setminus \Omega_{NR}^{\gamma_R=1}$.

Corollary 3.3. *For separate sales channels, $\Omega_{NR}^{\gamma_R=1} \subset \Omega_{NR}^{\gamma_R=\delta}$. Moreover, the area $\Omega_{NR}^{\gamma_R=\delta} \setminus \Omega_{NR}^{\gamma_R=1}$ gets smaller in δ .*

Corollary 3.4. *With separate sales channels, for all $i \in \{N, R\}$ and $(\delta, c_N) \in \Omega_{FR}^{\gamma_R=1} \cap \Omega_{FR}^{\gamma_R=\delta}$: B_i^* is larger with product independent sales efforts compared to product dependent sales efforts.*

Corollary 3.4 on the other hand, focuses on conditions where the firm finds it optimal to offer remanufactured products, and indicates that when sales efforts are product dependent, the commissions offered for both new and remanufactured product sales are decreased compared to those offered when the sales efforts are product independent. As a result of this discounted commission structure, the time that either sales agent spends promoting product is less when the effectiveness of selling activities are product dependent as opposed to product independent. As a direct consequence of this, not only the remanufactured product volume, but also the total volume of products sold under the **FR** policy is lower when the sales effort effectiveness is product dependent. Specifically, $t_N^*|_{\gamma_R=\delta} < t_N^*|_{\gamma_R=1}$ and $t_R^*|_{\gamma_R=\delta} < t_R^*|_{\gamma_R=1}$, resulting in $q_N^*|_{\gamma_R=\delta} < q_N^*|_{\gamma_R=1}$ and $q_R^*|_{\gamma_R=\delta} < q_R^*|_{\gamma_R=1}$.

3.4.2 Joint Sales Channel for New and Remanufactured Products

Differing from the separate sales channel configuration in §3.4.1, firms may elect to manage the sales of new and remanufactured product in a joint channel. The firm must therefore determine the compensation scheme for the joint sales channel agent as well as the pricing for the new and remanufactured products. The sales agent will be offered a compensations scheme of the following form: $s(q_N, q_R) = s(q_N) + s(q_R)$. We can further combine the two fixed wage portions of the compensation scheme into one since there is only one sales agent such that $A_N + A_R = A$. This results in $s(q_N, q_R) = A + B_N q_N + B_R q_R$. The firm's decision problem can be formally written as in equation (1), with $s_N(q_N) + s_R(q_R)$ replaced with $s(q_N, q_R)$ for the joint channel sales agent's compensation, who will additionally determine her optimal sales efforts for both the new and remanufactured products (t_N^* and t_R^*).

3.4.2.1 Joint Channel with Product Dependent Sales Effort Effectiveness.

As before, we first examine the optimal policies for a firm utilizing a joint sales channel for new and remanufactured products, with product dependent sales effort effectiveness.

Proposition 3.4. *There exists a unique solution to the firm's problem with a joint sales channel with product dependent sales effort effectiveness ($\gamma_R = \delta$), which results in identical policies to those identified with separate sales channels. When $c_N > \frac{3\delta-3}{\delta-4}$ and $\delta \leq \frac{2}{5}$ or $c_N > \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$ and $\delta > \frac{2}{5}$, the **FR** policy is optimal; when $\frac{1}{2} \leq c_N \leq \frac{3\delta-3}{\delta-4}$ and $\delta \leq \frac{2}{5}$, the **LR** policy is optimal; whereas when $c_N \leq \frac{1}{2}$ and $\delta \leq \frac{2}{5}$ or $c_N \leq \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$ and $\delta > \frac{2}{5}$, the **NR** policy is optimal. The equilibrium solution is characterized in Table 3.4.*

Proposition 3.4 states that the optimal remanufacturing policies of the firm employing a joint channel sales agent can be partitioned for all (δ, c_N) identically to the firm that employs separate channels for new and remanufactured products. In

Table 3.4: Optimal Policy with Product Dependent Joint Sales Channel Efforts

	FR	LR	NR
B_R^*	$\frac{2(1-c_N+\delta)\delta}{1+6\delta-\delta^2}$	$\frac{\delta(1-3\delta+c_N\delta)}{2-5\delta}$	—
B_N^*	$\frac{(1-c_N+\delta)(1+\delta)}{1+6\delta-\delta^2}$	$\frac{2-2c_N-4\delta+3c_N\delta}{2-5\delta}$	$1 - c_N$
p_R^*	$\frac{\delta(2c_N-1+5\delta-c_N\delta)}{1+6\delta-\delta^2}$	$\frac{\delta(1-3\delta+c_N\delta)}{2-5\delta}$	—
p_N^*	$\frac{1+5\delta+c_N\delta-2\delta^2}{1+6\delta-\delta^2}$	$\frac{2(1-2\delta-c_N\delta)}{2-5\delta}$	1
t_R^*	$\frac{\delta(1-c_N+\delta)}{1+6\delta-\delta^2}$	$\frac{\delta(2c_N-1)}{2-5\delta}$	—
t_N^*	$\frac{1-c_N+c_N\delta-\delta^2}{(1-\delta)(1+6\delta-\delta^2)}$	$\frac{2-2c_N+c_N\delta-3\delta}{2-5\delta}$	$1 - c_N$
q_R^*	$\frac{\delta(1-c_N+\delta)}{1+6\delta-\delta^2}$	$\frac{2-2c_N+c_N\delta-3\delta}{2-5\delta}$	—
q_N^*	$\frac{\delta(1-c_N+\delta)}{1+6\delta-\delta^2}$	$\frac{2c_N-1}{2-5\delta}$	$1 - c_N$

other words, *the result that sales force incentives may render remanufacturing undesirable remains valid in a joint channel.* Comparing Table 3.4 to Table 3.2 reveals that equal prices, efforts, and quantities sold for new and remanufactured products can be achieved from either channel configuration for product dependent sales efforts. On the other hand, the optimal sales commission structure is significantly different between the two channel configurations. This implies that while joint and separate channels can incorporate identical remanufacturing policies by utilizing linear payment schemes to compensate their sales agents, the commissions offered differ between the channel configurations.

Corollary 3.5. *For a joint sales channel with product dependent sales efforts: $B_N^* > B_R^*$.*

Furthermore, Corollary 3.5 states that the key result regarding a comparison between new and remanufactured product sales commissions continues to hold under the joint channel, even though the commission structures are different. This is again the result of the per product profits (as determined through optimal product pricing) and the remanufacturing supply constraint. Additionally, these results for the

commissions in a joint sales channel do not conform with the results from Zhang and Mahajan (1995). Remanufactured products are substitutes at any point in time to new products, but complements across time since their supply is dependent on previously sold new products. Therefore, when firms participate in remanufacturing, different commissions must be offered for new and remanufactured products due to the unique supply and demand relationship they have.

3.4.2.2 Joint Channel with Product Independent Sales Effort Effectiveness.

We next investigate the robustness of the previous insights for a joint sales channel with product independent sales efforts.

Proposition 3.5. *There exists a unique solution to the firm's problem with a joint sales channel with product independent sales effort effectiveness ($\gamma_R = 1$), which results in identical policies to those identified with separate sales channels. When $c_N > 1 - 2\delta$ and $\delta \leq \frac{3}{8}$ or $c_N > \frac{1-5\delta+\delta\sqrt{6\delta}}{1-6\delta}$ and $\delta > \frac{3}{8}$, the **FR** policy is optimal; when $\frac{1-\sqrt{1-2\delta}}{2} \leq c_N \leq 1 - 2\delta$ and $\delta \leq \frac{3}{8}$, the **FC** policy is optimal; whereas when $c_N \leq \frac{1-\sqrt{1-2\delta}}{2}$ and $\delta \leq \frac{3}{8}$ or $c_N \leq \frac{1-5\delta+\delta\sqrt{6\delta}}{1-6\delta}$ and $\delta > \frac{3}{8}$, the **NR** policy is optimal. The equilibrium solution is characterized in Table 3.5.*

Proposition 3.5 states that the equivalence between the remanufacturing policies under joint and separate channels continue to hold under the product independent sales force efforts assumption, implying that *the result that sales force incentives may render remanufacturing undesirable is robust to the channel setting and sales force effectiveness.*

Corollary 3.6. *For a joint sales channel with product independent sales efforts: $B_N^* > B_R^*$.*

Along similar lines, Corollary 3.6 shows the robustness of our result regarding the comparison between optimal sales commissions for new and remanufactured products

Table 3.5: Optimal Policy with Product Independent Joint Sales Channel Efforts

	FR	FC	NR
B_R^*	$\frac{1-c_N+\delta}{3}$	δ	—
B_N^*	$\frac{(1+\delta)(1-c_N+\delta)}{6\delta}$	$\frac{1+\delta}{2}$	$1 - c_N$
p_R^*	$\frac{1-c_N-\delta+2c_n\delta+4\delta^2}{6\delta}$	$\frac{1}{2}$	—
p_N^*	$\frac{5+c_N-\delta}{6}$	$1 - \frac{\delta}{2}$	1
t_R^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	—
t_N^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	$1 - c_N$
q_R^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	—
q_N^*	$\frac{(1-c_N+\delta)}{6\delta}$	$\frac{1}{2}$	$1 - c_N$

and allows us to formalize an important conclusion. *Under any channel configuration (joint or separate), and sales force effectiveness (product dependent or product independent), sales commissions should be higher for new products.*

Corollary 3.7. *With a joint sales channel, for all $i \in \{N, R\}$ and $(\delta, c_N) \in \Omega_{FR}^{\gamma_R=1} \cap \Omega_{FR}^{\gamma_R=\delta}$: B_i^* is larger with product independent sales efforts compared to product dependent sales efforts.*

Corollary 3.7 is analogous to Corollary 3.4, indicating that in a joint sales channel, commissions with independent sales efforts are higher than those for product dependent sales efforts for both new and remanufactured products.

3.4.3 A Comparison of Commissions Across Joint and Separate Sales Channels

Recognizing a firm can choose a joint or separate sales channels for a variety of reasons⁵, our study is concerned with how the compensation structures may differ

⁵In our deterministic setting, it is straightforward to show that the firm can achieve the first best optimal solution in the absence of demand uncertainty with risk neutral agents under both joint and separate sales channels (Laffont & Martimort, 2001). When other contextual factors, such

between the two channel structures. As such, Corollary 3.9 follows:

Corollary 3.8. *For all (δ, c_N) , $\gamma_R \in \{\delta, 1\}$, and $i \in \{N, R\}$: B_i^* for a separate sales channel is less than B_i^* for a joint sales channel.*

Corollary 3.8 indicates that if a firm utilizes a joint sales channel to promote its new and remanufactured products, then it should offer higher sales commissions for both new and remanufactured product sales than it would otherwise offer if it utilized separate sales channels, regardless of the effectiveness of sales efforts. The intuition behind this result is as follows. Since the joint channel sales agent is required to actively promote both new and remanufactured products in the same market, his efforts dedicated towards the two products have competing effects on demand. Therefore, to mitigate the consequences from potentially lower sales agent effort (and thus demand), the firm must offer higher commissions for the sales of both new and remanufactured products compared to those offered to sales agents in separate channels.

3.5 Extensions

In order to verify the robustness of the key insights from this paper, we first relax the deterministic demand assumption to determine whether demand uncertainty or risk aversion alters the sales agent's compensation structures in §3.5.1. Then, in §3.5.2, we account for interactions in the costs of effort for a joint channel agent to simultaneously promote new and remanufactured products.

as demand uncertainty, risk aversion, or cost interactions between new and remanufactured product sales efforts are involved, the equivalence of profits between sales channel configurations will not necessarily hold.

3.5.1 The Effect of Demand Uncertainty and Risk Aversion

Whereas the main analysis considers product pricing and sales agent effort as the only two factors that contribute towards demand realizations for new and remanufactured products, a natural extension is to relax this assumption and allow the demands for new and remanufactured products to additionally include uncertainty. As such, we assume that there is demand uncertainty in the form of $\hat{q}_N = q_N + \epsilon_N$ and $\hat{q}_R = q_R + \epsilon_R$, where ϵ_N and ϵ_R follow a bivariate normal distribution with variances σ_N^2 , σ_R^2 and correlation ρ , and the sales agents are risk averse with a constant risk aversion factor r ⁶. In this case, it is straightforward to show that the compensation offered to the sales agents will require an additional certainty equivalent component of $\frac{r}{2}(B_N^2\sigma_N^2 + 2\rho B_N B_R \sigma_N \sigma_R + B_R^2\sigma_R^2)$ under the joint channel and $\frac{r}{2}(B_N^2\sigma_N^2)$ and $\frac{r}{2}(B_R^2\sigma_R^2)$ under separate channels (Pratt, 1964; Holmstrom & Milgrom, 1991). As one would expect, a positive correlation between the demands for new and remanufactured products (indicated by the additional term $2\rho B_N B_R \sigma_N \sigma_R$ in the joint channel agent's utility) effectively means that the joint channel agent is additionally burdened, whereas a negative correlation would benefit the agent's utility due to the substitution effects in product demand uncertainties.

An analytical investigation of the influence of demand uncertainty and risk aversion on the optimal product portfolio, firm profits, or agent compensation schemes is very tedious due to the additional number of parameters involved (σ_N , σ_R , ρ , and r). Therefore, we revert to numerical analysis to obtain insights. We start with a baseline case, where we set $\sigma_N = 0.5$, $\sigma_R = 0.5$, $\rho = 0$, and $r = 1$, and consider a broader range for each parameter in all scenarios considered in §4 to highlight the robustness of our sales commission related results under demand uncertainty. For δ

⁶In the agency literature, this approach is commonly referred to as the LEN (linear contract, exponential utility, and normal errors) framework.

and c_N , we focus on a specific range ($\delta \geq 0.75$ and $c_N \geq 0.75$) such that remanufacturing is optimal⁷. Figure 3.7 shows the effects of σ_N , σ_R , and r on B_N^* and B_R^* for the joint and separate sales channels, while Figure 3.8a shows the impact of ρ on the joint sales channel.

Figures 3.7 and 3.8a illustrate the robustness of our results under demand uncertainty and risk aversion. First, we observe that $B_N^* > B_R^*$ for product independent and product dependent sales efforts under joint and separate sales channel configurations, i.e., the insights from Corollaries 3.1, 3.2, 3.5, and 3.6 continue to hold when demand is uncertain. Second, $B_N^*|_{\gamma_R=1} > B_N^*|_{\gamma_R=\delta}$ and $B_R^*|_{\gamma_R=1} > B_R^*|_{\gamma_R=\delta}$, i.e., the insights from Corollaries 3.4 and 3.7 also continue to hold. Third, $B_N^*|_{\{separate\}} < B_N^*|_{\{joint\}}$ and $B_R^*|_{\{separate\}} < B_R^*|_{\{joint\}}$, implying that the result from Corollary 3.8 also holds. Finally, in both Figures 3.7 and 3.8a, B_N^* and B_R^* are decreasing in σ_N , σ_R , ρ , and r , indicating that an increase in uncertainty, correlation between demand uncertainties, or risk aversion reduces the sales commissions for new and remanufactured products. This, in turn, implies that increased uncertainty requires a higher fixed wage for both sales agents due to the IR constraint on the sales agents, which is consistent with Basu *et al.* (1985).

3.5.2 Sales Effort Cost Interactions

So far we have assumed that the costs of effort for new and remanufactured product sales are independent, i.e., given any effort level choice pair (t_N, t_R) the total cost of effort to be incurred by the agent(s) is $V(t_N, t_R) = \frac{t_N^2}{2} + \frac{t_R^2}{2}$. This however, may not necessarily be the case as there may be some dependency between the costs of effort in the joint setting, i.e., a cost structure of the form $V(t_N, t_R) = \frac{t_N^2}{2} + \frac{t_R^2}{2} - \mu t_N t_R$, where a positive μ (i.e., reinforcing efforts) would imply a lower total cost of effort

⁷Figures 3.7 and 3.8 focus on $\delta = 0.75$ and $c_N = 0.75$ for ease of illustration, but similar patterns are observed in the broader range of parameters.

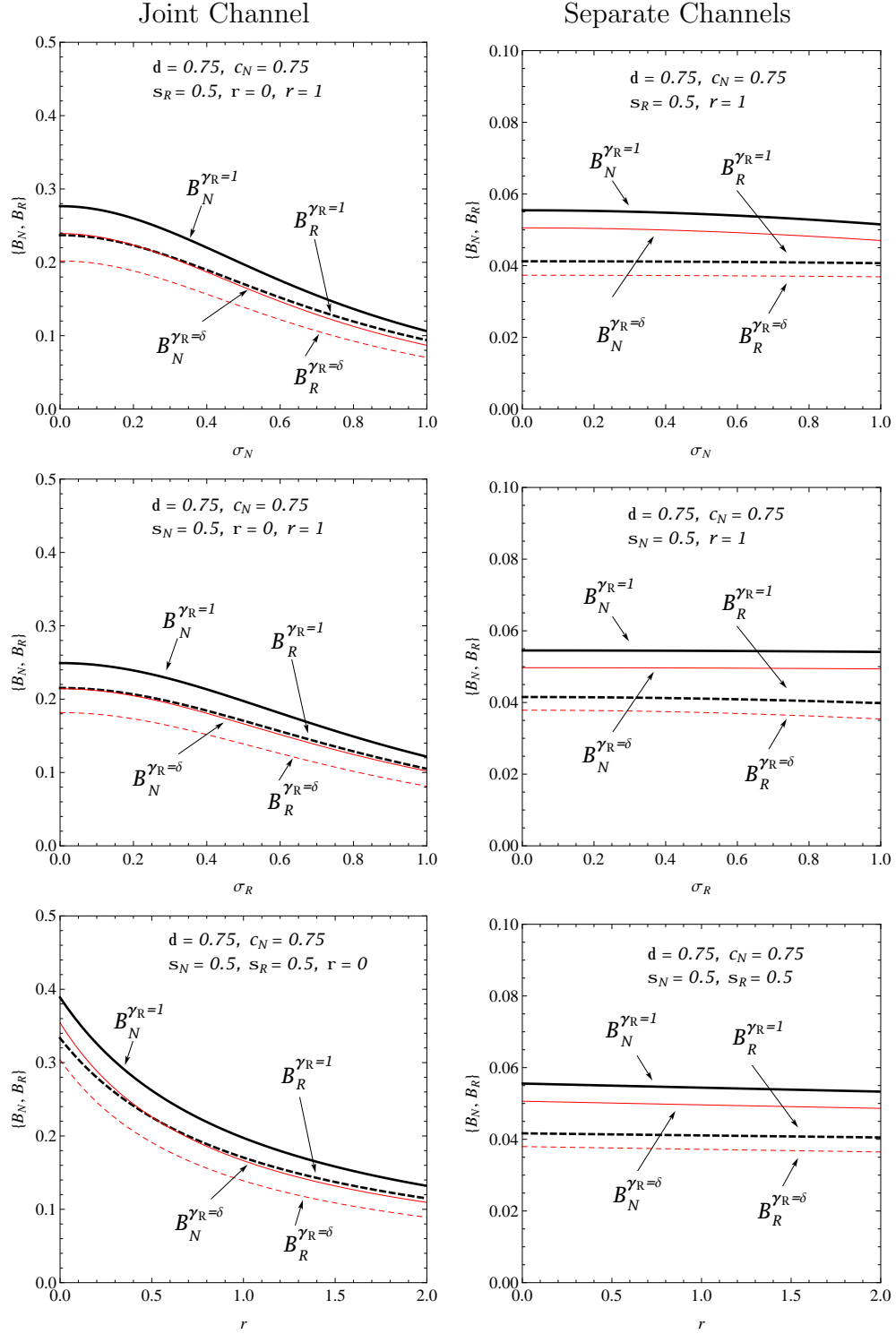


Figure 3.7: The Impact of Demand Uncertainty and Risk Aversion on Commissions B_N^* and B_R^* .

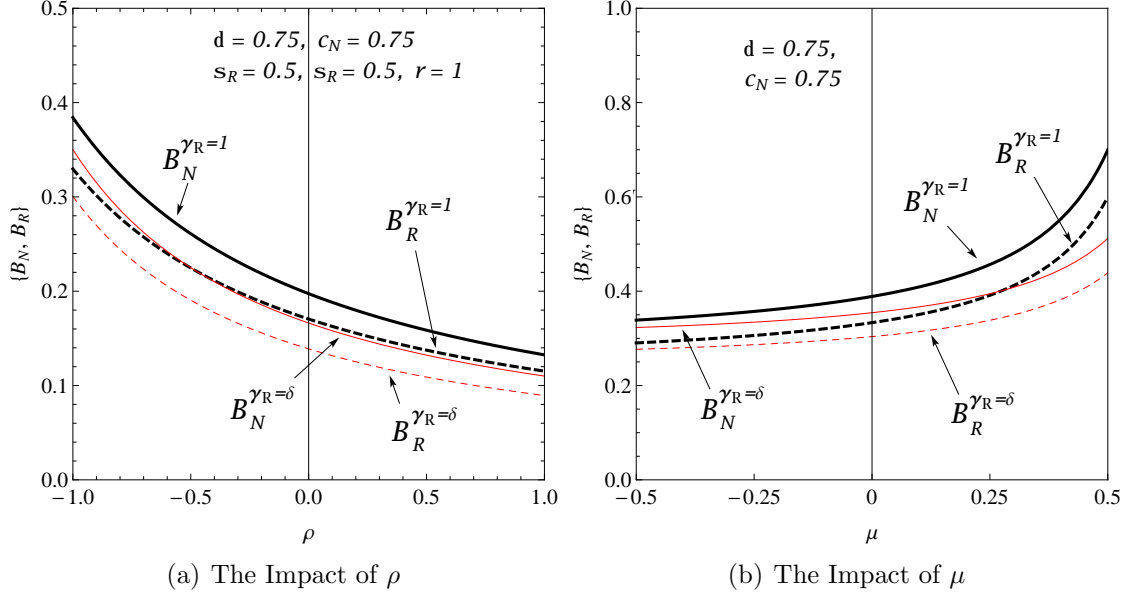


Figure 3.8: The Impacts of ρ and μ on Commissions B_N^* and B_R^* .

and a negative μ (i.e., undermining efforts) would imply a higher total cost of effort. We investigate the impact of such an interaction term next.

Figure 3.8b illustrates B_N and B_R as a function of μ for product dependent and product independent sales efforts in a joint channel setting⁸, and shows that the findings from Corollaries 3.5 and 3.6 are preserved: $B_N^* > B_R^*$ in the presence of a cost of effort interaction term. In other words, irrespective of the value of μ , the firm will find it optimal to always incentivize the sales of new products more than remanufactured products. This interaction term will also have an impact on the firm's remanufacturing decision. Intuitively, firm profits will be increasing in μ , which is a direct result of the positive synergy in selling efforts between new and remanufactured products. As μ increases, the firm will find it optimal to remanufacture for even lower

⁸To avoid boundary effects, μ is assumed to be in $[-1/2, 1/2]$. Note that the joint channel sales agent's utility is jointly concave in t_N and t_R if $-1 < \mu < 1$. When $\mu \geq 1$, the agent's utility would be unbounded in effort, and when $\mu \leq -1$, the agent would never exert effort for both products simultaneously.

values of δ and c_N .

3.6 Conclusions

Our objective in this paper is to provide guidance on sales force management practices to firms that engage in remanufacturing. We show that profitable remanufacturing requires not only managing the demand for new and remanufactured products through pricing and market segmentation, but also providing the right incentives for a sales force. We provide a number of insights for managers of firms selling new and remanufactured products to improve the performance of their sales force. The key insights are as follows.

