Reciprocity towards Incentives for Supply Chain Restoration Investment: Models, Experimental Studies and Surveys

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Declaration

The work in this thesis is based on research carried out at the Business School, Durham University, United Kingdom. No part of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text.

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Abstract

In this thesis, we evaluate the use of incentives offered beyond a contract compared with those within a contract to motivate supplier investment in restoration capability, which can serve as a signal of reciprocity. In the first chapter, we analytically examine to what extent a Direct incentive, which is paid by the manufacturer unconditionally prior to disruption, differs from an Indirect incentive, which is promised to be paid when a disruption occurs in a dyadic supply chain. We specify the conditions under which the two types of incentive are economically equivalent for both a manufacturer and a supplier. More importantly, we derive a ratio of investment amount to incentive value as a proxy of supplier reciprocity towards incentives offered by the manufacturer. Our analytical results indicate that reciprocal concern drives higher investment amount per unit incentive under Direct incentive than under Indirect incentive. The results further suggest that the manufacturer should always offer a Direct incentive as long as it is economically equivalent to an Indirect one, and should do so particularly when an ambiguous prospect for recovery outcomes is anticipated with less optimism.

The following chapter examines supplier reciprocal behaviour towards manufacturer incentives in a laboratory setting. The experimental study confirms prior analytical results that a Direct incentive can induce stronger reciprocal responses as opposed to an Indirect incentive. We reveal that the offer of a Direct incentive particularly strengthens suppliers reciprocal behaviour in long-term relationships. This result provides evidence for a synergy by coupling Direct incentives with long-term relationships. Furthermore, we observe that subjects decisions in repeated game conditions are associated with learning behaviours, in which the selfish motive of maximising their own benefits can be restrained when they repeatedly interact.

In the third chapter, we evaluate the moderating effects of perceived relational factors on the relationship between manufacturer incentives and observed supplier investments in the experiment. A post-experiment survey was developed to capture individual differences in subjects perceptions of the buyer-supplier relationship. We provide evidence that a supplier's investment decision towards its manufacturer's incentive offered is moderated by self-perception and felt obligation of the relationship. The underlying determinants of the perceived relational factors are explored. We suggest that ambiguity and other-regarding preferences are associated with self-perception; whereas, perpetrator justice sensitivity is related to the felt obligation for reciprocity in the buyer-supplier relationship.

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To my family

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Chapter 1

Introduction

1.1 Research Background

Supply chains have become ever more vulnerable due to the compound factor of the changing business environment (Wagner and Neshat 2012, Peck 2005). The risks associated with supply disruptions exist in every cycle of a supply chain, and thus the vulnerability of any one point in the supply chain could lead to the failure of the entire supply-chain network. As Hendricks and Singhal (2005, 2003) illustrate, supply-chain disruption can have detrimental economic effects on firm performance in both the short- and long-term. Taking the worlds top-five significant disruptions of 2017 (Khan and Perez 2017) as an example, Table 1.1 reveals that unforeseen and unexpected disruptions lead firms to take a long time to recover.

Table 1.1: Top 5 most significant disruption events in 2017 (Khan and Perez 2017)

Disruption Event	**Location**	**Recovery Length**
Late Winter Storm	United States	23 weeks
Laredo Border Closing	United States, Mexico	24 weeks
Hurricane Harvey	United States	17 weeks
Hurricane Irma	United States	33 weeks
Hurricane Maria	Puerto Rico	23 weeks

The disruptions caused by either natural or manmade events may cause insufficient production capacity, which affects firms' resilience and responsiveness in supply chains (Tomlin 2006, Wagner and Bode 2006). For instance, in December 2018, the world's leading semiconductor chip maker, ASML, suffered the delay of deliveries due to a fire at its supplier Prodrive. The fire accident destroyed part of Prodrive's production capacity and some inventories. To help Prodrive recovering from the disruption as soon as possible, ASML decided to actively support and work with Prodrive to restart production. Similarly, a shortage of chip resin caused by the Japan earthquake in 2011 led Mitsubishi Gas Chemical (MGC), the world's largest producer of bismaleimide-triazine (BT) resin, to halt its production at two plants. The insufficient supply capacity caused delays for almost 50% of global businesses in smartphone assembly and handset chip production. However, since MGC's BT resin was custom fitted to the chip produced by manufacturing firms, switching suppliers meant that the manufacturing firms would have had to change their product design, resulting in long delays to restore capacity (Hille 2011). The limited flexibility of specific assets may increase the potential risk that the existing supplier is encouraged to be opportunistic by delaying production restoration. Another classic example was a fire at the Philips microchip plant in 2000, which led to a challenge for Nokia to find an alternative supplier for one of its key components. Nokia and Philips worked together to restore production capacity so that shipment disruptions to customers of Nokia were avoided (Latour 2001). Therefore, from the cases above, cooperating with the existing supplier to restore capacity, instead of switching to alternative suppliers, may provide effective solutions to disruption recovery in many circumstances.

In recent years, an increasing number of researchers have highlighted the importance of investment in restoration capability due to its effectiveness in the improvement of responsiveness to disruption recovery (Nooraie and Parast 2016, Craighead et al. 2007). However, there exists a problem for which the supplier may fail to make a sufficient effort to restore the production capacity in the presence of supply chain disruption. To address this problem, it is important for the manufacturing firm to consider the use of incentives to efficiently motivate the supplier's restoration

investment. In the past, much attention has been paid to the design of incentive contracts to motivate a supplier's capability investment in supply chains (Davis and Leider 2015, Tomlin 2003, Cachon and Lariviere 2001). It is generally agreed that a well-designed complete contract can provide a safeguard to reduce the supplier's opportunistic behaviour when a manufacturer makes decisions that benefit themselves (Woolthuis et al. 2005, Lyons and Mehta 1997, Williamson 1985). However, due to human-bound rationality, it is not possible to involve all aspects of transactions in a contract, particularly in an uncertain supply-chain environment (Grossman and Hart 1986). Thus, incentive misalignment is likely to occur when a contract is incomplete, such that the supplier could behave opportunistically out of concern for their own interest and thereby cause failure in supply-chain coordination and efficiency.

1.2 Motivation of the Research

According to traditional economics, most analytical models assume that people are rational and make decisions that maximise their own benefits. However, when there exist social interactions, individuals' rationality is most often limited by their cognitive bias or emotions (Kahneman 2003, Kaufman 1999). Experimental economics provides a well-established methodological foundation for investigating how social interaction influences human behaviour (Camerer 2011, Camerer et al. 2011, Frey and Meier 2004, Gächter et al. 2004). In the past two decades, an increasing number of researchers have integrated the theories and methodologies of behavioural economics with supply chain management. In particular, the aspect of supply chain contracting mechanisms has been widely studied. Several scholars have showed that enforceable contracts in laboratory settings fail to perform consistently with theoretical predictions due to human factors (Katok and Pavlov 2013, Katok and Wu 2009, Ho and Zhang 2008, Lim and Ho 2007). For example, Katok and Pavlov (2013) found that human subjects fail to be incentivised when the coordinating contracts are offered without concerns for fairness. Falk and Fischbacher (2006) revealed that people make decisions not only out of concern for their own material payoffs, but

also care about the payoffs of the other party.

The above-mentioned studies in Behavioural operations management (BOM) have highlighted the importance of social preferences, such as fairness and reciprocity in supply chain decisions under contractual incentives. However, much less attention has been paid to relational incentives beyond contractual requirements in supply chains. Under the condition that one party in a relationship has the feeling having no control, that party is more likely to exhibit prosocial behaviour when interacting with the other party (Falk and Kosfeld 2006). Thus, in a supply-chain context, when a manufacturer voluntarily offers an unconditional incentive, a supplier who feels it has no control is more likely to reciprocate in response to the manufacturer's generous action. In this thesis, we are motivated to specifically focus on two types of relational incentives (Direct vs. Indirect) that aim to induce suppliers' reciprocal responses in restoration investment. The Direct incentive that prepaid before a disruption occurs is beyond a contract setting, which is viewed as an unconditional or voluntary action. The Indirect incentive that pre-committed on a relational contract is only realised after a disruption occurs. We draw upon motivation crowding theory and propose that Direct incentive mechanism is a more efficient tool to intrinsically motivate a supplier to invest more.

In a supply-chain relationship, it is possible that the supplier fails to meet their commitments so that the manufacturer may suffer great losses, especially when a disruption occurs. Under an incomplete contract, the cooperative relationship between the manufacturer and the supplier plays an important role in motivating the supplier's investment in capacity restoration, which helps to hedge against supply-chain disruption risks and free-riding problems (Beer et al. 2017, Taylor and Plambeck 2007*b*). It is likely that the maintenance of an on-going long-term relationship between both supply-chain parties can provide a solid foundation for strengthening cooperation and coordination in supply chains. As documented by previous research, the stability of a relationship indicates the potential for reciprocity in supply-chain transactions (Beer et al. 2017, Özer et al. 2014, Wu 2013). Out of concern for reciprocity, the supplier is more willing to invest in restoration capability depending on the manufacturer's offered incentive and, consequently, behave less

opportunistically.

When faced with a disruption, there are uncertainties regarding the consequences of disruption recovery. According to Ellsberg (1961), the probabilities of recovery outcomes in supply chains can be either known (i.e. risk) or unknown (i.e. ambiguity). In an ambiguous environment, the supplier, as the follower, is likely to increase the exposure to risks arising from opportunism. As a result, the understanding of the supplier's reciprocal behaviour in uncertainty is particularly important for unforeseen disruptions. Existing studies in behavioural economics provide evidence that most people prefer risky prospects with known probabilities over ambiguous prospects with unknown probabilities (Milliken 1987, Ellsberg 1961). Thus, in supply-chain relationships, supply-chain parties may regard the risky and ambiguous uncertainty differently, and, consequently, make different choices and express various levels of preference.

1.3 Research Contributions

This thesis extends research on incentive mechanisms which is based on motivation crowding theory (Frey and Jegen 2001). In social psychology, reciprocity, as an intrinsic motivation, is viewed as the driver of human decisions (Falk et al. 1999). A widespread body of previous literature has placed more emphasis on the role of external incentives in crowding out (i.e.undermining) intrinsic motivation (Lane 1991, Deci and Ryan 1985, Lepper et al. 1973, Deci 1971). However, most efforts to date have focused on the effect of external incentives in enhancing intrinsic motivation (Frey and Jegen 2001, Ryan and Deci 2000, Frey 1997*a*). These studies provide evidence that external incentives can induce higher intrinsic motivation if they are voluntarily offered with less controlling. By comparing external incentives based on their types of commitment (i.e. unconditional versus conditional), this study provides interesting insights into the circumstances under which the incentives offered can motivate stronger reciprocal responses. More importantly, the role of incentive mechanisms is highlighted in the context of supply-chain disruptions.

Furthermore, this study contributes to the existing BOM literature by incorpo-

rating theories of social preferences in behavioural economics and psychology into studies of behavioural operations. As documented by Fehr and Fischbacher (2002), social preferences involve preferences for fairness, reciprocity and altruism. To date, the role of the preference for fairness in supply-chain relationships has been extensively discussed in the field of BOM; however, the preference for reciprocity, which may also play a role in supply-chain cooperation, has received relatively little attention. This study advances the existing research by specifically focusing on the preference for reciprocity in operations management. The existence of reciprocity enables the exchange parties to build on-going relationships as well as reducing the opportunistic behaviour. Our study combines transaction cost theory (Williamson 1979, 1985), which emphasises the potential risk for opportunism under uncertainty, with social exchange theory (Emerson 1976), which dominates the existing theoretical explanation on the embeddedness of reciprocity in social interactions between exchange parties, to develop our theoretical framework.

Building on these theories, we hold that long-term exchange relationships are important to achieve a better understanding of supplier reciprocal behaviour, particularly towards the choice of incentive types by manufacturers. However, a relationship-building process that involves human interaction is difficult to explain using analytical models. Thus, our experimental study broadens the views of the preference for reciprocity in exchange relationships through an incentive-investment game. Our results have highlighted the importance of combining long-term relationships and Direct incentives offered prior to disruption by manufacturers to enhance supplier reciprocity. Second, in our survey-based study, we advance the existing research on supply-chain relationships by examining perceived relational factors based upon self-perception and the felt obligations to understand the moderating effects of relationship-based perceptions on reciprocal behaviour. Holding that perceptions of buyer-supplier relationships are significant for a better understanding of reciprocity, we also explore the underlying factors associated with relationship perceptions.

Methodologically, this study innovates to provide an overview of modelling-, experimental- and survey-based research. This study advances the modelling of reciprocity that follows incentive mechanisms in supply chain settings by taking

a two-step approach. Most research on reciprocity model draws attention to the consequences of reciprocity (Bolton and Ockenfels 2000, Fehr and Schmidt 1999). Our model provides evidence to distinguish between a supplier's propensity for reciprocity and reciprocal behaviour in response to the incentive offered by a manufacturer. The first step of our modelling process involves the propensity for reciprocity, which is measured by the probability of a decision to invest; while the second step refers to the extent of reciprocity, which is derived from the ratio of investment amount to incentive value. Notably, the derived ratio provides the basis for the measurement of actual reciprocal behaviour under different treatments in our laboratory study.

In our experimental study, we contribute to the existing research on the experimental design by bridging the gap between endogenous and exogenous decision-variables. In fact, decision-making is a process of selection. This study extends the existing research by investigating the effects of incentive type that viewed as the endogenous variable on decision making, which allows subjects to freely choose their choice with no control. In addition, most existing studies in BOM emphasise using experimental approaches to test whether human social behaviour deviates from the theoretical model that follows the assumption that people are self-interested. Although experimental studies have improved the internal validity of results, they have failed to find evidence for outcomes caused by the subjects' own perceptions. To date, few studies have focused on the link between survey and experimental measures of reciprocity in supply-chain relationships. Generally, survey-based methods are effective tools used to gather subjective data, including subjects' general attitudes, perceptions, beliefs and feelings. In a buyer-supplier relationship, it is important to know each party's perception of the relationship. The combination of experiment- and survey-based measures can advance the understanding of the extent to which survey-measured relationship perceptions correlate with experiment-measured reciprocal behaviour in supply-chain relationships.

In practice, supply-chain disruption is unforeseen and complex. This study highlights that the maintenance of long-term relationships plays a key role in strengthening supplier reciprocity in capacity investment and, thus, may reduce the potential

risk for free riding when facing disruption risks. It is worthwhile to note that the benefits for long-term relationships are more prominent when coupling the long-term cooperative supply-chain relationships with the offer of unconditional incentives prior to a disruption. In addition, we observe that players are motivated to adjust strategies in repeated interactions. The long-term relationship-building process can motivate the counterpart to restrain their selfish motive of maximising their own benefits. Psychologically, people differ in their perceptions and cognitive processes. Our post-experiment survey provides evidence that each party's relationship perceptions impact decision-making when they interact. In supply-chain disruption, the understanding of buyer-supplier relationships from a perceptual point of view can help decision-makers make decisions that better motivate their counterpart's prosocial behaviour and thereby improve supply-chain resiliency and responsiveness.

1.4 Research Overview

In this thesis, we aim to study how the use of efficient incentive mechanisms can motivate the supplier's investment in restoration capability with the concern for reciprocity. To address this research question, we are motivated to provide a more thorough and comprehensive understanding about the supplier's restoration investment towards the incentive offered by using model-based, experimental and survey-based approaches. Chapter 1 gives a general introduction of the whole thesis. A brief review of the key theories most relevant to this thesis is provided: transaction cost economics theory (Williamson 1979), social exchange theory (Emerson 1976, Blau 1968), motivation crowding theory (Frey and Jegen 2001), and theory of decision under uncertainty (Ellsberg 1961). A detailed explanation of theory relating to the modelling or hypotheses development in each of the three studies is provided in the following chapters (Chapters 2, 3 and 4). In Chapter 2 (study 1), we develop analytical model to evaluate the manufacturer's decision between the prepaid financial incentive before and the promised price incentive after a disruption, in which the two alternatives are equally valued. Also, we further incorporate uncertainty about the future recovery outcomes (i.e. risk vs. ambiguity) into the

supplier's reciprocal responses to the incentive offered by the manufacturer, particularly across different beliefs about the outcomes. In this model-based study, we aim to answer the following research questions:

1. Given the two incentives are equally valued, which incentive mechanism can induce the supplier's higher investment amount per unit incentive with the concern for reciprocity?

2. How does the uncertainty about the future recovery outcomes (risk vs. ambiguity) affect the supplier's reciprocity across different beliefs about the recovery outcomes?

Our basic model assumes that the expected payoffs for both types of incentives are equally valued, which is a strict condition in the theoretical modelling. However, in reality, people's decisions may be various rely upon different expected payoffs. Also, reciprocity that drives supply chain partners' decisions and behaviour is fundamentally affected by the repeated interaction, which cannot be well-captured by model-based study. We therefore conduct an experiment study and investigate whether the supplier's reciprocity through repeated interaction deviates from that under one-shot interaction. Since humans do not always act rationally, they may make choices deviates from the traditional model of rational behaviour and thereby lead to different payoffs. In a laboratory environment, we relax the assumption that the expected payoffs are equal valued for both incentives. Chapter 3 (study 2) experimentally provides new insights into the factors influencing supplier reciprocity from both endogenous and exogenous perspectives. Specifically, the endogenous variable refers to the type of incentive offered that is voluntarily chosen by subjects; whereas, the exogenous variable involves the type of relationship and uncertainty that are manipulated by experimenters. In this study, we aim to address the following research questions:

1. How do different types of incentive (Direct vs. Indirect) affect decisions on incentive value by the manufacturer and investment amount by the supplier?

2. How do different types of relationships (one-shot vs. repeated interactions), and those of uncertainties about future recovery outcome (risk vs. ambiguity)

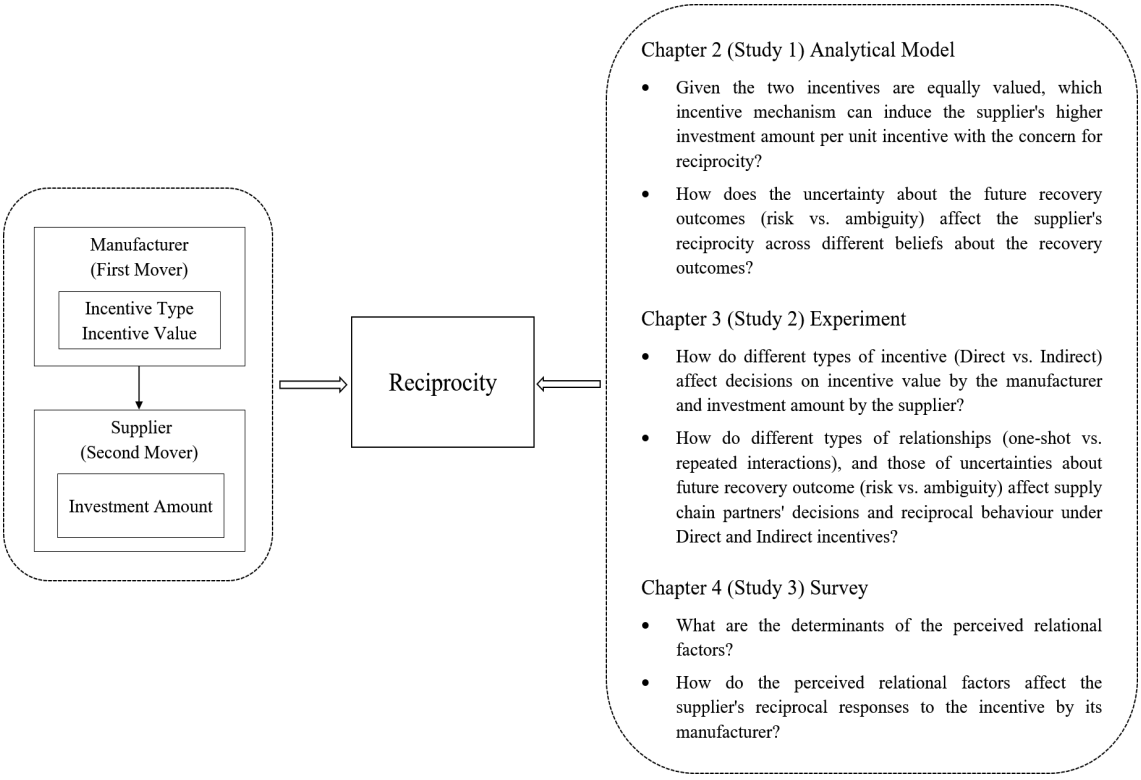
affect supply chain partners' decisions and reciprocal behaviour under Direct and Indirect incentives?

In the experimental study, we manipulate the relationship and uncertainty conditions. Since individuals differ in their perceptions, the differences between subjects in the groups may lead to different results. Thus, we further implement a post-experimental survey to capture the subjects' individual differences in the perceptions of the partner relationship. Chapter 4 (study 3) discusses the factors influencing the perceptions of relationships held between supply chain parties and examines the moderating role of perceived relational factors in the relationship between the manufacturer's incentive and the supplier's investment decisions, which are measured in the study 2. In this chapter, we try to answer the following questions:

1. What are the determinants of the perceived relational factors?
2. How do the perceived relational factors affect the supplier's reciprocal responses to the incentive by its manufacturer?

Figure 1.1 shows the overall framework of the three studies in this thesis.

Figure 1.1: Overall framework of thesis



Chapter 2

The Modelling of Reciprocity towards Incentives for Supply Capacity Restoration

2.1 Introduction

A supply chain disruption is mostly unpredictable and occurred with detrimental economic effects. The shortage of supply caused by either external or internal disruption events would lead to the upstream suppliers halting production at plant, and subsequently delay their manufacturers' businesses. As a result, investments in supply chain restoration capability beforehand play an important role in enabling firms to be more resilient and responsive to disruptions (Nooraie and Parast 2016, Bakshi and Kleindorfer 2009, Baiman and Rajan 2002). To ensure restoration capacity, the common strategy used by manufacturers is either seeking an alternative supplier or working with the existing supplier via offering an incentive to induce the supplier's investment. Evidence from practice suggests that working with the existing supplier to restore capacity instead of seeking an alternative supplier may provide more effective solutions to disruption recover (Hille 2011, Latour 2001).