First, managing sales force incentives in the presence of remanufactured products can be contrary to common intuition. A remanufactured product is not an ordinary product line extension, and hence the associated sales force incentives should be managed carefully. Even when remanufactured products can provide higher profit margins and per unit profits than new products, one needs to consider the supply and demand interaction between the two. With remanufacturing, the impact of the sales force is driven not only by the relative profit margins or demand uncertainty, but also by the supply constraints. Because of this dependency, our results indicate that a remanufacturing firm should offer higher commissions for the sales of new products than for remanufactured products and this insight holds irrespective of the channel setting (i.e., joint versus separate channels), sales force effectiveness (product dependent or product independent), or demand uncertainty. The practical implication of this result is that salespeople in product recovery divisions of firms should be paid lower commissions than those in the new product marketing divisions, with the understanding that the main driver of this differentiation is not the profit margins they provide, but rather the inherent supply dependence on new product sales. Without new product sales there can be no remanufactured product to sell, so the policies

to maximize the revenue from the higher margin remanufactured products become irrelevant.

Second, our comparison between joint and separate channel configurations for new and remanufactured products reveals that the structure of sales force compensations should differ significantly between channel configurations. Essentially, the responsibility to actively promote both new and remanufactured products in the same channel decreases the effort dedicated towards each product to increase their sales. In other words, for a given commission level, the sales force in a joint channel internalizes the substitution between efforts for new and remanufactured products and exerts lower effort than the same in a separate channel setting. This, in turn, implies that a joint channel requires higher per unit sales commissions to achieve the same level of sales as in a separate channel. Nevertheless, the fixed wages in these channel configurations can be adjusted such that the total amount of time dedicated to sales activities for both products is the same for both channel configurations, resulting in identical pricing policies and firm profits for joint and separate sales channels. In sum, a joint channel configuration should provide higher (lower) commissions (fixed wages) for both new and remanufactured products than a separate channel configuration. This implies that remanufacturing firms should tailor their sales force compensation practices to the channel configuration they prefer. In practice, for instance, this implies that a firm like Bosch, who uses different channel configurations for sales of different remanufactured product categories, should use different commission structures in compensating sales force activities in those categories.

Third, our analysis shows that seemingly profitable remanufacturing opportunities may not be optimal for a firm to pursue when a firm hires a sales force, whose costs can reduce the profitability of remanufacturing. In other words, the cost effectiveness of closed-loop manufacturing activities (such as remanufacturing) may

not be sufficient to justify their profitability. Understanding the supply dynamics behind closed-loop processes, and adjusting product pricing and sales force management practices accordingly, is a key factor in achieving possible economic gains. Without understanding the effects of supply dynamics and sales force incentives, seemingly attractive opportunities can undermine profits.

Lastly, our results regarding the impact of sales force effectiveness on the profitability of remanufacturing and sales force commissions allow us to make a practical conjecture, and identify an important empirical research question that can help firms considering remanufacturing as a business opportunity. Product dependent sales force effectiveness appears to be representative of B2C settings, where a salesperson may have no established relationship with the customer and is focused solely on promoting a product. On the other hand, product independent sales activities appears to be representative of B2B settings, which involve relationship development and maintenance, repeated interactions, and a level of trust between the salesperson and customer. Given this conjecture, our results imply that remanufacturing in a B2B setting may be profitable under relatively lower cost efficiency gains from remanufacturing than in a B2C setting. This may partially explain why remanufacturing practices are more prevalent for firms engaged in B2B activities (e.g. Xerox and Caterpillar) than for firms engaged in B2C activities, such as consumer goods manufacturers. This interpretation implies that sales commissions in a B2B remanufacturing setting should be relatively higher than those in a B2C setting.

Future experimental work testing this conjecture would provide better theoretical and managerial guidance on remanufacturing strategies for firms, both with respect to product pricing and sales agent compensation plans. We also believe that the distinction between product dependent versus product independent sales force effectiveness may be observed between different product categories (e.g., innovative versus

utilitarian products) even within an industry. The important message to remanufacturing firms is that understanding where they lie in this spectrum is an important question they need to address before undertaking remanufacturing.

We also note that remanufacturing divisions may not always be viewed as profit centers. We interviewed managers of a major telecommunications company who suggested that a separate remanufacturing division may indeed frequently be forced by new product divisions to limit the offering of remanufactured products, even when they could provide very high margins. For such firms, remanufacturing divisions are often viewed as cost centers, where remanufacturing is a strategy to reduce associated end-of-life costs. For such firms, the priority in pricing would be given to new-product marketing division, and the pricing and sales force commissions for remanufactured products would be determined given the new product channel's choices. An extension of our model, omitted for brevity, that represents this setting allows us to show the robustness of our insights under this alternative view of a remanufacturing division as well.

Finally, we close by noting that an immediate question that deserves attention in our setting is the effect of competition in the market for remanufactured products. Our analysis in this paper focuses on a monopolistic setting where only the intra-firm channels compete for the sales of new and remanufactured products. Alternatively, remanufactured products could be sold by a separate company or a separate company could compete against the firm which sells both new and remanufactured products. It is important to understand how the presence of such competition affects our results, which we consider an important area of future research. Additionally, the formulation of the model in this paper is indicative of the supply constraints faced within the context of remanufacturing, but the underlying implications of utilizing a sales force to promote sales of a firm that produces a portfolio of products, yet faces a capacity constraint on the total production, has not been explored.

CHAPTER IV

FOCUSED OR FLEXIBLE TARGETS? HOW ORGANIZATIONAL DESIGN INFLUENCES THE DEFINITION OF SUCCESS FOR STRATEGIC INITIATIVES

4.1 *Introduction and Related Literature*

Strategic initiatives represent the force that accelerates an organizational mass into action, overcoming inertia and resistance to change. Strategic initiatives are collections of finite-duration discretionary projects and programs, outside the organization's day-to-day operational activities, that are designed to help the organization achieve its targeted performance.

– Kaplan and Norton (2008, p.103)

Scholars agree that defining the goals of strategic initiatives is paramount in facilitating their successful execution (Cooper, 1993). The establishment of target outcomes for an initiative and the management of its execution are related; yet, the effects that organizational and operational factors have on the definition of which outcomes constitute successful completion have received inadequate attention, as noted in the strategy (Rotemberg & Saloner, 1994), organizational behavior (Hoegl & Gemuenden, 2001), R&D management (Nobelius, 2001; Loch & Tapper, 2002), product development (Bhattacharya *et al.*, 1998), project management (Morris & Jamieson, 2004; Pons, 2008), and engineering (Antonsson & Otto, 1995) literatures.

Defining success for strategic initiatives is far from straightforward, as they are subject to complex challenges. First, their execution requires input from multiple

stakeholders with diverse knowledge competencies. The interactions between these stakeholders often exhibit strong interdependencies with respect to the attainment of the overarching objective. For example, in product development projects¹, the consumer needs identified by the marketing specialists directly affect the development goals of the engineering specialists; yet at the same time, the capabilities of the engineering specialists impose limitations to the types of products the marketing specialists can conceptualize and promote. Said differently, extra effort by one stakeholder rarely substitutes for the deficiencies from another stakeholder in value creation. Due to such complementarities, *impetus* (commitment) from all the stakeholders becomes a necessity for successful project execution; yet, such commitment can be neither guaranteed, nor assumed (Milgrom & Roberts, 1990). Stakeholder interactions are a challenging endeavor to manage (Souder, 1988; Song *et al.*, 1997; Hoegl *et al.*, 2004; Kretschmer & Puranam, 2008; Kavadias & Kovach, 2010).

Second, not only do the stakeholders need to commit costly effort, but they are required to do so under considerable uncertainty regarding the eventual success (Loch & Kavadias, 2011). For example, initiatives may face uncertainty in their market success, technical feasibility, production readiness, or even the “right” timing, among other things. These uncertain aspects cannot be completely resolved *ex ante* and they weaken the relationship between the efforts committed to the project tasks, and the respective outcomes. The combination of inherent uncertainty with knowledge specialization gives rise to information asymmetries between the different stakeholders. Thus, the horizontal and vertical information asymmetry (between the various specialists and between the specialists and senior management, respectively) gives rise to moral hazard issues. Given these challenges, senior management needs to carefully craft incentive plans and define what constitutes “success” in order to mitigate

¹Projects in this paper describe strategic initiatives. Thus, the terms are used interchangeably (Project Management Institute, 2000; Kaplan & Norton, 2008).

risks, manage the information asymmetries, and ensure stakeholder impetus (Hoegl *et al.*, 2004; Kretschmer & Puranam, 2008). In that regard, the definition of successful outcomes from a strategic initiative represents the translation of its strategic objective into an implementable action (Loch & Kavadias, 2011). The delineation of such actionable targets constitutes the success criteria for the project outcome: a set of a few specific key deliverables constitutes a *focused* definition of success; whereas a larger dispersion in the set of successful outcomes constitutes a *flexible* definition. Thus, focused targets only allow a narrowly specified outcome from an initiative to be considered successful (i.e., exact on time and on budget completion, with precise adherence to each and every *a priori* prescribed performance requirement). Flexible targets consider a broader set of ranked final outcomes from the initiative as acceptable (Loch & Bode-Greuel, 2001). Although focused targets concentrate attention to high value (and potentially high uncertainty) outcomes, they may imply costly incentives to guarantee impetus. Alternatively, flexibility may allow for less costly incentives to achieve impetus, but the actual outcomes may be of lower value to the firm. The literature is far from conclusive about the need for flexible as opposed to focused targets. Some argue that strategic initiatives require a focused definition of target outcomes (Cooper, 1993; Bhattacharya *et al.*, 1998; Kaplan & Norton, 2008), while others claim the merits of a more flexible target establishment (Sobek *et al.*, 1999; Loch & Bode-Greuel, 2001; Klingebiel & Rammer, 2013). In the prior literature, Rotemberg and Saloner (1994) consider the closest similar setting to ours. They develop a model where a specialist is compensated for the delivery of a high value outcome, with the possibility of additional compensation for the delivery of an outcome that is of a lower value, when secondary outcomes are allowed. Their model attempts to rationalize conditions where firms might benefit from narrow business strategies (strategic pursuit of focused as opposed to more broadly aspiring objectives). The

goal of this paper is to understand how flexibility in the definition of successful outcomes for a strategic initiative affects its execution, under different project-specific and organization-specific contexts.

Our contribution to the literature accounts for two distinct realities. First, we extend the work of Rotemberg and Saloner (1994), as we recognize that the cross-functional nature of modern organizations is more suitable for capturing the realities of implementing strategic initiatives. Therefore, we analyze multi-task initiatives to capture the stakeholders' interactions during execution. Second, senior management has specific objectives in mind when undertaking strategic initiatives, yet these may fail to deliver their *ex ante* expectations upon completion. We recognize that this contingency rarely implies a binary "acceptable" or "unacceptable" outcome for the firm, or a continuum of monetary rewards often assumed in the literature (McGrath & Keil, 2007). Strategic initiatives have a set of potential outcomes that can be prioritized *a priori* and a key consideration is whether to concentrate on the *ex ante* "best" outcome, or to allow (i.e., tolerate) lesser valued outcomes. Therefore, a firm may have the opportunity (and benefit) to consider the value from *a priori* secondary outcomes (Loch & Bode-Greuel, 2001).

Our approach allows us to explore how the *organizational design* of the firm influences the execution of these projects. Traditionally, firms managed their functional departments separately. These *functional* organizational structures involve functional managers leading groups of functional specialists whose interactions on specific projects occur across functional boundaries (Wheelwright & Clark, 1992). Functional organizations facilitate task specialization through technical guidance from the functional managers and intradepartmental knowledge transfer between stakeholders with the same technical skills. More recently, firms have organized in *project-based* organizational structures, where cross-functional experts are brought under a distinct management structure focused on a particular project and led by a dedicated project

manager. These project managers mitigate many of the cross-functional integration challenges amongst the stakeholders and are held accountable for the project execution (Clark & Wheelwright, 1992). Project-based organizations trade off functional skill expertise for the benefits of better stakeholder coordination (Allen, 2001; Harris & Raviv, 2002).

We develop an agency framework where we account for different organizational structures and we consider what shall be defined as a successful outcome for a strategic initiative. We compare a principal–multi-agent model with a multi-task principal–agent model. The former involves a principal and multiple agents (i.e., functional experts each responsible for a specialized task) and captures the underlying dynamism of a functional organization; the latter represents senior management and a single team responsible for multiple tasks (i.e., a coordinated project team responsible for multiple tasks) to capture the tight coordination characteristics of a project-based organization. For both models, we explore how senior management (the principal) can tailor the target outcomes (the definition of success) to influence stakeholder (the agents) impetus for the execution of an initiative.

Our analysis suggests that strategy implementation rests critically upon the proper *alignment* between the targets set and the organizational structure; such alignment materializes through a well crafted performance measurement and incentive plan. This allows us to highlight the dual role of performance metrics: they *communicate* the scope of successful outcomes (i.e., what types of project outcomes will be rewarded), and they *enable* the organizational impetus (i.e., incentivize the necessary effort commitment) from the relevant stakeholders. Overall, we show that initiatives with identical inherent uncertainty and project value might admit entirely different definitions of what constitutes success, depending on the organizational design. High-risk initiatives benefit from flexibility in what is considered successful, whereas the definition of success for low-risk initiatives is contingent on the organizational design;

flexible targets should be specified in functional organizations, whereas focused targets should be specified in project-based organizations. Flexible targets provide a *tolerance for failure* to the stakeholders and reduce the incentives required to ensure impetus in functional organizations. Yet, such tolerance for failure encourages shirking in project-based organizations. Lastly, as the costs of stakeholder effort increase, flexible definitions of success become dominant in functional organizations, whereas focused definitions become dominant in project-based organizations. Said differently, as the costs of effort increase, the definition of success shapes to address the dominant form of information asymmetry encountered by the different organizational forms. Project-based organizations suffer from vertical information asymmetry between the stakeholders and senior management, which is best managed with focused definitions that alleviate the asymmetry. Functional organizations, however, are additionally challenged with horizontal information asymmetry (hidden information) between the stakeholders. These cross-functional coordination challenges are best managed with flexible definitions, which provide a tolerance for failure that enables the necessary effort commitment from the stakeholders.

4.2 Model Setup

In order for a firm to successfully execute a strategic initiative, senior management must credibly communicate the target outcomes (i.e., the results which constitute “success”) to the organizational stakeholders, and offer them sufficient incentives to ensure impetus during the execution. We assume that the metrics defined by senior management and the incentives offered to the stakeholders are enforceable contracts, and thus the firm must compensate the stakeholders accordingly. In this section, we outline the relationship between stakeholder effort and value creation, implementation challenges due to the organizational structure, and how the definition of success influences the stakeholders’ incentives.

4.2.1 The Relationship Between Effort and Value

The overall value of an initiative is determined by the value contributions from all the tasks required to complete the initiative. Specifically, if v_i is the contribution from task i to the value of the project, then the total project value is $V = f(\vec{v}_i)$, where $\vec{v}_i = (v_1, v_2, \dots, v_n)$ represents the vector of task value contributions and $f : \mathbb{R}^n \rightarrow \Omega \subset \mathbb{R}$ represents a general mapping between the individual contributions and the total value. Note that the general mapping of f encompasses settings where the initiative tasks exhibit either complementary or substitutable value contributions to one another in generating total project value (Milgrom & Roberts, 1990). Let Ω be the finite and compact set of all potential outcome values of V from the set of n tasks required for the project's execution. Without loss of generality, we assume that the contributions v_i are binary, i.e., $v_i \in \{v^H, v^L\}$, where v^H (v^L) represents a high (low) value contribution such that $v^H > v^L > 0$. The overall value $V(\vec{v}_i)$ is increasing in v_i (i.e., $V(v_1, \dots, v^H, \dots, v_n) > V(v_1, \dots, v^L, \dots, v_n)$). Furthermore, we define $\bar{V} = \max\{V \in \Omega\}$ as the largest potential outcome of V , and \underline{V} as the lowest potential outcome of V that is considered acceptable (i.e., "successful") by the firm. Our conceptualization of the total project value shares similarities to an NK fitness landscape (Kauffman, 1993), which has been used to model complex performance values in the extant organizational behavior, strategic management, and innovation management literature (Levinthal & Warglien, 1999; Rivkin, 2000; Siggelkow & Rivken, 2005; Lenox *et al.*, 2007).

To complete each task of the initiative, either some minimal effort $e_i = L$, or significant effort $e_i = H$ can be exerted. Lower effort represents settings where lack of impetus takes place. Significant effort ($e_i = H$) results in a high valued contribution (v^H) with probability p_1 ; the equivalent probability through minimal effort ($e_i = L$) is p_0 . We assume $0 < p_0 \leq \frac{1}{2}$ and $p_0 < p_1 \leq 1$. Thus, the probability of a high valued outcome from low effort commitment is never greater than the likelihood

of a low outcome; and, the probability of a high valued outcome is higher with high effort commitment than low effort commitment. These assumptions about the value landscape allow us to capture an essential feature of strategy execution: there exist distinct, rank-ordered outcomes that depend stochastically on the stakeholders' efforts.

4.2.2 Organizational Structure

Strategic initiatives take place within organizations with a specific design, i.e., the hierarchical reporting structure among the different stakeholders. We consider two archetypical organizational structures to capture key trade-offs related to the execution of strategic initiatives. On one end, *functional* organizations rely on functional managers to foster functional expertise, yet are prone to interaction challenges between the stakeholders from different functions; i.e., hidden information between stakeholders regarding their true effort commitment to the project. Alternatively, *project-based* organizations trade-off functional expertise to mitigate the cross-functional interaction challenges through the use of dedicated project managers, who coordinate the stakeholders' efforts.

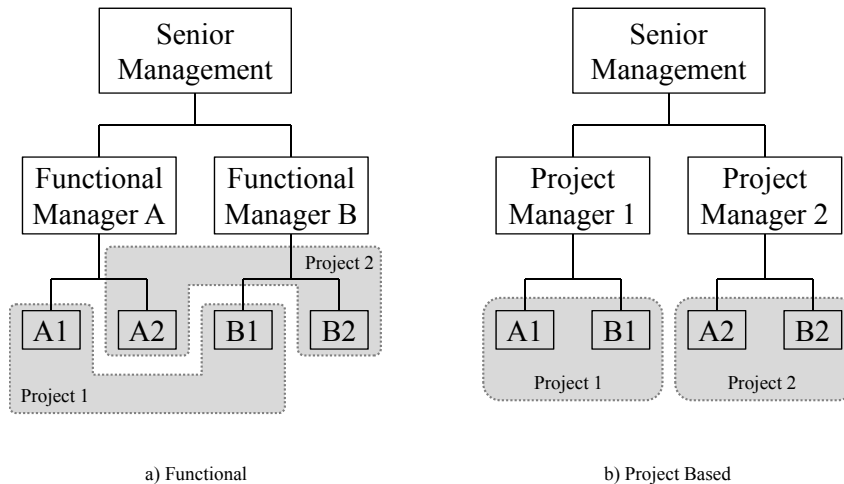


Figure 4.1: Organizational Structures

We conceptualize a functional organization as a setting where the multiple tasks required for project execution are each the responsibility of a different (functional) stakeholder, with an associated cost of high effort $C(e^H) = c_f$. We assume that low effort bears minimal cost, i.e., normalized to $C(e^L) = 0$. Project-based organizations, instead, engage dedicated managers that serve as an explicit coordinating mechanism between the functional stakeholders that execute the project tasks. These project managers ensure the project team coordinates their efforts, which cost $C(e^H) = c_p$ per task. The technical expertise provided by the functional managers (Hobday, 2000; Galbraith, 2008) and the cross-functional monitoring and coordination costs incurred by project managers (Tsai, 2002) makes the costs of effort different for the stakeholders of the two different organizational structures; i.e., $0 < c_f < c_p$ (Allen, 2001; Burgelman, 1983; Kavadias & Kovach, 2010). Functional (Project-Based) organizational structures are graphically represented in Figure 4.1a (4.1b), with A and B used to delineate two different technical specializations (e.g., marketing and engineering) and 1 and 2 used to delineate two different initiatives undertaken by the firm.

4.2.3 Definition of Success and Stakeholder Incentives

Senior management defines the target outcomes (i.e., subset of potential outcomes that are considered successful) and the respective incentive scheme to induce the execution of the initiative. Since Ω represents the set of all possible outcome realizations, we define $\Omega_N = \{V \in \Omega : V = \bar{V}\}$ as a narrowly specified subset that represents a *focused* definition of success, and $\Omega_B = \{V \in \Omega : V \geq \underline{V}\}$ as a broader set that accommodates a *flexible* definition. Therefore, we define $\Omega_N \subset \Omega_B \subseteq \Omega$. Through the incentive scheme, senior management *communicates* the set of successful outcomes (Ω_N or Ω_B). Figure 4.2 illustrates how the stakeholder's value contributions determine the landscape of potential outcomes of a strategic initiative (Ω), and how senior

management can use focused or flexible definitions of success to communicate which potential outcomes are acceptable (Ω_N or Ω_B).

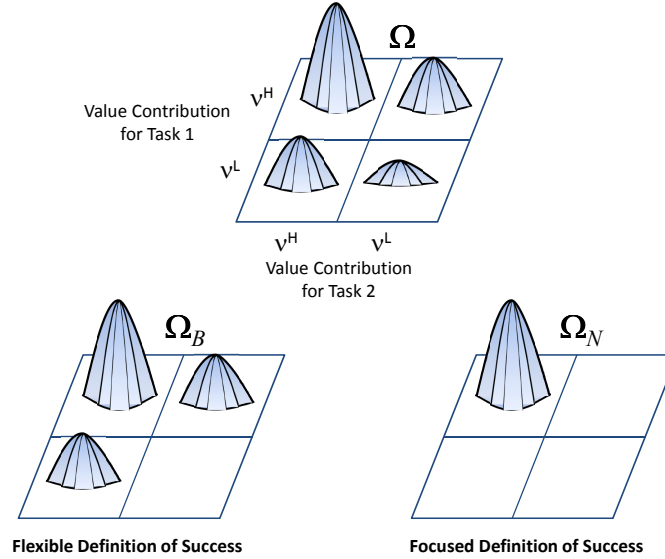


Figure 4.2: Defining Target Outcomes

We assume that the stakeholders are risk neutral and paid a fixed wage w for employment. Beyond this fixed wage, senior management offers a bonus $b(V, \Omega)$ to the stakeholders for the successful completion of the strategic initiative. $b(V, \Omega)$ is dependent on the definition of success and the final project value $V \in \Omega$. We consider bonus payments contingent on the successful completion of strategic initiatives as opposed to ownership equity of the project outcome. This is more consistent with current management practice and better captures intra-organizational incentive structures (Mihm, 2010). Additionally, we consider the stakeholders to have limited liability; i.e., senior management cannot offer negative bonuses should the project's outcome not meet the requirements specified. Both functional and project managers are paid a fixed wage for employment, which are comparable and therefore normalized

to zero without loss of generality. In exchange for the fixed wage, these middle managers either provide technical (in functional organizations) or project management (in project-based organizations) expertise. Technical expertise facilitates a lower cost of effort for stakeholders, whereas project management expertise facilitates coordination between stakeholders with different technical specializations. In summary, the combination of the defined target outcomes with the respective incentives achieves a dual role: they cascade senior management's vision through the communication of the initiative's success criteria, and ensure impetus from the stakeholders that are required for the execution.