In high demand conditions, manufacturing firms' operations to some extent risk suppliers' capacity constraints as a result of disruption events. Thus, the suppliers are expected to proactively exert their efforts in investing in restoration capability

to mitigate the disruption risks. To better motivate the suppliers to do so, manufacturers should put an emphasis on offering an effecient incentive mechanism. In previous studies, there are two main streams of incentive mechanisms available to deal with supply chain problems: (1) formal (i.e. rule-based) incentive contract; and (2) informal (i.e. relational-based) incentive contract (Cachon and Lariviere 2001, Tomlin 2003, Taylor and Plambeck 2007*a*,*b*). It is generally agreed that a well-designed complete contract can provide a safeguard to reduce the opportunistic behaviour when a manufacturer makes decisions that benefit its supplier (Woolthuis et al. 2005, Lyons and Mehta 1997, Williamson 1985). However, due to human-bound rationality, it is not possible to specify all aspects of conditions in a contract, particularly in an uncertain supply chain environment (Grossman and Hart 1986). In this case, a formal contract alone may lead to incentive misalignment and thus be insufficient to motivate supplier's cooperation to restoration capability investment.

More recently, a growing number of scholars have shed some light on relational mechanism, which is viewed as a complement for formal contract (Lu et al. 2015, Poppo and Zenger 2002). The relational mechanism emphasises collaborative behaviour in long-term relationships through repeated interactions, especially in an uncertain environment (Klein et al. 2007, Macneil 1980*a*). Drawing from social exchange theory, the repeated interactions that help to reinforce cooperation can motivate the supplier to merit the buyer's relational incentives with stronger reciprocal responses (Kanagaretnam et al. 2010, Heide and John 1992, Blau 1964). Since an exchange party may not completely follow the norm of reciprocity during repeated transactions, the social exchange built on reciprocity should be remaining conditioned by the formal contract. Thus, the combination of relational incentives and formal contracts is crucial to encourage greater cooperation than relational or formal contracting in isolation under uncertain circumstances.

The traditional economic theory assumes that people are self-interested and make rational choices aimed at maximizing their own interests. In view of this, suppliers are more likely to behave opportunistically and free ride on the external incentive offered by manufacturers when a formal contract is incomplete. Recent literature on relational contracting in supply chain management places more emphasis on the

form of an incentive on price/quantity promise in repeated interactions, which is viewed as an alternative solution to mitigating problems arising from opportunism (Taylor and Plambeck 2007*a*,*b*). However, much less attention has been paid to relational-based supply chain decisions beyond contractual requirements. Despite the fact that relational-based contracting mechanisms embed social considerations (e.g. reciprocity) and repeated interactions in improving supply chain efficiency, they remain conditional incentives on informal contracts that involve binding orders.

In the context of supply chain disruption, these contracting mechanisms are effective only if a disruption occurs and the supplier is able to restore its supply pipeline. In other words, although these incentives are pre-committed, the benefits of such incentives ex post are delayed until a disruption event has occurred. A previous study by Povel and Raith (2004) provides evidence that ex post incentive mechanisms fail to work in reality especially when firms operate under financial stress. We therefore argue that suppliers who are financially constrained are unwilling to cooperate and are under-invest in capacity restoration. In the discipline of psychology, some research, such as Falk and Kosfeld (2006), Kreps (1997), Frey (1997*c*) that is underpinned by motivation crowding theory has highlighted the importance of unconditional or voluntary incentives offered by one party in a relationship in inducing stronger reciprocal responses from the other party. Therefore, we propose a relational incentive beyond the contract setting, in which an unconditional or voluntary incentive that signals more prosocial action enhances supplier's intrinsic motivation on capacity restoration investment.

To do so, this paper specifically looks at two types of incentives offered by the manufacturer with the aim of inducing supplier's restoration capability investment. In line with the research in economics, our study defines the incentives in terms of two dimensions: form and timing of realization (Benhabib et al. 2010, Frederick et al. 2002, Shafir et al. 1993, Baker et al. 1988). In particular, we investigate two forms of incentive: prepaid financial incentive vs. promised price incentive. We consider the timing of incentive realization to be either before or after a disruption. We term the prepaid financial incentive before the disruption 'Direct incentive' and the promised price incentive that becomes effective only if disruption occurs 'Indirect incentive'.

The Direct incentive is not just a financial commitment, but also a mechanism to better induce the supplier's intrinsic motivation of reciprocity in investment decisions. Such incentive has been empirically studied and proved to be effective in the mail survey context (Hager et al. 2003, Church 1993). The promise-based Indirect incentive is closely related to Hu et al. (2013), which examines the buyer's promised wholesale price and/or order quantity contract incentives to motivate the supplier's investments. We aim to evaluate the manufacturer's choice between the financial incentive paid upfront and the promised price incentive implemented conditionally after the disruption, in which the two alternatives are equally valued. Further to that, we also investigate the effects of uncertainty about the future recovery outcomes, risk vs. ambiguity, on the supplier's reciprocity towards the manufacturer's incentive offered, in particular, across different beliefs about the recovery outcomes.

Our research contributes to the existing literature in the following ways. First, we draw on social exchange theory, and extend it by combining with motivation crowding theory and theory of decision under uncertainty to gain new insights into the design of effective incentive mechanisms with the concern of suppliers' reciprocal responses. Second, this study advances the existing literature on the modelling of reciprocity by examining the supplier's intention-based reciprocity towards the manufacturer's incentives for restoration investment under a strong condition that the economic motivation underlying consequence-based reciprocity has been addressed. Based upon this premise, we employ a two-step approach to the modelling of the supplier's reciprocal behaviour: the first step establishes the supplier's propensity for reciprocity, which follows Falk and Kosfeld (2006) and McCabe et al. (2003). The second step evaluates the extent of reciprocity, which takes into account the effects of both incentive type and disruption uncertainties. Our results show that the Direct incentive is viable and consequently induces higher extent of reciprocity, given that the supplier's propensity to invest under Direct incentive is no less than that of Indirect incentive. Third, we incorporate different expectations/beliefs into the probabilities of future recovery outcomes, which can be categorized as known and unknown, corresponding to risky and ambiguous recovery outcomes. The results reveal that the supplier assigns a higher value of investment per unit incentive

received, particularly when an ambiguous prospect for recovery outcome is anticipated with less optimism. By doing so, we contribute to a greater clarity and better understanding of supplier reciprocity towards incentives offered in investing capacity restoration under disruption uncertainties.

The remainder of this paper is organised as follows. Section 2.2 comprises the literature review by consolidating the related theoretical and empirical research that underpins our study. In Section 2.3, we describe the model and present analytical findings. Our numerical results are reported in Section 2.4. In Section 2.5, we conclude by summarising the key findings and stating the limitations of the study.

2.2 Literature Review

Social exchange theory primarily focuces on on voluntary aspects of an inter-organisational exchange, which emphasises value co-creation through on-going and cooperative relationships (Emerson 1976, Blau 1964). The fundamental underneath the cooperative relationship are human's social concerns for reciprocity, in which individuals are more willing to reward a kind action but punish an unkind one (Berg et al. 1995, Fehr et al. 1993, Emerson 1976, Blau 1964). In a supply chain exchange, social concerns for reciprocity play an important role in influencing supply chain partners' behaviour and decisions (Wu et al. 2014, Zhao et al. 2008). A growing number of studies in behavioural operations management provide evidence that social preferences for reciprocity have significant effects on supply chain performance (Ho et al. 2014, Katok and Pavlov 2013, Loch and Wu 2008). Reciprocity, as the fundamental to human's relationship, drives cooperative behaviour which is largely conditioned on the others' actions (Riolo et al. 2001, Trivers 1971). Fehr and Fischbacher (2004) indicate that individuals increase their own contributions if the contribution of others increases. Ahmed (2011) considers an investment game, in which the exchange party is willing to exhibit stronger reciprocity when a more generous value is offered by its counterparty. The existing literature on reciprocity define the term in two classifications: consequence-based and intention-based (Falk and Fischbacher 2006, Cooper and Kagel 2016). The consequence-based reciprocity emphasises peo-

ple's reciprocal behaviour as being shaped by distributional outcomes (Bolton and Ockenfels 2000, Fehr and Schmidt 1999), while several other studies show that second movers who reciprocate more are relying on first movers' actions that signal a more kind intention (Falk and Fischbacher 2006, Dufwenberg and Kirchsteiger 2004, McCabe et al. 2003). It is important that the intention-based reciprocity can not be studied alone without taking account of distributional outcomes (Falk and Fischbacher 2006). However, it has been relatively under-researched. Previous studies on consequence-based reciprocity places more emphasis on the fair distribution of payoffs between two parties. However, the fair distribution of payoffs is problematic in supply chain settings since in reality all supply chain parties aim to seek profit maximisation (Liu and Papageorgiou 2018). In our modelling, the economic motivation underlying consequence-based reciprocity should not be dismissed. We therefore capture the intention-driven reciprocity given the ultimate expected payoffs that are valued with equality under the two incentive mechanisms.

In the context of incentive contracting, Levin (2003), Poppo and Zenger (2002), Macaulay (1963) have highlighted the role of relational incentives as a complement to the formal contracts . More recently, a growing body of literature on the supply chain contracting has begun to place more emphasis on the role of relational incentive mechanisms which involve promised incentives in supply chain capacity investment (Davis and Leider 2015, Hu et al. 2013, Taylor and Plambeck 2007*a*,*b*). This stream of the literature examines the design of an efficient contract, aimed at incentivising the supplier to invest in capacity to build supply chain flexibility and resilience against the changing environment. Hu et al. (2013) consider the use of promised premium-price incentive by firms to encourage suppliers' restoration capacity investments in the presence of supply chain disruption. Taylor and Plambeck (2007*a*) compare the supply chain performance under both price-only and price-and-quantity promises which are incentivised to induce suppliers' capacity investment. In a related research, Taylor and Plambeck (2007*b*) propose a simpler relational contract which allows for the conditions in which the supplier's capacity investment cannot be directly monitored. Tomlin (2003) investigates the relationship between firm commitment and supplier capacity when the capacity investments

are under the unenforceable compliance regime. Baker et al. (2002) document that relational incentives that involve repeated interactions in a supply chain relationship can reinforce long-term cooperation and accordingly motivate capacity investment. Although these relational contracts that are pre-committed ease some shortages in formal contracting, they are in essence the ex post incentives and remain have the ex post binding effect under a controlled environment. Povel and Raith (2004), for instance, has argued that the ex post pre-committed incentives would limit the firm's investment behaviour when a firm faces financial constraints. As documented by Fehr and Gächter (2001), incentives on contracts are less efficient for reciprocity-based voluntary cooperation that drives a successful long-term relationship (Fehr and Gächter 2001). Previous experimental studies provide evidence that people who are driven by reciprocity are likely to contribute more toward a more generous incentive under a purely voluntary cooperation (Fehr and Falk 2002, Fischbacher et al. 2001, Fehr et al. 1997).

On the bright side, some other studies provide empirical evidence that incentives in non-contracting settings may encourage the other party's stronger reciprocal responses to one's prosocial behaviour. Falk and Kosfeld (2006) shows an agent in a two-stage principal-agent game is better motivated and behave more reciprocally when a principal signals a prosocial behaviour without any enforcement. A trust game experiment by McCabe et al. (2003) shows that agents are more willing to exhibit their reciprocal intention towards principals' unconditional offers, as compared to conditional ones. Principals offering incentives in non-contractible settings may induce agents to invest more to reciprocate the principals' prosocial behaviour. Similarly, Ellingsen and Johannesson (2008) in their study suggests that agents exert more effort and are more proactive in an unconditional situation as compared to a conditional one. Previous research in the social psychology literature have placed more emphasis on the role of external incentives in crowding out (i.e.undermining) intrinsic motivation by drawing from Motivation Crowding Theory (Deci and Ryan 1985, Lepper et al. 1973, Deci 1971). However, most efforts to date have focused on the effects of external incentives in enhancing intrinsic motivation (Frey and Jegen 2001, Ryan and Deci 2000, Frey 1997*a*). These studies provide evidence that

external incentives can induce higher intrinsic motivation if they are voluntarily offered with less controlling. Further, the timing of incentive is also crucial to the design of incentive mechanisms. Several studies document that incentives offered ex-ante have a positive impact on the contracting parties (Hu et al. 2013, Roider 2006). The proactive ex-ante actions in building restoration capability are of great help to improve the responsiveness to the recovery (Craighead et al. 2007, Tomlin 2006). Therefore, this paper draws upon these studies by examining whether the unconditional ex-ante incentive, which serves a signal of a more prosocial behaviour, motivates a supplier's stronger reciprocal response, which leads to higher investment in capacity restoration as against disruption uncertainties.

In making investment decisions on capacity restoration under disruption uncertainties, suppliers will also have to have a view about future recovery outcomes that could be either risky or ambiguous(Hult et al. 2010, Blackhurst* et al. 2005). The risk condition in general is related to events that have known probabilities whereas the ambiguity condition refers to unknown probabilities as regards to future recovery outcomes (Milliken 1987, Ellsberg 1961). Ellsberg (1961) shows that people are more averse to decisions under ambiguity than under risk conditions. The existing literature on supply chain disruptions distinguishes between internal and external factors that influence supply chain disruptions (Wu et al. 2006, Kleindorfer and Saad 2005). The probabilities for recovery outcomes may be more likely to be estimated when a disruption is caused by internal risks, whereas remain ambiguous upon investment decision when it is caused by external environmental factors (Wu et al. 2006). Evidence from studies in cognition suggests that beliefs about the likelihood of future events under either ambiguous or risky situation may influence the probability distributions and thereby people's behavioural preference (Pulford 2009). People with positive expectation about future outcomes (optimism) may behave differently from someone who expects the negative outcomes (pessimism) (Einhorn and Hogarth 1985). An ambiguity avoider's attitude towards the successful chance of an event tends to be worse for the ambiguous prospect that allows more pessimistic (Curley et al. 1986). By saying that, optimists and alike are more likely to exhibit ambiguity seeking behavior for the ambiguous prospect with positively

framed scenario (Bier and Connell 1994). We therefore examine the extent to which a supplier's beliefs about future recovery outcomes effect on its reciprocal response to incentive conditions described above.

2.3 The Model

We consider a two-echelon decentralised supply chain channel with a single supplier who produces units under a regular wholesale contract (q_1, w_1). That is, the manufacturer places a regular order q_1 at wholesale price w_1 when there is no disruption. However, when disruption occurs, the manufacturer orders q_2 units at the post-disruption wholesale price w_2 per unit, $w_2 \geq w_1, q_2 \geq q_1$. In our base setting, the manufacturer as a quantity determiner and the supplier as a price maker aim to maximise their own expected payoff, and thus we derive w_i and q_i for $i = 1, 2$ to be parameters in determining incentive values and investment amount. Furthermore, we assume that the maximum market scale faced by the manufacturer moves from M_1 to M_2, $M_2 \geq M_1$. The status of a supply chain i is assumed to be with either no disruption $(i = 1)$ or disruption $(i = 2)$ (Hu et al. 2013, Gümüs et al. 2012, Gurnani and Shi 2006). For simplicity, we assume that under Normal and Disrupted status the manufacturer has a linear market demand

$$q_i = M_i - p_i. \tag{2.3.1}$$

The probability of a supply chain disruption β follows U [0,1]. The supplier can fulfil the manufacturer's order with no disruption and will lose all capacity otherwise. In the case of disruptions, with restored capacity, the supplier produces at unit production cost $c_2 > 0$ $(c_2 \geq c_1)$. The manufacturer charges market price p_2 per unit when disruption occurs and p_1 otherwise $(p_2 \geq p_1)$.

In the face of disruption uncertainties, the manufacturer considers the use of incentives either 'Direct' or 'Indirect' to induce the supplier's investment in restoration capability, along with the initial regular contract. The 'Direct incentive' I^D is paid upfront prior to disruption. By contrast, the promised 'Indirect incentive' I^I takes effect after a disruption occurs in the form of the revised wholesale price,

and/or order quantity. Following the initial incentive decision by the manufacturer, the supplier needs to decide whether or not to invest in restoration capability development before any disruption occurs with investment $F > 0$. If the supplier invests, there are three possible disruption recovery outcomes: full recovery, partial recovery, and no recovery. If the supplier does not invest, we assume that it will be incapable of recovering from disruption following Hu et al. (2013), Gümüs et al. (2012). The manufacturer's payoff upon disruption is conditioned on the supplier's investment decision. In the case that the supplier does not invest, the manufacturer will suffer a loss L.

Figure 2.1: Determinants of Supplier Investment Decision

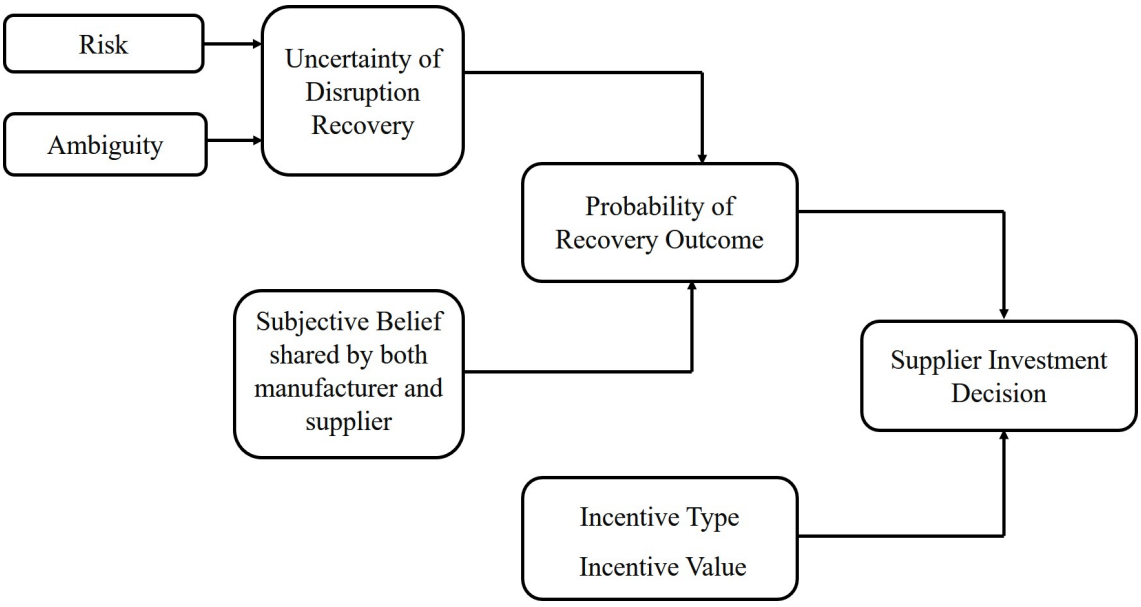


Figure 2.1 illustrates what core elements lead to a change in the probability of recovery outcomes, and how the change occurs. To a large extent, the probability of each possible recovery outcome depends on the unforeseen nature of disruption and the manufacturer's initial belief as to the uncertainty about future recovery. As aforementioned, the probabilities of recovery outcomes are categorised into two dimensions: (1) risk; (2) ambiguity (Ellsberg 1961). With the risk prospect, the

disruption that caused by internal factors enables the probability of recovery outcomes largely to be estimated/known with certainty. However, with the ambiguity prospect, both supply chain parties have vague information about the probability of each recovery outcome in particular when the disruption results from external environmental factors. Thus, the probability, in this case, is unknown/ambiguous with uncertainty.

Drawing from the theory of decision under uncertainty (Ramsey 1931), individuals' future decisions may be affected by their beliefs about the future uncertain events. In other words, the probabilities of disruption recovery outcomes can be further updated based on both supply chain parties' subjective beliefs about recovery degree. To assess the probability of each recovery outcome more accurately, we therefore incorporate the subjective beliefs about the disruption recovery outcomes into the objective factors influencing recovery from disruptions.

In this study, we consider four types of beliefs for both types of recovery probabilities: optimistic, pessimistic, most likely and neutral. Any belief held by the manufacturer has been shared with its supplier. More specifically, optimism implies a strong initial belief in full recovery outcome that the probability of full recovery is greater than that of partial or no recovery. By contrast, pessimists believe the disruption would be completely not recovered and thus the probability of no recovery dominates that of the other two recovery outcomes. In 'most likely' scenario, the manufacturer holds a view that the disruption is most likely to be partially recovered, meaning that the probability of partial recovery is greater than the other two. Furthermore, 'neutral belief' indicates that the three types of recovery outcomes are perceived to be occurred equally likely.

Moreover, the supplier's investment decision that followed by the manufacturer's incentive offered suggests that the type of incentive offered intuitively also has an impact on the supplier's investment in restoration capability. In view of this, we capture both the probability of recovery outcomes and the type of incentive offered to examine the supplier's reciprocal behaviour when making an investment decision. We consider how do the above-mentioned determinants that are either objective or subjective interact to determine the supplier's restoration capability investment.

Following Berger et al. (2004), we employ a decision tree approach to visualise the decision process in the presence of disruption risks.