4.2.3.1 Functional Organizational Structure Incentives.

Stakeholder expected utility is denoted with the f superscript in functional organizations, and determined as $E[U_i^f(e_i)] = \psi(e_i, \vec{e}_{-i}, b) + w - c(e_i)$, where ψ is the expected project bonus to the stakeholder based on: her dedicated effort towards task i , the effort dedicated to all other project tasks by the rest of the stakeholders \vec{e}_{-i} , and the compensation plan offered by the firm b . In functional organizations, senior management must ensure that each stakeholder will exert high effort on their task, irrespective of the effort committed by the other stakeholders. Let $E[U_i^f(e_i)] = g_i : \{H, L\} \times \{1, \dots, n\} \rightarrow \mathbb{R}$ where n is the total number of tasks required for project completion and $g_i(e_i, k)$ represents the stakeholder's utility when she chooses $e_i \in \{H, L\}$ and k other stakeholders choose H where $k \in \{0, 1, \dots, n-1\}$. Firm profits for functional organizations are $\Pi^f(b) = V(\vec{v}_i) - \sum_{i=1}^n b$; i.e., the total value of the project minus the bonuses paid for each of the n project tasks to the stakeholders. The senior manager's problem in a functional organization can be formalized as follows:

$$\max_{b \geq 0} \quad \Pi^f(b) = V(\vec{v}_i) - \sum_{i=1}^n b \quad (4.1f)$$

$$s.t. \quad g_i(H, k) \geq g_i(L, k) \quad \forall \{i, k\} \quad (4.2f)$$

$$E[U_i^f(e_i)] \geq w_0 = w \quad (4.3f)$$

$$e_i^* = \underset{e_i}{\operatorname{argmax}} \psi(e_i, \vec{e}_{-i}, b) + w - c(e_i) \quad \forall i \quad (4.4f)$$

Equation (4.1f) states the firm's profit maximization equation. The challenge of incentivizing stakeholder commitment in functional organizations is formalized in (4.2f), which ensures that each stakeholder would be better off if they chose to exert high effort rather than low effort, irrespective of the other stakeholders' choices. This additionally excludes the uninteresting cases where senior management would prefer any stakeholder to exert low effort ($e_i = L$) for their respective task. Each stakeholder's individual rationality constraint is formalized in (4.3f); on expectation, they will not receive a utility below their reservation utility w_0 (outside option for wages should they elect to not support in the project), which we normalize to the stakeholder's current wage w . Therefore, each stakeholder is, at worst, indifferent between working on this particular strategic initiative and employment elsewhere at their current wage w . Equation (4.4f) is the incentive compatibility constraint, and indicates that the stakeholders working on the project will choose their effort level as to maximize their expected utility.

4.2.3.2 *Project-Based Organizational Structure Incentives.*

Project-based organizations alleviate the hidden information problems associated with stakeholder dynamics that are present in functional organizations through the explicit involvement of project managers. Through the use of team meetings and communication exchanges, a project manager ensures (as part of her job duties) a common information context among all the project stakeholders. As such, the utility for each of the stakeholders in the team can be maximized with full knowledge of the other stakeholder's effort allocation decisions. In essence, the project manager allows the various stakeholders to function as a singular team where the individual

stakeholders have fully aligned objectives (Groves, 1973). Therefore, senior management induces high effort from each of the stakeholders through performance incentives considering the total utility for all of the stakeholders. The expected utility for all of the stakeholders (the team) is denoted with the p superscript, and determined as $E[U^p(\vec{e})] = \psi(\vec{e}, b) + \sum_{i=1}^n w - c(\vec{e})$; where ψ is the total expected bonus to the team based on the effort allocation decision for each of the tasks and \vec{e} is the vector describing the effort allocation for each of the tasks. In project-based organizations, senior management must incentivize the team to exert high effort on all of the project tasks and not some smaller subset thereof.

Let $E[U^p(\vec{e})] = h_i : \{H, L\} \times \{1, \dots, n\} \rightarrow \mathbb{R}$ where n is the total number of tasks required for project completion such that $h_i(e_i, m)$ represents the team's utility when the team exerts $e_i \in \{H, L\}$ for task i and H for some of the m other tasks where $m \in \{0, 1, \dots, n-1\}$. Firm profits for project-based organizations are $\Pi^p(b) = V(\vec{v}_i) - b$, which is simply the value of the project minus a bonus paid to project team. Note that the bonus b serves as compensation for all project tasks $i \in [1, 2, \dots, n]$. The senior manager's problem in a project-based organization can be formalized as follows:

$$\max_{b \geq 0} \quad \Pi^p(b) = V(\vec{v}_i) - b \quad (4.1p)$$

$$s.t. \quad h_i(H, m) \geq h_i(L, m) \quad \forall \{i, m\} \quad (4.2p)$$

$$E[U^p(\vec{e})] \geq \sum_{i=1}^n w_0 = \sum_{i=1}^n w \quad (4.3p)$$

$$\vec{e}^* = \operatorname{argmax}_{\vec{e}} \quad \psi(\vec{e}, b) + \sum_{i=1}^n w - c(\vec{e}) \quad (4.4p)$$

Equation (4.1p) states the firm's profit maximization equation. The condition guaranteeing high effort allocation for all of the tasks is formalized in (4.2p). The project team receives a higher utility (in expectation) if they exert high effort on all of the tasks and not some smaller subset thereof. This constraint is similar to (4.2f) for functional organizations in 4.2.3.1, which explicitly excludes situations where the firm would employ a stakeholder responsible for a task on an initiative, yet prefer

that they not fully commit to the project. The stakeholder’s individual rationality constraint is formalized in (4.3p); on expectation, they will not receive a utility below their reservation utility w_0 , which we normalize to the stakeholder’s current wage w . Equation (4.4p) is the incentive compatibility constraint, and indicates that the project team (guided by the project manager) will choose the effort level for each of the necessary project tasks in such a way as to maximize the team’s total expected utility.

4.2.4 Decision Sequence

For a given organizational structure, senior management must first determine if any potential value V in the value landscape Ω of the project is sufficient to incentivize the stakeholders to commit to the initiative. Next, the bonuses b are determined for each potential outcome of the project $V \in \Omega$ and communicated to the stakeholders. This defines the set of successful outcomes (Ω_N or Ω_B) and conveys the objectives of the strategic initiative to the stakeholders. Then, the stakeholders determine the level of effort they wish to exert on the project tasks. We consider the effort allocation decisions for each task to occur simultaneously. This can be equally interpreted as decisions occurring sequentially, without any information about them being verified during the process (i.e. imperfect or hidden information in a sequential game) unless a project manager is employed to coordinate the efforts² (Van den Steen, 2012).

Once the project is completed, the final project value $V(\vec{v}_i)$ is realized. If the project is considered successful (per the initial definition of success), the firm compensates the stakeholders accordingly. If $V \notin \Omega_j$ for $j \in \{N, B\}$ then the project is viewed as a failure by the firm (and stakeholders). It is assumed that all of the

²This structure allows us to capture the fact that in functional organizations, it is difficult, if not impossible, for stakeholders to verify the effort allocation decisions from other stakeholders. Dedicated project managers represent a credible mechanism for such cross effort validation in project-based organizations.

potential project values $V \in \Omega$ are common knowledge *a priori*.

4.3 Model Analysis

In our analysis, we consider initiatives that require two distinct tasks for completion ($n = 2$). This implies that a single project executed in a firm involves two stakeholders, each responsible for one of the two tasks. Then, either H or L effort must be exerted towards the two project tasks by each of the stakeholders, with stochastically resulting contributions v^H or v^L for each.

We specify $\Omega = \{f(v^H, v^H), f(v^H, v^L), f(v^L, v^H), f(v^L, v^L)\}$, where $f(v^H, v^H) > f(v^H, v^L) = f(v^L, v^H) > f(v^L, v^L)$. To simplify notation, we define $f(v^H, v^H) = f_h$, $f(v^H, v^L) = f(v^L, v^H) = f_l$, and $f(v^L, v^L) = f_x$. The bonuses offered to the stakeholders are defined as $\vec{b} = \{b_h, b_l, b_x\}$, respectively. Additionally, \vec{b} is dependent on both the organizational structure of the firm and definition of success. We define $\underline{V} = f_l$, such that f_x outcomes are never acceptable to the firm. Further, we define a focused definition of success as only allowing a project outcome $\bar{V} = f_h$, such that f_h is the only element in Ω_N . Lastly, we define a flexible definition of success as $\Omega_B = \{f_h, f_l\}$, such that f_l outcomes are additionally considered successful.

We focus our analysis on the definition of success for strategic initiatives under different organizational settings, and therefore we assume away confounding idiosyncratic effects from stakeholders or tasks. Therefore, we assume that the stakeholders have symmetric capabilities in task execution and each task poses comparable challenges; thus, the only differences between the costs of effort (c_f and c_p) stem from the organizational structure. Finally, we assume that senior management cannot distinguish the effective contributions from each task; therefore they cannot differentiate compensation amongst the stakeholders. Thus, in the event that $V(\vec{v}_i) < \bar{V}$, senior management cannot determine which tasks contributed v^L instead of v^H to $V(\vec{v}_i)$, and therefore they must pay the same bonus to all of the project stakeholders

(Jones, 1984). Still, senior management can offer differentiated bonuses $b(V, \Omega)$ for each specific outcome value $V(\vec{v}_i) \in \Omega$.

We define a measure for each stakeholder's certainty of contributing high value towards the initiative outcome by considering the marginal benefit from high effort.

Definition 4.1. A MEASURE OF UNCERTAINTY

The marginal benefit from high effort $p_1 - p_0 = \Delta$ is a measure of the certainty that high effort yields a valuable project contribution. \boxtimes

From this definition of Δ , projects with a lower Δ exhibit more uncertainty than those with a higher Δ . Said differently, the projects of higher uncertainty are characterized by a lower Δ and exhibit a larger disconnect between effort and outcome. As p_0 decreases, then a lack of effort is more likely to not contribute value to the project; whereas when p_1 increases, then effort commitment is more likely to contribute value. Since Δ increases whenever p_0 decreases or p_1 increases, the overall certainty that stakeholder effort will result in a high value contribution is increasing in Δ .

First we investigate firms with functional organizational structures. This is represented as a multi-agent problem where each agent performs a singular task. Then, we follow with the analysis of project-based organizational structures. We represent these project teams as a single agent with multiple tasks. Last, we compare the optimal definitions of success (target outcomes) and the associated incentive plans that achieve stakeholder impetus.

4.3.1 Functional Organizational Structures

Definition 4.2 describes the general structure of the incentive plan for functional organizations given both focused and flexible definitions of success, which communicate the project outcomes that are considered acceptable to the firm³.

³For notational clarity in the remaining analysis, we use $X|_Y$ to describe X given the condition Y . For example, $\vec{b}|_{\Omega_N}$ means the vector of bonuses \vec{b} given a focused definition of success, $V \in \Omega_N$.

Definition 4.2. COMMUNICATING TARGET OUTCOMES IN FUNCTIONAL ORGANIZATIONS

$f_x \notin \{\Omega_N, \Omega_B\}$ and $f_l \notin \Omega_N$, therefore:

$$\vec{b}|_{\Omega_N} = \{b_h \geq c_f, b_l = 0, b_x = 0\} \text{ and } \vec{b}|_{\Omega_B} = \{b_h \geq c_f, b_l \geq c_f, b_x = 0\}. \boxtimes$$

Definition 4.2 indicates that since f_x outcomes are never acceptable to the firm, $b_x = 0$ for both focused and flexible definitions of success (i.e., no bonus is paid to the stakeholders for an f_x outcome). Additionally, since f_h outcomes are acceptable for both focused and flexible definitions, $b_h \geq c_f$. Lastly, since f_l outcomes are only acceptable for flexible definitions, we have $b_l \geq c_f$ when flexible definitions are specified, but $b_l = 0$ for focused definitions. Definition 4.2 elucidates how the firm uses performance incentives to communicate the objectives of an initiative to the stakeholders. Given this framework, we can now identify the optimal incentive structure offered to the stakeholders, given either a focused or flexible definition of success.

Proposition 4.1. FUNCTIONAL ORGANIZATION INCENTIVE STRUCTURE

In functional organizations, the optimal incentive structure depends on the relationship between Δ and p_0 , as follows:

$$\text{If } \Delta > p_0: \vec{b}|_{\Omega_N} = \{b_h = \frac{c_f}{p_0\Delta}, b_l = 0, b_x = 0\}, \vec{b}|_{\Omega_B} = \{b_h = \frac{2c_f}{\Delta}, b_l = \frac{c_f}{\Delta}, b_x = 0\}.$$

$$\text{If } \Delta \leq p_0: \vec{b}|_{\Omega_N} = \{b_h = \frac{c_f}{p_0\Delta}, b_l = 0, b_x = 0\}, \vec{b}|_{\Omega_B} = \{b_h = c_f \left(2 + \frac{1-\Delta}{p_0\Delta}\right), b_l = c_f, b_x = 0\}.$$

With a focused definition of success in functional organizations, senior management offers a bonus $b_h = \frac{c_f}{p_0\Delta}$ to maximize firm profits ($\Pi^f|_{\Omega_N} = f_h - 2b_h$) when the highest potential outcome is realized, and offers no bonuses for all other outcome realizations. As expected, the bonus offered for $V = f_h$ outcomes increases in uncertainty with a focused definition of success; i.e., $\frac{\partial b_h}{\partial \Delta} < 0$. With a flexible definition of success, the incentive structure that maximizes expected firm profits in

equilibrium ($E[\Pi^f]_{|\Omega_B} = p_1^2(f_h - 2b_h) + 2p_1(1 - p_1)(f_l - 2b_l)$) depends on the relationship between Δ and p_0 . If $\Delta > p_0$, then project uncertainty is low compared to the likelihood of task success from low effort. This results in an incentive structure of $b_h = \frac{2c_f}{\Delta}$, $b_l = \frac{c_f}{\Delta}$, and $b_x = 0$. Alternatively, if $\Delta \leq p_0$, then project uncertainty is high compared to the likelihood of task success from low effort. For these more uncertain projects, senior management offers high powered incentives for $V = f_h$ outcomes and low powered incentives for $V = f_l$ outcomes. Specifically, for these more uncertain projects $b_h = c_f \left(2 + \frac{1-\Delta}{p_0\Delta}\right)$, $b_l = c_f$, and $b_x = 0$.

It is important to note that for high uncertainty projects, a flexible definition of success shapes the respective incentive structure to exhibit two interesting properties: (i) the spread between bonuses for $V = f_h$ and $V = f_l$ outcomes is larger for high uncertainty projects than for low uncertainty projects ($b_h|_{\Delta \leq p_0} > b_h|_{\Delta > p_0}$ and $b_l|_{\Delta \leq p_0} < b_l|_{\Delta > p_0}$), and (ii) the bonuses offered for $V = f_l$ outcomes are independent of the uncertainty ($b_l|_{\Delta \leq p_0} = c_f$). This means that if a certain threshold for project uncertainty is exceeded ($\Delta \leq p_0$), then the firm benefits from an incentive structure that increases the bonuses offered for the *a priori* best outcome, but decreases the bonuses offered for the *a priori* secondary outcomes. In other words, the firm rewards a secondary outcome, but only as a means to guarantee stakeholder impetus in the hopes that the best outcome is realized. Thus, secondary outcomes offer an “insurance” mechanism to the stakeholders, so that they will bear the risk and exert effort to achieve the best outcome. Our finding bears managerial significance as it offers intuition regarding the value of an approach that tolerates secondary outcomes, which under certain circumstances might be viewed as failure; i.e., when a focused definition of success is used. In our setting, a flexible definition of success captures such a tolerance for failure. We show that under certain settings (cross-functional teams in functional organizations), tolerance for failure might be the most beneficial avenue to pursue risky strategic initiatives. Manso (2011) identifies conditions that

render tolerance for failure beneficial when structuring multi-period incentives for a single stakeholder. Our analysis finds benefits when structuring the incentives for multiple stakeholders for a single period.

We further compare the incentives associated with focused and flexible definitions of success to determine which initiatives can be pursued in functional organizations.

Definition 4.3. THE SET OF FEASIBLE INITIATIVES FOR FUNCTIONAL ORGANIZATIONS

There exist cost of effort thresholds $\underline{c}_f(f_h, \Delta, p_0)$ and $\overline{c}_f(f_h, \Delta, p_0)$ such that for all $c_f < \underline{c}_f$: $(f_h - 2b_h)|_{\Omega_N} > 0$ and for all $c_f < \overline{c}_f$: $(f_h - 2b_h)|_{\Omega_B} > 0$. Let $a_f(c_f; f_l, f_h, \Delta, p_0)$ represent a potential initiative for a functional organization and \mathbb{F} be the finite and compact set of all of the potential initiatives. Therefore, $\mathbb{F}_N = \{a_f \in \mathbb{F} : c_f \leq \underline{c}_f\}$ and $\mathbb{F}_B = \{a_f \in \mathbb{F} : c_f \leq \overline{c}_f\}$ represent the sets of all initiatives that can be pursued with focused or flexible definitions of success, respectively. \boxtimes

The set of feasible initiatives allows us to capture an additional metric for strategy execution. In addition to managing the success (profits) from each initiative, it is often important from a strategic viewpoint that senior management has the ability to pursue a wide range of initiatives; i.e., a broad portfolio of potential initiatives. Definition 4.3 outlines the conditions for which initiatives can be profitably pursued by a functional organization with focused and flexible target outcomes.

Proposition 4.2. THE DEFINITION OF SUCCESS AND THE SET OF FEASIBLE INITIATIVES

For a functional organization, the set of feasible initiatives are ordered as follows:
 $\mathbb{F}_N \subset \mathbb{F}_B \subset \mathbb{F}$.

Proposition 4.2 indicates that functional organizations can pursue more initiatives through a flexible definition of success than a focused definition, which results from the higher bonuses for $V = f_h$ outcomes associated with focused definitions

($b_h|_{\Omega_N} > b_h|_{\Omega_B}$). When the stakeholders' costs of effort are low ($c_f < \underline{c}_f$), initiatives can be pursued with either focused or flexible definitions of success. When $\underline{c}_f < c_f < \bar{c}_f$, stakeholders' costs of effort are sufficiently high such that focused definitions of success cannot be profitably pursued since the bonus offered exceeds the project value; whereas, when $c_f > \bar{c}_f$, the stakeholders' costs of effort are so high that neither focused nor flexible definitions of success can be specified to ensure stakeholder impetus and guarantee profitable returns. Since riskier (i.e., more radical) initiatives tend to be of higher cost, Proposition 4.2 indicates that in addition to allowing the pursuit of more initiatives, flexible definitions also allow senior management to pursue more challenging initiatives; i.e, "long shot" projects with higher risks or costlier efforts. Managerially, this implies that in functional organizations, a culture of focused definitions of success may unintentionally limit the types of initiatives a firm can profitably pursue. Said differently, senior management's effort to focus stakeholder attention to the best possible outcome may "backfire", and lead to a total lack of impetus for some initiatives.

Since flexible definitions allow *a priori* lower valued $V = f_l$ project outcomes to be considered as successful, the overall firm expected profits need to be compared between focused and flexible definitions of success.

Proposition 4.3. THE DEFINITION OF SUCCESS IN FUNCTIONAL ORGANIZATIONS

A focused definition of success is optimal ($E[\Pi^f]|_{\Omega_N} > E[\Pi^f]|_{\Omega_B}$) if and only if:

$$\frac{f_l p_0 (1 - p_0 - \Delta)}{p_0 - \Delta} < c_f < \frac{1}{2} f_h p_0 \Delta \quad \text{and} \quad \Delta < p_0.$$

Proposition 4.3 outlines conditions that describe when it is more beneficial to employ a focused definition of success than a flexible one in functional organizations. While neither focused nor flexible definitions of success are universally optimal, flexible definitions are more profitable under a wider range of conditions. When the cost of stakeholder effort is relatively low ($c_f < \frac{f_l p_0 (1 - p_1)}{p_0 - \Delta}$) and the uncertainty relatively

high ($\Delta < p_0$), then focused definitions required increased incentives, which get further amplified for higher levels of uncertainty. When the cost of stakeholder effort is high ($c_f > \frac{1}{2}f_h p_0 \Delta$) and uncertainty is high ($\Delta < p_0$), then the costs to incentivize stakeholder impetus becomes prohibitively high to undertake the initiative. Finally, when uncertainty is low ($\Delta > p_0$), the profit from an initiative with a focused definition of success never dominates the expected profits from the same initiative with a flexible definition.

The analysis points out that the stakeholder interactions in functional organizations give rise to significant indirect costs. These interactions require sizeable incentives to ensure impetus with focused definitions of success; the presence of hidden information regarding the other stakeholders' effort commitment contributes to the increased incentives. In contrast, flexible definitions alleviate the stakeholders' consequences from hidden information. Therefore, even when there is considerable certainty that stakeholder efforts contribute value to an initiative, the indirect costs associated with the stakeholder's strategic interactions may render a project less profitable with a focused definition of success. Flexible definitions allow the potential for lower incentives to induce impetus, which may result in higher firm profits, despite the lower value of secondary project outcomes that may be admitted.

Figure 4.3 shows when focused or flexible target outcomes are preferred under functional organizational structures, contingent on the measure of project uncertainty in the x axis (Δ), and the measure of the proportional value from secondary outcomes in the y axis ($\frac{f_l}{f_h}$). Recall that lower values of Δ indicate higher uncertainty. Eventually, the high powered incentives required to guarantee impetus from stakeholders who strategically interact lead to limited conditions where focused definitions of success are beneficial. Specifically, focused definitions of success are only preferred if there is moderate uncertainty and the value of f_l outcomes is significantly less than that of f_h outcomes; i.e., settings where there is a clearly superior outcome among all the

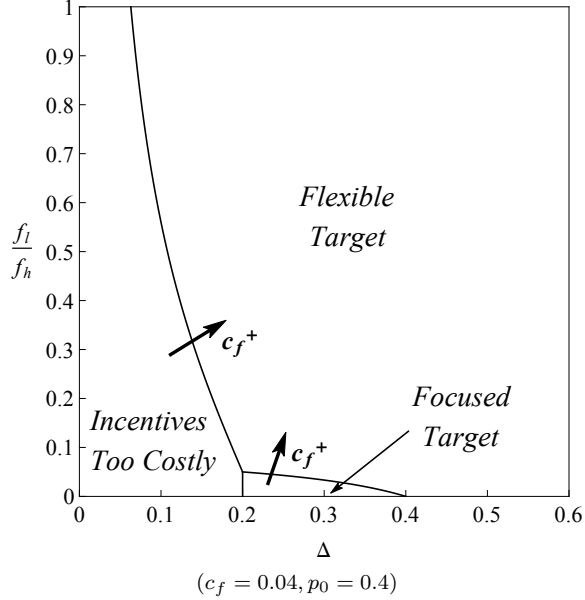


Figure 4.3: Functional Organizational Structure

value scenarios in the landscape.

Corollary 4.1. DEFINITIONS OF SUCCESS UNDER ADDITIVE VALUE CONTRIBUTIONS

In functional organizations, focused definitions of success are never optimal when the stakeholders' contributions to project value are additive.

Corollary 4.1 states an interesting conclusion based on the findings from Proposition 4.3. If the stakeholder contributions to the total project value are additive (a strong form of effort substitutability often assumed in the literature), then $\frac{f_l}{f_h} \in (\frac{1}{2}, 1)$ (see Appendix for the formal claim). Under this range of the *a priori* secondary project outcomes ($V = f_l$), focused definitions of success are never optimal. Therefore, the definition of success for initiatives with additive value contributions benefit from flexibility.

Proposition 4.4. COST IMPLICATIONS IN FUNCTIONAL ORGANIZATIONS

Let $F(c_f, \Delta, \frac{f_l}{f_h})$ define the boundary condition $E[\Pi^f]_{\Omega_B} = 0$: $\frac{F_{\Delta}}{F_{c_f}} > 0$ and $\frac{F_{\frac{f_l}{f_h}}}{F_{c_f}} > 0$.

Let $G(c_f, \Delta, \frac{f_l}{f_h})$ define the boundary condition $E[\Pi^f]_{\Omega_B} = E[\Pi^f]_{\Omega_N} : \frac{G_\Delta}{G_{c_f}} > 0$
and $\frac{G_{\frac{f_l}{f_h}}}{G_{c_f}} > 0$.