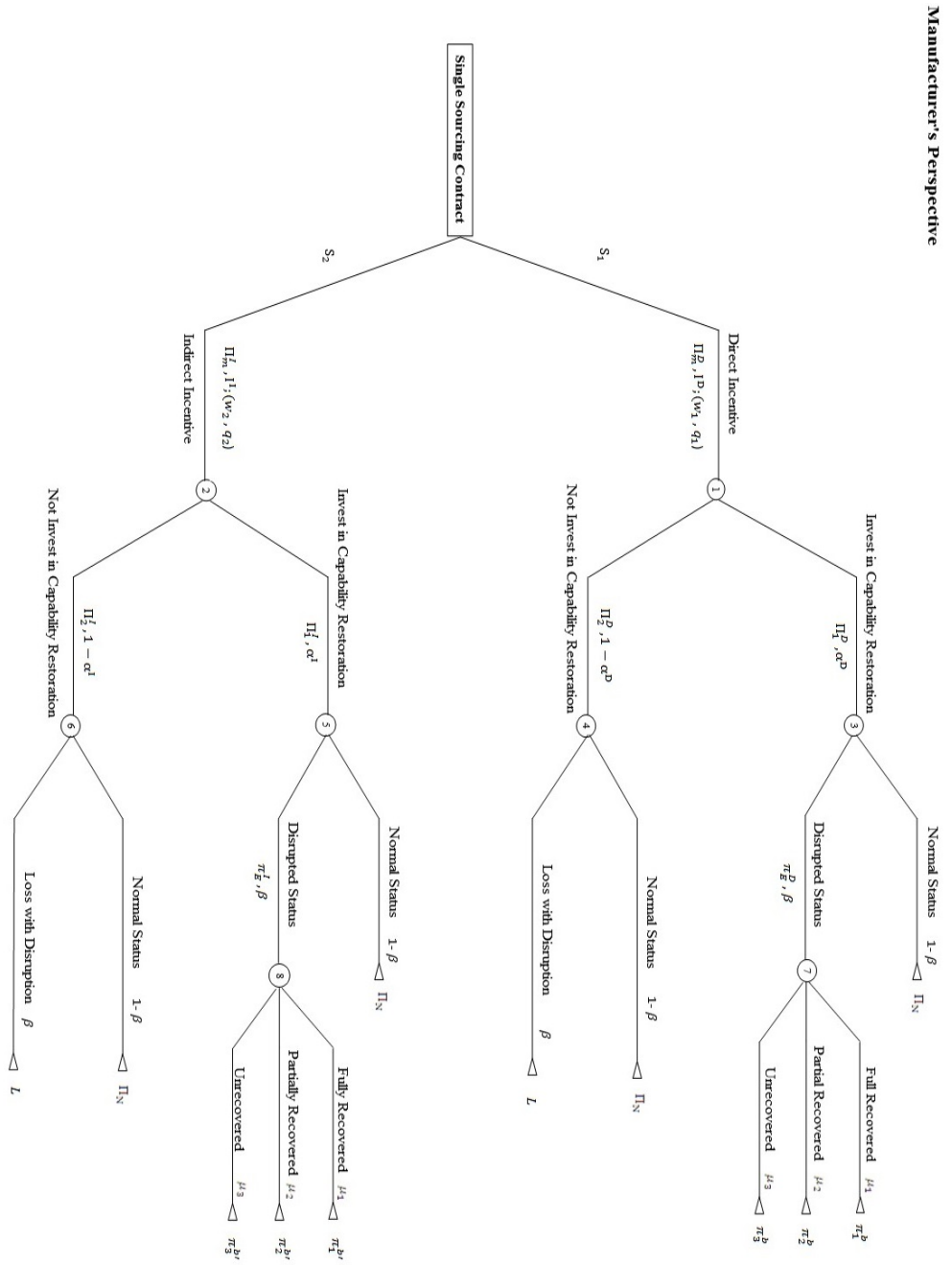


Figure 2.2: The decision tree from the manufacturer's perspective

Starting from the end node of the Decision Tree (see Figure 2.2), the manufacturer's expected payoffs of each possible recovery outcome resulted from working

with the existing supplier are respectively given by π_i^b for Direct incentive and $\pi_i^{b'}$ for Indirect incentive. The probability of each recovery outcome given the supplier's restoration investment is denoted by μ_i for both Direct and Indirect incentives. $i = 1, 2, 3$ represents full, partial and no recovery, respectively. The total expected payoff for each type of incentive is the weighted sum of each recovery outcome by the probability of recovery. Here we use π_E^D and π_E^I to denote the expected payoff with risky certainty, respectively, under Direct and Indirect incentive.

$$\pi_E^D = \sum_{i=1}^{N} \mu_i \pi_i^b, \pi_E^I = \sum_{i=1}^{N} \mu_i \pi_i^{b'} \tag{2.3.2}$$

In the Direct incentive condition, the expected payoff of each disruption recovery outcome is

$$\begin{cases} \pi_1^b = (p_2 - w_1)q_1 & \text{full recovery} \\ \pi_2^b = \theta(p_2 - w_1)q_1 \ (0 < \theta < 1) & \text{partial recovery} \\ \pi_3^b = -(p_2 - w_1)q_1 & \text{no recovery} \end{cases}$$

θ denotes the proportion of recovery from disruptions. Likewise, in the Indirect incentive context, the wholesale price w_1 and the order quantity q_1 are substituted by w_2 and q_2, respectively, from the above weighted profit functions. The expected payoff is calculated in the same way as shown above.

Given post-disruption wholesale price w_2, we first find the manufacturer's best response q_2^* under the Indirect incentive condition. The manufacturer chooses q_2 to maximise his payoff Π_m^I under Indirect incentive and then we can have the optimal order quantity $q_2^* = \frac{M_2 - w_2}{2}$. Next, given the manufacturer's best response q_2^*, the supplier maximises Π_s^I and we get $w_2^* = \frac{M_2 + c_2}{2}$. Similarly, the equilibrium solutions for regular order quantity q_1^* and wholesale price w_1^* are given as

$$q_1^* = \frac{M_1 - w_1}{2} \qquad w_1^* = \frac{M_1 + c_1}{2}$$

Thus when substitute the above solutions into (1) we have the following result:

Lemma 1 *If $w_1 \leq w_2$ and $q_1 \leq q_2$, there exists the optimal response in which the manufacturer places the order quantity $q_i^*(w_i) = \frac{M_i - w_i}{2}$ at the price $w_i^* = \frac{M_i + c_i}{2}$ and determines the market price $p_i^* = \frac{M_i + w_i}{2}$, for $i = 1, 2$.*

Remarks.

As aforementioned, we construct two relational incentive mechanisms in the presence of supply chain disruption: (1) unconditional; (2) unconditional. For the first type, an Direct incentive payment I^D is provided along with the initial regular order (q_1, w_1). For the latter one, the manufacturer promises to complete the incentive contract (q_2, w_2) only when the disruption has occurred. In other words, if there is any disruption, the manufacturer in fact offers Direct incentive that relevant to the initial regular contract (q_1, w_1) whereas Indirect incentive that related to the promised incentive contract (q_2, w_2). Following backwards induction, Lemma 1 indicates that the manufacturer finds the equilibrium to the order quantity and wholesale price for both normal and disrupted status are specifically solved in the same way.

The focus of this study is to investigate the two types of incentives that are used to induce the supplier's capability investments, with the concern for reciprocity. The Direct incentive is meaningful only if there is any disruption otherwise this will become a sunk cost. By contrast, the Indirect incentive is expected to be realised as promised after a disruption occurs and thus will have no effect without any disruption. The analysis that refers to the manufacturer's Indirect incentive value I^I is shown in Lemma 2.

Lemma 2 *The Indirect incentive value is given by the supplier's payoff difference between the normal and the disrupted status, where*

$$I^I = w_2^* q_2^* - w_1^* q_1^* \tag{2.3.3}$$

Remarks.

In a Indirect incentive setting, the manufacturer only commits to increase the wholesale price and/or order quantity if disruption occurs. In view of this, the Indirect incentive simply associates with the change of wholesale price and/or order quantity. As we assumed, the post-disruption wholesale price w_2 and order quantity q_2 meets $w_1 \leq w_2$, $q_1 \leq q_2$ respectively. Thus, the Indirect incentive value I^I is implicitly equal to an increase in the manufacturer's payment to the supplier when disruption occurs. In other words, the manufacturer's Indirect incentive value is, in fact, equivalent to the supplier's revenue surplus. Lemma 2 suggests that the incentive value offered by the manufacturer under Indirect incentive in the presence of disruption is constant across all types of beliefs about the probability of recovery outcomes. Based on the optimal solutions shown in Lemma 1, we can compare the manufacturer's total expected payoff under Direct incentive with that under Indirect incentive. The following lemma shows the condition under which the Direct incentive outperforms the conditional one.

Lemma 3 *The manufacturer is better off when offering Direct incentive as compared to Indirect incentive, that is,* $\Pi_m^D > \Pi_m^I$*, if:*

$$0 < I^D < \beta[\alpha^D(\sum_{i=1}^{N} \mu_i \pi_i^b - L) - \alpha^I(\sum_{i=1}^{N} \mu_i \pi_i^{b'} - L)] \equiv \hat{I^D} \tag{2.3.4}$$

Accounting for the type of incentive with the known probability of each outcome (i.e. risky prospect), we can first derive the threshold of Direct incentive I^D. As shown in the Decision Tree, the manufacturer's expected payoff is denoted by Π_m^D and Π_m^I under the unconditional and Indirect incentives respectively, where

$$\Pi_m^D = \alpha^D \Pi_1^D + (1 - \alpha^D)\Pi_2^D - I^D \tag{2.3.5}$$

$$\Pi_m^I = \alpha^I \Pi_1^I + (1 - \alpha^I)\Pi_2^I \tag{2.3.6}$$

From the manufacturer perspective, we have the upper threshold of Direct incentive $\hat{I^D}$ as given in (4) when we let $\Pi_m^D = \Pi_m^I$.

Remarks.

The above Inequality (2.3.4) shows the conditions in which Direct incentive is financially viable when the two options are equally valued. If the incentive value I^D is below the threshold $\hat{I^D}$, the manufacturer would choose to offer the Direct incentive. The manufacturer can randomize the Direct incentive value, following the range $[0, \hat{I^D}]$. Specifically, the probability of disruption, the probability of the supplier's decision to invest, loss resulted from the decision to not invest and the manufacturer's expected payoff of disruption recovery together determine the range for incentive value. Furthermore, it is noted that the propensity for reciprocity plays a vital role at the beginning of a cooperation. In a cooperative buyer-supplier relationship, it provides the fundamental motive for suppliers' decisions to invest in restoration capability and thus becomes a prerequisite for the extent of reciprocity towards manufacturers' prosocial behaviour. The probabilities of supplier's decision to invest, i.e. α^D and α^I, are assumed to reflect the supplier's propensity for reciprocity under unconditional and Indirect incentives respectively. According to (2.3.4), the upper value $\hat{I^D}$ must need to satisfy $\hat{I^D} > 0$. Accordingly, we have the following relationship between α^D and α^I :

$$\frac{\alpha^D}{\alpha^I} > \frac{\sum_{i=1}^N \mu_i \pi_i^{b'} - L}{\sum_{i=1}^N \mu_i \pi_i^b - L} \tag{2.3.7}$$

To satisfy $I^D > 0$, if $\alpha^D > \alpha^I$, no matter what the absolute size of expected payoff $\sum_{i=1}^N \mu_i \pi_i^b$ and $\sum_{i=1}^N \mu_i \pi_i^{b'}$ but only that the comparative ratio of the two expected payoffs, either $\frac{\sum_{i=1}^N \mu_i \pi_i^{b'}}{\sum_{i=1}^N \mu_i \pi_i^b}$ or $\frac{\sum_{i=1}^N \mu_i \pi_i^b}{\sum_{i=1}^N \mu_i \pi_i^{b'}}$, is required to be less than $\frac{\alpha^D}{\alpha^I}$. By contrast, if

$\alpha^D < \alpha^I$, it requires to satisfy $\sum_{i=1}^{N} \mu_i \pi_i^{b'} < \sum_{i=1}^{N} \mu_i \pi_i^b$ for $I^D > 0$. Further, based on Lemma 1 and 3, we compare the upper threshold $\hat{I^D}$ with I^I, the relative threshold ratio Θ can be written as:

$$\Theta = \frac{\beta[\alpha^D(\sum_{i=1}^{N} \mu_i \pi_i^b - L) - \alpha^I(\sum_{i=1}^{N} \mu_i \pi_i^{b'} - L)]}{I^I}$$

If $\Theta < 1$, then the manufacturer can offer a smaller amount of I^D than I^I given the equivalent expected payoffs for the two types of incentive. Here we see that the loss value L matters to the ratio Θ. The following lemma shows how the manufacturer's loss L resulting from the supplier's decision to not invest influences the difference in incentive value between the two types of incentive.

Lemma 4 *When offers of unconditional and conditional invectives are economically equivalent for the manufacturer, Direct incentive value offered prior to disruption is smaller as compared to Indirect incentive value offered post-disruption, that is,* $\hat{I^D} < \hat{I^I}$ *when* L *satisfies the following:*

(a) if $\alpha^D > \alpha^I$, *then* $\frac{\beta(\alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b - \alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'}) - I^I}{\beta(\alpha^D - \alpha^I)} < L < 0$;

(b) if $\alpha^D < \alpha^I$, *then* $\frac{\alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'} - \alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b}{\alpha^I - \alpha^D} < L < 0$;

(c) if $\alpha^D = \alpha^I$, *then the loss value* L *has no effect on* Θ.

Remarks.

According to (2.3.7), the supplier's propensity for reciprocity is largely determined by the manufacturer's weighted expected payoff of recovery outcomes. A comparison of incentive value under Direct and Indirect incentive depends on the loss suffered by the manufacturer when the supplier does not invest. For a given wholesale price, order quantity and the probability of each recovery outcome, the

loss value L is calibrated by the supplier's propensity for reciprocity under Direct and Indirect incentive. The upper loss value is required to be less than 0 and the lower bound is greatly dependent on the supplier's propensity. When $\alpha^D > \alpha^I$, L shifts upwards as the probability of disruption β and the difference between α^D and α^I increases. Here, β needs to satisfy $\beta < \frac{I^I}{\alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b - \alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'}}$. When $\alpha^D < \alpha^I$, the loss value L is regardless of β but being influenced by the value of α^D and α^I. Likewise, L increases with the difference between the two values. On the other hand, L is associated with the supplier's decision to invest. From backwards induction, a large amount of loss would result in a lower payoff so that the supplier will choose to not invest in restoration capability.

As shown in Supplier's Decision Tree (see Figure 2.3), a supplier only involves one-stage decision as to whether or not invest in restoration capability under Direct and Indirect incentive.

In our assumption, if the supplier's investment takes place, the investment amount F then is considered to be a sunk cost. If the supplier does not invest in restoration capability, he/she will suffer opportunity loss upon disruption. The supplier's expected payoff under Direct and Indirect incentives is, respectively, shown as in (2.3.8) and (2.3.9). We denote the supplier's expected payoffs by adding prime as superscript based on the notations of the manufacturer's expected payoff.

$$\Pi_s^D = max[\Pi_1^{D'} - F^D + \lambda I^D, \Pi_2^{D'} + I^D] \tag{2.3.8}$$

$$\Pi_s^I = max[\Pi_1^{I'} - F^I, \Pi_2^{I'}] \tag{2.3.9}$$

As aforementioned, both the manufacturer and the supplier hold common beliefs about the likelihood of each recovery outcome. The probability of disruption recovery outcome can be either risky (known) or ambiguous (unknown). When we take the uncertainty under each type of incentive into consideration, the thresholds of λ and δ can be obtained. Here we can establish the following definition.

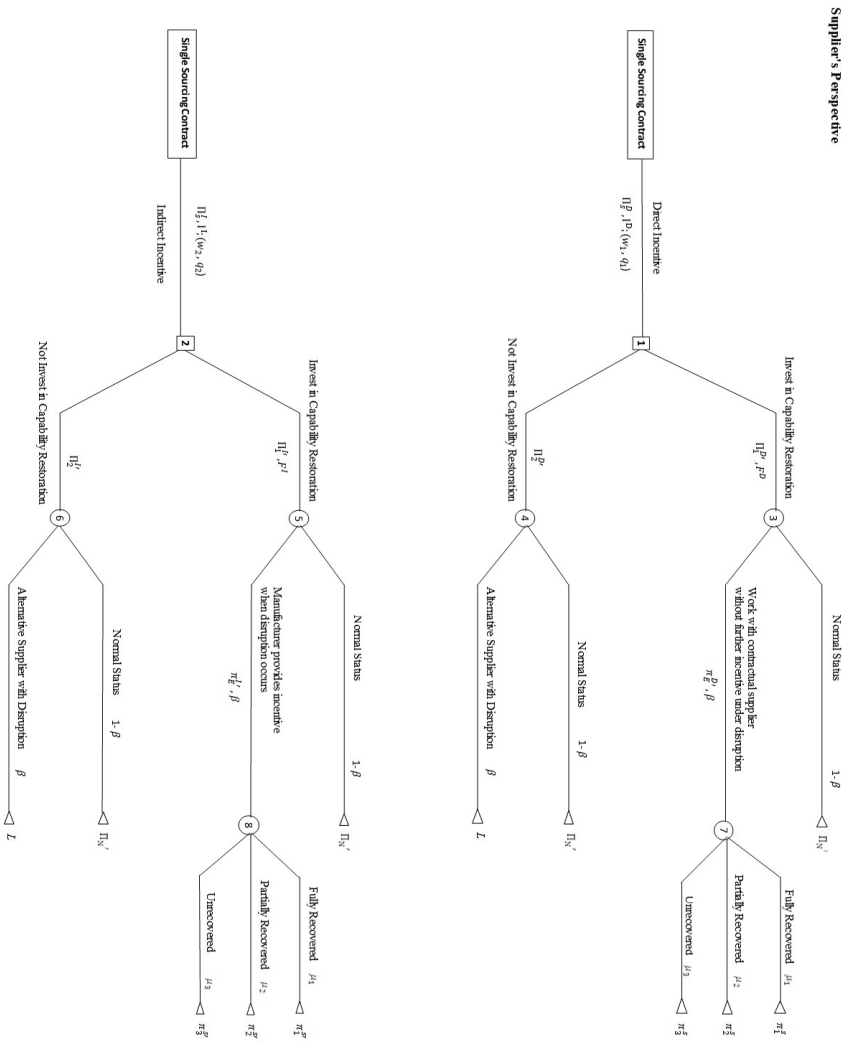


Figure 2.3: The decision tree from the supplier's perspective

Definition 1 *Let λ be the reciprocity loading factor induced by Direct incentive and δ induced by ambiguous uncertainty. The combined effect of Direct incentive and ambiguous uncertainty on reciprocity has a loading scaler $\lambda + \delta + \lambda\delta$.*

Remarks.

As the main focus of our study is the modelling of the supplier's reciprocity in restoration capability. The reciprocity scaler is defined in two dimensions: (1) incentive type (2) uncertainty type about future recovery outcomes.

We first set the reciprocity scaler associated with Indirect incentive and risky

certainty to 1 saying the supplier is not motivated to exhibit reciprocity towards the manufacturer's reactive action with known probability of recovery prospects. According to Falk and Fischbacher (2006), Direct incentive that indicates a more kind action can reinforce reciprocity. The supplier may be intrinsically motivated to invest more towards an Direct incentive. Accordingly, when the likelihood of future recovery outcomes is known, we amplify the intrinsic value of Direct incentive to λI^D if the supplier invests in restoration capability. Here, λ is the reciprocity scaler in relation to the supplier's reciprocal concern in Direct incentive. Following Ellsberg (1961), people are more likely to be ambiguity averse when the future outcome is uncertain. An ambiguity-averse person would rather choose a known probability of future outcomes over the one with an unknown probability. Accordingly, we assigned an unknown probability of recovery degree to $\delta\mu_i$ for Indirect incentive ($0 < \delta < 1$). Here δ indicates the reciprocal concern associated with ambiguous uncertainty under Indirect incentive with the decision to invest.

When Direct incentive meets ambiguous uncertainty, the simple sum of two scalers does not capture the whole reciprocal effect. As a more prosocial action is taken under ambiguous uncertainty, this may lead to synergy effects that contribute to the reinforcement of reciprocity. Generally, the synergy effect occurs when two or more units produces the joint value greater than the sum of their individual values (Tanriverdi 2006, Cao and Zhang 2011). Thus, in our study, we define the synergies between Direct incentive and ambiguous uncertainty as the additional effect produced by the integration of Direct incentive with environmental uncertainty beyond the value added by the individual units. Accordingly, we measure the effect of unknown recovery probability under Direct incentive using the product of $\lambda\delta$. Overall, the combined effect of Direct incentive and ambiguous uncertainty on reciprocity creates value greater than the sum of Direct incentive and ambiguous uncertainty and thus we define the reciprocity loading factor on the Direct incentive and ambiguity synergy as $\lambda + \delta + \lambda\delta$.

There exist four types of outcomes regarding the supplier's investment decision. We use F^I and $F^{I'}$ denote the risky and ambiguous outcomes under Indirect incentive while F^D and $F^{D'}$ denote those under Direct incentive.

$$0 < F^D < \beta(\sum_{i=1}^{N} \mu_i \pi_i^s - L) + (\lambda - 1)I^D \tag{2.3.10}$$

$$0 < F^{D'} < \beta(\lambda\delta \sum_{i=1}^{N} \mu_i \pi_i^s - L) + (\lambda + \delta - 1)I^D \tag{2.3.11}$$

$$0 < F^I < \beta(\sum_{i=1}^{N} \mu_i \pi_i^{s'} - L) \tag{2.3.12}$$

$$0 < F^{I'} < \beta(\delta \sum_{i=1}^{N} \mu_i \pi_i^{s'} - L) \tag{2.3.13}$$

As mentioned in the introduction, the supplier's investment induced per unit of incentive offered is regarded as a proxy of reciprocity. The ratio of the supplier's investment to the incentive offered by the manufacturer under Direct incentive with risky prospect is given by $\frac{F^D}{I^D}$, while that under Indirect incentive is given by $\frac{F^I}{I^I}$. Similarly, with an ambiguous prospect, the ratio is given by $\frac{F^{D'}}{I^D}$ under Direct incentive while $\frac{F^{I'}}{I^I}$ under Indirect incentive. It is clear that $\frac{F^I}{I^I} > \frac{F^{I'}}{I^I}$ since the reciprocity loading factor δ shrinks the upper value of $F^{I'}$. Thus, under Indirect incentive, compared with ambiguous uncertainty, the supplier's extent of reciprocity is higher when the probability of recovery is known with certainty. Let $I^D = I^I$, we then compare $\frac{F^{D'}}{I^D}$ and $\frac{F^{I'}}{I^I}$. From the manufacturer perspective, we look at the condition under which $I^D < I^I$. From the supplier perspective, here we aim to specifically look at the supplier's investment amount under Direct and Indirect incentives with ambiguity when $I^D = I^I$. It suggests that $\frac{F^{D'}}{I^D} > \frac{F^{I'}}{I^I}$ can be satisfied if the condition that meets $F^{D'} > F^{I'}$ can be derived.

Theorem 1 *When supplier reciprocity for ambiguous uncertainty loading factor δ satisfies the relationship*

$$\underline{\delta} \equiv \frac{(1-\lambda)I^D}{\beta(\lambda \sum_{i=1}^{N} \mu_i \pi_i^s - \sum_{i=1}^{N} \mu_i \pi_i^{s'}) + I^D} < \delta < 1 \tag{2.3.14}$$

then the supplier exhibits higher reciprocity under Direct incentive with unknown probability for recovery outcomes, as compared to Indirect incentive condition.

Remarks.