Proposition 4.4 formally indicates that as the cost of effort in functional organizations increases, the conditions in which focused definitions of success are most beneficial become more constrained. In addition, as expected, more initiatives are considered infeasible and not pursued. The partition (defined by $F(c_f, \Delta, \frac{f_l}{f_h})$) between the regions where incentives are too costly, and where flexible definitions are optimal, is shifted upwards and to the right. Additionally, the range of conditions that render focused definitions of success optimal decreases, as the partition between the regions where flexible or focused definitions are optimal from Figure 4.3 is shifted upwards and to the right (defined by $G(c_f, \Delta, \frac{f_l}{f_h})$); still bound from the right by $\Delta < p_0$. The shifts in partitions between these regions as the cost of effort increases are illustrated by the c_f^+ arrows in Figure 4.3. Proposition 4.4 highlights the fact that as costs increase, flexible definitions of success become more preferred to focused definitions in functional organizations.

4.3.2 Project-Based Organizational Structures

In project-based organizations, project managers are able to coordinate the various stakeholders' actions such that they function as a singular team. Therefore, project managers are able to alleviate the horizontal hidden information problem amongst the stakeholders. However, information asymmetry still exists vertically between the team and senior management. Senior managers must incentivize the team to exert high effort for each of the project tasks and not some smaller subset thereof. Definition 4.4 describes the general properties of the incentive plan for project-based organizations considering both focused and flexible definitions of success.

Definition 4.4. COMMUNICATING TARGET OUTCOMES IN PROJECT-BASED ORGANIZATIONS

$f_x \notin \{\Omega_N, \Omega_B\}$ and $f_l \notin \Omega_N$ therefore

$$\vec{b}|_{\Omega_N} = \{b_h \geq 2c_p, b_l = 0, b_x = 0\}, \vec{b}|_{\Omega_B} = \{b_h \geq 2c_p, b_l \geq c_p, b_x = 0\}. \boxtimes$$

Definition 4.4 echoes Definition 4.1 and indicates that no bonus should be paid for f_x project outcomes, (i.e., $b_x = 0$ if $V = f_x$, as these outcomes are never acceptable to the firm). The compensation b_h for f_h outcomes serves to compensate the team for both project tasks, for both focused and flexible definitions of success. Lastly, since f_l outcomes are only acceptable for flexible definitions, we have $b_l \geq c_p$ when flexible definitions are specified but $b_l = 0$ for focused definitions. Given this framework, we can now identify the optimal incentive structure offered to the team in project-based organizational structures, given either a focused or flexible definition of success.

Proposition 4.5. PROJECT-BASED ORGANIZATION INCENTIVE STRUCTURE

In project-based organizations, the optimal incentive structure is:

$$\vec{b}|_{\Omega_N} = \{b_h = \frac{2c_p}{\Delta(2p_0+\Delta)}, b_l = 0, b_x = 0\}, \vec{b}|_{\Omega_B} = \{b_h = \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)}, b_l = c_p, b_x = 0\}.$$

With a focused definition of success, senior management in project-based organizations offers a bonus $b_h = \frac{2c_p}{\Delta(2p_0+\Delta)}$ to maximize firm profits ($\Pi^p|_{\Omega_N} = f_h - b_h$) when the highest potential outcome is realized. They offer no bonus for all other outcome realizations. As expected, $\frac{\partial b_h}{\partial \Delta} < 0$, indicating that the bonus offered for $V = f_h$ outcomes increases in uncertainty with focused definitions of success. With a flexible target outcome, the incentive plan $\vec{b}|_{\Omega_B} = \{b_h = \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)}, b_l = c_p, b_x = 0\}$ maximizes expected firm profits in equilibrium ($E[\Pi^p]|_{\Omega_B} = p_1^2(f_h - b_h) + 2p_1(1 - p_1)(f_l - b_l)$). Unlike the case with functional organizations, there is a singular incentive plan for flexible definitions of success in project-based organizations. Yet, the bonus offered for secondary outcomes only covers the cost of effort, a similar result obtained in functional organizations. Thus, senior management accepts these lower valued outcomes

only as a means to potentially reduce the bonuses associated with $V = f_h$ outcomes. Once more, we see that flexible definitions of success serve as an indication from senior management of a relatively tolerant for failure organizational environment.

We further compare the incentives associated with focused and flexible definitions of success to determine which initiatives can be pursued in project-based organizations.

Definition 4.5. THE SET OF FEASIBLE INITIATIVES FOR PROJECT-BASED ORGANIZATIONS

There exist cost of effort thresholds $\underline{c}_p(f_h, \Delta, p_0)$ and $\overline{c}_p(f_h, \Delta, p_0)$ such that for all $c_p < \underline{c}_p: (f_h - 2b_h)|_{\Omega_N} > 0$ and for all $c_p < \overline{c}_p: (f_h - 2b_h)|_{\Omega_B} > 0$. Let $a_p(c_p; f_l, f_h, \Delta, p_0)$ represent a potential initiative for a project-based organization and \mathbb{P} be the finite and compact set of all of the potential initiatives. Therefore, $\mathbb{P}_N = \{a_p \in \mathbb{P} : c_p \leq \underline{c}_p\}$ and $\mathbb{P}_B = \{a_p \in \mathbb{P} : c_p \leq \overline{c}_p\}$ represent the sets of all potential initiatives that can be pursued with a focused or flexible definition of success, respectively. \boxtimes

Definition 4.5 defines the conditions for which initiatives can be profitably pursued by a project-based organization with focused and flexible target outcomes.

Proposition 4.6. THE DEFINITION OF SUCCESS AND THE SET OF FEASIBLE INITIATIVES

For a project-based organization, the set of feasible initiatives are ordered as follows:

if $p_0 < 1 - p_1$ then $\mathbb{P}_N \subset \mathbb{P}_B \subset \mathbb{P}$; else, if $p_0 \geq 1 - p_1$ then $\mathbb{P}_B \subset \mathbb{P}_N \subset \mathbb{P}$.

Proposition 4.6 for project-based organizational structures conveys an important insight when accounted together with Proposition 4.2. Specifically, in functional organizations, focused definitions of success always result in higher bonuses for $V = f_h$ outcomes (b_h) compared to flexible definitions; the same is not always true for project-based organizations. In project-based organizations, whether the bonus b_h is higher

with focused or flexible definitions depends on the relative magnitude between the likelihoods of a high-value contribution from low effort (p_0) and a low-value contribution from high effort ($1 - p_1$). In other words, it depends on the size of the type I or type II “errors” regarding the outcome from effort; e.g. high contribution from low effort or low contribution from high effort. When the likelihood of a low-value contribution from high effort dominates that of a high-value contribution from low effort ($p_0 < 1 - p_1$), the sets of feasible initiatives are ordered like those in functional organizations; as the costs of effort increase, more initiatives can be undertaken with flexible definitions of success than with focused definitions. However, when the likelihood of a high-value contribution from low effort dominates ($p_0 \geq 1 - p_1$), the order reverses. This is because the bonuses required to ensure impetus with flexible definitions of success exceed those required with focused definitions. Interestingly, this relationship ($p_0 \geq 1 - p_1$) is strengthened as either p_0 or p_1 increase, indicating a higher likelihood that a high value contribution will be achieved from either low or high effort. Therefore, as the probability of a high outcome increases, flexible definitions of success result in higher bonuses and a smaller set of feasible initiatives than focused ones. Thus, the possibility of some compensation for $V = f_l$ outcomes makes it more difficult to induce effort commitment on all of the tasks. In order to provide enough incentive to induce effort on all of the project tasks, the bonus for $V = f_h$ outcomes must be increased beyond the levels offered by senior management for focused definitions. This observation uncovers a very fundamental difference in the role of flexible (or more tolerant for lower outcomes) definitions. Flexible definitions of success communicate some tolerance for failure in functional organizations, which results in an overall increase in firm profits; yet, the same is not obvious for project-based organizations. Such tolerance may encourage intentional under-investment in effort (shirking), as the team “hedges” their effort allocation due to the high likelihood of a valuable contribution from low efforts, which results in increased incentives to achieve

impetus on all of the project tasks.

Next, we compare the overall firm expected profits between focused and flexible definitions of success. We identify conditions when each definition might be *ex ante* more profitable for the firm.

Proposition 4.7. THE DEFINITION OF SUCCESS IN PROJECT-BASED ORGANIZATIONS

A focused definition of success is optimal ($E[\Pi^p]_{\Omega_N} > E[\Pi^p]_{\Omega_B}$) if and only if:

$$\frac{f_l}{p_0}(1 - p_0 - \Delta)(2p_0 + \Delta) < c_p < \frac{1}{2}f_h\Delta(2p_0 + \Delta).$$

Proposition 4.7 states the conditions for when focused definitions of success are more beneficial than flexible definitions in project-based organizations. When the stakeholders' costs are relatively high ($c_p > \frac{1}{2}f_h\Delta(2p_0 + \Delta)$), then the incentives required to guarantee impetus on both tasks are too costly with narrowly defined, focused target outcomes. When the costs are relatively low ($c_p < \frac{f_l}{p_0}(1 - p_0 - \Delta)(2p_0 + \Delta)$), the expected profits with a flexible definition of success are higher than with a focused definition, even though lower valued outcomes (f_l) are considered acceptable. When costs are low, the incentives required to ensure stakeholder impetus are relatively lower as well; therefore, the additional costs associated with flexible target outcomes are mitigated by the additional revenue from lower value outcomes. Figure 4.4 indicates when focused or flexible definitions of success are preferred with project-based organizational structures, with Δ for the x axis, and $\frac{f_l}{f_h} \in (0, 1)$ for the y axis.

As shown in Figure 4.4 for project-based organizations, high uncertainty (low Δ) makes it too costly to incentivize initiatives and guarantee impetus. Unlike the result for functional organizational structures, with low uncertainty (high Δ), focused definitions of success are more beneficial. When uncertainty is low, the incentives required to guarantee impetus on both project tasks with focused definitions are sufficiently low such that secondary project outcomes (f_l) from flexible definitions should not be accepted. Specifically, the bonuses awarded for $V = f_h$ outcomes

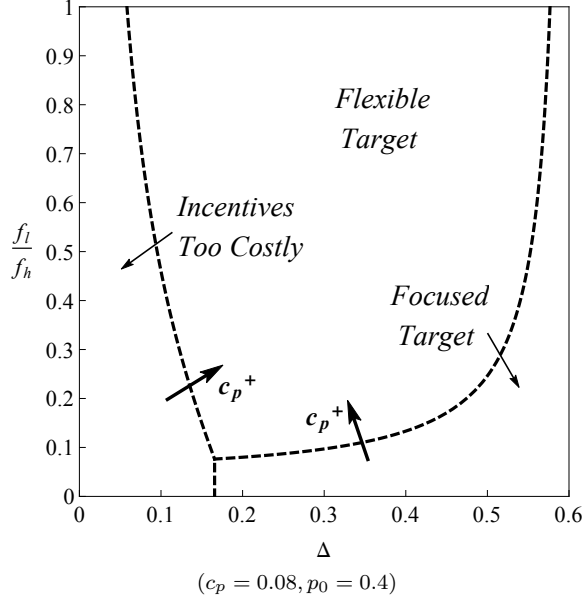


Figure 4.4: Project-Based Organizational Structure

are increasing at a faster rate with flexible definitions than focused definitions as uncertainty is reduced, thus making focused definitions of success more beneficial for low uncertainty initiatives; i.e., $\frac{\partial b_h|\Omega_B}{\partial \Delta} > \frac{\partial b_h|\Omega_N}{\partial \Delta}$. When there is moderate uncertainty, focused definitions of success are preferred only when the relative value of $V = f_l$ outcomes is low compared to $V = f_h$ outcomes.

Proposition 4.8. COST IMPLICATIONS IN PROJECT-BASED ORGANIZATIONS

Let $X(c_p, \Delta, \frac{f_l}{f_h})$ define the boundary condition $E[\Pi^p]|\Omega_B = 0$: $\frac{X_\Delta}{X_{c_p}} > 0$ and $\frac{X_{\frac{f_l}{f_h}}}{X_{c_p}} > 0$.

Let $Y(c_p, \Delta, \frac{f_l}{f_h})$ define the boundary condition $E[\Pi^p]|\Omega_B = E[\Pi^p]|\Omega_N$: $d\frac{Y_\Delta}{Y_{c_p}} < 0$ and $\frac{Y_{\frac{f_l}{f_h}}}{Y_{c_p}} > 0$.

Proposition 4.8 formalizes how the relative dominance of flexible and focused definitions of success are influenced by stakeholder costs. As the cost of effort in project-based organizations increases, the conditions in which flexible definitions of success are most beneficial are diminished. As a result, more initiatives are considered

unprofitable and not undertaken (i.e., $X(c_p, \Delta, \frac{f_l}{f_h})$ defining the partition between the regions where incentives are too costly and where flexible definitions are optimal from Figure 4.4 is shifted upwards and to the right) or, initiatives that are undertaken are more profitable through focused definitions of success (i.e., $Y(c_p, \Delta, \frac{f_l}{f_h})$ defining the partition between the regions where flexible definitions or focused definitions are optimal from Figure 4.4 is shifted upwards and to the left). The shifts in partitions between these regions $\left(X(c_p, \Delta, \frac{f_l}{f_h}) \text{ and } Y(c_p, \Delta, \frac{f_l}{f_h})\right)$ as the cost of effort increases are illustrated by the c_p^+ arrows in Figure 4.4. In summary, as the costs of effort and coordination increase in project-based organizations, the benefits from focused definitions of success dominate those from more broadly defined, flexible target outcomes.

4.3.3 Comparing Organizational Structures

A visual comparison between figures 4.3 and 4.4 indicates that the same initiative can be undertaken through entirely different definitions of success in different organizational structures. Said differently, this observation bears significant managerial attention: *the organizational design affects the definition of what constitutes a successful outcome for an initiative.* More specifically, when uncertainty is low (high Δ), focused definitions of success are more beneficial in project-based organizations, whereas flexible definitions are more beneficial in functional organizations. Table 1 summarizes the range of target outcomes, contingent on the initiative's uncertainty and the relative value of *a priori* secondary outcomes.

In addition, we compare the expected profits between the different organizational structures for focused and flexible definitions of success.

Corollary 4.2. FUNCTIONAL VS. PROJECT-BASED ORGANIZATION PROFITS

If $\frac{c_p}{c_f} > \left(1 + \frac{p_1}{p_0}\right)$ then $E[\Pi^f]_{\Omega_N} > E[\Pi^p]_{\Omega_N}$. If $\frac{c_p}{c_f} > (1 + \alpha)$ then $E[\Pi^f]_{\Omega_B} > E[\Pi^p]_{\Omega_B}$, where $\alpha(p_1, p_0) \in [1, 2]$.

Corollary 4.2 outlines when initiatives are more profitably managed by functional

Table 4.1: Interplay Between Definition of Success and Organizational Structure

		Project Uncertainty	
		<i>Low</i>	<i>High</i>
Project Value	$\frac{f_L}{f_H} = High$	Focused for Project-Based Flexible for Functional	Flexible
Landscape	$\frac{f_L}{f_H} = Low$	Focused	None

or project-based organizations, given the definition of success. With focused definitions of success, functional organizations are preferred if the relative costs of effort between project-based and functional organizations is above a threshold: $\frac{c_p}{c_f} > \left(1 + \frac{p_1}{p_0}\right)$, where $\frac{p_1}{p_0} > 1$ since $p_1 > p_0$. This condition can be rewritten in terms of Δ to better explain how project uncertainty determines the preferable organizational structure. If focused definitions are specified and uncertainty is high $\left(\Delta < p_0\left(\frac{c_p}{c_f} - p_0\right)\right)$, then initiatives in functional organizations are more profitable than those in project-based organizations. This implies that there are conditions where functional (project-based) organizational structures are preferred for strategic initiatives with high (low) uncertainty. This result indicates that when the incentives required to ensure impetus are explicitly accounted for, then prior theory suggesting the need for organizational structures with more centralized decision authority (as it is the case with project-based organizations in our model) may be incomplete in the case of projects with high uncertainty (Hobday, 2000; Siggelkow & Rivken, 2005). With flexible definitions of success, initiatives in functional organizations are more profitable than those in project-based organizations when the relative cost of effort is above a threshold; i.e., $\frac{c_p}{c_f} > (1 + \alpha)$, where α is a function of p_1 and p_0 and bound between one and two. This means that flexible definitions of success are more profitable in functional organizations than in project-based organizations when the relative costs of effort and

coordination in project-based organizations are significantly high. In that regard, Corollary 4.2 formalizes the relative size of the trade-offs between the *explicit* coordination costs associated with project-based organizations, and the *implicit* costs associated with the stakeholder's strategic interactions in functional organizations (i.e., the higher incentives required in functional organizations to mitigate the horizontal information asymmetry problem between the stakeholders). If the explicit coordination costs in project-based organizations are sufficiently high (low), then functional (project-based) organizational structures are preferred.

Corollary 4.3. COSTS OF EFFORT IN FUNCTIONAL VS. PROJECT-BASED ORGANIZATIONS

As the costs of effort increase, flexible definitions of success become preferred in functional organizations and focused definitions of success become preferred in project-based organizations.

Corollary 4.3 combines the results from Propositions 4.4 and 4.8 to relate how the definition of success is influenced by increasing costs of effort in both functional and project-based organizations. In functional organizations, the stakeholders are subjected to a hidden information problem; none of them know whether the others commit to the project. In this context, senior management's use of a flexible definition mitigates these consequences, and induces stakeholders to exert effort through relatively lower incentives. Then, as the costs of effort increase, the challenges associated with the hidden information problem become aggravated and the settings where flexible definitions of success are optimal expand. In project based organizations, the employment of a project manager mitigates the hidden information problem. Yet, senior management is still challenged with a moral hazard problem with the stakeholders. Focused definitions of success clearly explicate a singular goal for the team, and only offer a bonus for this singular project outcome. Therefore, focused definitions help mitigate the moral hazard problem, whereas flexible definitions can lead to

situations where stakeholders intentionally under-invest in effort. As the costs of effort increase, the potential benefits associated with flexible definitions of success diminish when uncertainty is low, thus expanding the conditions when focused definitions are preferred for project-based organizations.

4.4 Conclusions

Strategic initiatives that are well defined, but poorly executed, yield limited value. Their implementation requires both guidance from concept to completion, and sufficient impetus from all the key stakeholders. Yet, both these conditions are difficult, if not impossible to guarantee for two important reasons: the inherent uncertainty with respect to how the initiative specific efforts translate into valuable outcomes, and the strategic behavior that may take place between stakeholders, especially in the context of cross-functional teams.

The extant literature and practitioners argue that in order to successfully manage the execution of these strategic initiatives, senior managers can structurally organize the various stakeholders in different ways (Galbraith, 2008). Two archetypical structures have dominated the discussion: in one extreme, firms organize as units based on functional specialization (marketing, engineering, finance, etc.); and at the other, firms group functional experts from different specialization backgrounds together into dedicated teams to be managed by experienced project managers. While functional organizations are typically easier to manage since functional boundaries and hierarchies are maintained, each functional group may not collaborate well with the others on specific initiatives. Alternatively, project managers in project-based organizations ensure tighter collaboration across functional boundaries, but at the expense of additional costs; either due to the dedicated resources for collaboration (Loch & Terwiesch, 2007), or the lower productivity in specialization of the stakeholders in project-based organizations (Hobday, 2000).

In this paper, we posit that the organizational design is a necessary, but not independent consideration for the successful implementation of strategic initiatives. Firms need to diligently account for the *alignment* between their organizational structure and the *definition of success* for their initiatives. Thus, given the organizational structure of the firm, managers need to craft performance metrics for the engaged stakeholders that serve two objectives: to *communicate* the scope of acceptable outcomes for the project (i.e., what constitutes a “successful” outcome), and *enable organizational impetus* towards the execution of the initiative (i.e., the commitment of effort towards the execution of the objectives). Focused definitions of success explicate very narrowly defined outcomes, while flexible definitions allow for broader (albeit *ex ante* possibly less desirable) outcomes to be considered successful. While incentive plans can be developed to guarantee stakeholder impetus for either focused or flexible definitions of success, it is noteworthy that flexibility typically involves lower costs (incentives) because it allows *a priori* secondary outcomes to be considered “successful” by the firm. In essence, a flexible definition of success provides a measure of insurance against uncertainty and establishes some tolerance for failure for the stakeholders. A limitation of this tolerance however, is the acceptance of secondary outcomes, which may deteriorate overall firm profits. Additionally, under certain conditions in project-based organizations, flexible definitions of success may encourage shirking, thus requiring higher powered incentives to guarantee impetus.

We find that for low risk initiatives, a broader set of successful outcomes should be allowed in functional organizations; whereas, a focused definition should be employed in project-based organizations. The surprising inability of functional organizations to pursue initiatives with focused definitions of success has organizational roots: the strategic interactions between the independent, cross-functional stakeholders. These interactions power the high incentives required to ensure impetus if success is narrowly defined, which results in higher costs to the firm compared to a broader definition of

success with the secondary potential outcomes. We find that flexible definitions are more effective in facilitating the implementation of high-risk strategic initiatives. In that light, we offer theoretical support to past claims about the detrimental effects of narrowly defined target outcomes for R&D projects (Loch & Bode-Greuel, 2001). Moreover, we show that the willingness of senior management to consider flexible target outcomes allows a firm to expand the potential set of initiatives they can undertake, and to pursue more risky projects, and therefore more ambitious strategies. Finally, as the costs of effort and coordination in project-based organizations increase, focused definitions of success become more beneficial under a larger range of project-specific conditions compared to flexible definitions. Adapting the incentive plans to the organizational structure is paramount in ensuring stakeholder impetus. An incentive plan developed for one firm may not provide for the successful implementation of strategic initiatives in another, simply due to the differences in their organizational structure.

APPENDIX A

PROOFS FROM CHAPTER III

Proof. Proposition 3.1:

With $B_N = B_R = 0$ (thus $t_N = t_R = 0$), solving for the customer's utility for new and remanufactured products $u_N = \theta - p_N$ and $u_R = \delta\theta - p_R$ determines $q_N = 1 - \frac{p_N - p_R}{1 - \delta}$ and $q_R = \frac{\delta p_N - p_R}{\delta(1 - \delta)}$. We will use the x superscript to designate the problem parameters without a sales force. By substituting q_N and q_R into equation (2) and examining the Hessian matrix for Π^x , $\mathcal{H}^x = \begin{vmatrix} -\frac{2}{1-\delta} & \frac{2}{1-\delta} \\ \frac{2}{1-\delta} & -\frac{2}{(1-\delta)\delta} \end{vmatrix}$, we can verify the firm's profit is jointly concave in p_N and p_R . Specifically, $-\frac{2}{1-\delta} < 0$ and $|\mathcal{H}^x| = \frac{4}{\delta(1-\delta)} > 0$ for all δ and c_N . Therefore, \mathcal{H}^x is negative definite with respect to p_N and p_R , thus jointly concave. However, despite joint concavity in the decision variables, there is no guarantee that the unconstrained optimal pair p_N and p_R does not violate the (RS) , (MC) , or (NN) constraints, thus the boundary point solutions must also be considered. Examining the market capacity constraint (MC) , we observe $q_R + q_N = 1 - \frac{p_R}{\delta} \leq 1$ is satisfied for all $\delta \in [0, 1]$ and $p_R > 0$, therefore this constraint is always satisfied. Thus, a Lagrangian with the (RS) and (NN) constraints is solved by analyzing the Karush-Kuhn-Tucker (KKT) conditions for equation (3.2), with λ_{RS}^x and λ_{NN}^x as the Lagrange multipliers for the (RS) and (NN) constraints for Π^x . Specifically:

$\mathcal{L}^x = (p_N - c_N)q_N + p_R q_R - \lambda_{RS}^x(q_R - q_N) - \lambda_{NN}^x(-q_R)$; substituting $q_N = 1 - \frac{p_N - p_R}{1 - \delta}$ and $q_R = \frac{\delta p_N - p_R}{\delta(1 - \delta)}$:

$$\mathcal{L}^x = (p_N - c_N) \left(1 - \frac{p_N - p_R}{1 - \delta}\right) + \frac{p_R(\delta p_N - p_R)}{\delta(1 - \delta)} - \lambda_{RS}^x \left(\frac{2\delta p_N - p_R - \delta p_R}{\delta(1 - \delta)} - 1\right) - \lambda_{NN}^x \left(\frac{p_R - \delta p_N}{\delta(1 - \delta)}\right)$$

The necessary KKT conditions are: 1) $\frac{\partial \mathcal{L}^x}{\partial p_N} = 0$; 2) $\frac{\partial \mathcal{L}^x}{\partial p_R} = 0$; 3) $\lambda_{RS}^x \left(\frac{2\delta p_N - p_R - \delta p_R}{\delta(1 - \delta)} - 1\right) - \lambda_{NN}^x \left(\frac{p_R - \delta p_N}{\delta(1 - \delta)}\right) = 0$

- 1) = 0; 4) $\lambda_{NN}^x(\frac{p_R - \delta p_N}{\delta(1-\delta)}) = 0$; 5) $\frac{2\delta p_N - p_R - \delta p_R}{\delta(1-\delta)} - 1 \leq 0$; 6) $\frac{p_R - \delta p_N}{\delta(1-\delta)} \leq 0$; 7) $\lambda_{RS}^x \geq 0$; and 8) $\lambda_{NN}^x \geq 0$.

The first four conditions generate four potential solution sets, of which two satisfy the last four KKT conditions. These potentially optimal solution sets are annotated as sets Q_z^a , with the a superscript defining the specific problem being addressed and the z subscript denoting the optimal policy for which the parameters define. These two solution sets are mutually exclusive and totally exhaustive for all δ and c_N , thus optimal. For $c_N \geq \frac{1-\delta}{2}$, $Q_{FR}^x = \{p_N = \frac{1+c_N+(4+c_N)\delta-\delta^2}{2(1+3\delta)}, p_R = \frac{\delta(c_N+2\delta)}{1+3\delta}, \lambda_{RS}^x = \frac{\delta(2c_N+\delta-1)}{1+3\delta}, \lambda_{NN}^x = 0\}$, and for $c_N < \frac{1-\delta}{2}$, $Q_{LR}^x = \{p_N = \frac{1+c_N}{2}, p_R = \frac{\delta}{2}, \lambda_{RS}^x = 0, \lambda_{NN}^x = 0\}$. Substitution of the terms in Q_{FR}^x and Q_{LR}^x into q_N and q_R confirms that $q_R > 0$ for all δ and c_N (the NN constraint is never binding), while $q_R = q_N = \frac{1-c_N+\delta}{2(1+3\delta)}$ (the RS constraint is binding) for Q_{BR}^x if $c_N \geq \frac{1-\delta}{2}$.

□

Proof. Proposition 3.2:

With $\gamma_R = \delta$, the demand for new and remanufactured products results in $q_N = 1 - \frac{(p_N - p_R) - (t_N - \delta t_R)}{1 - \delta}$ and $q_R = \frac{\delta p_N - p_R - \delta(t_N - t_R)}{\delta(1 - \delta)}$. The firm's problem is formalized below by substituting q_N and q_R into equation (3.1) as follows, with the (*IR*) and (*IC*) constraints shown for both the new and remanufactured product sales agents and differentiated by the N and R subscripts, with the $\{s, \delta\}$ superscript denoting separate sales agents with product dependent sales effort effectiveness ($\gamma_R = \delta$):

$$\begin{aligned}
& \max_{p_N, p_R, A_N, A_R, B_N, B_R} && \Pi^{\{s, \delta\}} = (p_N - c_N)q_N + p_R q_R - (A_N + B_N q_N) - (A_R + B_R q_R) \\
& \text{s.t.} && U(t_N) = A_N + B_N q_N - \frac{1}{2} t_N^2 \geq 0 && (IR_N) \\
& && U(t_R) = A_R + B_R q_R - \frac{1}{2} t_R^2 \geq 0 && (IR_R) \\
& && t_N = \operatorname{argmax}_{t_N} U(t_N) && (IC_N) \\
& && t_R = \operatorname{argmax}_{t_R} U(t_R) && (IC_R) \\
& && q_R \leq q_N && (RS) \\
& && q_R + q_N \leq 1 && (MC)
\end{aligned}$$

$$q_R \geq 0 \quad (NN)$$

First, we will solve the agents' subproblems by determining t_N and t_R from the incentive compatibility (IC_N and IC_R) constraints. By substituting the values for q_N and q_R into $U(t_N)$ and $U(t_R)$, we have:

$$U(t_N) = A_N + B_N \left(1 - \frac{(p_N - p_R) - (t_N - \delta t_R)}{1 - \delta} \right) - \frac{t_N^2}{2} \text{ and}$$

$$U(t_R) = A_R + B_R \left(\frac{\delta p_N - p_R - \delta(t_N - t_R)}{\delta(1 - \delta)} \right) - \frac{t_R^2}{2}$$

Noting that $\frac{\partial^2 U(t_N)}{\partial t_N^2} = \frac{\partial^2 U(t_R)}{\partial t_R^2} = -1 < 0$, the utility for each agent is concave and thus can be determined through first order conditions. Therefore, we must solve the following two equations simultaneously for t_N and t_R : $\frac{\partial U(t_N)}{\partial t_N} = \frac{B_N}{1 - \delta} - t_N = 0$ and $\frac{\partial U(t_R)}{\partial t_R} = \frac{B_R}{1 - \delta} - t_R = 0$. This results in $t_N = \frac{B_N}{1 - \delta}$ and $t_R = \frac{B_R}{1 - \delta}$.

Recognizing that the firm only needs to satisfy (not exceed) each agent's IR constraint we can restate the IR constraints as: $A_N + B_N q_N = \frac{1}{2} t_N^2$ and $A_R + B_R q_R = \frac{1}{2} t_R^2$. Substituting terms back into the firm's optimization problem yields:

$$\begin{aligned} \max_{p_N, p_R, A_N, A_R, B_N, B_R} \quad & \Pi^{\{s, \delta\}} = (p_N - c_N)q_N + p_R q_R - \frac{1}{2} t_N^2 - \frac{1}{2} t_R^2 \\ \text{s.t.} \quad & q_R \leq q_N \quad (RS) \\ & q_R + q_N \leq 1 \quad (MC) \\ & q_R \geq 0 \quad (NN) \end{aligned}$$

Substituting $t_N = \frac{B_N}{1 - \delta}$ and $t_R = \frac{B_R}{1 - \delta}$ into q_N and q_R yields: $q_N = \frac{B_N - \delta B_R + (1 - \delta - p_N + p_R)(1 - \delta)}{(1 - \delta)^2}$ and $q_R = \frac{(\delta p_N - p_R)(1 - \delta) - \delta(B_N - B_R)}{\delta(1 - \delta)^2}$. By examining the Hessian matrix for $\Pi^{\{s, \delta\}}$,

$$\mathcal{H}^{\{s, \delta\}} = \begin{vmatrix} -\frac{1}{(1 - \delta)^2} & 0 & \frac{1}{(1 - \delta)^2} & -\frac{1}{(1 - \delta)^2} \\ 0 & -\frac{1}{(1 - \delta)^2} & -\frac{\delta}{(1 - \delta)^2} & \frac{1}{(1 - \delta)^2} \\ \frac{1}{(1 - \delta)^2} & -\frac{\delta}{(1 - \delta)^2} & -\frac{2}{1 - \delta} & \frac{2}{1 - \delta} \\ -\frac{1}{(1 - \delta)^2} & \frac{1}{(1 - \delta)^2} & \frac{2}{1 - \delta} & -\frac{2}{\delta(1 - \delta)} \end{vmatrix}$$

we can verify the firm's profit is jointly concave in B_N , B_R , p_N , and p_R if $0 < \delta < \frac{2}{5}$. Specifically, the first principal minor $-\frac{1}{(1 - \delta)^2} < 0$ for all δ and c_N , the second principal minor $\frac{1}{(1 - \delta)^4} > 0$ for all δ and c_N , the third principal minor $\frac{\delta(2 + \delta) - 1}{(1 - \delta)^6} < 0$

for $0 < \delta < \sqrt{2} - 1$, while the fourth principal minor $|\mathcal{H}^{\{s,p\}}| = \frac{2-5\delta}{\delta(1-\delta)^6} > 0$ for $0 < \delta < \frac{2}{5}$. Since $\frac{2}{5} < \sqrt{2} - 1$, $\Pi^{\{s,\delta\}}$ is only negative definite (thus jointly concave in all four decision variables) for $0 < \delta < \frac{2}{5}$. This implies that there is no interior global maximum for the unconstrained problem if $\frac{2}{5} < \delta < 1$. Since we cannot guarantee that the global maximum when $0 < \delta < \frac{2}{5}$ does not violate the (RS) , (MC) , or (NN) constraints, the boundary point solutions must also be considered. Therefore, the following Lagrangian is analyzed, with $\lambda_{RS}^{\{s,\delta\}}$, $\lambda_{MC}^{\{s,\delta\}}$, and $\lambda_{NN}^{\{s,\delta\}}$ representing the (RS) , (MC) , and (NN) constraints for $\Pi^{\{s,\delta\}}$ from equation (3.1):

$$\mathcal{L}^{\{s,\delta\}} = \frac{2p_R(\delta(B_R - B_N) + (\delta(2p_N - c_N) - p_R)(1-\delta)) - \delta(B_N^2 + B_R^2) + 2\delta(B_N - B_R\delta + (1-\delta)(1-\delta - p_N))(p_N - c_N)}{2\delta(1-\delta)^2}$$

$$\lambda_{RS}^{\{s,\delta\}} \left(\frac{\delta^2(B_R - 2p_N + p_R) + \delta(B_R - 2B_N + 2p_N - (1-\delta)^2) - p_R}{(1-\delta)^2\delta} \right) - \lambda_{MC}^{\{s,\delta\}} \left(\frac{\delta B_R - p_R(1-\delta)}{\delta(1-\delta)} \right) - \lambda_{NN}^{\{s,\delta\}} \left(\frac{(p_R - \delta p_N)(1-\delta) + \delta(B_N - B_R)}{(1-\delta)^2\delta} \right)$$

The necessary KKT conditions are: 1) $\frac{\partial \mathcal{L}^{\{s,\delta\}}}{\partial p_N} = 0$; 2) $\frac{\partial \mathcal{L}^{\{s,\delta\}}}{\partial p_R} = 0$; 3) $\frac{\partial \mathcal{L}^{\{s,\delta\}}}{\partial B_N} = 0$; 4) $\frac{\partial \mathcal{L}^{\{s,\delta\}}}{\partial B_R} = 0$; 5) $\lambda_{RS}^{\{s,\delta\}} \left(\frac{\delta^2(B_R - 2p_N + p_R) + \delta(B_R - 2B_N + 2p_N - (1-\delta)^2) - p_R}{(1-\delta)^2\delta} \right) = 0$; 6) $\lambda_{MC}^{\{s,\delta\}} \left(\frac{\delta B_R - p_R(1-\delta)}{\delta(1-\delta)} \right) = 0$; 7) $\lambda_{NN}^{\{s,\delta\}} \left(\frac{(p_R - \delta p_N)(1-\delta) + \delta(B_N - B_R)}{(1-\delta)^2\delta} \right) = 0$; 8) $\frac{\delta^2(B_R - 2p_N + p_R) + \delta(B_R - 2B_N + 2p_N - (1-\delta)^2) - p_R}{(1-\delta)^2\delta} \leq 0$; 9) $\frac{\delta B_R - p_R(1-\delta)}{\delta(1-\delta)} \leq 0$; 10) $\frac{(p_R - \delta p_N)(1-\delta) + \delta(B_N - B_R)}{(1-\delta)^2\delta} \leq 0$; 11) $\lambda_{RS}^{\{s,\delta\}} \geq 0$; 12) $\lambda_{MC}^{\{s,\delta\}} \geq 0$; and 13) $\lambda_{NN}^{\{s,\delta\}} \geq 0$.

The first seven KKT conditions generate seven potential solution sets, of which three satisfy the last six KKT conditions. These are $Q_{FR}^{\{s,\delta\}} = \{p_N = \frac{1+5\delta+c_N\delta-2\delta^2}{1+6\delta-\delta^2}, p_R = \frac{\delta(1-2c_N-5\delta+c_N\delta)}{-1-6\delta+\delta^2}, B_N = \frac{1-c_N+c_N\delta-\delta^2}{1+6\delta-\delta^2}, B_R = \frac{(1-c_N+\delta)\delta(1-\delta)}{1+6\delta-\delta^2}, \lambda_{RS}^{\{s,\delta\}} = \frac{(c_N(4-\delta)+3\delta-3)\delta}{1+6\delta-\delta^2}, \lambda_{MC}^{\{s,\delta\}} = 0, \lambda_{NN}^{\{s,\delta\}} = 0\}$ for $\frac{3\delta-3}{\delta-4} \leq c_N < 1$; $Q_{LR}^{\{s,\delta\}} = \{p_N = \frac{2(1-2\delta-c_N\delta)}{2-5\delta}, p_R = \frac{\delta(1-3\delta+c_N\delta)}{2-5\delta}, B_N = \frac{(2-2c_N-3\delta+c_N\delta)(1-\delta)}{2-5\delta}, B_R = \frac{(2c_N-1)\delta(1-\delta)}{2-5\delta}, \lambda_{RS}^{\{s,\delta\}} = 0, \lambda_{MC}^{\{s,\delta\}} = 0, \lambda_{NN}^{\{s,\delta\}} = 0\}$ for $0 < \delta < \frac{2}{5}$ and $\frac{1}{2} \leq c_N \leq \frac{3\delta-3}{\delta-4}$ or $\frac{2}{5} < \delta < 1$ and $\frac{3\delta-3}{\delta-4} \leq c_N < \frac{1}{2}$; and $Q_{NR}^{\{s,\delta\}} = \{p_N = 1, p_R = -, B_N = 1 - c_N, B_R = -, \lambda_{RS}^{\{s,\delta\}} = 0, \lambda_{MC}^{\{s,\delta\}} = 0, \lambda_{NN}^{\{s,\delta\}} = \delta(1 - 2c_N)\}$ for $0 < c_N \leq \frac{1}{2}$. By examining the Lagrange multipliers, we see that the (RS) constraint is tight for $Q_{FR}^{\{s,\delta\}}$, the (NN) constraint is tight for $Q_{NR}^{\{s,\delta\}}$, while $Q_{LR}^{\{s,\delta\}}$ is unconstrained. Note that for $Q_{NR}^{\{s,\delta\}}$, since there is no remanufactured product in the market ($q_R = 0$), the demand for new products is $q_N = 1 - p_N + t_N$.

Next, we note that all three solution sets ($Q_{FR}^{\{s,\delta\}}$, $Q_{LR}^{\{s,\delta\}}$, and $Q_{NR}^{\{s,\delta\}}$) are feasible when $\frac{2}{5} < \delta < 1$ and $\frac{3\delta-3}{\delta-4} \leq c_N \leq \frac{1}{2}$, so the profits for each of these scenarios must be compared. Substituting each solution set into the firm's profit function yields: $\Pi^{\{s,\delta\}}|_{Q_{FR}^{\{s,\delta\}}} = \frac{(1-c_N+\delta)^2}{2(1+6\delta-\delta^2)}$, $\Pi^{\{s,\delta\}}|_{Q_{LR}^{\{s,\delta\}}} = \frac{(4-6c_N+c_N^2)\delta-2(1-c_N)^2}{10\delta-4}$, and $\Pi^{\{s,\delta\}}|_{Q_{NR}^{\{s,\delta\}}} = \frac{1}{2}(1-c_N^2)$. By comparing $\Pi^{\{s,\delta\}}|_{Q_{FR}^{\{s,\delta\}}}$, $\Pi^{\{s,\delta\}}|_{Q_{LR}^{\{s,\delta\}}}$, and $\Pi^{\{s,\delta\}}|_{Q_{NR}^{\{s,\delta\}}}$ when $\frac{2}{5} < \delta < 1$ and $\frac{3\delta-3}{\delta-4} \leq c_N \leq \frac{1}{2}$, we determine that $\Pi^{\{s,\delta\}}|_{Q_{FR}^{\{s,\delta\}}} > \max\{\Pi^{\{s,\delta\}}|_{Q_{LR}^{\{s,\delta\}}}, \Pi^{\{s,\delta\}}|_{Q_{NR}^{\{s,\delta\}}}\}$ if $c_N \geq \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$, while $\Pi^{\{s,\delta\}}|_{Q_{NR}^{\{s,\delta\}}} > \max\{\Pi^{\{s,\delta\}}|_{Q_{FR}^{\{s,\delta\}}}, \Pi^{\{s,\delta\}}|_{Q_{LR}^{\{s,\delta\}}}\}$ if $c_N < \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$. Therefore $Q_{FR}^{\{s,\delta\}}$ is optimal if $\{c_N > \bar{c}_1 \text{ and } \delta \leq \ddot{\delta}\}$ or $\{c_N > \bar{c}_2 \text{ and } \delta > \ddot{\delta}\}$, $Q_{LR}^{\{s,\delta\}}$ is optimal if $\bar{c}_3 \leq c_N \leq \bar{c}_1$ and $\delta \leq \ddot{\delta}$, while $Q_{NR}^{\{s,\delta\}}$ is optimal if $\{c_N \leq \bar{c}_3 \text{ and } \delta \leq \ddot{\delta}\}$ or $\{c_N \leq \bar{c}_2 \text{ and } \delta > \ddot{\delta}\}$, where $\bar{c}_1 = \frac{3\delta-3}{\delta-4}$, $\bar{c}_2 = \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}$, $\bar{c}_3 = \frac{1}{2}$, and $\ddot{\delta} = \frac{2}{5}$. □

Proof. Corollary 3.1:

Using algebra to compare $(B_N, B_R) \in Q_{FR}^{\{s,\delta\}}$ confirms $B_N = \frac{1-c_N+c_N\delta-\delta^2}{1+6\delta-\delta^2} > B_R = \frac{(1-c_N+\delta)\delta(1-\delta)}{1+6\delta-\delta^2} \forall (\delta, c_N) \in \Omega_{FR}^{\{s,\delta\}}$. Similarly, comparing $(B_N, B_R) \in Q_{LR}^{\{s,\delta\}}$ confirms $B_N = \frac{(2-2c_N-3\delta+c_N\delta)(1-\delta)}{2-5\delta} > B_R = \frac{(2c_N-1)\delta(1-\delta)}{2-5\delta} \forall (\delta, c_N) \in \Omega_{LR}^{\{s,\delta\}}$. □

Proof. Corollary 3.3:

For $\Omega_{NR}^{\gamma_R=1} \subset \Omega_{NR}^{\gamma_R=\delta}$, to prove the area $\Omega_{NR}^{\gamma_R=\delta} \setminus \Omega_{NR}^{\gamma_R=1}$ gets smaller in δ , we will define the set $R(\delta, c_N) = \Omega_{NR}^{\gamma_R=1} \subset \Omega_{NR}^{\gamma_R=\delta} = R_1 \cup R_2 \cup R_3$, where $R_1 = (\delta, c_N) | \{0 < \delta < \frac{3}{8}, \frac{1-\sqrt{1-2\delta}}{2} < c_N < \frac{1}{2}\}$, $R_2 = (\delta, c_N) | \{\frac{3}{8} < \delta < \frac{2}{5}, \frac{1-5\delta+\delta^{3/2}\sqrt{6}}{1-6\delta} < c_N < \frac{1}{2}\}$, and $R_3 = (\delta, c_N) | \{\frac{2}{5} < \delta < 1, \frac{1-5\delta+\delta^{3/2}\sqrt{6}}{1-6\delta} < c_N < \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6}\}$. This partition splits the range of δ into three parts for analysis, as each has a different set of upper and lower bounds on c_N for the set $R(\delta, c_N)$. To prove that the set is getting smaller in δ , we will compare the difference between the upper and lower bounds as δ increases. We will define these difference between bounds as: $\Delta_{R1} = \frac{1}{2} - \frac{1-\sqrt{1-2\delta}}{2}$, $\Delta_{R2} = \frac{1}{2} - \frac{1-5\delta+\delta^{3/2}\sqrt{6}}{1-6\delta}$,

and $\Delta_{R3} = \frac{\delta-5+\sqrt{1+6\delta-\delta^2}}{\delta-6} - \frac{1-5\delta+\delta^{3/2}\sqrt{6}}{1-6\delta}$. Now, by taking the derivatives of Δ with respect to δ , we can determine whether the set is getting bigger or smaller in δ .

$$\begin{aligned}\frac{\partial \Delta_{R1}}{\partial \delta} &= -\frac{1}{2\sqrt{1-2\delta}} < 0 \quad \forall \delta \in (0, \frac{3}{8}), \quad \frac{\partial \Delta_{R2}}{\partial \delta} = \frac{-2+3\sqrt{6}\sqrt{\delta}(-1+2\delta)}{2(1-6\delta)^2} < 0 \quad \forall \delta \in (\frac{3}{8}, \frac{2}{5}), \\ \frac{\partial \Delta_{R3}}{\partial \delta} &= \frac{3\sqrt{\frac{3}{2}}\sqrt{\delta}(-1+2\delta)-1}{(1-6\delta)^2} + \frac{(17-3\delta)\sqrt{1-(-6+\delta)\delta}-1}{(-6+\delta)^2} - \frac{1+3\delta}{\sqrt{1-(-6+\delta)\delta}} < 0 \quad \forall \delta \in (\frac{2}{5}, 1).\end{aligned}$$

□

Proof. Proposition 3.4:

Proposition 3.4 involves the firm utilizing a single sales agent (channel) to promote both new and remanufactured products. Further, we will assume that the sales effort effectiveness is product dependent ($\gamma_R = \delta$). Determining the demand for new and re-manufactured products results in $q_N = 1 - \frac{(p_N - p_R) - (t_N - \delta t_R)}{1 - \delta}$ and $q_R = \frac{\delta p_N - p_R - \delta(t_N - t_R)}{\delta(1 - \delta)}$.

First, we will solve the agent's subproblem by determining t_N and t_R from the incentive compatibility (*IC*) constraint of equation (3.1) for $\Pi^{\{j, \delta\}}$, where the superscript $\{j, \delta\}$ refers to a joint sales channel with $\gamma_R = \delta$. By substituting the values for q_N and q_R into $U(t_N, t_R)$, we have:

$$U(t_N, t_R) = A + B_N \left(1 - \frac{p_N - p_R - t_N + t_R \delta}{1 - \delta}\right) + B_R \left(\frac{\delta(p_N - t_N + t_R) - p_R}{(1 - \delta)\delta}\right) - \frac{1}{2}(t_N^2 + t_R^2)$$

By examining the Hessian matrix for $U(t_N, t_R)$, $\mathcal{H}^{\{j, \delta\}} = \begin{vmatrix} -1 & 0 \\ 0 & -1 \end{vmatrix}$, we can verify that the agent's utility is jointly concave in t_N and t_R , thus allowing the optimal efforts to be determined through first order conditions. These are $t_N = \frac{B_N - B_R}{1 - \delta}$ and $t_R = \frac{B_R - \delta B_N}{1 - \delta}$. Note that the effort that the agent exerts towards either product is dependent on the commissions of both products.

We can restate the IR constraint from equation (3.1) as: $A + B_N q_N + B_R q_R = \frac{1}{2}(t_N^2 + t_R^2)$. By substituting terms back into equation (3.1), relabeling the non-negativity constraint for q_R from (*NN*) to (*NN1*), and controlling for the non-negativity in t_N and t_R from the (*IC*) constraint with the (*NN2*) and (*NN3*) constraints, the firm's optimization problem is:

$$\max_{p_N, p_R, A, B_N, B_R} \quad \Pi^{\{j, \delta\}} = (p_N - c_N)q_N + p_R q_R - \frac{1}{2}t_N^2 - \frac{1}{2}t_R^2$$

$$\begin{aligned}
s.t. \quad q_R &\leq q_N && (RS) \\
q_R + q_N &\leq 1 && (MC) \\
q_R &\geq 0 && (NN1) \\
t_N &\geq 0 && (NN2) \\
t_R &\geq 0 && (NN3)
\end{aligned}$$

Note that we now have two additional non-negativity constraints, as the agent must not exert negative effort towards either product. These were not necessary with separate sales agents (channels) as their efforts were guaranteed positive as long as the commissions B_N and B_R are positive.