Theorem 1 illustrates the supplier's extent of reciprocity towards the uncertainty with the probabilities of recovery outcomes. We denote δ as the ambiguity dimension reciprocity. It captures the impact of ambiguous outcomes on supplier's reciprocity towards an uncertain future. As shown in (2.3.13), the upper value of supplier's investment under Indirect incentive shifts downwards due to the effect of ambiguous uncertainty. In Theorem 1, we find the condition under which the Direct incentive induces higher reciprocity than Indirect incentive when the probability of recovery is ambiguous. We derive that there exists δ satisfying $\frac{F^{D'}}{I^D} > \frac{F^{I'}}{I^I}$. From (2.3.14), we see that, to some extent, δ depends on the value of λ. It is clear that $\underline{\delta}$ needs to meet $0 < \underline{\delta} < 1$. As such, we can derive an upper bound of λ shown as follows.

$$\lambda < \frac{\beta \sum_{i=1}^{N} \mu_i \pi_i^{s'} - I^D}{\beta \sum_{i=1}^{N} \mu_i \pi_i^{s}} \tag{2.3.15}$$

Likewise, in the situation that the probability of recovery is risky, to compare $\frac{F^D}{I^D}$ and $\frac{F^I}{I^I}$ by letting $I^D = I^I$, we have the following result:

$$\lambda > \frac{\beta(\sum_{i=1}^{N} \mu_i \pi_i^{s'} - \sum_{i=1}^{N} \mu_i \pi_i^{s})}{I^D} + 1 \tag{2.3.16}$$

The following theorem illustrates our findings on the effect of incentive type on the supplier's reciprocity.

Theorem 2 *When supplier reciprocity for incentive type parameter λ satisfies the relationship*

$$\frac{\beta(\sum_{i=1}^{N}\mu_i\pi_i^{s'}-\sum_{i=1}^{N}\mu_i\pi_i^{s})}{I^D}+1<\lambda<\frac{\beta\sum_{i=1}^{N}\mu_i\pi_i^{s'}-I^D}{\beta\sum_{i=1}^{N}\mu_i\pi_i^{s}} \tag{2.3.17}$$

then the supplier exhibits higher reciprocity under Direct incentive with known probability for recovery outcomes, as compared to Indirect incentive condition.

Remarks.

Theorem 2 shows the supplier's extent of reciprocity towards the manufacturer's incentive offered. The ratio *per se* represents the supplier's reciprocity under each type of incentive. As indicated in Definition 1, λ denote the incentive type dimension reciprocity and measures how the type of incentive influences the supplier's reciprocity in investment decisions. The decision to invest under each type of incentive reflects the supplier's underlying intentions for reciprocity. Specifically, a higher probability of supplier's investment in restoration capability signals a stronger intention to reciprocate. In the absence of intentions, the supplier is less likely to invest. From the view of incentive type, Direct incentive signals good intentions which imply a larger extent for reciprocity. To sum up, the supplier is sufficiently intrinsic motivated to invest in restoration capability when the unconditional Direct incentive is offered. As indicated in (2.3.17), we derive that there exists λ satisfying $\frac{F^D}{I^D}>\frac{F^I}{I^I}$. Our underlying assumption that $\lambda>1$ supports the situation where the incentive type reciprocity loading factor amplifies the Direct incentive value.

Theorem 3 *Under Direct incentive, the value of either* $\frac{F^D}{I^D}$ *or* $\frac{F^{D'}}{I^D}$ *is not affected by the probability of disruption. However, under Indirect incentive, the value of either* $\frac{F^I}{I^I}$ *or* $\frac{F^{I'}}{I^I}$ *linearly increases with the probability of disruption.*

Remarks.

According to (2.3.10), we can derive the ratio of $\frac{\hat{F}^D}{\hat{I}^D}$ is equal to $\frac{\beta(\sum_{i=1}^{N}\mu_i\pi_i^{s}-L)}{\hat{I}^D}+(\lambda-1)$. Based on Lemma 3, the incentive value I^D depends on the probability of β. Here, it is clear see that the ratio of $\frac{\hat{F}^D}{\hat{I}^D}$ is independent of the probability of disruption β. Similarly, the same result applies to the ratio of $\frac{\hat{F}^{D'}}{\hat{I}^D}$. Thus it suggests that the supplier's decision to invest is not influenced by the probability of

disruption if the manufacturer chooses to offer Direct incentive. As for the choice of Indirect incentive, the supplier's investment amount is relevant to β but the Indirect incentive value is not the case. Consequently, we see that ratio of either $\frac{\hat{F}^I}{\hat{I}^I}$ or $\frac{\hat{F}^{I'}}{\hat{I}^I}$ is dependent upon the probability of disruption. To sum up, the supplier does not pay much attention to the probability of disruption in their investment decision if a Direct incentive is offered. Rather, the supplier focuses more on the disruption probability for restoration capability investment if the Indirect incentive is offered.

2.4 Numerical Analysis and Discussion

In this section, we conduct numerical analysis to investigate to what extent the probability of disruption and the belief as to recovery outcomes affect our key variables (i.e.$F, I, F/I$) for risky and ambiguous prospects, respectively, under Direct and Indirect incentives. Parameters are assigned based on our assumptions as stated in our model and with reference to Hu et al. (2013). We let $M_1 = 50$, $M_2 = 51$, $c_1 = 0$, $c_2 = 1$, $\theta = 0.5$, $\lambda = 3$, $\delta = 5$, $L = -1$. For simplicity, we let $p_1 = p_2$, $q_1 = q_2$. We mainly focus on how the change of wholesale price influences both the manufacturer and the supplier's decisions. Given the equilibrium solution for the decentralised supply chain, we can then obtain $p_1 = p_2 = 37.5$, $q_1 = q_2 = 13$, $w_1 = 25$, $w_2 = 26$.

Furthermore, we use the values in Table 2.1 as a baseline for the probabilities of recovery outcomes (μ_i) under Direct and Indirect incentives across the four different types of beliefs and those in Table 2.2 as the supplier's probability of decision to invest (α^D, α^I). The probability of disruption β takes values from 0 to 1 with increments of 0.05.

Table 2.1: Probability of disruption recovery outcomes across four beliefs

	Full Recovery (μ_1)	**Partial Recovery** (μ_2)	**No Recovery** (μ_3)
Pessimistic	0.05	0.05	**0.90**
Optimistic	**0.90**	0.05	0.05
Most Likely	0.25	**0.5**	0.25
Neutral	0.333	0.333	0.333

Table 2.2: A baseline for probability of investment for Direct and Indirect incentive across four beliefs

	Direct Incentive (α^D)	**Indirect Incentive** (α^I)
Pessimistic	0.10	0.10
Optimistic	0.80	0.80
Most Likely	0.60	0.60
Neutral	0.50	0.50

2.4.1 Numerical Analysis with respect to Disruption Probability and Initial belief

Figure 2.4 illustrates that the Direct incentive value varies against the disruption probability and the beliefs in recovery outcomes, whereas the Indirect incentive value remains constant across all the cases as we set the wholesale price and order quantity as parameters in this study. Under each type of belief, the Direct incentive value linearly increases in the probability of disruption. Notably, the optimistic belief generates the highest upper value of Direct incentive when the two options are economically equivalent for the manufacturer. By contrast, the pessimistic attitude is not economically viable. In this situation, the values of Direct incentive and supplier investment are both negative. Hence we exclude this scenario from this part

of our analysis.

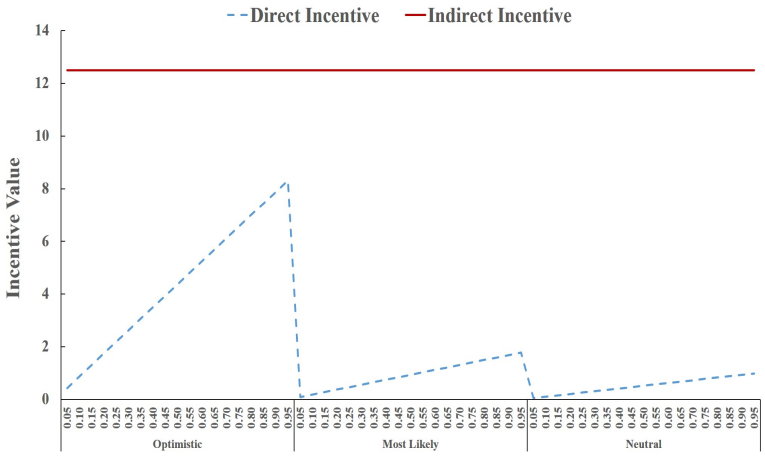


Figure 2.4: Incentive value across belief scenarios against β

Figure 2.5 shows how the supplier's investment in restoration capability is affected by both the beliefs about the disruption recovery outcomes and the probability of disruption. The trend for the supplier's investment amount against the probability of disruption is identical to that for the manufacturer's incentive value as shown in Figure 2.4.

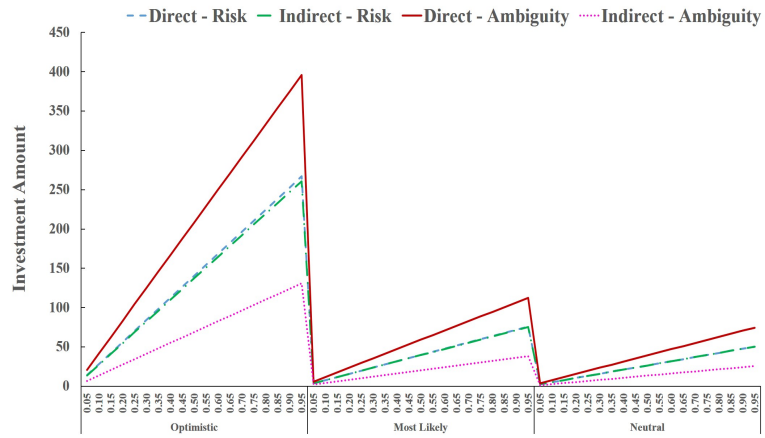


Figure 2.5: Supplier investment amount across belief scenarios against β

It is clear that the supplier provides the highest upper bound of investment amount when the belief about recovery degree is optimistic regardless of the incentive type and the uncertainty about future recovery outcomes. Interestingly, in each of the three scenarios, the supplier is more inclined to invest more when the manufacturer offers the Direct incentive with the ambiguous (i.e.unknown) probability of recovery outcomes. On the other hand, the Indirect incentive with ambiguous probability of recovery outcomes gives the lowest investment amount. The amount falls in the middle with risky (i.e. known) probability of recovery degree. For the risky prospect, we specifically find that the difference in the investment amount between Direct and Indirect incentives is significantly small.

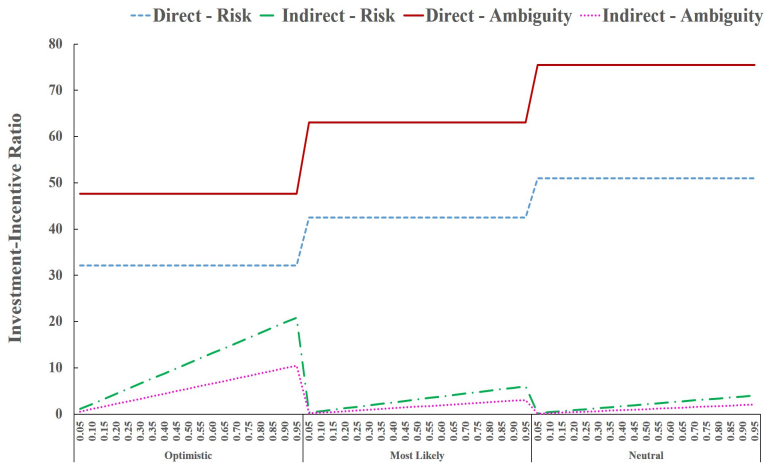
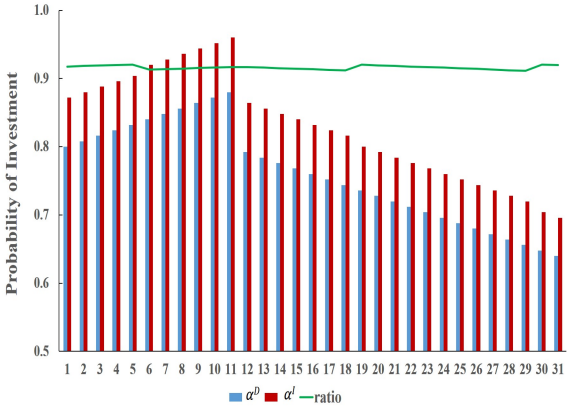


Figure 2.6: The ratio of investment amount to incentive value across belief scenarios against β

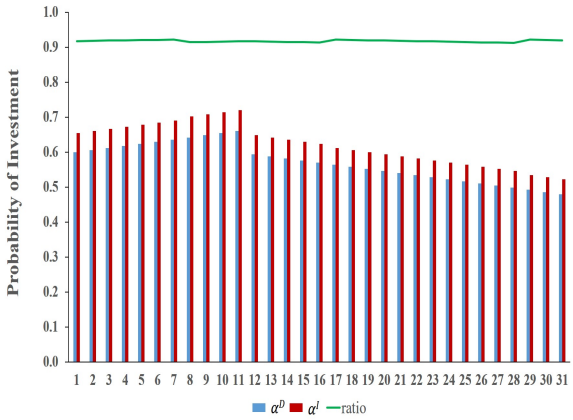
Figure 2.6 displays the ratio of the amount of investment required per unit of incentive received across the three belief scenarios. Clearly, this is a result of what we observed in Figures 2.4 and 2.5. Note that the ratio in each scenario is kept at a constant level with Direct incentive for both risky and ambiguous prospects. It implies that the investment-incentive ratio is independent of the probability of disruption no matter what the future belief is. Conversely, the pattern under the Indirect incentive yields a mirror image of the above. Notably, we observe that the investment-incentive ratio under Indirect incentive is relevant to the probability of disruption. As the probability of disruption increases, the ratio for each belief

scenario increases.

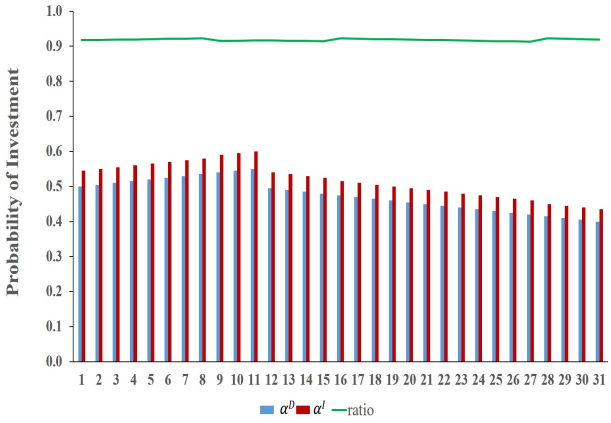
As indicated in (2.3.7), the relative values of α^D and α^I are obtained when I^D becomes viable (i.e. $I^D \geq 0$). However, it is not obvious that to what extent the relative values vary satisfying $I^D \geq 0$. Given the initial parameter settings, we perform a sensitivity analysis of I^D with respect to α^D and α^I, aiming at finding the thresholds $(\bar{\alpha^D}, \bar{\alpha^I})$ satisfying $I^D \geq 0$. α^D and α^I are changing by $\pm 10\%$ based on the value given in Table 2.2. As can be seen in Figure 2.7, the plotted trend lines illustrate that the relative values of the thresholds $(\bar{\alpha^D}, \bar{\alpha^I})$ for $I^D \geq 0$ under each type of belief about future recovery outcome do not vary and are very close to 1 for our settings.



(a) Optimistic Scenario



(b) Most Likely Scenario



(c) Neutral Scenario

Figure 2.7: Different cases of α^D and α^I obtained when $I^D \geq 0$ across different beliefs about recovery degree

2.4.2 Discussion

In this study, we initial compare two incentive mechanisms, Direct vs. Indirect, in inducing supplier's restoration capability investment with the concern for reciprocity. First, our results suggest that Direct incentive that signals a more prosocial behaviour is more likely to intrinsically motivate the supplier's reciprocity. That is, the supplier is likely to be motivated to invest more in building restoration capability towards the manufacturer's generous offer. Consequently, responsiveness and success of disruption recoveries can be improved. The theoretical foundation for the effects of Direct incentive on supplier's reciprocal behaviour is based on Motivation Crowding Theory (Frey 1997*b*). This theory highlights that, under certain conditions, the use of price incentive mechanism decreases individuals' motivation to act and thus crowds out intrinsic motivation to reciprocate. However, in the condition that the incentive is voluntarily offered, our findings provide evidence that the upfront prepaid incentive that makes suppliers feel of giving more voluntary to perform can enhance intrinsic motivated reciprocity as compared to the promise-based price/quantity incentive.

Second, this study takes a two-step approach to the modelling of the supplier's reciprocity. In the first step, our findings show that the propensity for reciprocity largely depends on the sizes of the wholesale price, order quantity as well as the loss value for Direct incentive to be economically viable. However, in the second step, we show that under Direct incentive greater propensity is not necessarily a prerequisite for a higher extent of reciprocity, which is measured by the ratio of the supplier's investment to the incentive value offered by the manufacturer. Given that the supplier's propensity for reciprocity under Direct incentive is not far less than that under Indirect incentive, the extent of reciprocity is higher under Direct incentive as compared to Indirect incentive across scenarios in our numerical settings. Our results echo the argument put forward by Frey and Jegen (2001) that Direct incentive strengthens the supplier's intrinsic motivation such that a stronger reciprocity is reinforced.

Third, drawing from traditional principal-agent theory (Fleisher 1991), each party in a contractual relationship has their own motive of profit maximisation.

This may lead to an agency problem, in which the manufacturer (principal) seeks to minimise the agency costs, for example, by offering generous incentive to induce investment by the supplier (agent), whereas the supplier aims to maximise its own profit and accordingly makes a minimum effort in restoration investment. Consequently, the moral hazard problem (e.g. free riding) will occur. However, our result shows that, due to the existence of reciprocity, the supplier is elicited to invest more when an incentive is offered upfront by the manufacturer, which aligns earlier findings by Falk and Kosfeld (2006) and Ellingsen and Johannesson (2008). This result suggests that, in the presence of disruption, an incentive prepaid upfront is more efficient than a promise-based contract incentive when the supplier has the sense of strong reciprocity. In doing so, the supplier's intrinsic motivation to invest will be raised.

Next, we investigate the impacts of different types of uncertainty about future recovery outcomes (i.e. risk vs. ambiguity) on supplier reciprocity for both Direct and Indirect incentives. When an ambiguity exists, the majority of people are ambiguity averse (Einhorn and Hogarth 1985) such that the expected payoffs of future recovery outcomes will be discounted in anticipating an ambiguous future. Thus suppliers should exhibit lower levels of reciprocity in ambiguity than in risk for both Direct and Indirect incentives. However, our study shows a contradictory finding. In the absence of the beliefs about future recovery outcomes, under Direct incentive with ambiguous uncertainty, the supplier becomes less ambiguity averse and is willing to exhibit stronger reciprocity to build restoration capability. Here Direct incentive implies a positive signal while the ambiguity implies the opposite one. Our finding suggests that the relative size of the two contrary effects determines the supplier's extent of reciprocity. Specifically, the size of the effect of Direct incentive is more salient than that of ambiguity on supplier reciprocity. The supplier with reciprocal concern is more willing to merit the prosocial behaviour displayed by the manufacturer when the future recovery outcomes are ambiguous. Hence, under Direct incentive, a higher level of reciprocity is more likely to be reinforced with ambiguous uncertainty. Conversely, Indirect incentive that signals a less prosocial action makes the supplier less appreciative of the incentive offered for the ambiguous

prospect, and therefore elicits more ambiguity averse decisions.

Finally, we take account of beliefs about the probabilities for future recovery outcomes. Due to the fact that the pessimistic belief is not economically viable, we mainly focus on discussing optimistic, most likely and neutral scenarios. Further, we note that the results for most likely and neutral scenarios are very close (see Fig.2.2-2.5), and thus we classify these two beliefs in the same category, namely less optimistic scenario. The common view is that individuals with higher optimism are less ambiguity averse (see, for example, Pulford (2009), Bier and Connell (1994)). Interestingly, our results show that, under Direct incentive, suppliers with optimistic beliefs become more ambiguity averse and exhibit the lowest reciprocity as compared to those with lower optimism (i.e. most likely and neutral beliefs). In contrast, an opposite case applies to Indirect incentive, which supports the common view. One of the explanation might be as follows. When belief is shared, in the optimistic scenario, the positive future recovery outcomes in general are more likely to take place, in particular when a more prosocial action is taken. The kindness exhibited from the offer of Direct incentive in the optimistic scenario is not as strong as that in less optimistic ones.

2.5 Conclusions and Future Research

In summary, we use a stylized model to analyse the role of the incentives specified beyond a contract mechanism as against within the relational contract to motivate suppliers' investment in disruption recovery. More specifically, we consider two types of incentive offered by the manufacturer: unconditional (prepaid) and conditional (promise-based) with risky and ambiguous prospects of future recovery outcomes across various beliefs. We provide analytical results which show that the use of Direct incentive leads to an outcome for the manufacturer that is at least as good as that where Indirect incentive is applied. In particular, we derive a ratio of the supplier's investment amount to the manufacturer's incentive value under the two types of incentive, which demonstrates the existence of supplier reciprocity towards unconditional generosity exhibited in the manufacturer's Direct incentive. Further-

more, we conduct a sensitivity analysis to investigate how the supplier's propensity for reciprocity changes with the incentive value offered by the manufacturer. Our analytical result indicates that the extent of supplier reciprocity in Direct incentive is greater than Indirect incentive when the supplier's propensity to reciprocate in Direct incentive is not far less than that in Indirect incentive. Our findings imply that free-riding and opportunistic behaviour associated with the supplier investment in building recovery capability may be alleviated when we take explicit account of supplier reciprocity into concern. The manufacturer should always offer Direct incentive as long as it is economically equivalent to the alternative, and should do so particularly when an ambiguous prospect for recovery outcomes is anticipated with less optimism.

In practice, managers from partner organisations need to jointly exert restoration effort to enable firms to be more resilient and responsive to disruptions. From the managerial perspective, this study provides insights into the conditions under which the design of incentive mechanisms can motivate stronger reciprocal responses by comparing relational incentives based on their types of commitments (unconditional vs. conditional). Since people are emotionally driven by their social concerns when making decisions in repeated exchanges, the manufacturing firms should incorporate supplier's response with the concern for reciprocity into the design of incentive mechanisms. We propose that, when the expected payoffs are equally valued to each incentive, firms should consider a prepaid incentive before disruption which raises the social value and promotes cooperative relationship for motivating the suppliers' capability investment. By taking the proactive action, the supplier's restoration investment will be well motivated. In addition, evidence from the analytical results of our model suggests that the use of Direct incentive mechanism is efficient particularly when an ambiguous probability of disruption recovery is anticipated with the less optimistic shared belief about future recovery outcomes. From the supplier's perspective, the Direct incentive allows the supplier to alleviate financial constraints and thereby free up its cash stuck in restoration capability investment. On the other hand, the prepaid incentive before disruption serves as a signal of trust. Using this incentive mechanism, suppliers are more likely to engage in a long-term relationship

that embeds reciprocity. In brief, supply chain partners must be well prepared for restoration capacity before a disruption has occurred. It requires both manufacturer and supplier to work together to build restoration capability in a proactive manner. The manufacturer should draw attention to the importance of a prepaid incentive before the disruption in motivating its supplier's investment that involves the norm of reciprocity, in particular under an uncertain environment. The supplier should positively exhibit reciprocal response to its manufacturer's proactive action, which can help to deal with financial stress. Importantly, an understanding of the supplier's reciprocal concern underlying a good cooperative relationship would be the key to a successful and timely recovery from disruptions.

Nonetheless, our study has a number of limitations. First of all, in our parameter settings, we assumed that market demand is deterministic, the future study could conduct with a stochastic demand to examine how the uncertainty of order quantity influences decisions for both the manufacturer and the supplier. In our numerical analysis, for simplicity, we assumed that market price and order quantity, respectively, does not change prior to and after disruptions. This assumption can be easily relaxed in future study. Furthermore, our research focused on the linear wholesale price contract. An alternative type of promise-based contract could be considered in future research. Second, we considered the ratio of investment amount per unit incentive offered as the proxy for reciprocity and treat the likelihood of investment as given. A possible extension of this research would be to investigate to what extent this explicit assumption can be relaxed. Finally, this paper does not explicitly model the manufacturer-supplier relationship. It is reasonable to conjecture that both the length and depth of such a relationship would affect the level of reciprocity exerted by the supplier. This can be best examined in a laboratory setting.

Chapter 3

Reciprocity in an Incentive-Investment Game: A Laboratory Study

3.1 Introduction

One of the most crucial aspects of managing disruption risk is to build up restoration capability beforehand and accordingly enable firms to be more resilient and responsive when a disruption occurs (Hu et al. 2013, Ambulkar et al. 2015). To mitigate disruption risks, supply chain parties should jointly make considerable efforts in restoration capability investment. In a exchange relationship, the repeated interactions that driven by social concerns are important to motivate both parties to concern about benefits to the other (Emerson 1976, Blau 1964). Thus, to induce the supply chain party to engage in prosocial behaviour, incentive mechanisms that involve social considerations are important to consider.

In Chapter 2, we have documented two streams of incentive mechanisms to address supply chain disruption problems: (1) standard incentive contracts (Davis and Leider 2015, Cachon 2003, Tomlin 2003); and (2) relational incentive contracts (Taylor and Plambeck 2007*a*,*b*). Due to the fact that suppliers' responses to disruptions may be not easy to specify in a traditional transaction-based contract, instead a relation-based contract may be adopted more widely (Taylor and Plambeck

2007*a*, Simatupang et al. 2002, Dyer and Singh 1998). In particular, a relation-based contract may greatly enhance collaboration, mitigate opportunistic behaviour from suppliers and also encourage their joint effort in hedging against disruption risks. A study by Beer et al. (2017) highlights that a proactive mechanism beyond contracting can be viewed as a stronger signal of trustworthiness that underlies reciprocity as compared to a contractual mechanism.

In this study, we distinguish between incentive mechanisms based on conditional and unconditional motivations. In line with incentive research in economics, the two identified incentive mechanisms are defined in terms of two dimensions: form of incentive and timing of incentive (Benhabib et al. 2010, Frederick et al. 2002, Baker et al. 1988, Shafir et al. 1993). We categorise the types of incentive into: (1) prepaid financial incentive (i.e. unconditional); (2) promised price incentive (i.e.conditional). The timing of incentive is considered to be either before- or after a disruption. We term the financial incentive prepaid before the disruption 'Direct' incentive and the promised price incentive that becomes effective only if disruption occurs 'Indirect' incentive. The 'Direct incentive' is not just a financial commitment, but also a mechanism that signals manufacturers' prosocial behaviour. It can better induce the supplier's intrinsic motivation of reciprocity in investment decisions. The 'Indirect incentive' is closely related to notions of incentive as described in Hu et al. (2013), which examines the buyer's promised wholesale price and/or order quantity contract incentives in motivating the supplier's investments. In our research, we view the type of incentive as a decision variable that may endogenously influence suppliers' reciprocal behaviour.

This study presents an experimental investigation of how different types of incentives affect decisions on incentive value that motivates reciprocal behaviour for manufacturers and investment amount that signals reciprocity for suppliers. Reciprocity as a social norm is most often induced by generous behaviours that can lead to voluntary cooperation (Fehr et al. 1997). It is in general identified as fundamental to social relations, with the implication that people are willing to reward kind actions (positive) and to punish unkind ones (negative).

The existing literature on social psychology provides evidence that people who engage in prosocial behaviour are more likely to shape a propensity to reciprocate based upon the generous behaviour of others (Weber et al. 2004, Perugini et al. 2003). In this study, Direct incentive as a more generous offer may be more likely to elicit a supplier's propensity for reciprocity that embedded in his decision to invest in restoration capability, as compared to Indirect incentive. In other words, the supplier may be more willing to opt to invest if the manufacturer's actions regarding incentives are perceived as kind. Depending on the propensity to invest, the supplier further makes a decision on investment amount which serves as the extent of reciprocity. We measure the extent of reciprocity using the return rate of investment amount to total amount available to invest which includes the incentive value received, following Kanagaretnam et al. (2010).

In addition, we also identify the exogenous treatment variables that affect the behaviour of both the manufacturer and supplier. To protect against supply chain disruptions, a key mitigation strategy for supply chain members is through effective collaboration with their partners (Braunscheidel and Suresh 2009, Christopher and Peck 2004). In view of this, long-term relationship building is crucial to enhance collaboration in a supply chain. With strong long-term buyer-supplier relationships, transaction costs can be reduced and suppliers' responsiveness can be achieved (Nyaga et al. 2010, Shin et al. 2000, Carr and Pearson 1999). Furthermore, the long-term relationship commitments can better encourage supply chain partners to invest jointly in their supply chain performance improvement initiatives (Cooper et al. 1997). Consequently, opportunism will be limited.

Although a large amount of evidence suggests that the long-term buyer-supplier relationships have been devoted to supply chain cooperation and collaboration, little has explored the behavioural motives underlying the buyer-supplier relationship in a supply chain setting. Research on evolutionary biology provides a root that the underlying rationale behind people's concern for reciprocity is closely related to long-term cooperative relationships (Riolo et al. 2001, Trivers 1971). In other words, the stability of the relationship between supply chain partners is more likely to motivate supplier reciprocal behaviour. A previous study by Dyer and Ouchi (1993)

provide consistent evidence that long-term relationships can greatly contribute to the reinforcement of reciprocity. As a result, such relationships that underly reciprocal interactions may make supply partners feel free from obligatory regulations/duties and thus mean they are willing to do more in managing supply chain disruption risks. Therefore, another focus of this study is to experimentally investigate whether and how different types of relationship, one-shot vs. repeated interactions, affect supply chain partners' decisions and reciprocal behaviour in restoration capability investment under Direct and Indirect incentives.

Most research on supply chain management has emphasised the importance of environmental uncertainty about future events that exist in disruption risks (Tse et al. 2016, Wu and Pagell 2011, Ellis et al. 2010, Yu et al. 2009). They provide evidence that environmental uncertainty characterised as unexpected changes to businesses has a significant impact on supply chain disruption. Thus, in the presence of a disruption, the probabilities for future recovery outcomes that involve uncertainty may be of importance in supply chain partners' decisions on restoration capability investment. Broadly speaking, the probabilities for future outcomes are classified into two categories: (1) risk; and (2) ambiguity. The risk condition is in general associated with events that have known probabilities in regard to future outcomes (Milliken 1987, Ellsberg 1961). In contrast, the ambiguity condition refers to events that have unknown probabilities of the future outcomes (Milliken 1987, Duncan 1972, Ellsberg 1961).

The existing literature on supply chain disruption distinguishes between internal and external factors influencing supply chain disruptions (Wu et al. 2006, Wagner and Bode 2006, Kleindorfer and Saad 2005). The probabilities for disruption recovery outcomes may be more likely to be estimated when a disruption caused by internal risks such as manufacturing risk, whereas ambiguous when it caused by external environmental factors, for example, natural disaster (Wu et al. 2006). Research on experimental economics provides evidence that people are more averse to decisions under ambiguity (unknown probabilities), as compared to decisions under risk (known probabilities) (Holt et al. 2002, Ellsberg 1961). That is, most people prefer a decision with known probabilities in comparison with a similar one with

unknown probabilities. In view of this, we argue that supply chain partners may perceive risk and ambiguous conditions differently and accordingly have differences in their behaviour when making decisions. As a result, we take account of different types of probabilities about future recovery outcome as our second treatment variable. The focus of this uncertainty treatment is to investigate the effects of different types of uncertainties about future recovery outcomes on supply chain partners' decisions and reciprocal behaviour under different types of incentives.

This experimental research develops an incentive-investment game, which allows us to study key factors influencing the supplier's investment decisions in building up restoration capability towards incentives by manufacturers. We use a 2 x 2 experimental design (i.e. recovery uncertainties: risk vs. ambiguity; relationships: repeated vs. one-shot). In our design, we primarily focus on suppliers' investment amount per unit incentive by manufacturers, which can serve as a signal in regard to the extent of reciprocity towards two different types of incentives by manufacturers. Our results indicate that suppliers' propensity for and the extent of reciprocity towards manufacturers' incentive offered are significantly increased with repeated interactions when Direct incentive is offered. In other words, the long-term relationships and Direct incentive can combine to reinforce the supplier's reciprocal behaviour. Regarding the uncertainty treatment, we show that Direct incentive induces higher incentive values and accordingly higher propensity to reciprocate in the risk condition than in the ambiguity condition. In order to understand whether subjects' decisions in later rounds are learned from their previous experience, we include a dummy variable for learning effects by looking at relationships between treatment dummies and the learning variables. We find that the learning effects on supplier's investment decisions are diminished in repeated games, which reveals that the long-term relationships restrain individuals' selfish motive of maximising their own benefits.

Our research contributes to the existing literature in the following ways. First, the majority of behavioural operations studies have highlighted the significance of long-term relationships in enhancing trustworthiness (Beer et al. 2017, Corts and Singh 2004, Özer et al. 2014). This study extends the previous research by exploring

the effects of long-term relationships on supplier reciprocal behaviour. We provide insights by demonstrating the importance of long-term relationships in motivating suppliers' propensity for and also extent of reciprocity, in particular, when an unconditional incentive is offered before a disruption occurs. In addition, previous studies on behavioural economics suggest that learning behaviour that generated through repeated interactions may be attributed to subjects' social norms in laboratory experiments (Gächter and Falk 2002, Fehr and Schmidt 2001, Andreoni 1988). We provide consistent evidence that subjects' behaviour is driven by reciprocity norms that are triggered in long-term interactions rather than learning free-riding.

Second, the existing literature on behavioural economics highlights the fact that most people are ambiguity averse (Heal and Millner 2018, Camerer and Weber 1992, Ellsberg 1961), and thus may be less responsive to environmental uncertainty. We contribute to the existing body of knowledge finding that, manufacturers who select Direct incentive are likely to offer higher incentive value, under the condition that the probability for future recovery outcomes is known with certainty.

Finally, drawing upon the investment game (also known as trust game) by Berg et al. (1995), we provide new insights into experimental design, which allows us to investigate the factors influencing the manufacturer-supplier social interactions (i.e. reciprocity) by integrating endogenous and exogenous views. In reality, decision-making is a process of selection. To our knowledge, we are the first to incorporate categorical decision variable as being selective into the experimental design, rather than imposing a treatment on a group of subjects. This may help to facilitate further research in the methodology.

The remainder of this paper is organised as follows. Section 2 presents the experimental design and procedure. In Section 3, we describe our hypotheses development. Our results are reported in Section 4, followed by a discussion in Section 5. In Section 6, we conclude by summarising the key findings and stating the limitations of the study.

3.2 Literature Review

In recent years, there has been a growing number of research papers incorporating human emotional factors into supply chain management. Most behavioural studies in operations management involve the investigation of the role of social preferences in the analysis of contract-based incentive mechanism in supply chain relationships. Katok and Pavlov (2013) show, in a laboratory setting, that fairness preferences have played an important role in supply chain contract performance. Loch and Wu (2008) provide experimental evidence that social preferences such as reciprocity can significantly affect exchange parties' decisions as well as supply chain performance. Özer et al. (2011) find that reciprocity motivates cooperative forecast information sharing and accordingly affects suppliers' capacity investment decisions. Haitao Cui et al. (2007) place an emphasis on the importance of firms' fairness concerns in supply chain coordination under a wholesale price contract.

However, in certain business circumstances, it is likely that the problem of contractual incompleteness may exist in particular when future events are unforeseen. According to Fehr et al. (1997), the involvement of reciprocity can serve as an effective tool to deal with problems arising from incomplete contracts. In other words, people's prosocial behaviour may be more likely to rely on intrinsic motivation in incomplete contracts. In view of this, an unconditional incentive mechanism that makes individuals feel out of control may be superior to the contract-based incentive induce more voluntary cooperation when contracts are incomplete (Gächter et al. 2004). In general, people's willingness to cooperate through this is dependent on others' behaviour in cooperation. To better motivate such voluntary cooperation, supply chain partners' concerns for reciprocity must be considered. In our study, suppliers who have reciprocal concerns are likely to invest more in restoration capability towards manufacturers' incentive offered.

Cooperative relationships between buyers and suppliers are most often observed in supply chains (Nyaga et al. 2010). According to Williamson (1985), the embeddedness of relationships can motivate both the buyer and the supplier to jointly engage in investments in relation-specific assets, resources and capabilities so as to generate synergy benefits. Relation-specific assets refer to assets that are specialised

or unique in developing competitive advantage between both exchange parties. With the involvement of relational concern, both parties are willing to jointly build resources and capabilities (Dyer and Singh 1998). Existing controlled laboratory experiments provide evidence that the role of long-term buyer-supplier relationship is significant in supply chain performance. For example, Loch and Wu (2008) run an experiment that asks subjects to play with paired partners repeatedly for 15 rounds. In the relationship group, the two players are asked to communicate by giving a short introduction before the game starts. In the control group, players are not allowed to communicate with each other. They find that relationship-based reciprocity motivates cooperation between the two exchange parties. Similarly, Wu (2013) extends Loch and Wu (2008)'s study by examining the impact of long-term relationships on various supply chain contracts. Subjects are asked to repeatedly play with their paired partners for 100 rounds. She shows that repeated interactions play an important role in reinforcing reciprocity and accordingly improve supply chain performance.

According to Gächter and Falk (2002), a gift-exchange game is designed to investigate how different types of relationship (i.e. one-shot vs. repeated) influence reciprocal behaviour in the context of wage-effort relation. Subjects are assigned to their treatment conditions as 'one-shot' and 'repeated game'. In each treatment, the role of subjects is assigned as 'firms' and 'workers'. Firms offer workers a wage determined at w, and then workers decide whether to accept the offer or not. The workers next have to choose an effort level e if they accept the offer and otherwise the game will be ended. They find evidence that long-term relationship significantly induces a higher level of reciprocity as compared to one-shot interaction. To our knowledge, the effects of supply chain relationships on how incentives by manufacturers influence supplier reciprocity have not been explored in supply chain settings. This study provides a comparison of the effects of incentive types on reciprocal behaviour between repeated and one-shot interactions. In addition, Gächter and Falk (2002) test whether learning behaviour in reciprocity distinguishes from spontaneous reciprocity. They observe that rational subjects who are self-interested are more likely to show imitation behaviour in reciprocity over repeated interactions. Over the long

run, workers learn to behave reciprocally towards firms' generous wage. In view of this, long-term relationships between exchange parties can be seen to contribute to reduced opportunistic behaviour (Corts and Singh 2004).

The existing literature on decisions about future event distinguishes between attitudes toward risk and attitudes toward uncertainty (Camerer and Weber 1992, Knight Frank 1921). Attitudes toward risk involve known probabilities of future outcomes whereas attitudes toward uncertainty involve unknown or ambiguous probabilities of future outcomes (Milliken 1987, Ellsberg 1961). A classical experiment by Ellsberg (1961) examines individuals' preference between uncertain and risk conditions. In Ellsberg (1961)'s experiment, there are two urns, one contains 100 red and black balls with unknown or ambiguous probability of each colour whereas the other contains 100 red and black balls that are evenly split with known probability. When subjects were asked to bet on a red (or black) ball drawing from each of urn, they have indifference in preference between red and black. That is, $p(red) = p(black)$ where $p(red)$ and $p(red)$ interpret the probabilities that a red ball and black ball is drawn from an urn respectively. However, when they were asked to bet on a red (or black) ball drawing from the two urns, most of them preferred to choose from the urn with known probability over that with unknown probability. That is to say, $p(unknown_{red}) \prec p(known_{red})$ which demonstrates the existence of ambiguity averse preferences. A similar result holds for black ball selection.

Following Ellsberg (1961)'s predictions, a significant numbers of studies including Curley and Yates (1985), Yates and Zukowski (1976), Slovic and Tversky (1974), Becker and Brownson (1964) provide further support for these findings. In the face of supply chain disruptions, predictions of uncertain future recovery outcomes are often difficult. As people in general have a preference for an event with known probability over that with unknown probability, vague information that makes the probabilities of disruption recovery ambiguous may motivate exchange parties to behave opportunistically (Williamson 1979) and accordingly decrease their willingness to make effort in restoration capability. Thus we argue that both manufacturers and suppliers' decisions on restoration capability may be less other-oriented and generous under the ambiguous condition as compared to the risky condition. To the

best of our knowledge, supply chain parties' attitudes or behaviours about uncertain events have not been well studied in laboratory experiments. In this study, we aim to investigate how different types of uncertainty influence manufacturers' decisions on incentivising suppliers' restoration investment as well as suppliers' decisions or behaviours in response to manufacturers' actions.

The study of reciprocity in experimental economics primarily originates from the ultimatum game (Güth et al. 1982). In the ultimatum game, the first mover proposes an offer and then the second mover decides to accept or reject. If the second mover accepts, both of movers are allocated with an amount as proposed. Otherwise, they receive nothing. The result shows that the majority of first movers offer 40% to 50% of the total money, which implies an inconsistency with the rational self-interest assumption. Following the ultimatum game, Berg et al. (1995) developed the investment game (i.e.trust game) that allows the second mover to send back a certain amount to the first mover.

Drawing upon the investment game by Berg et al. (1995), this study places an emphasis on suppliers' reciprocal behaviour towards incentives by manufacturers in regard to investment in restoration capability. In Berg et al's (1995) investment game, two players are anonymously paired. Player A plays the role of a proposer and Player B plays the role of a responder. Player A is given an amount of X and then decides an amount Y, between 0 and X, that A sends to Player B. After that, the amount sent is tripled by the experimenter such that Player B who receives an amount of 3Y has to decide the amount to return to Player A between 0 and 3Y. They find a positive reciprocity, in which the amount offered by Player A is positively correlated with the amount sent back by Player B. In an exchange relationship, the existence of reciprocity is in general interpreted by an exchange party's decision depending on the other party's action. A fraction of the total return f implicitly interprets the extent to which Player B reciprocates towards Player A's action. If the amount returned by Player B is higher than the amount sent by Player A, the Player B is viewed as being reciprocal towards the Player A's action. Take the example that Player A offers an amount of £10, the total return that Player B receives will be £30. The amount Player B returned to Player A and its remaining

amount under different types of fraction of the total return are shown as in Table 3.1.

Table 3.1: The amount returned to Player A and the net returns to Player B

f	0	1/3	1/2	2/3
Amount returned	0	10	15	20
Net return	30	20	15	10

3.3 Experimental Design and Procedure

We conduct a laboratory experiment which observes reciprocity in an incentive-investment setting, with a design motivated by the trust/investment game proposed by Berg et al. (1995). We consider a two-stage game in a two-tier supply chain involving a manufacturer (M) and a Supplier (S). The following sections describe our experimental design and procedure in details.

3.3.1 Game Design

In our game, all players were given a background scenario, in which a manufacturer offers an incentive to motivate its supplier to invest in recovery capacity aimed at mitigating disruption risks. There are three possible outcomes of recovery: (1) full recovery; (2) partial recovery; (3) no recovery, which can lead to a highest, medium and lowest payoff respectively. Due to the unpredictable nature of disruptions, the probability of each recovery outcome can be either risky (i.e.known) or ambiguous (i.e.unknown). Both players have the shared information and are initially endowed with the same amount E such that the difference in wealth status regarding the prospect of disruption recovery between them can be minimized and negative payoffs can be ruled out (Kraft et al. 2018).

The experiment includes four treatments. First, in the *one-shot interaction treatment*, the subjects were anonymous and randomly re-matched each round. They

were not allowed to communicate with each other and told that they would be paired with a different player in every round. According to Bolton et al. (2005), Loch and Wu (2008), the one-shot setting excludes possible social considerations from repeated interactions and thereby prevents relationship-building. Second, the relationship between both players can be reinforced through the repeated interactions. In our *repeated interactions treatment*, both players are in a long-term relationship. However, the paired subjects in fact did not know each other before, we therefore make them initialize a relationship by allowing them to chat with each other for 3 minutes. The subjects repeatedly played with the same partner over the entire 25 rounds. Before the experiment started, participants were given a card and were informed that they needed to find the person who has the same number on the card. We allowed them to chat with each other for about 3 minutes. The communication process here may help us to form a social relation that eventually contributes to the initialization of reciprocity. After the informal conversation at the outset, both players made their decisions individually without any further communication during the game. Third, in the Ambiguity treatment, the subjects were given a hypothetical scenario, showing that the probabilities of disruption recovery outcomes are unknown when a disruption occurs. Based upon the hypothetical scenario, the subjects were making investment decisions accordingly. In contrast, in the Risk treatment, the subjects were given a scenario, showing that the probabilities of disruption recovery outcomes are known, which are estimated to be 50% or greater.