Substituting $t_N = \frac{B_N - B_R}{1 - \delta}$ and $t_R = \frac{B_R - \delta B_N}{1 - \delta}$ into q_N and q_R yields: $q_N = \frac{B_N(1 + \delta^2) - B_R(1 + \delta) + (p_R - p_N)}{(1 - \delta)^2}$ and $q_R = \frac{\delta(2B_R - B_N(1 + \delta)) + (p_N - p_R)(1 - \delta)}{(1 - \delta)^2 \delta}$. By examining the Hessian matrix for $\Pi^{\{j, \delta\}}$,

$$\mathcal{H}^{\{j, \delta\}} = \begin{vmatrix} -\frac{1 + \delta^2}{(1 - \delta)^2} & \frac{1 + \delta}{(1 - \delta)^2} & \frac{1 + \delta^2}{(1 - \delta)^2} & -\frac{1 + \delta}{(1 - \delta)^2} \\ \frac{1 + \delta}{(1 - \delta)^2} & -\frac{2}{(1 - \delta)^2} & -\frac{1 + \delta}{(1 - \delta)^2} & \frac{2}{(1 - \delta)^2} \\ \frac{1 + \delta^2}{(1 - \delta)^2} & -\frac{1 + \delta}{(1 - \delta)^2} & -\frac{2}{1 - \delta} & \frac{2}{1 - \delta} \\ -\frac{1 + \delta}{(1 - \delta)^2} & \frac{2}{(1 - \delta)^2} & \frac{2}{1 - \delta} & -\frac{2}{\delta(1 - \delta)} \end{vmatrix}$$

we can verify the firm's profit is jointly concave in B_N , B_R , p_N , and p_R if $0 < \delta < \frac{2}{5}$. Specifically, the first principal minor $-\frac{1 + \delta^2}{(1 - \delta)^2} < 0$ for all δ and c_N , the second principal minor $\frac{1}{(1 - \delta)^4} > 0$ for all δ and c_N , the third principal minor $\frac{\delta(2 + \delta) - 1}{(1 - \delta)^4} < 0$ for $0 < \delta < \sqrt{2} - 1$, while the fourth principal minor $|\mathcal{H}^{\{j, \delta\}}| = \frac{2 - 5\delta}{\delta(1 - \delta)^4} > 0$ for $0 < \delta < \frac{2}{5}$. Since $\frac{2}{5} < \sqrt{2} - 1$, $\Pi^{\{j, p\}}$ is only negative definite (thus jointly concave in all four decision variables) for $0 < \delta < \frac{2}{5}$. Since there is no interior global maximum for the unconstrained problem if $\frac{2}{5} < \delta < 1$, and we cannot guarantee that the global maximum when $0 < \delta < \frac{2}{5}$ does not violate the (RS) , (MC) , or (NN) constraints, the boundary point solutions must also be considered. Therefore, we account for the (RS) , (MC) , $(NN1)$, $(NN2)$, and $(NN3)$ constraints with the Lagrange multipliers $\lambda_{RS}^{\{j, \delta\}}$, $\lambda_{MC}^{\{j, \delta\}}$, $\lambda_{NN1}^{\{j, \delta\}}$, $\lambda_{NN2}^{\{j, \delta\}}$, and $\lambda_{NN3}^{\{j, \delta\}}$; and the following Lagrangian is analyzed:

$$\begin{aligned} \mathcal{L}^{\{j,\delta\}} = & \frac{(p_N - c_N)(B_N(1+\delta^2) - B_R(1+\delta) + (1-\delta)(1-\delta - p_N + p_R)) + (B_R - p_R)(B_N(1+\delta) - B_R) + p_R(B_R + p_R + p_N(1-\delta))}{(1-\delta)^2} - \\ & \frac{2p_R^2 + B_N^2\delta(1+\delta^2)}{2(1-\delta)^2\delta} - \lambda_{RS}^{\{j,\delta\}} \left(\frac{4(B_R - B_N)}{(1-\delta)^2} + \frac{3B_N - B_R + 2p_N - 2p_R}{1-\delta} - \frac{p_R}{\delta} - 1 - B_N \right) - \lambda_{MC}^{\{j,\delta\}} \left(B_N + \frac{B_R - B_N}{1-\delta} - \frac{p_R}{\delta} \right) - \\ & \lambda_{NN1}^{\{j,\delta\}} \left(\frac{\delta(B_N(1+\delta) - 2B_R) - (\delta p_N - p_R)(1-\delta)}{(1-\delta)^2\delta} \right) - \lambda_{NN2}^{\{j,\delta\}} \left(\frac{B_R - B_N}{1-\delta} \right) - \lambda_{NN3}^{\{j,\delta\}} \left(\frac{B_N\delta - B_R}{1-\delta} \right) \end{aligned}$$

The necessary KKT conditions are:

$$\begin{aligned} 1) \frac{\partial \mathcal{L}^{\{j,\delta\}}}{\partial p_N} = 0 \quad 2) \frac{\partial \mathcal{L}^{\{j,\delta\}}}{\partial p_R} = 0 \quad 3) \frac{\partial \mathcal{L}^{\{j,\delta\}}}{\partial B_N} = 0 \quad 4) \frac{\partial \mathcal{L}^{\{j,\delta\}}}{\partial B_R} = 0 \quad 5) \lambda_{RS}^{\{j,\delta\}} \left(\frac{4(B_R - B_N)}{(1-\delta)^2} + \frac{3B_N - B_R + 2p_N - 2p_R}{1-\delta} - \frac{p_R}{\delta} - 1 - B_N \right) = 0 \\ 6) \lambda_{MC}^{\{j,\delta\}} \left(B_N + \frac{B_R - B_N}{1-\delta} - \frac{p_R}{\delta} \right) = 0 \quad 7) \lambda_{NN1}^{\{j,\delta\}} \left(\frac{\delta(B_N(1+\delta) - 2B_R) - (\delta p_N - p_R)(1-\delta)}{(1-\delta)^2\delta} \right) = 0 \quad 8) \lambda_{NN2}^{\{j,\delta\}} \left(\frac{B_R - B_N}{1-\delta} \right) = 0 \\ 9) \lambda_{NN3}^{\{j,\delta\}} \left(\frac{B_N\delta - B_R}{1-\delta} \right) = 0 \quad 10) \frac{4(B_R - B_N)}{(1-\delta)^2} + \frac{3B_N - B_R + 2p_N - 2p_R}{1-\delta} - \frac{p_R}{\delta} - 1 - B_N \leq 0 \\ 11) B_N + \frac{B_R - B_N}{1-\delta} - \frac{p_R}{\delta} \leq 0 \quad 12) \frac{\delta(B_N(1+\delta) - 2B_R) - (\delta p_N - p_R)(1-\delta)}{(1-\delta)^2\delta} \leq 0 \\ 13) \frac{B_R - B_N}{1-\delta} \leq 0 \quad 14) \frac{B_N\delta - B_R}{1-\delta} \leq 0 \\ 15) \lambda_{RS}^{\{j,\delta\}} \geq 0 \quad 16) \lambda_{MC}^{\{j,\delta\}} \geq 0 \quad 17) \lambda_{NN1}^{\{j,\delta\}} \geq 0 \quad 18) \lambda_{NN2}^{\{j,\delta\}} \geq 0 \quad 19) \lambda_{NN3}^{\{j,\delta\}} \geq 0 \end{aligned}$$

The first nine KKT conditions generate 21 potential solution sets, of which four satisfy the last ten KKT conditions. These are $Q_{FR}^{\{j,\delta\}} = \{p_N = \frac{1+5\delta+c_N\delta-2\delta^2}{1+6\delta-\delta^2}, p_R = \frac{\delta(1-2c_N-5\delta+c_N\delta)}{-1-6\delta+\delta^2}, B_N = \frac{(-1+c_N-\delta)(1+\delta)}{-1+(-6+\delta)\delta}, B_R = \frac{2(-1+c_N-\delta)\delta}{-1+(-6+\delta)\delta}, \lambda_{RS}^{\{j,\delta\}} = \frac{(3+c_N(-4+\delta)-3\delta)\delta}{-1+(-6+\delta)\delta}, \lambda_{MC}^{\{j,\delta\}} = 0, \lambda_{NN1}^{\{j,\delta\}} = 0, \lambda_{NN2}^{\{j,\delta\}} = 0, \lambda_{NN3}^{\{j,\delta\}} = 0\}$ for $c_N \geq \frac{3\delta-3}{\delta-4}$; $Q_{LR}^{\{j,\delta\}} = \{p_N = \frac{2(1-2\delta-c_N\delta)}{2-5\delta}, p_R = \frac{\delta(1-3\delta+c_N\delta)}{2-5\delta}, B_N = \frac{2-2c_N-4\delta+3c_N\delta}{2-5\delta}, B_R = \frac{\delta((c_N-3)\delta+1)}{2-5\delta}, \lambda_{RS}^{\{j,\delta\}} = 0, \lambda_{MC}^{\{j,\delta\}} = 0, \lambda_{NN1}^{\{j,\delta\}} = 0, \lambda_{NN2}^{\{j,\delta\}} = 0, \lambda_{NN3}^{\{j,\delta\}} = 0\}$ for $0 < \delta < \frac{2}{5}$ and $\frac{1}{2} \leq c_N \leq \frac{3\delta-3}{\delta-4}$ or $\frac{2}{5} < \delta < 1$ and $\frac{3\delta-3}{\delta-4} \leq c_N < \frac{1}{2}$; $Q_{NR}^{\{j,\delta\}} = \{p_N = 1, p_R = -, B_N = 1 - c_N, B_R = -, \lambda_{RS}^{\{j,\delta\}} = 0, \lambda_{MC}^{\{j,\delta\}} = 0, \lambda_{NN1}^{\{j,\delta\}} = \delta(1 - 2c_N), \lambda_{NN2}^{\{j,\delta\}} = 0, \lambda_{NN3}^{\{j,\delta\}} = 0\}$ for $c_N \leq \frac{1}{2}$; and $Q_{XX}^{\{j,\delta\}} = \{p_N = \frac{(3+2c_N)\delta-2}{4\delta-2}, p_R = \frac{\delta}{2}, B_N = \frac{c_N+\delta-1}{2\delta-1}, B_R = \frac{\delta(c_N+\delta-1)}{2\delta-1}, \lambda_{RS}^{\{j,\delta\}} = 0, \lambda_{MC}^{\{j,\delta\}} = 0, \lambda_{NN1}^{\{j,\delta\}} = 0, \lambda_{NN2}^{\{j,\delta\}} = 0, \lambda_{NN3}^{\{j,\delta\}} = \frac{\delta(2c_N-1)}{4\delta-2}\}$ for $c_N = \frac{1}{2}$ and $\delta \neq \frac{1}{2}$. By examining the Lagrange multipliers, we see that the (RS) constraint is tight for $Q_{FR}^{\{j,\delta\}}$, the $(NN1)$ constraint for non-negative remanufactured product demand is tight for $Q_{NR}^{\{j,\delta\}}$, the $(NN3)$ constraint for non-negative effort towards remanufactured products is tight for $Q_{XX}^{\{j,\delta\}}$, while $Q_{LR}^{\{j,\delta\}}$ is unconstrained. Note that for $Q_{NR}^{\{j,\delta\}}$, since there is no remanufactured product in the market ($q_R = 0$), the demand for new products is $q_N = 1 - p_N + t_N$.

Next, we note that all four solution sets ($Q_{FR}^{\{j,\delta\}}$, $Q_{LR}^{\{j,\delta\}}$, $Q_{NR}^{\{j,\delta\}}$, and $Q_{XX}^{\{j,\delta\}}$) are feasible in overlapping regions of δ and c_N , so the profits for each of these scenarios must be compared. Substituting each solution set into the firm's profit function yields:

$\Pi^{\{j,\delta\}}|_{Q_{FR}^{\{j,\delta\}}} = \frac{(1-c_N+\delta)^2}{2(1+6\delta-\delta^2)}$, $\Pi^{\{j,\delta\}}|_{Q_{LR}^{\{j,\delta\}}} = \frac{(4-6c_N+c_N^2)\delta-2(1-c_N)^2}{10\delta-4}$, $\Pi^{\{j,\delta\}}|_{Q_{NR}^{\{j,\delta\}}} = \frac{1}{2}(1 - c_N^2)$, and $\Pi^{\{j,\delta\}}|_{Q_{XX}^{\{j,\delta\}}} = \frac{3\delta-2-2c_N(c_N+2\delta-2)}{8\delta-4}$. At $c_N = \frac{1}{2}$, $\Pi^{\{j,\delta\}}|_{Q_{XX}^{\{j,\delta\}}} = \Pi^{\{j,\delta\}}|_{Q_{LR}^{\{j,p\}}} = \Pi^{\{j,\delta\}}|_{Q_{NR}^{\{j,\delta\}}}$, therefore $Q_{XX}^{\{j,\delta\}}$ never results in strictly superior profits, and is therefore never the optimal set of parameters. Noting that $\Pi^{\{j,\delta\}}|_{Q_{FR}^{\{j,\delta\}}} = \Pi^{\{s,\delta\}}|_{Q_{FR}^{\{s,\delta\}}}$, $\Pi^{\{j,\delta\}}|_{Q_{LR}^{\{j,\delta\}}} = \Pi^{\{s,\delta\}}|_{Q_{LR}^{\{s,\delta\}}}$, and $\Pi^{\{j,\delta\}}|_{Q_{NR}^{\{j,\delta\}}} = \Pi^{\{s,\delta\}}|_{Q_{NR}^{\{s,\delta\}}}$ for all δ and c_N , the resulting partition of the optimal parameter set follows identically to that from Proposition 3.2.

□

Propositions 3.3 and 3.5 are solved in an identical manner to Proposition 3.2 and are omitted for brevity. Furthermore, Corollaries 3.2, 3.4, 3.5, 3.6, 3.7, and 3.8 are solved in an identical manner to Corollary 3.1 and are also omitted for brevity.

APPENDIX B

PROOFS FROM CHAPTER IV

We define ψ_h the expected compensation if both stakeholders exert effort H , ψ_l if only one of the two stakeholders exerts effort H , and ψ_x if neither stakeholder exerts effort H (both exert a minimal, costless effort L). Therefore:

$$\psi_h = p_1^2(b_h) + 2p_1(1 - p_1)(b_l) + (1 - p_1)^2(b_x)$$

$$\psi_l = p_0p_1(b_h) + p_0(1 - p_1)(b_l) + p_1(1 - p_0)(b_l) + (1 - p_0)(1 - p_1)(b_x)$$

$$\psi_x = p_0^2(b_h) + 2p_0(1 - p_0)(b_l) + (1 - p_0)^2(b_x)$$

Proof. Proposition 4.1: Functional Organization Incentive Structure

Constraint (4.2f) results into two conditions that must be satisfied in order to avoid a lack of impetus ($e_i = H$) from either of the two stakeholders. Specifically we require $\psi_h - c_f \geq \psi_l$ and $\psi_l - c_f \geq \psi_x$. The first of these two equations implies that each stakeholder would prefer to exert costly effort towards the project instead of shirking as long as the other stakeholder exerted effort as well. The second equation implies that each stakeholder would prefer to exert costly effort even if the other stakeholder does not. Together, these two conditions imply that each stakeholder would prefer to exert a costly effort towards the project, irrespective of the actions of the other stakeholder. Constraint (4.3f) requires that if the stakeholder exerts effort, their expected utility should at least equal their current wage w : $\psi_h + w - c_f \geq w$ and $\psi_l + w - c_f \geq w$. Equation (4.4f) indicates that each stakeholder will exert an effort that will maximize their expected utility, and is satisfied by the constraints posed in (4.2f); since the agent's effort choice is binary (4.2f) ensures that the agent would always prefer to exert high effort.

With a focused definition of success, the firm will only offer a bonus b_h in the event a $V = f_h$ project outcome is achieved, thus maximizing $\Pi^f = f_h - 2b_h$ is equivalent to minimizing b_h . To ensure stakeholder impetus, $b_h = \frac{c_f}{p_0\Delta}$ is the smallest bonus that can be offered which satisfies the conditions in Equations (4.2f) and (4.3f). From Definition 4.2, this results in $\vec{b}|_{\Omega_N} = \{b_h = \frac{c_f}{p_0\Delta}, b_l = 0, b_x = 0\}$.

With a flexible definition of success, the firm will offer bonuses b_h or b_l depending on whether a $V = f_h$ or $V = f_l$ project outcome is achieved, respectively. Since the compensation plan is offered by senior management and accepted by the stakeholders prior to the project outcome realization, senior management must ensure impetus on all project tasks based on the expected profits to the firm given either $V = f_h$ or $V = f_l$ outcomes. Therefore, the firm must determine b_h and b_l by maximizing $E[\Pi^f]|_{\Omega_B} = p_1^2(f_h - 2b_h) + 2p_1(1 - p_1)(f_l - 2b_l)$, while considering the constraints posed in (4.2f) and (4.3f): $\psi_h - c_f \geq \psi_l$, $\psi_l - c_f \geq \psi_x$, $\psi_h + w - c_f \geq w$ and $\psi_l + w - c_f \geq w$.

Three incentive structures satisfy the constraints posed in (4.2f) and (4.3f), and are noted with superscripts A-C:

$$\begin{aligned}\vec{b}|_{\Omega_B}^A &= \{b_h = c_f \left(2 + \frac{1 - \Delta}{p_0\Delta}\right), b_l = c_f, b_x = 0\} \\ \vec{b}|_{\Omega_B}^B &= \{b_h = \frac{2c_f}{\Delta}, b_l = \frac{c_f}{\Delta}, b_x = 0\} \\ \vec{b}|_{\Omega_B}^C &= \{b_h = c_f, b_l = \frac{c_f(1 + p_1\Delta)}{\Delta(1 - 2p_1)}, b_x = 0\} \text{ iff } p_1 < \frac{1}{2}\end{aligned}$$

By substituting each incentive structure into $E[\Pi^f]$, we determine that:

$E[\Pi^f]|_{\vec{b}|_{\Omega_B}^C} < \max \left\{ E[\Pi^f]|_{\vec{b}|_{\Omega_B}^A}, E[\Pi^f]|_{\vec{b}|_{\Omega_B}^B} \right\}$; therefore $\vec{b}|_{\Omega_B}^C$ is never optimal. Further, $E[\Pi^f]|_{\vec{b}|_{\Omega_B}^A} > E[\Pi^f]|_{\vec{b}|_{\Omega_B}^B}$ when $p_0 > \frac{p_1}{2}$; i.e., $\Delta \leq p_0$.

□

Proof. Proposition 4.2: The Definition of Success and the Set of Feasible Initiatives

Substituting $b_h|_{\Omega_N} = \frac{c_f}{p_0\Delta}$ into $V_h|_{\Omega_N} = f_h - 2b_h$ yields $V_h|_{\Omega_N} = f_h - \frac{2c_f}{p_0\Delta}$.

Similarly for flexible target outcomes (and keeping the superscript notation outlined in Proposition 4.1 to differentiate the incentive plans), when $\Delta \leq p_0$ then $V_h|_{\Omega_B}^A = f_h - 4c_f - 2c_f \frac{(1-\Delta)}{p_0\Delta}$, whereas when $\Delta > p_0$ then $V_h|_{\Omega_B}^B = f_h - \frac{4c_f}{\Delta}$. Through algebra it can be shown that $V_h|_{\Omega_N} > 0$ when $c_f < \underline{c}_f$, where $\underline{c}_f = \frac{1}{2}f_h p_0 \Delta$. Additionally: if $\Delta \leq p_0$ then $V_h|_{\Omega_B}^A > 0$ when $c_f < \overline{c}_f^A$, where $\overline{c}_f^A = \frac{f_h p_0 \Delta}{2(1-\Delta+2p_0\Delta)}$; whereas, if $\Delta > p_0$ then $V_h|_{\Omega_B}^B > 0$ when $c_f < \overline{c}_f^B$, where $\overline{c}_f^B = \frac{1}{4}f_h \Delta$. Further, $b_h|_{\Omega_N} > b_h|_{\Omega_B}^A$ when $\Delta \leq p_0$, and $b_h|_{\Omega_N} > b_h|_{\Omega_B}^B$ when $\Delta > p_0$. Therefore, it can also be shown that $0 < \underline{c}_f < \overline{c}_f^A$ when $\Delta \leq p_0$, and $0 < \underline{c}_f < \overline{c}_f^B$ when $\Delta > p_0$; thus $0 < \underline{c}_f < \overline{c}_f$. □

Proof. Proposition 4.3: The Definition of Success in Functional Organizations

The total expected firm profits in a functional organization are calculated as: $E[\Pi^f] = p_1^2(f_h - 2b_h) + 2p_1(1 - p_1)(f_l - 2b_l) + (1 - p_1)^2(f_x - 2b_x)$. With a focused definition of success, this yields $E[\Pi^f]|_{\Omega_N} = p_1^2(f_h - \frac{2c_f}{p_0\Delta})$. The expected profits with a flexible definition depends on the relationship between Δ and p_0 , such that: if $\Delta \leq p_0$ then $E[\Pi^f]|_{\Omega_B}^A = p_1^2 \left(f_h - 4c_f - 2c_f \frac{(1-\Delta)}{p_0\Delta} \right) + 2p_1(1 - p_1)(f_l - 2c_f)$; and if $\Delta > p_0$ then $E[\Pi^f]|_{\Omega_B}^B = p_1^2 \left(f_h - \frac{4c_f}{\Delta} \right) + 2p_1(1 - p_1)(f_l - \frac{2c_f}{\Delta})$. Through algebra, it can be shown that: if $\Delta > p_0$ then $E[\Pi^f]|_{\Omega_N} < E[\Pi^f]|_{\Omega_B}^B$; and if $\Delta \leq p_0$ then $E[\Pi^f]|_{\Omega_N} > E[\Pi^f]|_{\Omega_B}^A$ only if $c_f > \frac{f_l p_0(1-p_0-\Delta)}{p_0-\Delta}$. If $c_f > \underline{c}_f = \frac{1}{2}f_h p_0 \Delta$ then focused definitions of success are not profitable in functional organizations (see Proposition 4.2). □

Proof. Proposition 4.4: Cost Implications in Functional Organizations

Let $F(c_f, \Delta, \frac{f_l}{f_h})$ define the function $E[\Pi^f]|_{\Omega_B} = 0$. Solving for f_l that results in $E[\Pi^f]|_{\Omega_B} = 0$ yields $f_l = \frac{2c_f(-2p_0^2+3p_0p_1-p_1^2+p_1)+f_h p_0 p_1(p_0-p_1)}{2p_0(p_1-1)(p_0-p_1)}$. Dividing each side of the equation by f_h , substituting $p_1 = p_0 + \Delta$, and setting the equation to 0 results in:

$$F = \frac{\Delta f_h p_0 (\Delta - 2p_0 \frac{f_l}{f_h} + p_0 - 2\Delta \frac{f_l}{f_h} + 2\frac{f_l}{f_h}) - 2c_f (-\Delta^2 + \Delta + \Delta p_0 + p_0)}{2\Delta f_h p_0 (\Delta + p_0 - 1)}.$$

From the implicit function theorem, $\frac{F_\Delta}{F_{c_f}} = -\frac{\partial F / \partial c_f}{\partial F / \partial \Delta}$ and $\frac{F_{f_l/f_h}}{F_{c_f}} = -\frac{\partial F / \partial c_f}{\partial F / \partial f_l/f_h}$.

$$\frac{\partial F}{\partial c_f} = -\frac{-\Delta^2 + \Delta + \Delta p_0 + p_0}{\Delta f_h p_0 (\Delta + p_0 - 1)} > 0 \text{ and}$$

$$\frac{\partial F}{\partial \Delta} = \frac{2c(2\Delta(\Delta+1)+p_0-1)-\Delta^2 f_h}{2\Delta^2 f_h (\Delta+p_0-1)^2} < 0 \text{ whenever } E[\Pi^f]|_{\Omega_B} \geq 0 \text{ and}$$

$$\frac{\partial F}{\partial f_l/f_h} = -1 < 0.$$

$$\text{Therefore: } \frac{F_\Delta}{F_{c_f}} = -\frac{\partial F / \partial c_f}{\partial F / \partial \Delta} > 0 \text{ and } \frac{F_{f_l/f_h}}{F_{c_f}} = -\frac{\partial F / \partial c_f}{\partial F / \partial f_l/f_h} > 0.$$

Let $G(c_f, \Delta, \frac{f_l}{f_h})$ define the function $E[\Pi^f]|_{\Omega_B} = E[\Pi^f]|_{\Omega_N}$. Solving for f_l while setting $E[\Pi^f]|_{\Omega_B} = E[\Pi^f]|_{\Omega_N}$ yields $f_l = \frac{c_f(p_1-2p_0)}{p_0(p_1-1)}$. Substituting $p_1 = p_0 + \Delta$, dividing each side by f_h , and setting the equation to 0 results in:

$$G = \frac{c_f(\Delta-p_0)}{f_h p_0 (\Delta+p_0-1)} - \frac{f_l}{f_h}.$$

Applying the implicit function theorem:

$$\frac{\partial G}{\partial c_f} = \frac{\Delta-p_0}{f_h p_0 (\Delta+p_0-1)} > 0 \text{ and}$$

$$\frac{\partial G}{\partial \Delta} = \frac{c(2p_0-1)}{f_h p_0 (\Delta+p_0-1)^2} < 0 \text{ and}$$

$$\frac{\partial G}{\partial f_l/f_h} = -1 < 0.$$

$$\text{Therefore: } \frac{G_\Delta}{G_{c_f}} = -\frac{\partial G / \partial c_f}{\partial G / \partial \Delta} > 0 \text{ and } \frac{G_{f_l/f_h}}{G_{c_f}} = -\frac{\partial G / \partial c_f}{\partial G / \partial f_l/f_h} > 0.$$

□

Proof. Corollary 4.1: Definition of Success Under Additive Value Contributions

Consider the following two component value function where the two components are additive and serve as pure substitutes. Let $V = f(\vec{v}_i) = \Sigma v_i$, where $v_i = \{v^H, v^L\}$ such that $0 < v^L < v^H$. Define $f_h = v^H + v^H$ and $f_l = v^H + v^L$. Therefore, $\frac{f_l}{f_h} = \frac{v^H + v^L}{2v^H}$. Taking the limit of $\frac{f_l}{f_h}$ as $v^L \rightarrow 0 = \frac{1}{2}$. Taking the limit of $\frac{f_l}{f_h}$ as $v^L \rightarrow v^H = 1$. Therefore $\frac{f_l}{f_h} \in (\frac{1}{2}, 1)$.