This experiment considers two incentives $j \in \{1, 2\}$ that motivate suppliers' investment in restoration capability. Incentive $j = 1$ denotes Direct incentive while $j = 2$ denotes Indirect incentive. In each round, the manufacturer chooses to offer the supplier an incentive, either Direct (monetary-based paid upfront prior to disruption) or Indirect (contract-based offered post-disruption), and determines an incentive value I between 0 and E in the first stage. Then in the second stage the supplier decides whether he would like to make an investment on capability restoration to help firms recovering from a disruption, and, if so, the investment amount F towards the incentive offered by the manufacturer. In Berg et al's investment game, the amount transferred by the second mover was increased by a multiplier.

In our design, we assign a loading scaler on manufacturers incentive value offered to determine the maximum investment amount F under different treatment conditions. According to the Definition of reciprocity in Chapter 1, the loading scaler $\eta_{i,j} > 0$ that is determined by both incentive type and uncertainty type about future recovery outcomes varies across all treatments. With each type of incentive, we set up the loading scaler as a benchmark to value the extent of reciprocity under risky uncertainty condition for $\eta_{R,j}$ and ambiguous uncertainty condition for $\eta_{A,j}$.

According to Molm et al. (2007), people will have different perceptions on the extent of reciprocity depending on various scenarios. To simply capture the combined effect of incentive type and uncertainty type on reciprocity, we first let Risk-Indirect condition serve as a baseline representing that the supplier is not motivated to display reciprocity when the manufacturer offers Indirect incentive under known future recovery prospects. As compared to Indirect incentive, Direct incentive represents a more prosocial action that can reinforce reciprocity. In this view, there should be more reciprocity when Direct incentive is offered whereas less reciprocity when Indirect incentive is offered. In addition, due to the reason that most people prefer a known probability of future outcomes over an unknown one, there should be a lower degree of reciprocity under ambiguous uncertainty than under risky uncertainty when Indirect incentive is offered. Based upon the baseline, we assume that the value of Direct incentive under the risky uncertainty condition (i.e.Risk-Direct) will be amplified by $\eta_{R,1}$ (i.e. $\eta_{R,1} > \eta_{R,2}$) and the value of Indirect incentive under the ambiguous uncertainty condition (i.e.Ambiguity-Indirect) will be reduced by $\eta_{A,2}$ (i.e. $\eta_{A,2} < \eta_{R,2} < \eta_{R,1}$).

Taking Direct incentive and ambiguous uncertainty together, the combined reciprocal effect cannot be simply captured by the sum of scalers $\eta_{R,1}$ and $\eta_{A,2}$, which are in relation to these two aspects. We therefore take into account their synergy effects since a more prosocial action taken under ambiguous uncertainty would create more value and thus induce more additional reciprocity than the sum of their individual values (Cao and Zhang 2011, Tanriverdi 2006). Their synergy effects are measured by using the product of $\eta_{A,2} \times \eta_{R,1}$. Accordingly, we have the overall reciprocity loading scaler $\eta_{A,1}$ on the Direct incentive and ambiguity synergy as

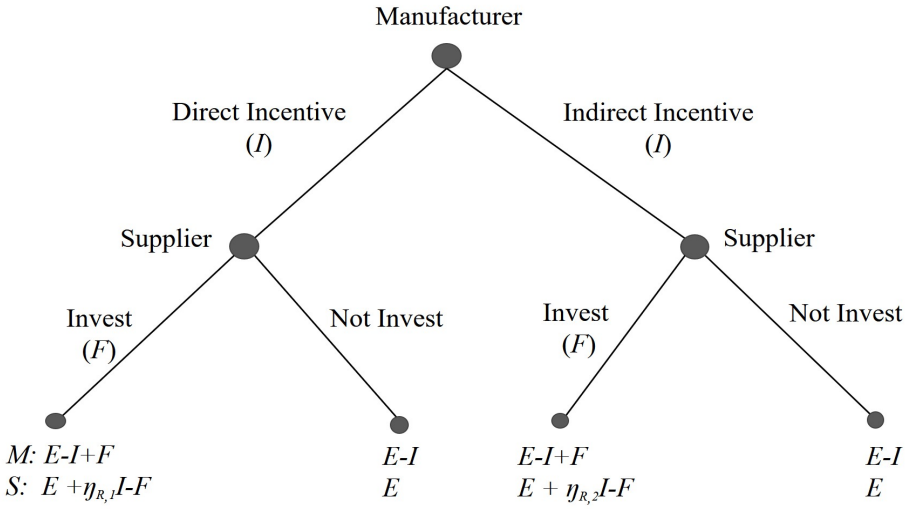
$\eta_{A,2} + \eta_{R,1} + \eta_{A,2} \times \eta_{R,1}$.

The total amount available for the supplier to invest is based on both the initial endowment and the multiplied incentive value. On making an investment decision, the supplier chooses an investment amount F ranging from 1 to $E + \eta_{i,j} I$. To study the supplier's reciprocal behaviour in decision making, the ratio of F to $E + \eta_{i,j} I$ is derived as a proxy of supplier reciprocity towards incentive offered by the manufacturer. If both players are aiming at maximising their own payoff, the manufacturer should offer nothing to the supplier and the supplier should invest nothing in restoration capability. When the manufacturer offers an incentive that signals kind attitude, the manufacturer earns a payoff of $\pi_m = E - I + F$ if the supplier decides to invest, or $\pi_m = E - I$ if the supplier does not invest. On the other hand, if the supplier chooses to invest, he earns a payoff of $\pi_s = E + \eta_{R,j} I - F$ for risky uncertainty and $\pi_s = E + \eta_{A,j} I - F$ for ambiguous uncertainty. Otherwise $\pi_s = E$ if he does not invest. Figure 3.1 illustrates the game sequence under different types of uncertainty regardless of relationship type.

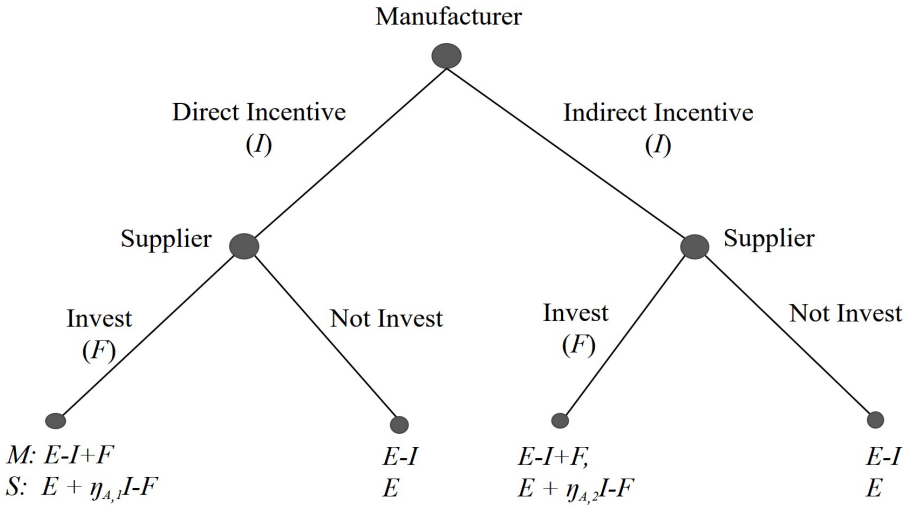
3.3.2 Experimental Procedure

All participants in the laboratory were not allowed to start the game before finished reading a one-page instruction, which gives them a brief understanding of our hypothetical scenario in a supply chain background. In our scenario, the manufacturer acts first to offer a type of incentive to motivate its supplier to invest in restoration capability. The supplier, as the second mover, responds by deciding whether or not to invest and if so the amount to invest. To verify they had understood the instruction, they were further asked to answer five related questions. Participants who failed to pass the manipulation check were excluded from the study.

At the beginning of the experiment, each player was endowed with 100 points, anonymously paired and assigned to either the role of manufacturer or supplier. In each round, the manufacturer player was asked to choose between Direct and Indirect incentive. Following the incentive type decision, the manufacturer player chose an incentive amount I from his/her endowment to the paired supplier. The manufacturer then kept $100 - I$. Any incentive amount offered was multiplied by



(a) Game sequence under risky uncertainty



(b) Game sequence under ambiguous uncertainty

Figure 3.1: Game sequence under different uncertainties

the experimenter such that, for example, $\eta_{i,j}I$ was passed onto the supplier. In other words, the supplier would have the amount of the endowment 100 and the amplified incentive value $\eta_{i,j}I$ in total. Controlling for the types of relationships, we manipulate the value of reciprocity loading scaler. According to the results of numerical analysis in Chapter 1, $\eta_{R,1}$ and $\eta_{R,2}$ are valued at 3.25 and 1.40 respectively while $\eta_{A,1}$ and $\eta_{A,2}$ are valued at 4.75 and 1.15 respectively. Next, the supplier

decided whether to invest in restoration capability followed by the manufacturer's decision. If the supplier chose to invest, he/she could decide to invest partial, all or none of the points received ($0 \leq F \leq 100+\eta_{i,j} I$). Otherwise, the supplier would only earn 100 points for this round, as would the manufacturer in the Indirect incentive decision. Notably, the manufacturer that opted for the Direct incentive would earn $100 - I$ in this case because the prepaid incentive becomes the sunk cost if the supplier did not invest.

We programmed the computer interface using the oTree system and uploaded the program in the Heroku server, which can be accessed via the internet. The experiment was conducted in June 2017. We recruited 122 students, who have studied different subjects, from the online recruitment system of Newcastle University. Specifically, students who study psychology or economics were excluded. The majority of participants were undergraduates, and also MBA, postgraduate and PhD students were included. These participants were randomly assigned into each treatment. Each treatment had one session, which included 26 to 36 participants. In all treatments, half the subjects played the role of manufacturers and half the role of suppliers. The experiment consisted of 28 rounds, starting with 3 practice rounds, followed by 25 real experimental rounds which their earnings were actually based upon. In behavioural games, it is in common to have practice rounds to minimise the potential bias in experimental results, which helps the participants develop familiarity with the experimental mechanism. The practice round data is excluded in our data analysis. The participants were monetarily incentivised, and their earnings included a £5 show-up fee and an additional compensation proportional to their total points earned in the experiment. Subjects earned on average £9.40, and each session lasted about 90 minutes.

3.4 Research Hypotheses

The focus of our experiment is to investigate whether and how supplier's reciprocity in building restoration capability is affected by the following three key aspects: (i) incentive offered by the manufacturer; (ii) type of relationship; (iii) uncer-

tainty about future recovery outcomes. In all treatments, the responses of suppliers and the incentive value offered by manufacturers should be positively dependent. If subjects' behaviour is motivated by concerns for reciprocity, the predictions for their extent of reciprocity may differ in the four treatments. We next discuss our first hypothesis about the supplier's investment decision and reciprocity towards an incentive value offered by the manufacturer under different types of incentive.

In some circumstances, it's not possible to specify every single aspect of business in a contract between manufacturers and suppliers, for instance, the suppliers' responses to unforeseen disruptions (Beer et al. 2017). Traditional theories of economic behaviour assume that people are self-interested and make rational choices aimed at maximizing their own benefits. In view of this, selfish suppliers may behave opportunistically and free ride on incentives offered by manufacturers such that they will not choose to invest in restoration capability regardless of what the type and value of incentive offered. However, recent studies in principal-agent relations suggest that an agent's decision can be intrinsically motivated by pro-social behaviour when a principal makes an unconditional incentive offer (Falk and Kosfeld 2006, Kreps 1997, Frey 1997*c*). A trust game experiment by McCabe et al. (2003) shows that agents are more willing to exhibit kind actions towards principals' unconditional decisions, as compared to conditional decisions. A study by Beer et al. (2017) demonstrates that suppliers' investment decisions can be intrinsically motivated by a generous offer that induces higher propensity to act kindly. Further, Coricelli et al. (2006) show that higher amounts offered can induce higher levels of investment. In this study, Direct incentive is more correlated with intrinsic motivation and thus we expect that Direct incentive that signals a more generous incentive offered by the manufacturer can motivate the supplier to reciprocate by investing, and, if so, investing more in restoration capability. Our study identifies reciprocal behaviour in two aspects. First, we look at the suppliers' propensity to reciprocate via their investment decisions towards the incentive offered by manufacturers in the incentive-investment game. Second, we measure their extent of reciprocity based on the return rate of investment amount relative to the amount available to invest. Therefore, we predict the following:

Hypothesis 1. **(a)** *In each type of relationship and of uncertainty about future recovery outcome, incentive value offered by manufacturers is higher in the Direct incentive condition than in the Indirect incentive condition.*

(b) *In each type of relationship and uncertainty about future recovery outcome, Direct Incentive increases suppliers' propensity to invest and investment amount in restoration capability as compared to Indirect Incentive.*

(c) *The extent of reciprocity will increase in the Direct incentive condition as compared to the Indirect incentive condition; i.e., on average, Direct incentive increases the return rate of investment amount relative to the amount available to invest.*

In general, most decisions regarding the future are made in an uncertain or ambiguous environment. In other words, the probabilities for future outcomes in uncertain environments are most often quite ambiguous (unknown) (Milliken 1987, Duncan 1972). Previous studies on experimental economics suggest that the majority of subjects are ambiguity averse such that are more willing to select a choice with known-risk probabilities than with unknown-ambiguous probabilities (Pulford 2009, Einhorn and Hogarth 1985, Ellsberg 1961). From the cognitive perspective, decision makers with known information may behave differently from those with ambiguous information (Curley et al. 1986), which implies that different extents of reciprocity may be exhibited. An empirical study by Eriksson and Sharma (2003) provides evidence that people are more willing to cooperate in a less uncertain environment. To the best of our knowledge, the existing literature on how these two types of probabilities for future outcomes affect the extent of reciprocity in a laboratory setting is limited. In our design, we hypothesize that suppliers who know the likelihood of future recovery outcomes will be more ambiguity averse with greater reciprocity than those with ambiguous likelihood. Thus, we develop the following hypotheses.

Hypothesis 2. **(a)** *In each type of relationship, incentive value offered by manufacturers is higher in the risk condition than in the ambiguity condition.*

(b) *In each type of relationship, incentives by manufacturers will induce suppliers' higher levels of investment (i.e. propensity to invest and investment amount) in the risk condition than in the ambiguity condition.*

(c) *The extent of reciprocity will increase in the risk condition as compared to the ambiguity condition; i.e., on average, risky uncertainty increases the return rate of investment amount relative to the amount available to invest.*

Our third set of hypotheses examines how the type of relationship affects suppliers' decision behaviour and reciprocity in building restoration capability. The type of relationship that firms perceive they have with their partners may have an influence on how they behave in that relationship. In this study, we mainly focus on two types of relationships: repeated (i.e.long-term relationship) and one-shot (i.e. no long-term relationship). Broadly, in reality, most supply chain transactions between supply partners are taken place on an ongoing basis. Evidence from previous research shows that manufacturing firms tend to move away from transactional mechanisms with many suppliers, towards long-term relational mechanisms with a selected few suppliers (Kalwani and Narayandas 1995, Dyer and Ouchi 1993). The long-term relationship commitments can encourage supply chain partners to jointly invest in supply chain performance improvement initiatives (Cooper et al. 1997). However, in a one-shot game, players interact only once, and do not know much about each other. In this case, cooperative behaviour will be unable to be observed. Different from one-shot interactions that exclude social considerations, repeated interactions that contribute to long-term relationship development can reinforce trust and reciprocity and thereby improve overall supply chain performance (Wu 2013, Loch and Wu 2008).

In a long-term relationship between a manufacturer and a supplier, the manufacturer may be motivated to engage in prosocial behaviour with the expectation

of a return from the supplier (Gouldner 1960). Correspondingly, the supplier who perceives the manufacturer's incentive as generous is likely to appreciate the manufacturer's prosocial behaviour and thus respond reciprocally to the incentive offered. Drawing upon the motivation crowding theory (Frey and Jegen 2001), we conjecture that repeated interactions that serve as a signal of reciprocity may motivate the supplier to invest more towards a generous incentive by the manufacturers as compared to one-shot interactions. Specifically, we focus on the role of repeated interactions in reciprocity under the Direct incentive which serves as a more generous incentive offered by the manufacturer. We summarize these hypotheses in the following.

Hypothesis 3. **(a)** *In each type of incentive, the value of incentive will be higher in a repeated game than in a one-shot game regardless of the type of uncertainty about the future recovery outcomes.*

(b) *In each type of uncertainty about the future recovery outcomes, incentive offered by manufacturers will induce suppliers' higher levels of investment (i.e. propensity to invest and investment amount) in a repeated game than in a one-shot game.*

(c) *In a repeated game, Direct incentive will induce higher extent of reciprocity than in a one-shot game; i.e., on average, repeated interaction increases the return rate of investment amount relative to the amount available to invest if Direct incentive is chosen.*

During the interactions between both players, learning behaviour may cause them to change their strategies or actions over the course of the game. As a result, we also focus on examining the potential impact exerted by learning in decision-making processes. Previous research on BOM provides explanations for learning effects over repeated interactions in the context of newsvendor problem, in which decision makers make order decisions have a tendency between the optimal quantity and the mean demand (Bostian et al. 2008, Bolton and Katok 2008, Benzion et al. 2008). Their studies demonstrate that human players' decisions are affected

by both the mean outcome and the last-period result so that they obtain experience to learn over time. In contrast, an experimental study by Gächter and Falk (2002) place an emphasis on the importance of learning effect in social norms such as reciprocity, rather than in expected-profit-maximisation, when subjects are interacting repeatedly. They provide evidence that participants tend to learn from their partners' reciprocal preference in repeated interactions. Based on this research, we conjecture that the long-term relationship may have a diminish impact on subjects' learning behaviour over time, which allows them to learn more from reciprocity. In our design, subjects will be given the results of their own and partners' previous and current period decisions in the end of each round. As a result, we develop the following hypothesis regarding subjects' learning effects.

Hypothesis 4. *Repeated interactions will diminish suppliers' learning behaviour as compared to one-shot interactions.*

3.5 Experiment Results

Our 2x2 experimental design provides outcomes about supply chain partners' decisions and reciprocity in four different treatments. We label the repeated game 'RG treatment', one-shot game 'OG treatment', risky uncertainty 'RU treatment', and ambiguous uncertainty 'AU treatment'. In our data analysis, we have 122 independent observations which are aggregated by each individual's 25-round decisions over all treatments. Since reciprocal behaviour is induced from paired interactions, the average ratio of one pair of participants is one observation for the measures of reciprocity across all treatments. That is, we analyse the incentive value I offered by the manufacturer and the supplier's investment amount F at the echelon level but the return rate of F to $\eta_{i,j} I + E$ in pairs. To verify our hypotheses, we use a Wilcoxon rank-sum (Mann-Whitney) test, which is a nonparametric test, to compare differences across all treatments.

Table 3.2: Treatment Comparison

Treatment	Incentive Type	Selected (%)	Incentive Value (I)	Invest (%)	Investment Amount (F)
1. RU-RG	Direct	59.33	59.60	92.13	116.67
	Indirect	40.67	50.51	78.14	52.70
	Difference*		0.08		0.01
2. AU-RG	Direct	59.69	45.72	84.02	148.52
	Indirect	40.31	50.80	85.50	53.50
	Difference*		0.23		0.01
3. RU-OG	Direct	63.00	56.12	80.95	98.85
	Indirect	37.00	43.13	81.08	47.63
	Difference*		< 0.01		0.01
4. AU-OG	Direct	63.43	40.88	67.12	81.98
	Indirect	36.57	41.58	72.66	49.55
	Difference*		0.33		0.02

Note. Difference* means the p -value of a rank-sum (nonparametric) test of the difference in incentive value, investment amount under each type of treatment.
*$p < 0.1$; **$p < 0.05$;***$p < 0.01$;

Table 3.2 reports the summary statistics of both manufacturers and suppliers' decisions, the average incentive value offered, and the average investment amount under each treatment. We find the following initial observations. First, the incentive decisions made by manufacturer players are identical across all treatments, in which a greater number of participants choose to offer Direct incentive over Indirect incentive. These results are similar to the suppliers' investment decisions. We note that supplier subjects' average investment amount under Direct incentive is almost double the amount invested under Indirect incentive across all four treatments (all are significant with $p < 0.05$). This suggests that Direct incentive offered by manufacturers that signals a kindness can motivate suppliers to invest more in restoration capability. Further, we observe that the differences in the average incentive value between Direct and Indirect incentives are significantly higher in the RU treatment than in the AU treatment ($p < 0.1$), regardless of the type of relationship. That is, fewer manufacturers are willing to offer more generous incentive when the uncertainty about future recovery outcomes is ambiguous, even though they have already

selected Direct incentive. In the following sections, the hypotheses developed in Section 3 are formally tested. We present below our findings under different types of incentive, followed by different types of relationship and uncertainty about future recovery outcomes.

3.5.1 Decisions and Reciprocity under Different Types of Incentive

We first investigate whether and how manufacturers' incentive types influence incentive-investment decisions which can serve as a proxy of suppliers' reciprocity in the absence of imposed exogenous treatment variables. We start by analysing the frequency of choosing Direct incentive which signals a prosocial attitude over 25 rounds. Our result shows that 61% of manufacturer subjects choose to offer Direct incentive, which is 22% higher than Indirect incentive. Further, a comparison of the frequency of choosing Direct incentive between the first 12 and the last 13 rounds confirms this result showing that 56.83 % and 65.45 % of subjects choose to offer Direct incentive in the first 12 and last 13 rounds, respectively. Next, we examine whether incentive values offered by manufacturers differ between the two types of incentive. A one-sided Wilcoxon rank-sum test confirms that choosing Direct incentive increases the incentive value in comparison with Indirect incentive ($p = 0.058$). This provides support for Hypothesis 1(a). We further verify this result by regressing incentive type on incentive value, which shows that Direct incentive offered by manufacturers has a significant positive effect on the incentive value ($p < 0.05$). This result provides a further support for Hypothesis 1(a). The detailed regression results are presented in below Section 3.5.5.