Through algebra, it can be shown through the conditions outlined in Proposition 4.3 that $E[\Pi^f]|_{\Omega_N} < E[\Pi^f]|_{\Omega_B}$ if $\frac{f_l}{f_h} \in (\frac{1}{2}, 1)$.

□

Proof. Proposition 4.5: Project-Based Organization Incentive Structure

Constraint (4.2p) results into two conditions that must be satisfied in order to avoid a lack of impetus ($e_i = H$) on either of the two tasks. Specifically we require $\psi_h - 2c_p \geq \psi_l - c_p$ and $\psi_h - 2c_p \geq \psi_x$. The first of these two equations implies that the project manager would prefer to ensure costly effort towards both project tasks instead of only one. The second equation implies that the project manager would prefer to ensure costly effort on both tasks as opposed to neither. Together, these two conditions imply that the project manager would prefer to ensure a costly effort towards both tasks as opposed to some smaller subset thereof. Constraint (4.3p) requires that if effort is exerted on the tasks, the expected utility should at least equal their current wage w : $\psi_h + w - 2c_p \geq w$. Equation (4.4f) indicates that the project manager will ensure effort in such a way as to maximize the team's expected utility, and is satisfied by the constraints posed in (4.2p).

With a focused definition of success, the firm will only offer a bonus b_h in the event a $V = f_h$ project outcome is achieved, thus maximizing $\Pi^p = f_h - 2b_h$ is equivalent to minimizing b_h . To ensure stakeholder impetus, $b_h = \frac{2c_p}{\Delta(2p_0 + \Delta)}$ is the smallest bonus that can be offered which satisfies the conditions in Equations (4.2p) and (4.3p). From Definition 3, this results in $\vec{b}|_{\Omega_N} = \{b_h = \frac{2c_p}{\Delta(2p_0 + \Delta)}, b_l = 0, b_x = 0\}$.

With a flexible definition of success, the firm will offer bonuses b_h or b_l depending on whether a $V = f_h$ or $V = f_l$ project outcome is achieved, respectively. Since the compensation plan is offered by senior management and accepted by the stakeholders prior to the project outcome realization, senior management must ensure impetus on all project tasks based on the expected profits to the firm given either $V = f_h$ or $V = f_l$ outcomes. Therefore, the firm must determine b_h and b_l by maximizing $E[\Pi^p]|_{\Omega_B} = p_1^2(f_h - b_h) + 2p_1(1 - p_1)(f_l - b_l)$, while considering the constraints posed

in (2p) and (3p): $\psi_h - 2c_p \geq \psi_l - c_p$, $\psi_h - 2c_p \geq \psi_x$, and $\psi_h + w - 2c_p \geq w$.

Two incentive structures satisfy the constraints posed in (4.2p) and (4.3p), and are noted with superscripts D and E:

$$\begin{aligned}\vec{b}|_{\Omega_B}^D &= \{b_h = \frac{2c_p}{\Delta}, b_l = \frac{c_p}{\Delta}, b_x = 0\} \\ \vec{b}|_{\Omega_B}^E &= \{b_h = \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)}, b_l = c_p, b_x = 0\}\end{aligned}$$

By substituting each incentive structure into $E[\Pi^p]$, we determine that:

$E[\Pi^p]|_{\vec{b}|_{\Omega_B}^D} < E[\Pi^p]|_{\vec{b}|_{\Omega_B}^E}$; therefore $\vec{b}|_{\Omega_B}^D$ is never optimal. This results in the optimal incentive plan for a flexible definition of success as $\vec{b}|_{\Omega_B}^E = \vec{b}|_{\Omega_B} = \{b_h = \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)}, b_l = c_p, b_x = 0\}$. \square

Proof. Proposition 4.6: The Definition of Success and the Set of Feasible Initiatives

Substituting $b_h|_{\Omega_N} = \frac{2c_p}{\Delta(2p_0+\Delta)}$ into $V_h|_{\Omega_N} = f_h - b_h$ yields $V_h|_{\Omega_N} = f_h - \frac{2c_p}{\Delta(2p_0+\Delta)}$. Similarly for flexible target outcomes $V_h|_{\Omega_B} = f_h - \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)}$. Through algebra it can be shown that $V_h|_{\Omega_N} > 0$ when $c_p < \underline{c}_p$, where $\underline{c}_p = \frac{1}{2}f_h\Delta(2p_0+\Delta)$. Additionally, $V_h|_{\Omega_B} > 0$ when $c_p < \bar{c}_p$, where $\bar{c}_p = \frac{f_h\Delta(2p_0+\Delta)}{2(1+\Delta(2p_0+\Delta-1))}$. Further, $b_h|_{\Omega_N} > b_h|_{\Omega_B}$ when $p_0 + p_1 < 1$. Therefore, it can also be shown that $0 < \underline{c}_p < \bar{c}_p$ when $p_0 + p_1 < 1$. \square

Proof. Proposition 4.7: The Definition of Success in Project-Based Organizations

The total expected firm profit in a project-based organization is calculated as: $E[\Pi^p] = p_1^2(f_h - b_h) + 2p_1(1 - p_1)(f_l - b_l) + (1 - p_1)^2(f_x - b_x)$. With focused target outcomes, this yields $E[\Pi^p]|_{\Omega_N} = p_1^2(f_h - \frac{2c_p}{\Delta(2p_0+\Delta)})$. The expected profits with a flexible definition of success $E[\Pi^p]|_{\Omega_B} = p_1^2(f_h - \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)}) + 2p_1(1 - p_1)(f_l - 2c_p)$. Through algebra, it can be shown that $E[\Pi^p]|_{\Omega_N} > E[\Pi^p]|_{\Omega_B}$ if $c_p > \frac{f_l}{p_0}(1 - p_0 - \Delta)(2p_0 + \Delta)$. If $c_p > \underline{c}_p = \frac{1}{2}f_h\Delta(2p_0 + \Delta)$ then focused definitions of success are not profitable in project-based organizations (see Proposition 4.5). \square

Proof. Proposition 4.8: Cost Implications in Project-Based Organizations

Let $X(c_p, \Delta, \frac{f_l}{f_h})$ define the function $E[\Pi^P]|_{\Omega_B} = 0$. Setting $E[\Pi^P]|_{\Omega_B} = 0$ and substituting $p_1 = p_0 + \Delta$ while dividing each side of the equality by f_h to transform f_l into $\frac{f_l}{f_h}$ results in:

$$X = (p_0 + \Delta) \left(p_0 + \Delta - \frac{2c_p(p_0 + \Delta + p_0\Delta)}{f_h\Delta(2p_0 + \Delta)} + 2\frac{f_l}{f_h} - 2(p_0 + \Delta)\frac{f_l}{f_h} \right).$$

From the implicit function theorem, $\frac{X_\Delta}{X_{c_p}} = -\frac{\partial X/\partial c_p}{\partial X/\partial \Delta}$ and $\frac{X_{f_l/f_h}}{X_{c_p}} = -\frac{\partial X/\partial c_p}{\partial X/\partial f_l/f_h}$.

$$\frac{\partial X}{\partial c_p} = -\frac{2(p_0 + \Delta)(p_0 + \Delta + p_0\Delta)}{f_h\Delta(2p_0 + \Delta)} < 0 \text{ and}$$

$$\frac{\partial X}{\partial \Delta} = \frac{2(-cp_0^2((p_0 - p_1)^2 - 2p_1) + (f_l + f_h p_1 - 2f_l p_1)(p_0^2 - p_1^2)^2 - p_0^2((p_0 - p_1)^2 - 2p_1)\gamma)}{f_h(p_0^2 - p_1^2)^2} > 0 \text{ and}$$

$$\frac{\partial X}{\partial f_l/f_h} = 2(1 - p_1)p_1 > 0.$$

$$\text{Therefore: } \frac{X_\Delta}{X_{c_p}} = -\frac{\partial X/\partial c_p}{\partial X/\partial \Delta} > 0 \text{ and } \frac{X_{f_l/f_h}}{X_{c_p}} = -\frac{\partial X/\partial c_p}{\partial X/\partial f_l/f_h} > 0.$$

Let $Y(c_p, \Delta, \frac{f_l}{f_h})$ define the function $E[\Pi^P]|_{\Omega_B} = E[\Pi^P]|_{\Omega_N}$. Setting $E[\Pi^P]|_{\Omega_B} = E[\Pi^P]|_{\Omega_N}$ and substituting $p_1 = p_0 + \Delta$ while dividing by f_h to transform f_l into $\frac{f_l}{f_h}$ results in:

$$Y = 2(p_0 + \Delta) \left(-\frac{p_0 c_p}{f_h(2p_0 + \Delta)} + \frac{f_l}{f_h} - (p_0 + \Delta)\frac{f_l}{f_h} \right).$$

Applying the implicit function theorem:

$$\frac{\partial Y}{\partial c_p} = -\frac{2p_0 p_1}{f_h(p_0 + p_1)} < 0 \text{ and}$$

$$\frac{\partial Y}{\partial \Delta} = -\frac{2p_0^2 c_p}{f_h(p_0 + p_1)^2} - (4p_1 + 2)\rho < 0 \text{ and}$$

$$\frac{\partial Y}{\partial f_l/f_h} = 2(1 - p_1)p_1 > 0.$$

$$\text{Therefore } \frac{Y_\Delta}{Y_{c_p}} = -\frac{\partial Y/\partial c_p}{\partial Y/\partial \Delta} < 0 \text{ and } \frac{Y_{f_l/f_h}}{Y_{c_p}} = -\frac{\partial Y/\partial c_p}{\partial Y/\partial f_l/f_h} > 0$$

□

Proof. Corollary 4.2: Functional vs. Project-Based Organization Profits

If a firm employs focused target outcomes, then the expected profits with a functional organization are $E[\Pi^F]|_{\Omega_N} = p_1^2(f_h - \frac{2c_f}{p_0\Delta})$ and $E[\Pi^P]|_{\Omega_N} = p_1^2(f_h - \frac{2c_p}{\Delta(2p_0 + \Delta)})$

with a project-based organization. By comparison, $E[\Pi^f]|\Omega_N > E[\Pi^p]|\Omega_N$ if $\frac{c_p}{c_f} > 1 + \frac{p_1}{p_0}$.

If a firm employs a flexible definition of success, then the expected profits with a functional organization are dependent of the relationship between Δ and p_0 , such that: if $\Delta \leq p_0$ then $E[\Pi^f]|\Omega_B^A = p_1^2 \left(f_h - 4c_f - 2c_f \frac{(1-\Delta)}{p_0\Delta} \right) + 2p_1(1-p_1)(f_l - 2c_f)$; and if $\Delta > p_0$ then $E[\Pi^f]|\Omega_B^B = p_1^2 \left(f_h - \frac{4c_f}{\Delta} \right) + 2p_1(1-p_1)(f_l - \frac{2c_f}{\Delta})$. With a project-based organization, the expected firm profits are $E[\Pi^p]|\Omega_B = p_1^2 \left(f_h - \frac{2c_p(1+\Delta(2p_0+\Delta-1))}{\Delta(2p_0+\Delta)} \right) + 2p_1(1-p_1)(f_l - 2c_p)$. By comparison, when $\Delta \leq p_0$ then $E[\Pi^f]|\Omega_B > E[\Pi^p]|\Omega_B$ if $\frac{c_p}{c_f} > 1 + \alpha_1$ where $\alpha_1 = \frac{p_0^3 - (1+2p_0)p_1^2 + p_1^3}{p_0^3 - p_0(1+p_0)p_1} \in [1, 2]$ when $\Delta \leq p_0$. Similarly, when $\Delta > p_0$ then $E[\Pi^f]|\Omega_B > E[\Pi^p]|\Omega_B$ if $\frac{c_p}{c_f} > 1 + \alpha_2$ where $\alpha_2 = \frac{p_0(2+p_0-p_1)+p_1}{(1+p_0)p_1-p_0^2} \in [1, 2]$ if $\Delta > p_0$. Since $\alpha_1 \in [1, 2]$ and $\alpha_2 \in [1, 2]$, for notational convenience we replace both with the general term α , such that $\alpha = \alpha_1$ if $\Delta \leq p_0$ and $\alpha = \alpha_2$ if $\Delta > p_0$.

□

Bibliography

- Abubakar, Binta, Richards, Darlington, & Nwanna, Gladson. 2010. Export And The Fashion Industry In The USA: Evaluating Likely Impact On The USA Economy. *International Business & Economics Research Journal (IBER)*, **9**(10).
- Agrawal, Vishal, Kavadias, Stylianos, & Toktay, L. Beril. 2011. Design and Introduction of Conspicuous Durable Products. *Working Paper*.
- Agrawal, Vishal, Ferguson, Mark, Toktay, L. Beril, & Thomas, Valerie. 2012. Is Leasing Greener Than Selling? *Management Science*, **58**(3), 523–533.
- Allen, Thomas J. 2001. Organizing for Product Development. *Working Paper*, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=297304.
- Anand, Gopesh, & Ward, Peter T. 2004. Fit, flexibility and performance in manufacturing: coping with dynamic environments. *Production and Operations Management*, **13**(4), 369–385.
- Antonsson, Erik K., & Otto, Kevin N. 1995. Imprecision in Engineering Design. *Journal of Mechanical Design*, **117**(B), 25–32.
- Atasu, Atalay, Sarvary, Miklos, & Wassenhove, Luk Van. 2008. Remanufacturing as a Marketing Strategy. *Management Science*, **54**(10), 1731–1746.
- Azadegan, Arash, Patel, Pankaj C, & Parida, Vinit. 2013. Operational Slack and Venture Survival. *Production and Operations Management*, **22**(1), 1–18.
- Bagwell, Kyle. 2007. The Economic Analysis of Advertising. *Pages 1701–1844 of: Armstrong, Mark, & Porter, Rob (eds), Handbook of Industrial Organization, vol. 3*. Amsterdam: North Holland.

- Basu, Amiya, Lal, Rajiv, Srinivasan, V., & Staelin, Richard. 1985. Salesforce Compensation Plans: An Agency Theoretic Perspective. *Marketing Science*, **4**(4), 267–291.
- Bausch, Andreas, & Pils, Frithjof. 2009. Product diversification strategy and financial performance: meta-analytic evidence on causality and construct multidimensionality. *Review of Managerial Science*, **3**(3), 157–190.
- Benito-Osorio, Diana, Guerras-Martin, Luis Angel, & Zuniga-Vicente, Jose Angel. 2012. Four decades of research on product diversification: a literature review. *Management Decision*, **50**(2), 325–344.
- Bennett, Jeff. 2011. Chrysler's PLans for Jeep Lift Toledo. *The Wall Street Journal*, November 17.
- Berger, Philip G., & Ofek, Eli. 1995. Diversification's effect on firm value. *Journal of Financial Economics*, **37**(1), 39–65.
- Bhattacharya, Shantanu, Krishnan, V., & Mahajan, Vijay. 1998. Managing New Product Definition in Highly Dynamic Environments. *Management Science*, **44**(11), S50–S64.
- Bosch. 2012a. *Bosch Auto Parts: Alternators and Starters*. <http://www.boschautoparts.com/alternatorsstarters/pages/alternatorsstarters.aspx>. Accessed: 12/13/2012.
- Bosch. 2012b. *CPO: Bosch Reconditioned Tools*. <http://www.cpotools.com/bosch-reconditioned-power-tools/bosch-reconditioned-power-tools,default,sc.html>. Accessed: 11/13/2012.
- Bourgeois III, L Jay. 1981. On the measurement of organizational slack. *Academy of Management Review*, **6**(1), 29–39.

- Boyabatlı, Onur, & Toktay, L Beril. 2004. Operational Hedging: A Review with Discussion. *working paper*.
- Boyer, Kenneth K, & Leong, G Keong. 1996. Manufacturing Flexibility at the Plant Level. *Omega International Journal of Management Science*, **24**(5), 495–510.
- Brocklebank, John, & Dickey, David. 2003. *SAS for Forecasting Time Series*. Cary, NC: SAS Institute.
- Bulow, Jeremy I. 1982. Durable-Goods Monopolists. *The Journal of Political Economy*, **90**(2), 314–332.
- Burgelman, Robert A. 1983. A Model of the Interaction of Strategic Behavior, Corporate Context, and the Concept of Strategy. *The Academy of Management Review*, **8**(1), 61–70.
- Cachon, Gerard P., & Lariviere, Martin A. 2005. Supply Chain Coordination with Revenue-Sharing Contracts: Strengths and Limitations. *Management Science*, **51**(1), 30–44.
- Cachon, Gerard P., Randall, Taylor, & Schmidt, Glen M. 2007. In Search of the Bullwhip Effect. *Manufacturing & Service Operations Management*, **9**(4), 457–479.
- Caldieraro, Fabio, & Coughlan, Anne T. 2007. Spiffed-Up Channels: The Role of Spiffs in Hierarchical Selling Organizations. *Marketing Science*, **26**(1), 31–51.
- Capon, Noel, Farley, John U, & Hoenig, Scott. 1990. Determinants of Financial Performance: A Meta-Analysis. *Management Science*, **36**(10), 1143–1159.
- Caves, Richard E., & Greene, David P. 1996. Brands' quality levels, prices, and advertising outlays: empirical evidence on signals and information costs. *International Journal of Industrial Organization*, **14**, 29–52.

- Chen, Fangruo. 2000. Sales-Force Incentives and Inventory Management. *Manufacturing & Service Operations Management*, **2**(2), 186–202.
- Chod, Jiri, & Rudi, Nils. 2005. Resource Flexibility with Responsive Pricing. *Operations Research*, **53**(3), 532–548.
- Choi, Kyong-Ae. 2011. Hyundai Net Profit Jumps 47% Amid Strong Growth Prospects. *The Wall Street Journal*, April 28.
- Chopra, Sunil, & Sodhi, ManMohan S. 2004. Managing risk to avoid supply chain breakdown. *Sloan Management Review*, **Fall**, 53–61.
- Clark, Kim B., & Wheelwright, Steven C. 1992. Organizing and Leading “Heavy-weight” Development Teams. *California Management Review*, **Spring**, 09–28.
- Colombo, L., & Lambertini, L. 2003. Dynamic advertising under vertical differentiation. *Journal of optimization theory and applications*, **119**(2), 261–280.
- Cooper, Robert G. 1993. *Winning at New Products*. Reading, MA: Addison-Wesley Publishing Company.
- Coughlan, Anne. 1993. Sales Force Compensation: A Review of MS/OR Advances. *Pages 611–651 of: Eliashberg, Jehoshua, & Lilien, Gary (eds), Handbook in Operations Research and Management Science: Marketing*. Amsterdam: Elsevier Science Publishers.
- da Silveira, Giovanni J.C. 2006. Effects of simplicity and discipline on operational flexibility: An empirical reexamination of the rigid flexibility model. *Journal of Operations Management*, **24**(6), 932–947.
- Daniel, Francis, Lohrke, Franz T, Fornaciari, Charles J, & Turner Jr, R Andrew. 2004. Slack Resources and Firm Performance: A Meta-Analysis. *Journal of Business Research*, **57**(6), 565–574.

- Debo, Laurens, Toktay, L. Beril, & Wassenhove, Luk Van. 2005. Market Segmentation and Product Technology Selection for Remanufacturable Products. *Management Science*, **51**(8), 1193–1205.
- Debo, Laurens, Toktay, L. Beril, & Wassenhove, Luk Van. 2006. Joint life-cycle dynamics of new and remanufactured products. *Production and Operations Management*, **14**(4), 498–513.
- Denis, David J., Denis, Diane K., & Yost, Keven. 2002. Global Diversification, Industrial Diversification, and Firm Value. *The Journal of Finance*, **57**(5), 1951–1975.
- Desai, Preyas, & Purohit, Devavrat. 1998. Leasing and Selling: Optimal Marketing Strategies for a Durable Goods Firm. *Management Science*, **44**(11), S19–S34.
- Dess, Gregory G, & Beard, Donald W. 1984. Dimensions of Organizational Task Environments. *Administrative Science Quarterly*, **29**(1), 52–73.
- Eisenhardt, Kathleen M, Furr, Nathan R, & Bingham, Christopher B. 2010. Microfoundations of Performance: Balancing Efficiency and Flexibility in Dynamic Environments. *Organization Science*, **21**(6), 1263–1273.
- Eroglu, Cuneyt, & Hofer, Christian. 2011. Lean, leaner, too lean? The inventory-performance link revisited. *Journal of Operations Management*, **29**(4), 356–369.
- FASB. 1997. *Statement of Financial Accounting Standards No. 131*. Houston, TX: Financial Accounting Standards Board.
- Ferguson, Mark, & Toktay, L. Beril. 2006. The Effect of Competition on Recovery Strategies. *Production and Operations Management*, **15**(3), 351–368.
- Ferguson, Mark, Jr., V. Daniel R. Guide, & Souza, Gilvan C. 2006. Supply Chain Coordination for False Failure Returns. *Manufacturing & Service Operations Management*, **8**(4), 376–393.