To test suppliers' responses to the choice of incentive, we initially analyse their propensity to reciprocity by computing the probability of choosing investment. A Chi-square test shows that there is no significant difference in the propensity to reciprocate between Direct and Indirect incentives. Then we compare suppliers' investment amount under Direct incentive with that under Indirect incentive. Using the Wilcoxon rank-sum test, we observe that, at an individual level, the difference in the average investment amount between the two types of incentive is statistically

significant ($p = 0.001$). This result indicates that the investment amount on average under Direct incentive condition is higher than that under Indirect incentive condition. To control for the choice of incentive type, we regress incentive type and incentive value offered on investment amount. We confirm that there is also a positive relationship between Direct incentive and suppliers' investment amount ($p = 0.000$). Therefore we find a partial support for hypothesis H1(b), in which the offer of Direct incentive will induce the supplier to invest more.

Further, we examine whether and how suppliers' extent of reciprocity differ between Direct and Indirect incentives. The results are shown in Table 3.3.

Table 3.3: Comparison of means between different types of incentives

Incentive type	Incentive Value (I)	Investment Amount (F)	Return Rate (F/E+λI)
Direct	50.42	110.76	0.33
Indirect	46.40	51.14	0.30
Direct - Indirect	4.03	59.61	0.03
Difference*	0.056	0.00	0.21

Note. Difference* means the p -value of a rank-sum (nonparametric) test of the difference in incentive value, investment amount, return rate between Direct and Indirect incentive under each type of treatment.
*$p < 0.1$; **$p < 0.05$;***$p < 0.01$;

Recall that we identify a reciprocity multiplier for each treatment, which is defined as a fully reciprocal benchmark, to magnify the total amount available to invest. To verify the impact of incentive types on the extent of reciprocity, we perform analyses of the return rate of investment amount to total amount available under Direct and Indirect incentives. We find that there is no statistically significant difference in reciprocating behaviour between Direct and Indirect incentives, thus Hypothesis 1(c) is not supported. However, we find a support from the result of regressing incentive type on the return rate, in which Direct incentive is positively correlated with the return rate.

3.5.2 Decisions and Reciprocity under Different Types of Uncertainty

We next examine the effect of uncertainty about future recovery outcome on decisions of both players and suppliers' reciprocity under the two types of incentive. We begin by comparing the incentive value between RU and AU treatments under Direct and Indirect incentives. A one-sided Wilcoxon rank-sum test confirms that, if Direct incentive is offered, the difference in incentive value compared to Indirect incentive is found to be significant ($p < 0.01$) where the average incentive value under the RU treatment is greater than that under the AU treatment. Thus Hypothesis 2(a) is supported. A regression of uncertainty type on incentive value shows that the risky uncertainty has a positive impact on incentive value offered by manufacturers ($p < 0.01$). This finding provides further support for Hypothesis 2(a).

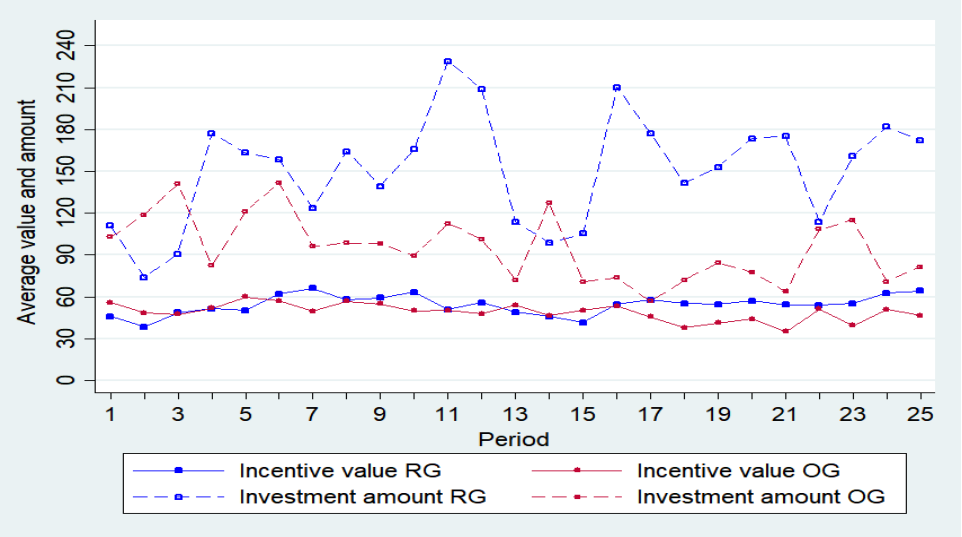
In addition, we investigate how suppliers' investment decisions differ between the RU and AU treatments. The results indicate that 46.75% of supplier subjects select to invest in the RU treatment as compared to that of 33.9% in the AU treatment. A Chi-square test confirms that there are significant differences in the probability of the decision to invest between RU and AU treatments ($p = 0.000$). Suppliers are less likely to invest in restoration capability when the probability of future recover outcome is unknown. Furthermore, we use Logistic regressions to verify the effect of types of uncertainty on suppliers' decision to invest. The dependent variable is a dummy variable equal to 1 if suppliers invest and equal to 0 otherwise. We observe that the probability that suppliers invest is negatively dependent on the ambiguous uncertainty. These results suggest that suppliers are more ambiguity averse, so that the propensity to reciprocate is less salient in the condition that the probability of recovery is unknown. Here we do find support for Hypothesis 2(b). We then examine whether the average investment amount differs between the RU and AU treatments under Direct and Indirect incentives. We find no significant differences if either Direct or Indirect incentive is offered, using a Wilcoxon rank-sum test. Thus these findings provide partial support for Hypothesis 2(b). Further, we investigate suppliers' extent of reciprocity at each incentive type across the uncertainty treat-

ments. We also note that their extent of reciprocity does not differ between risk and ambiguity treatments. Therefore, Hypothesis 2(c) in which the uncertainty about future recovery outcome will have no effect on suppliers' extent of reciprocity, is not supported.

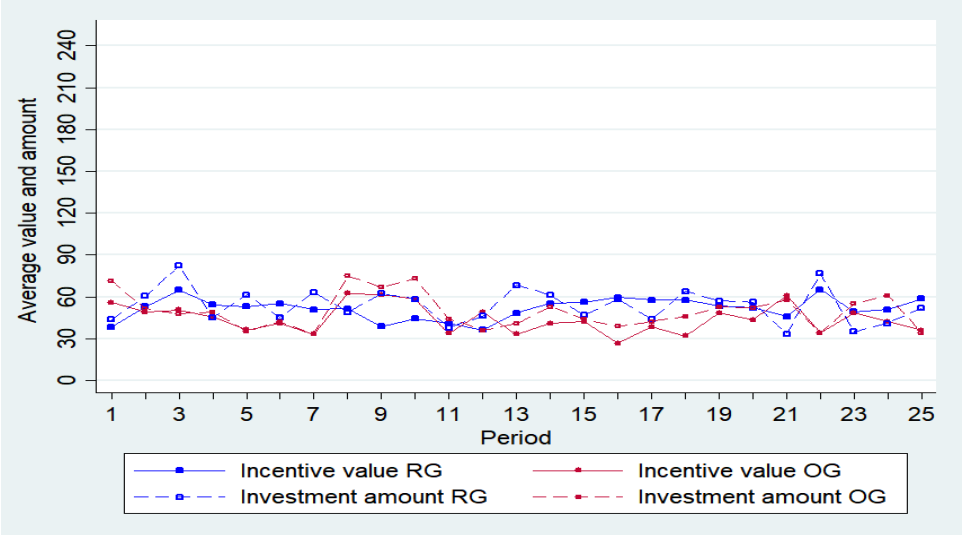
3.5.3 Decisions and Reciprocity under Different Types of Relationship

In this section, a comparison of investment amount, incentive value and the extent of reciprocity between one-shot and repeated interaction games under the two types of incentive is been made. Figure 3.2 shows the average incentive values and investment amounts in the OG and RG treatments for each round. Several key observations are highlighted. First, the obvious result is that the incentive values offered by manufacturers correspond to higher investment amounts within the RG and OG treatments respectively. Second, the incentive values on average increase steadily in the RG treatment from round 16 onwards. In addition, the investment amounts on average are basically greater in the RG treatment than in the OG treatment. Last, we find that suppliers' investment amounts are significantly higher under Direct incentive than under Indirect incentive. These results indicate that, if Direct incentive is offered, long-term relationships greatly motivate suppliers' investment behaviour such that they are more willing to invest more towards manufacturers' prosocial action. Further, we note similar results hold for suppliers' extent of reciprocity (see Figure 3.3).

At the individual level, we start by analysing the differences in incentive value offered by manufacturers between the one-shot and repeated games, using a one-sided Wilcoxon rank-sum test. We observe that, if Direct incentive is offered, the average incentive value is not significantly different between the OG and RG treatments ($p = 0.180$). But a significant difference is found across the relationship treatments for the choice of Indirect incentive ($p < 0.1$). This result indicates that, if Indirect incentive is selected, only repeated interactions induce higher incentive value offered by manufacturer subjects. Hence, the results provide partial support for Hypothesis 3(a).

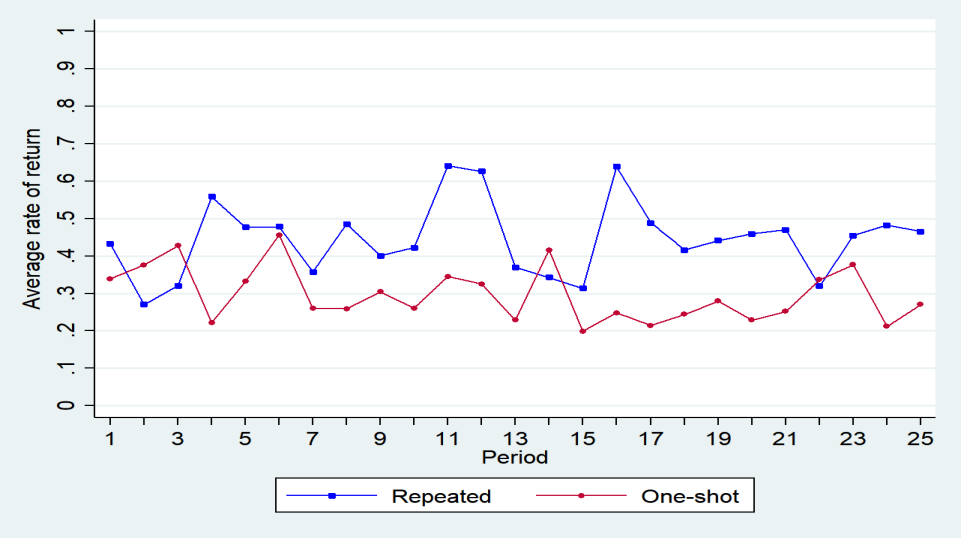


(a) Direct incentive

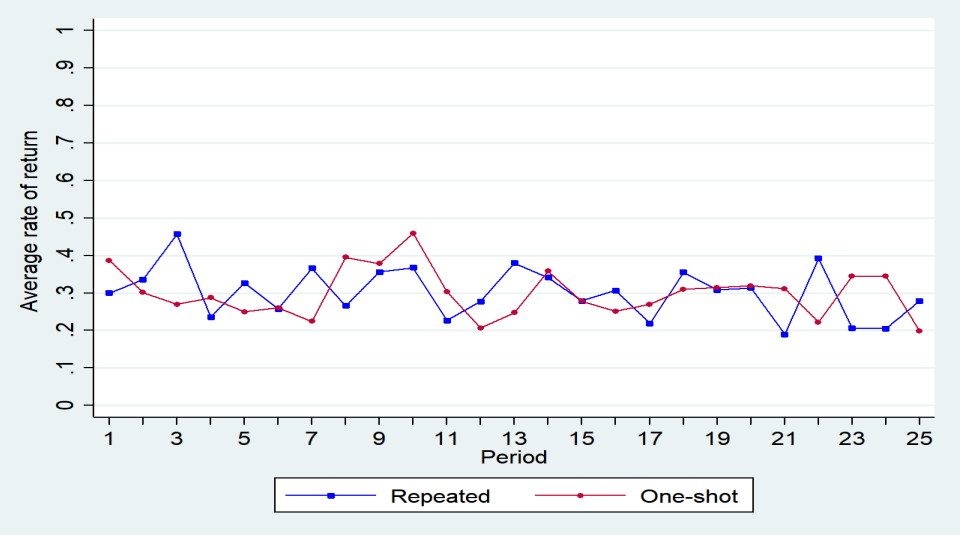


(b) Indirect incentive

Figure 3.2: Incentive value and investment amount under different types of incentive in relationship treatment



(a) Direct incentive



(b) Indirect incentive

Figure 3.3: Rate of return under different types of incentive in relationship treatment

Furthermore, we compare the suppliers' responses to the incentive value offered by manufacturers under Direct and Indirect incentives across the relationship treatments. We find similar results hold for the suppliers' propensity to reciprocate as in the uncertainty treatments. Using a Chi-square test, we observe that the probability that suppliers invest is significantly higher in the repeated game than in the one-shot game ($p = 0.000$). We also find evidence to support the positive correlation between the propensity to invest and repeated interactions using a Logistic regression. To control for interaction effects, we include an interaction term to assess whether there is an interaction effect of relationship and incentive type on suppliers' propensity to reciprocate. We repeat the same regression and find strong evidence that Direct incentive that moderates the type of relationship makes suppliers more likely to invest in a long-term relationship ($p < 0.05$). We further test Hypothesis 3(b) to examine the effect of investment amount in the OG and RG treatments under Direct and Indirect incentives respectively. We find no significant difference between the two treatments if either Direct or Indirect incentive is offered. Thus, Hypothesis 3(b) is partially supported. In addition, we use Tobit regressions with random effects accounting for investment amount censored at zero. Such random effect regressions are commonly used in the experimental economics literature (Beer et al. 2017, Özer et al. 2014). Interestingly, our results show that relationship interacting with the type of incentive has a joint effect on suppliers' investment amount ($p < 0.01$). Specifically, we find that one-shot interaction diminishes the effect of Direct incentive on investment amount.

Next, we examine the impact of relationship on suppliers' extent of reciprocity under the choice of incentive type. Hypothesis 3(c) predicts that in repeated games, the choice of Direct incentive increases the extent of reciprocity as compared to one-shot games. A one-sided Wilcoxon rank-sum test confirms our prediction that suppliers make significantly higher return rate of investment amount to the total amount available to invest with manufacturers' selection of Direct incentive when they interact repeatedly ($p = 0.067$). Furthermore, a Tobit regression of return rate on relationship dummies and relationship-type interaction term is used. The result demonstrates that, similar to the joint effects on suppliers' investment amount, the

one-shot games also have a negative moderating effect on the link between Direct incentive and supplier' extent of reciprocity. In other words, the choice of Direct incentive induces stronger reciprocity from suppliers in particular in the repeated interactions. Therefore, we see that the data provides a support for Hypothesis 3(c).

3.5.4 Learning Behaviour in Incentive and Investment Decisions

In our experiment, each subject interacted with a different player over 25 rounds for the one-shot game treatment whereas with a fixed partner for the repeated game treatment. During the experiment, they may have an opportunity to adjust their strategies in accordance with the paired players' decisions in the previous periods. As a result, it is possible that the subjects' reciprocal behaviour that we observe may be associated with learning. For example, in our aggregate-level data analysis, the positive regression coefficient shows that higher investment amount provided in the last-period increases manufacturers' incentive value in the current period ($p < 0.01$).

To verify the impact of learning effects on our results, we employ a one-sided Wilcoxon rank-sum test and include a dummy variable for learning. The variable is equal to 0, which represents an absence of learning for the first 12 rounds and 1 otherwise. A test of learning effects on investment amount in the one-shot game treatment indicates that there is a statistically significant difference in suppliers' investment amount between the initial 12 and later 13 rounds ($p = 0.01$). The investment amount in the initial 12 rounds is larger than that in the later 13 rounds, which shows that the investment amount decreases over the later 13 rounds. Also, similar results were observed for incentive value ($p < 0.05$). These results suggest that both manufacturer and supplier subjects' decisions have strong responses to their past experiences.

Further, we test the learning effect on the extent of reciprocity in the OG treatment and find that there is a significant decrease in the extent of reciprocity over the later 13 rounds as compared to the initial 12 rounds ($p = 0.056$). Next, we again use the one-sided Wilcoxon rank-sum test to investigate whether our main variables change with learning under the RG treatment.

Our result indicates that there is no significant difference in learning effects between the first 12 and the later 13 rounds when subjects were interacting repeatedly ($p = 0.498$), which suggests that neither players learn to behave uncooperatively over 25 rounds. This result is consistent with earlier studies that demonstrate that subjects imitate reciprocity over a long-term period (Gächter and Falk 2002). To sum up, we provide evidence that suppliers' responses to the incentive offered by manufacturers under one-shot interactions are more selfish than under repeated interactions. Long-term relationships which restrain individuals' self-interest motive of maximising their own benefits matter for suppliers' reciprocity. Thus we do find a support for Hypothesis 3(d).

3.5.5 Regression Analysis of Incentive and Investment Decisions

The detailed results of the regression analysis discussed above are summarized as follows (See Tables 3.4 - 3.7). Overall, the observed results provide support for the hypotheses. We use Tobit random effects regressions to analyse treatment effects for three dependent variables: investment amount, incentive value and ratio of investment amount to incentive value. The investment amount and incentive value are censored at zero. Moreover, we use Logit regression to analyze the treatment effect for decision on whether to invest in restoration capability or not.

In our regression model, a supplier's decision in the current round may be influenced by its manufacturer's incentive decisions in the current round. Regarding the learning effect, a manufacturer may make decision in the next round based on its decision on the type of incentive in that round and the paired supplier's investment amount decision in the last round. In view of this, an iteration process is applicable to regression for incentive value and thus we include initial incentive value, that is, the first round incentive value as an independent variable.

Note that when the interaction term with respect to relationship and incentive type is considered in the regression models, the interaction effect is statistically significant whereas the impact of incentive type on investment amount is weakened. In other words, manufacturer players' decisions on incentive type is moderated by the

type of relationship held between both parties. Repeated interaction strengthens the link between incentive type and investment amount. Here the relationship treatment is denoted by "Exp-relationship". Similarly, the uncertainty treatment is denoted by "Exp-uncertainty".

Table 3.4: Regressions on suppliers' investment amount

Independent Variables	Model 1	Model 2	Model 3	Model 4
Incentive value	0.0186***	0.0184***	0.0189***	0.0187***
	(0.000844)	(0.000839)	(0.000843)	(0.000838)
Incentive type	0.394***	0.409***	0.142*	0.151*
	(0.0494)	(0.0492)	(0.0804)	(0.0798)
Exp-relationship	0.235	0.238	-0.0365	-0.0476
	(0.167)	(0.166)	(0.227)	(0.227)
Exp-uncertainty	0.152	0.141	0.0304	0.0183
	(0.168)	(0.168)	(0.244)	(0.243)
Incentive type x Exp-relationship			0.391***	0.409***
			(0.0978)	(0.0972)
Exp-relationship x Exp-uncertainty			0.0703	0.0777
			(0.331)	(0.330)
Incentive type x Exp-uncertainty			0.144	0.140
			(0.0987)	(0.0980)
Learning		-0.175***		-0.183***
		(0.0438)		(0.0435)
Constant	2.551***	2.647***	2.707***	2.812***
	(0.152)	(0.153)	(0.172)	(0.173)
Observations	1,205	1,205	1,205	1,205
Number of subjects	61	61	61	61

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Regressions on manufacturers' incentive value

Independent Variables	Model 1	Model 2	Model3	Model 4
Initial incentive value	0.189**	0.190**	0.187**	0.188**
	(0.0812)	(0.0813)	(0.0812)	(0.0812)
Investment amount	0.0586***	0.0583***	0.0590***	0.0587***
	(0.0110)	(0.0110)	(0.0111)	(0.0111)
Incentive type	-0.175	-0.0709	1.786	1.838
	(2.115)	(2.120)	(3.282)	(3.282)
Exp-relationship	7.029*	7.058*	6.388	6.310
	(4.266)	(4.268)	(6.112)	(6.115)
Exp-uncertainty	-6.955*	-7.010*	-7.445	-7.512
	(4.217)	(4.219)	(6.528)	(6.531)
Incentive type x Exp-relationship			-1.781	-1.649
			(3.997)	(4.001)
Exp-relationship x Exp-uncertainty			3.914	3.973
			(8.363)	(8.367)
Incentive type x Exp-uncertainty			-2.521	-2.548
			(3.999)	(3.998)
Learning		-1.174		-1.155
		(1.804)		(1.806)
Constant	32.82***	33.41***	32.57***	33.21***
	(6.014)	(6.086)	(6.501)	(6.579)
Observations	1,181	1,181	1,181	1,181
Number of subjects	61	61	61	61

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.6: Regressions on reciprocity

Independent Variables	Model 1	Model 2	Model 3	Model 4
Incentive type	0.0405***	0.0424***	0.00232	0.00381
	(0.0141)	(0.0141)	(0.0227)	(0.0226)
Exp-relationship	0.0775	0.0776	-0.0401	-0.0418
	(0.0493)	(0.0493)	(0.0666)	(0.0666)
Exp-uncertainty	0.0104	0.00918	-0.0348	-0.0367
	(0.0497)	(0.0497)	(0.0711)	(0.0710)
Incentive type x Exp-relationship			0.106***	0.107***
			(0.0282)	(0.0281)
Exp-relationship x Exp-uncertainty			0.121	0.123
			(0.0969)	(0.0968)
Incentive type x Exp-uncertainty			-0.0272	-0.0278
			(0.0283)	(0.0283)
Learning		-0.0266**		0.0282**
		(0.0127)		(0.0126)
Constant	0.263***	0.276***	0.313***	0.328***
	(0.0427)	(0.0432)	(0.0485)	(0.0490)
Observations	1,170	1,170	1,170	1,170
Number of subjects	61	61	61	61

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.7: Logit regressions on suppliers' decision to invest

Independent Variables	Model 1	Model 2	Model 3	Model 4
Incentive value	0.0186***	0.0184***	0.0189***	0.0187***
	(0.000844)	(0.000839)	(0.000843)	(0.000838)
Incentive type	0.394***	0.409***	0.142*	0.151*
	(0.0494)	(0.0492)	(0.0804)	(0.0798)
Exp-relationship	0.235	0.238	-0.0365	-0.0476
	(0.167)	(0.166)	(0.227)	(0.227)
Exp-uncertainty	0.152	0.141	0.0304	0.0183
	(0.168)	(0.168)	(0.244)	(0.243)
Incentive type x Exp-relationship			0.391***	0.409***
			(0.0978)	(0.0972)
Exp-relationship x Exp-uncertainty			0.0703	0.0777
			(0.331)	(0.330)
Incentive type x Exp-uncertainty			0.144	0.140
			(0.0987)	(0.0980)
Learning		-0.175***		-0.183***
		(0.0438)		(0.0435)
Constant	2.551***	2.647***	2.707***	2.812***
	(0.152)	(0.153)	(0.172)	(0.173)
Observations	1,205	1,205	1,205	1,205
Number of subjects	61	61	61	61

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.6 Discussion

Following the analyses conducted in the previous section, we summarise that a supplier's reaction is perceived to be more kind if it is motivated by an unconditional offer than if it is motivated by a conditional offer in the presence of supply chain disruptions. Our experimental results show that Direct incentive offered by manufacturers is positively correlated with suppliers' investment decisions. Most supplier subjects are greatly motivated by Direct incentive and thereby respond by investing more in restoration capability. As a result, Direct incentive that is perceived as a prosocial signal is more likely to motivate suppliers to be more cooperative. We also find suppliers are willing to invest more if given a higher incentive value. Surprisingly, the extent of reciprocity was not found to be significantly higher in Direct incentive than in Indirect incentive. In our regression analyses, we observed that this result may be caused by an interaction effect of relationship and incentive type, in which Direct incentive strengthens the extent of reciprocity only when the manufacturer and supplier are in long-term relationships.