- Ferrer, Geraldo, & Swaminathan, Jayashankar. 2006. Managing New and Remanufactured Products. *Management Science*, **52**(1), 15–26.
- Galbraith, Jay R. 2008. Organization Design. *In: Cummings, Thomas G. (ed), Handbook of Organization Development*. Thousand Oaks, CA: SAGE Publications.
- Gasparro, Annie. 2012. Starbucks Breaks Ground for Georgia Plant. *The Wall Street Journal*, July 13.
- George, Gerard. 2005. Slack Resources and the Performance of Privately Held Firms. *Academy of Management Journal*, **48**(4), 661–676.
- Gerwin, Donald. 1993. Manufacturing Flexibility: A Strategic Perspective. *Management science*, **39**(4), 395–410.
- Goerzen, Anthony, & Beamish, Paul W. 2003. Geographic scope and multinational enterprise performance. *Strategic Management Journal*, **24**(13), 1289–1306.
- Goldstein, Susan Meyer, & Iossifova, Albena R. 2012. Ten years after: interference of hospital slack in process performance benefits of quality practices. *Journal of Operations Management*, **30**(1), 44–54.
- Goll, Irene, & Rasheed, Abdul. 1997. Rational decision-making and firm performance: the moderating role of the environment. *Strategic Management Journal*, **18**(7), 583–591.
- Goyal, Manu, & Netessine, Serguei. 2007. Strategic Technology Choice and Capacity Investment Under Demand Uncertainty. *Manufacturing Science*, **53**(2), 192–207.
- Goyal, Manu, & Netessine, Serguei. 2011. Volume flexibility, product flexibility, or both: The role of demand correlation and product substitution. *Manufacturing & Service Operations Management*, **13**(2), 180–193.

- Groves, Theodore. 1973. Incentives in Teams. *Econometrica*, **41**(4), 617–631.
- Guide, Daniel, & Li, Jiay. 2010. The Potential for Cannibalization of New Product Sales by Remanufactured Sales. *Decision Sciences*, **41**(3), 547–572.
- Guide, Daniel, Teunter, Ruud H., & Wassenhove, Luk N. Van. 2003. Matching Demand and Supply to Maximize Profits from Remanufacturing. *Manufacturing & Service Operations Management*, **5**(4), 303–316.
- Guide, Daniel, Muyldermans, Luc, & Wassenhove, Luk N. Van. 2005. Hewlett-Packard Company Unlocks the Value Potential from Time-Sensitive Returns. *Interfaces*, **35**(4), 281–293.
- Guide, Daniel, Souza, Gilvan, VanWassenhove, Luk, & Blackburn, Joseph. 2006. Time Value of Commercial Product Returns. *Management Science*, **52**(8), 1200–1214.
- Harris, Milton, & Raviv, Artur. 2002. Organization Design. *Management Science*, **48**(7), 852–865.
- Hayes, Robert, & Wheelwright, Steven C. 1984. *Restoring our Competitive Edge: Competing Through Manufacturing*. New York: John Wiley.
- Hazen, Benjamin T., Overstreet, Robert E., Jones-Farmer, L. Allison, & Field, Hubert S. 2012. The role of ambiguity tolerance in consumer perception of remanufactured products. *International Journal of Production Economics*, **135**, 781–790.
- Heeley, Michael B, King, David R, & Covin, Jeffrey G. 2006. Effects of Firm R&D Investment and Environment on Acquisition Likelihood. *Journal of Management Studies*, **43**(7), 1513–1535.

- Hendricks, Kevin B, Singhal, Vinod R, & Zhang, Rongrong. 2009. The effect of operational slack, diversification, and vertical relatedness on the stock market reaction to supply chain disruptions. *Journal of Operations Management*, **27**(3), 233–246.
- Hitt, Michael A, Hoskisson, Robert E, & Kim, Hicheon. 1997. International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management journal*, **40**(4), 767–798.
- Hobday, Mike. 2000. The project-based organization: an ideal form for managing complex products and systems? *Research Policy*, **29**, 871–893.
- Hoegl, Martin, & Gemuenden, Hans Georg. 2001. Teamwork Quality and the Success of Innovative Projects. *Organization Science*, **12**(4), 435–449.
- Hoegl, Martin, Weinkauff, Katharina, & Gemuenden, Hans Georg. 2004. Interteam Coordination, Project Commitment, and Teamwork in Multiteam R&D Projects: A Longitudinal Study. *Organization Science*, **15**(1), 38–55.
- Holmstrom, Bengt, & Milgrom, Paul. 1987. Aggregation and Linearity in the Provision of Intertemporal Incentives. *Econometrica*, **55**(2), 303–328.
- Holmstrom, Bengt, & Milgrom, Paul. 1991. Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design. *Journal of Law, Economics, and Organization*, **7**, 24–52.
- HP. 2012. *HP Remanufactured Products*. <http://www8.hp.com/us/en/hp-information/refurbished/how-to-buy.html>. Accessed: 09/28/2012.
- Huang, Ryan. 2013. *Samsung bets on product, biz diversity*. <http://www.zdnet.com/samsung-bets-on-product-biz-diversity-7000011930/1>. Accessed: 05/20/2014.

- Hylleberg, Svend. 1992. *Modeling Seasonality: Advanced Textbooks in Econometrics*. New York, NY: Oxford University Press USA.
- Jack, Eric P., & Raturi, Amitabh S. 2003. Measuring and comparing volume flexibility in the capital goods industry. *Production and Operations Management*, **12**(4), 480–501.
- Jones, Gareth R. 1984. Task Visibility, Free Riding, and Shirking: Explaining the Effect of Structure and Technology on Employee Behavior. *The Academy of Management Review*, **9**(4), 684–695.
- Joseph, Kissan, & Thevaranjan, Alex. 1998. Monitoring and Incentives in Sales Organizations: An Agency-Theoretic Perspective. *Marketing Science*, **17**(2), 107–123.
- Kaplan, Robert S., & Norton, David P. 2008. *The Execution Premium: Linking Strategy to Operations for Competitive Advantage*. Boston, MA: Harvard Business Press.
- Kauffman, Stuart. 1993. *The Origins of Order: Self-organization and Selection in Evolution*. New York: Oxford University Press.
- Kavadias, Stylianos, & Kovach, Jeremy. 2010. *Innovation at Cooper Lighting 2.0: Continuous Improvement of the Innovation Process?* Atlanta, GA: Working Case at Georgia Institute of Technology.
- Keats, Barbara W, & Hitt, Michael A. 1988. A causal model of linkages among environmental dimensions, macro organizational characteristics, and performance. *Academy of Management Journal*, **31**(3), 570–598.
- Kekre, Sunder, & Srinivasan, Kannan. 1990. Broader product line: a necessity to achieve success? *Management Science*, **36**(10), 1216–1232.

- Ketokivi, Mikko, & Jokinen, Mikko. 2006. Strategy, uncertainty and the focused factory in international process manufacturing. *Journal of Operations Management*, **24**(3), 250–270.
- Khanna, Naveen, & Poulsen, Annette B. 1995. Managers of financially distressed firms: villains or scapegoats? *The Journal of Finance*, **50**(3), 919–940.
- Kim, W Chan, Hwang, Peter, & Burgers, Willem P. 1993. Multinationals' diversification and the risk-return trade-off. *Strategic Management Journal*, **14**(4), 275–286.
- Kim, Young Sang, & Mathur, Ike. 2008. The impact of geographic diversification on firm performance. *International Review of Financial Analysis*, **17**(4), 747–766.
- Kim, Young Sang, Mathur, Ike, & Nam, Jouahn. 2006. Is operational hedging a substitute for or a complement to financial hedging? *Journal of Corporate Finance*, **12**(4), 834–853.
- Kirca, Ahmet H., Hult, G. Tomas M., Roth, Kendall, Cavusgil, S. Tamer, Perry, Morys Z., Akdeniz, M. Billur, Deligonul, Seyda Z., Mena, Jeannette A., Pollitte, Wesley A., Hoppner, Jessica J., Miller, Joseph C., & White, Ryan C. 2011. Firm-Specific Assets, Multinationality, and Financial Performance: A Meta-Analytic Review and Theoretical Integration. *Academy of Management Journal*, **54**(1), 47–72.
- Kittell, Matt, & Page, Kari. 2008. *Responsible Purchasing Guide: toner cartridges*. Tech. rept. Responsible Purchasing Network, Oakland, CA.
- Kleindorfer, Paul R, & Saad, Germaine H. 2005. Managing disruption risks in supply chains. *Production and Operations Management*, **14**(1), 53–68.
- Klingebiel, Ronald K., & Rammer, Christian. 2013. Resource Allocation Strategy for Innovation Portfolio Management. *Strategic Management Journal*, **forthcoming**.

- Kodak. 2008. *Global Sustainability: Eastman Kodak Company 2008 Annual Report*.
- Kretschmer, Tobias, & Puranam, Phanish. 2008. Integration Through Incentives Within Differentiated Organizations. *Organization Science*, **19**(6), 860–875.
- Kumar, MV. 2009. The relationship between product and international diversification: the effects of short-run constraints and endogeneity. *Strategic Management Journal*, **30**(1), 99–116.
- Laffont, Jean-Jacques, & Martimort, David. 2001. *The Theory of Incentives I: The Principal-Agent Model*. Princeton, NJ: Princeton University Press.
- Lal, Rajiv, & Srinivasan, V. 1993. Compensation Plans for Single- and Multi-product Salesforces: An Application of the Holmstrom-Milgrom Model. *Management Science*, **39**(7), 777–793.
- Lampel, Joseph, & Giachetti, Claudio. 2013. International diversification on manufacturing operations: Performance implications and moderating forces. *Journal of Operations Management*, **31**(4), 213–237.
- Lee, Hau L., & Tang, Christopher S. 1997. Modelling the Costs and Benefits of Delayed Product Differentiation. *Management Science*, **43**(1), 40–53.
- Lee, K. P. 2010. Volkswagen to Build Cars in Malaysia. *The Wall Street Journal*, December 21.
- Lenox, Michael J., Rockart, Scot F., & Lewin, Arie Y. 2007. Interdependency, Competition, and Industry Dynamics. *Management Science*, **53**(4), 599–615.
- Levinthal, Daniel A., & Warglien, Massimo. 1999. Landscape Design: Designing for Local Action in Complex Worlds. *Organizational Science*, **10**(3), 342–357.
- Linebaugh, Kate, & Hagerty, James R. 2011. Business Abroad Drives U.S. Profits. *The Wall Street Journal*, July 25.

- Loch, Christoph H., & Bode-Greuel, Kerstin. 2001. Evaluating growth options as sources of value for pharmaceutical research projects. *R&D Management*, **31**(2), 231–248.
- Loch, Christoph H., & Kavadias, Stylianos. 2011. Implementing strategy through projects. *Pages 225–251 of: Morris, Peter W. G., Pinto, Jeffrey K., & Soderlund, Jonas (eds), The Oxford Handbook of Project Management*. Oxford: Oxford University.
- Loch, Christoph H., & Tapper, U.A. Steffan. 2002. Implementing a strategy-driven performance measurement system for an applied research group. *Journal of Product Innovation Management*, **19**, 185–198.
- Loch, Christoph H., & Terwiesch, Christian. 2007. *Handbook of New Product Development Management*. Ch: Coordination and Information Exchange: Butterworth Heinemann.
- Loftus, Peter. 2011. J&J Profit Falls 20% on Charges. *The Wall Street Journal*, July 19.
- Majumder, Pranab, & Groenevelt, Harry. 2001. Competition in Remanufacturing. *Production and Operations Management*, **10**(2), 125–141.
- Manso, Gustavo. 2011. Motivating Innovation. *Journal of Finance*, **66**(5), 1823–1960.
- McGrath, Rita Gunther, & Keil, Thomas. 2007. The Value Captor’s Process: Getting the Most out of Your New Business Ventures. *Harvard Business Review*, **May**, 128–136.
- McGrath, Steve, & Rauwald, Christoph. 2012. German Car Makers Reap China Gains. *The Wall Street Journal*, April 4.

- Michaud, Celine, & Llerena, Daniel. 2011. Green Consumer Behaviour: an Experimental Analysis of Willingness to Pay for Remanufactured Products. *Business Strategy and the Environment*, **20**, 408–420.
- Mihm, Jurgen. 2010. Incentives in New Product Development Projects and the Role of Target Costing. *Management Science*, **56**(8), 1324–1344.
- Milgrom, Paul, & Roberts, John. 1990. Rationalizability, Learning, and Equilibrium in Games with Strategic Complementarities. *Econometrica*, **58**(6), 1255–1277.
- Miller, C. Chet, ogilvie, dt, & Glick, William H. 2006. Assessing the external environment: an enrichment of the archival tradition. *Research Methodology in Strategy and Management*, **3**, 97–122.
- Mishina, Yuri, Pollock, Timothy G, & Porac, Joseph F. 2004. Are more resources always better for growth? Resource stickiness in market and product expansion. *Strategic Management Journal*, **25**(12), 1179–1197.
- Misra, Sanjog, Nair, Harikesh S, & Daljord, Øystein. 2013. Homogenous Contracts for Heterogeneous Agents: Aligning Salesforce Composition and Compensation. *Working Paper*.
- Modi, Sachin B, & Mishra, Saurabh. 2011. What drives financial performance—resource efficiency or resource slack?: Evidence from US Based Manufacturing Firms from 1991 to 2006. *Journal of Operations Management*, **29**(3), 254–273.
- Morgan, Neil A., & Rego, Lopo L. 2009. Brand Portfolio Strategy and Firm Performance. *Journal of Marketing*, **73**(1), 59–74.
- Morris, Peter, & Jamieson, Ashley. 2004. *Translating Corporate Strategy into Project Strategy: Realizing Corporate Strategy Through Project Management*. Newtown Square, PA: Project Management Institute.

- Mukherjee, Ashok, Mitchell, Will, & Talbot, F. Brian. 2000. The impact of new manufacturing requirements on production line productivity and quality at a focused factory. *Journal of Operations Management*, **18**(2), 139–168.
- Nippa, Michael, Pidun, Ulrich, & Rubner, Haraald. 2011. Corporate Portfolio Management: Appraising Four Decades of Academic Research. *Academy of Management Perspectives*, **25**(4), 50–66.
- Nobelius, Dennis. 2001. Empowering project scope decisions: introducing R&D content graphs. *R&D Management*, **31**(3), 265–274.
- Pagell, Mark, & Krause, Daniel R. 2004. Re-exploring the relationship between flexibility and the external environment. *Journal of Operations Management*, **21**(6), 629–649.
- Palepu, Krishna. 1985. Diversification Strategy, Profit Performance and the Entropy Measure. *Strategic Management Journal*, **6**(3), 239–255.
- Palich, Leslie E., Cardinal, Laura B., & Miller, C. Chet. 2000. Curvilinearity in the Diversification-Performance Linkage: An Examination of Over Three Decades of Research. *Strategic Management Journal*, **21**(2), 155–174.
- Pesch, Michael J., & Schroeder, Roger G. 1996. Measuring Factory Focus: An Empirical Study. *Production and Operations Management*, **5**(3), 234–254.
- Pince, Cerag, Ferguson, Mark, & Toktay, L. Beril. 2012. Remanufacturing under Warranty and Consumer Returns. *Working Paper*.
- Pons, Dirk. 2008. Project Management for New Product Development. *Project Management Journal*, **39**(2), 82–97.
- Porter, Michael. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*. New York: Simon and Schuster.

- Pratt, John W. 1964. Risk Aversion in the Small and in the Large. *Econometrica*, **32**(1–2), 122–136.
- Project Management Institute. 2000. *A Guide to the Project Management Body of Knowledge*. Newtown Square, PA: Project Management Institute.
- Qian, Gongming, Khoury, Theodore A., Peng, Mike W., & Qian, Zhengming. 2010. The Performance Implications of Intra- And Inter-Regional Geographic Diversification. *Strategic Management Journal*, **31**(9), 1018–1030.
- Ramdas, Kamalini. 2003. Managing Product Variety: An Integrative Review and Research Directions. *Production and Operations Management*, **12**(1), 79–101.
- Randall, Taylor, & Ulrich, Karl. 2001. Product Variety, Supply Chain Structure, and Firm Performance: Analysis of the U.S. Bicycle Industry. *Management Science*, **47**(12), 1588–1604.
- Rao, Ram C. 1990. Compensating Heterogeneous Salesforces: Some Explicit Solutions. *Marketing Science*, **9**(4), 319–341.
- Rauwald, Christoph. 2012. Audi Sees Little Change in Operating Income. *The Wall Street Journal*, March 1.
- Ray, Saibal, Boyaci, Tamer, & Aras, Necati. 2005. Optimal prices and trade-in rebates for durable, remanufacturable products. *Manufacturing & Service Operations Management*, **7**(3), 208–228.
- Reichfeld, Frederick, & Teal, Thomas. 1996. *The Loyalty Effect: The Hidden Force Behind Growth, Profits, and Lasting Value*. Cambridge, MA: Harvard Business School Press.
- Rivkin, Jan W. 2000. Imitation of Complex Strategies. *Management Science*, **46**(6), 824–844.

- Robert Baum, J, & Wally, Stefan. 2003. Strategic decision speed and firm performance. *Strategic Management Journal*, **24**(11), 1107–1129.
- Rotemberg, Julio J., & Saloner, Garth. 1994. Benefits of Narrow Business Strategies. *The American Economic Review*, **84**(5), 1330–1349.
- Scott-Thomas, Caroline. 2012. *Datamonitor Analyst: Product failure is the Area 51 of the food industry*. <http://www.foodnavigator-usa.com/Markets/Datamonitor-analyst-Product-failure-is-the-Area-51-of-the-food-industry>. Accessed: 05/20/2014.
- Shah, Rachna, & Ward, Peter T. 2003. Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management*, **21**(2), 129–149.
- Sharfman, Mark P, Wolf, Gerrit, Chase, Richard B, & Tansik, David A. 1988. Antecedents of organizational slack. *Academy of Management Review*, **13**(4), 601–614.
- Siggelkow, Nicolaj, & Rivken, Jan W. 2005. Speed and Search: Designing Organizations for Turbulence and Complexity. *Organization Science*, **16**(2), 101–122.
- Sirmon, David G, Hitt, Michael A, & Ireland, R Duane. 2007. Managing firm resources in dynamic environments to create value: Looking inside the black box. *Academy of Management Review*, **32**(1), 273–292.
- Skinner, Wickham. 1969. Manufacturing - missing link in corporate strategy. *Harvard Business Review*, **May-June**, 136–145.
- Skinner, Wickham. 1974. The focused factory. *Harvard Business Review*, **May-June**, 113–121.
- Sobek, Duward K., Ward, Allen C., & Liker, Jeffrey K. 1999. Toyota's Principles of Set-Based Concurrent Engineering. *Sloan Management Review*, **Winter**, 67–83.

- Song, X. Michael, Montoya-Weiss, Mitzi M., & Schmidt, Jeffrey B. 1997. Antecedents and Consequences of Cross-Functional Cooperation: A Comparison of RnD, Manufacturing, and Marketing Perspectives. *Journal of Product Innovation Management*, **14**, 35–47.
- Souder, William E. 1988. Managing Relations Between R&D and Marketing in New Product Development Projects. *Journal of Product Innovation Management*, **5**, 6–19.
- Souza, Gilvan C. 2013. Closed-Loop Supply Chains: A Critical Review, and Future Research. *Decision Sciences*, **44**(1), 7–38.
- Stokey, Nancy L. 1981. Rational Expectations and Durable Goods Pricing. *The Bell Journal of Economics*, **12**(1), 112–128.
- Subramanian, Ravi, & Subramanyam, Ramanth. 2012. Key Factors in the Market for Remanufactured Products. *Manufacturing & Service Operations Management*, **14**(2), 315–326.
- Swamidass, Paul M, & Newell, William T. 1987. Manufacturing strategy, environmental uncertainty and performance: a path analytic model. *Management Science*, **33**(4), 509–524.
- Tang, Charles Y, & Tikoo, Surinder. 1999. Operational flexibility and market valuation of earnings. *Faculty Working Papers*, **20**(8), 30.
- Tang, Christopher S. 2006. Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics: Research and Applications*, **9**(1), 33–45.
- Taylor, Terry. 2002. Supply Chain Coordination Under Channel Rebates with Sales Effort Effects. *Management Science*, **48**(8), 991–1007.

- Terlap, Sharon. 2011. GM to Reopen U.S. Truck Plant. *The Wall Street Journal*, March 25.
- Terlap, Sharon, & Winterstein, Paulo. 2011. GM Halts Two European Factories as Japan Quake Cuts Supplies. *The Wall Street Journal*, March 18.
- Thompson, James. 1967. *Organizations in Action: Social Science Bases of Administrative Theory*. New York, NY: McGraw Hill.
- Tibken, Shara. 2011. Intel Cuts Its Outlook; Giant Blames Thai Flood for \$1 Billion Drop in Sales Goal. *The Wall Street Journal*, December 13.
- Tita, Bob. 2012. Deere Bets Big on Expanding Global Demand. *The Wall Street Journal*, May 16.
- Treat, Alan, Honnold, Vincent, & Wise, Jeremy. 2012. *Remanufactured Goods: An Overview of the U.S. and Global Industries, Markets, and Trade*. Tech. rept. 332–525. United States International Trade Commission, Washington, DC. Publication 4356.
- Tremblay, Victor J., & Polasky, Stephen. 2002. Advertising with subjective horizontal and vertical product differentiation. *Review of Industrial Organization*, **20**(3), 253–265.
- Tsai, Wenpin. 2002. Social Structure of Coopetition Within a Multiunit Organization: Coordination, Competition, and Intraorganizational Knowledge Sharing. *Organization Science*, **13**(2), 179–190.
- Tsay, Andy A., & Agrawal, Narendra. 2000. Channel Dynamics Under Price and Service Competition. *Manufacturing & Service Operations Management*, **2**(4), 372–391.

- Tseng, Chiung-Hui, Tansuhaj, Patriya, Hallagan, William, & McCullough, James. 2007. Effects of firm resources on growth in multinationality. *Journal of International Business Studies*, **38**(6), 961–974.
- Van den Steen, Eric. 2012. A Theory of Explicitly Formulated Strategy. *Working Paper*, **HBS Working Paper Series**(<http://www.hbs.edu/faculty/Pages/item.aspx?num=42526>).
- Van Mieghem, Jan A. 1998. Investment strategies for flexible resources. *Management Science*, **44**(8), 1071–1078.
- Vokurka, Robert J, & O’Leary-Kelly, Scott W. 2000. A review of empirical research on manufacturing flexibility. *Journal of Operations Management*, **18**(4), 485–501.
- Voss, Glenn B, Sirdeshmukh, Deepak, & Voss, Zannie Giraud. 2008. The Effects of Slack Resources and Environmental Threat on Product Exploration and Exploitation. *Academy of Management Journal*, **51**(1), 147–164.
- Waldman, Michael. 1993. A New Perspective on Planned Obsolescence. *Quarterly Journal of Economics*, **108**(1), 273–283.
- Wefald, Andrew J, Katz, Jeffrey P, Downey, Ronald G, & Rust, Kathleen G. 2010. Organizational slack, firm performance, and the role of industry. *Journal of Managerial Issues*, **22**(1), 70–87.
- Wheelwright, Steven, & Clark, Kim. 1992. *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*. New York: Free Press.
- Wholey, Douglas R, & Brittain, Jack. 1989. Characterizing environmental variation. *Academy of Management Journal*, **32**(4), 867–882.
- Woolridge, Jeffrey. 2002. *Econometric Analysis of Cross-Section and Panel Data*. Cambridge, MA: MIT Press.

Zhang, Changning, & Mahajan, Vijay. 1995. Development of optimal salesforce compensation plans for independent, complementary and substitutable products. *International Journal of Research in Marketing*, **12**(4), 355–362.

Zhang, Qingyu, Vonderembse, Mark A, & Lim, Jeen-Su. 2003. Manufacturing flexibility: defining and analyzing relationships among competence, capability, and customer satisfaction. *Journal of Operations Management*, **21**(2), 173–191.