We further investigate whether and how the effects of relationship on reciprocity may vary under different types of incentive. We show that repeated interactions significantly increase suppliers' propensity for reciprocation. This suggests that suppliers are more likely to cooperate to invest in restoration capability when long-term relationships are salient. Recently, a study by Wu (2013) examined supply chain members' social behaviour under different types of contracts in repeated interactions. Also, Loch and Wu (2008) look at the buyer-supplier social preference in repeated interactions based on a wholesale price contract. However, little research focuses on supply chain members' social preference with consideration of the effect of a non-contractible incentive (e.g.Direct incentive) on reciprocity in repeated interactions. Previous research on cognitive evaluation provides evidence that individuals' reciprocity can be intrinsically motivated if the external incentive is perceived as a form of unconditional action (Ryan 1982, Deci 1971). In this paper, our results highlight that repeated interactions are positively correlated with suppliers' extent of reciprocity only if Direct incentive is offered. If a less prosocial incentive (i.e.Indirect incentive) is offered, we find repeated and one-shot interac-

tions do not make any differences in the extent of reciprocity. Thus, our results suggest that, when a manufacturer offers an incentive upfront before a disruption occurs, long-term relationships can greatly contribute to the reinforcement of reciprocity and accordingly enhance supply chain efficiency and mitigate supply chain disruption risks.

Furthermore, we examine the impacts of uncertainty about future recover outcomes on reciprocity under different types of incentive. We first discuss our settings for the reciprocity multipliers. Our experiment assigned different multipliers (i.e. benchmark) to examine supplier subjects' extent of reciprocity across the uncertainty treatments under Direct and Indirect incentives. The multipliers may amplify or shrink the total amount suppliers have available to invest such that supplier players may value manufacturer players' incentive decisions differently under a different combination of scenarios. Recall that Direct incentive condition was assigned a larger multiplier than Indirect incentive condition due to the signalling effect of a prosocial behaviour. In view of this, Direct incentive offered by manufacturers implicitly suggests that suppliers are expected to provide a higher investment amount and consequently produces a higher return rate of investment amount to the total amount available to invest.

Next, we combine the multipliers of the two incentive types with the effects of uncertainty about future recovery outcomes. Most research on uncertainty emphasises that individuals are more ambiguity averse when the probability of future outcomes are ambiguous. Taking Direct incentive into consideration, suppliers received proactive signal may become less ambiguity averse, i.e., for a choice of Direct incentive, they provide higher investment amount and exhibit higher extent of reciprocity in an ambiguity environment. Thus, our design amplified the effect of ambiguity under Direct incentive, aiming to make the offer of Direct incentive in the AU treatment more attractive. We assigned the highest multiplier to the AU treatment with Direct incentive. For the combination of negative signals such as Indirect-ambiguity condition, the lowest multiplier was assigned. The multipliers for the RU treatments are valued between those two extreme conditions. Interestingly, we only observe that suppliers' propensity to reciprocate is significantly more strong in the condition that

the probability of disruption recovery is known. But the result does not hold for the ambiguity condition, even if more prosocial actions are taken by manufacturers. This phenomenon may be a result of ambiguous aversion. Drawing from the theory of reciprocity (Falk and Fischbacher 2006, Gouldner 1960), suppliers have willingness to exhibit their propensity to reciprocate towards manufacturers' prosocial behaviour. However, when the uncertainty of future outcomes is ambiguous, they may feel that they are taking on more risk in investing in restoration capability. Thus they would be more loss averse and limit their reciprocal behaviour so as to reduce costs and mitigate the losses caused by the ambiguous uncertainty.

Our data analysis is concerned about whether the subjects have learned from the previous rounds and strategically adjust their behaviour accordingly. Our results indicate that, in one-shot games, suppliers have a strategic motive to decrease their extent of reciprocity over time. But, in repeated games, supplier participants no longer decrease the extent of reciprocity. A recent experimental study by Özer et al. (2014) that examines the time and experience effects on cross-country supply chains showed that long-term relationships increase levels of trust and trustworthiness for the within-country groups. Gächter and Falk (2002) report that subjects' reciprocity can be reinforced by imitating their partners' behaviour in repeated games. Consistent with their studies, our findings further suggest that subjects are more relation-driven and long-term relationships matter for the motivations of reciprocity in restoration capability investment. By contrast, the absence of long-term relationships will drive the suppliers to exhibit opportunism and be more selfish.

3.7 Conclusion

In our study, a 2x2 experiment has been designed to examine whether and how different types of relationship and uncertainty about future recovery outcomes affect suppliers' reciprocity towards an incentive offered by manufacturers in building supply chain restoration capability. We measure suppliers' reciprocal behaviour from aspects of the propensity for and the extent of reciprocity. We suggest that suppliers are more likely to invest in long-term relationships and are more ambiguity averse in their investment when the probability of future outcomes is unknown. In particular, we focus on the role of incentives specified as unconditional (Direct) as against conditional incentives (Indirect) in motivating suppliers' investment in disruption recovery from a social exchange perspective. Our experimental design is innovative in that decisions made on the two types of incentive are selective rather than imposed, and thus we define the type of incentive as a decision variable. We identify conditions under which Direct incentive is prominent to induce suppliers' reciprocity. The results suggest that in repeated interactions, suppliers exhibit stronger reciprocity when Direct incentive is offered by manufacturers. We also show that long-term relationships discipline suppliers' selfish behaviour such that they exhibit a lower extent of reciprocity towards manufacturers' generous offer.

Practically, our experimental results have important managerial implications for the design of incentive mechanisms to motivate the supplier to invest in restoration capability, from the perspective of social preference. Motivation of our study is arose from the evidence that people in general display a stronger prosocial behaviour, for example reciprocity, when they are intrinsically motivated by external incentives (Ostrom 2014, Frey 1997*c*). From the results of our experiment, unconditional pre-paid incentives ex ante disruption can be more favourable for suppliers who anticipate a long-term relationship. As a result, supply chain managers should be motivated to manage supply chain relationships by means of unconditional incentives to elicit more reciprocity and thus reinforce collaboration at best.

Nonetheless, our study has a number of limitations. First of all, we employ four full reciprocal benchmarks that derived from our previous model-based study. In particular, the predicted multiplier is significantly higher in AU treatment with

Direct incentive to make ambiguous uncertainty more attractive. This critical condition that allows our results to hold implies that the supplier is more likely to display reciprocal concern with ambiguity if it is incentivised by an unconditional offer rather than via a conditional one. However, even the highest multiplier is given, the result that against our prediction shows that suppliers are more ambiguous averse when Direct incentive is offered and are likely to elicit less reciprocity. The dynamics of the multiplier could be further explored. Second, our experiment does not control alternative behavioural factors, for example, individuals' justice fairness. We attempt to address this issue by asking participants to complete a short questionnaire regarding their general perceptions, or social attitudes. Third, in our game design, we give the investment of production site for the supplier as one of an example for Direct incentive according to a theoretical study by Stecke and Kumar (2009). In the future, a field experimental study can be conducted to explore Direct incentive that is applicable to the real world. Finally, an additional method of statistical testing would have enabled us to take into account the the number of round regarding the choice of incentive. Thus, a further study will look at whether both the frequency and value aspects have an influence on suppliers' reciprocity.

Chapter 4

How the Perceived Buyer-supplier relationships Impacts Supplier Reciprocal Behaviour: A Post-experimental Survey Method

4.1 Introduction

The buyer-supplier relationship has been widely acknowledged to be significant in supply chain management (Özer et al. 2014, Ambrose et al. 2010, Terpend et al. 2008). In the context of supply chain disruption, every supply chain member is vulnerable to disruption events that involve high ambiguity regarding the ability to recover from disruptions (Ambulkar et al. 2015). Under ambiguous environmental uncertainty, the potential for decision-makers to behave opportunistically increases (Williamson 1979) and, consequently, such action may negatively impact relationship performance (Wathne and Heide 2000). Previous studies suggest that transaction-based and relation-based mechanisms have provided the foundations for the governance of the buyer-supplier relationship (Kang and Jindal 2015, Liu et al. 2009, Hawkins et al. 2008). A transaction-based mechanism emphasises the role of opportunism in environmental uncertainty; whereas, a relation-based mechanism highlights collaborative behaviour in buyer-supplier relationships through relational

exchange. Both mechanisms are important in mitigating opportunism and building strong supply chain relationships, which enable firms to be more responsive to changes in an uncertain environment (Spekman and Davis 2004).

In recent years, the importance of the buyer-supplier relationship has been highlighted in a controlled laboratory environment. Several researchers from behavioural operation studies indicate that a good relationship between buyer and supplier greatly contributes to social cooperation that underpinned by reciprocity and, accordingly, improves supply chain performance (Beer et al. 2017, Özer et al. 2014, Wu 2013, Loch and Wu 2008). In these laboratory settings, the relationship conditions are imposed on each group of subjects and are manipulated by providing subjects with instructions and orientating tasks concerned with having either communication or no communication with paired partners before the game begins. Although these experiments provide us with reliable and valid measures of relationship effects on reciprocity, they cannot explain how the subjects' behavioural decisions vary regarding the perceptions of relationships at individual levels. Evidence from social-psychological studies suggests that individuals in general are very heterogeneous in their perception of relationships, which is a spontaneous, unconscious thought process (Ferguson and Bargh 2004, Fazio 1986, Snyder et al. 1977). These studies provide explanations regarding the effects of social perception on people's behaviour, in which people's behaviour is most often shaped by their perceptions.

A study by Kenny (1994) has conceptualised the perceptions of relationships in an interpersonal context from the aspects of self- and other-perception. Self-perception relies on the exchange party's perceptions that are shaped personally (Powers and Reagan 2007, Ganesan 1994, Kenny 1994, Han et al. 1993); whereas, other-perception is associated with the exchange party's sense of obligation to reciprocate that is conditioned by the behaviour of the counterpart (Kenny 1994, Heide and John 1992, Dwyer et al. 1987). To investigate how the perceived relational factors link with individual behaviour, we argue that the need to combine experiment data that reflects actual behaviour with non-experimental data that reflects individual perception, for example survey-based data, is a matter of concern. Drawing upon these studies, we classified the perceived relational factors into two dimensions:

(1) self-perception of reciprocity-based relationship that reported by subjects; (2) feeling of obligation to reciprocate that driven by others' behaviours.

Research on behavioural economics has recently begun to place more emphasis on the correlation between experimental and survey measures (Maximiano 2012, Naef and Schupp 2009). To our knowledge, research that combines these two measurement approaches is limited in the area of operations management. Instead, most studies concerning behavioural operations management (BOM) have focused on the deviations of human social behaviour from the theoretical predictions in a laboratory environment (Katok and Pavlov 2013, Wu 2013, Loch and Wu 2008). Little is known about the validity of experimental data regarding heterogeneous subjects (Naef and Schupp 2009). Therefore, we aim to fill this gap and explore to what extent the supplier attitudes or perceptions gathered from our post-experimental survey affect behaviour toward incentives by manufacturers in a controlled experiment.

In past decades, social exchange theorists demonstrated that reciprocity is a key element that exists in social relationships (Buunk and Schaufeli 1999, Gouldner 1960), while a lack of reciprocity may lead to failure in a stable cooperative relationship. Evidence from experimental economics shows that the reciprocal concern that contributes to the reinforcement of buyer-supplier relationships crucially has an impact on behavioural decisions (Caliendo et al. 2012). In the supply chain context, if suppliers perceive they have good relationships with manufacturers, it is likely that they behave reciprocally in response to the manufacturers' kind actions. Thus, to gain an insight into supplier reciprocal behaviour in a supply chain relationship, it is critical to understand to what extent suppliers shape their perceptions of relationships with manufacturers. Drawing on these two distinct perceptions, we provide insights into the perceptions of relationships held between buyer and supplier by specifically focusing on how supplier investment decisions that reflect their reciprocity towards incentives by manufacturers are affected by suppliers' own perceptions versus those considered to have been driven by others. In other words, we expect to examine the moderating effects of perceived relational factors on incentive-investment decisions made by both parties through a combination of the survey and experimental data.

The existing understanding of buyer-supplier relationships is mostly driven by exploring the factors that can strengthen such relationships from the perspective of, for example, trust, information exchange, transaction-specific investment, and cooperation (Powers and Reagan 2007, Ganesan 1994). This study extends the existing literature on supply chains by considering some unexplored social factors that influence the perceptions of relationships held between manufacturers and suppliers from the perceived relational perspective. Frey and Meier (2004) provide evidence that strong social attitudes contribute to high levels of perceived cooperative relationships. Depending on prosocial attitudes, the cooperative buyer-supplier relationship based on positive perceptions may be of significance to elicit strong prosocial behaviour such as positive reciprocity. By integrating the relevant underlying theories with the scenarios of our research, we select ambiguity preference, other-regarding preference, and perpetrator justice sensitivity as potential factors. An understanding of such factors can provide insights into how the perceptions of relationships held between manufacturers and suppliers influence reciprocal behaviour.

In an environment characterised by high uncertainty that involves ambiguity, decision-makers may make decisions depending on ambiguity preference (Heal and Millner 2018). Previous studies in behavioural economics have found that most people who are ambiguity averse prefer known over unknown probabilities of events (Camerer and Weber 1992, Ellsberg 1961). Thus, the perception of relationships that one party in a supply chain has with their partner may operate through the sense of ambiguous uncertainty during supply chain disruptions. Therefore, we are interested in investigating how firms' ambiguity preferences significantly affect the perceptions of relationships they have with partners and, thus, their behavioural decisions. According to Heath and Tversky (1991), ambiguity preference is shaped by people's own subjective perceptions concerning the judgement of probabilities of future events. We therefore are motivated to explore the relationship specifically between ambiguity preference and self-perception of buyer-supplier relationships.

Research on social psychology suggests that people do not always behave out of self-interest, but also act with other-regarding behaviour (Haisley and Weber 2010, Frohlich et al. 2004, Itoh 2004). According to Cox (2002), other-regarding

preferences are more closely related to individuals' unconditional kindness, which is motivated by altruism. People who have unconditional kindness in general behave prosocially without expectation of a return from the other party (Hung et al. 2011, Fehr and Gächter 2000). In other words, people make decisions about whether to act kindly depending on their own spontaneous perceptions, rather than being orientated by others. Thus, we aim to investigate how other-regarding preference relates to self-measured perception of reciprocity-based buyer-supplier relationships.

According to the theory of reciprocity, individuals with feelings of obligation to care about others, in general, willing to reward fair behaviour and punish unfair behaviour (Falk and Fischbacher 2006). This theory suggests that people's attitudes that are conditioned by the behaviour of others depend on the level of fairness perceived between the exchange parties. A study documented by Schmitt et al. (2010) stresses the importance of justice sensitivity in shaping prosocial attitudes/behaviour. The concept of justice sensitivity that involves individuals' reactions for perceived fairness comprises three dimensions: victim, observer and perpetrator justice sensitivities. The first two dimensions are respectively related to reactive and neutral reactions to unfair events. Importantly, perpetrator justice sensitivity that involves an active reaction to treating others unfairly has been found to be positively associated with positive reciprocity (Baumert et al. 2014). In other words, it is more likely that higher levels of sensitivity to perpetrator justice can strengthen people's reciprocal concern as well as diminish free-riding behaviour. Therefore, the need to investigate the link between perpetrator justice and felt obligation to reciprocate within buyer-supplier relationships is a matter of concern.

In summary, the primary goal of this paper is to develop a framework for explaining the moderating effects of perceived relational factors on the relationship between manufacturer incentives and supplier reciprocal behaviour. To do so, we initially focus on the underlying factors that influence relational perceptions about the reciprocity-based relationship between the manufacturer and the supplier. We further examine the interaction between manufacturer incentives and those two different perceived relational factors that comprise self-measured perception of reciprocity-based relationship and felt obligation to reciprocate within a rela-

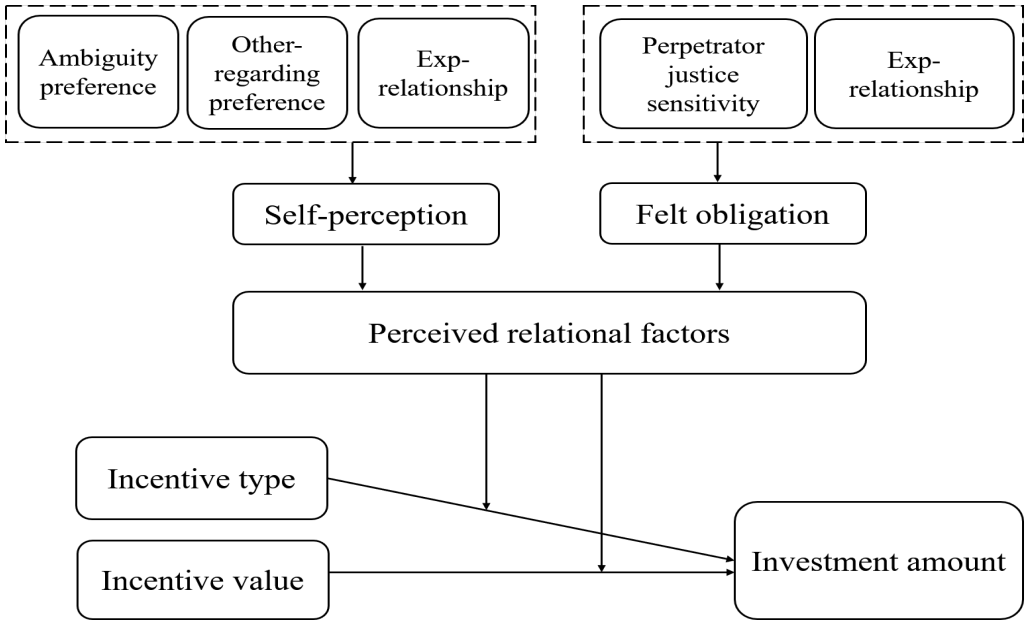
tionship. In particular, incentives by manufacturers have been categorised into two dimensions: type and value. In this study, we distinguish between these dimensions, which are both moderated by the perceived relational factors. More importantly, we consider the interaction effects by integrating the post-experimental survey data relevant to supplier perceptions or attitudes and the actual supplier reciprocal behaviour observed experimentally. This comparison provides insights into research on the predictions of reciprocal behaviour through the understanding of perceptions about the level of relationship between two parties.

Our contributions to the existing research are as follows: First, there is a limited line of research that focuses on various perceptions of relationships in supply chains. We contribute to the research by examining how the different types of perceptions of the buyer-supplier relationship moderate the link between incentives offered by manufacturers and actual reciprocal behaviour. Second, this research extends the literature on supply chain relationships by exploring the factors that shape perceptions about the level of relationship between manufacturers and suppliers. Third, we advance the existing research on psychological cognition by distinguishing the effects of incentive value and type when they are moderated by different types of perceptions of the buyer-supplier relationship through the lens of human cognition mechanism. Last, in previous research, the buyer-supplier relationship condition that drives reciprocity is mostly imposed in controlled experimental settings (Wu 2013, Loch and Wu 2008). There is limited evidence to explain the link between survey-based measures of personal perceptions or attitudes and experimental measures of actual behaviour. This study methodologically contributes to the BOM research by integrating the post-experimental survey and the experimental measures. Our theoretical frameworks presenting the moderated models are displayed in Figures 4.1.

The remainder of the paper is structured as follows: In Section 2, we review the relevant literature and develop frameworks that explain how the perceived buyer-supplier relationship moderates the effects of manufacturer incentives offered regarding supplier investment decisions and provide research hypotheses. In Section 3, we present the research methodologies, followed by an introductory presentation of the

findings and a discussion of their implications. Finally, we conclude by outlining the limitations of the study and suggesting directions for future research.

Figure 4.1: The moderation model of perceived relational factors



4.2 Theoretical Background

The relationship between buyers and suppliers has been recognised as essential to the success of a supply chain. With a collaborative and strong relationship, both supply chain parties can jointly try to reduce risks and, thus, improve overall supply chain performance and competitive advantage (Cao and Zhang 2011, Paulraj et al. 2008, Mentzer et al. 2000). In recent years, several researchers have distinguished between two broad categories of interaction between buyers and suppliers: *transaction-based* and *relation-based* interactions (Liu et al. 2009, Lee and Cavusgil 2006, Yu et al. 2006, Heide 1994). From the perspective of transactional exchange, risks of opportunism resulting from uncertainty require supply chain partners to safeguard potential opportunistic behaviour by making a legal agreement (Poppo and Zenger 2002, Osborn and Baughn 1990). From the relational perspective, a

governance mechanism based on social norms, for example, reciprocity, can help to create additional value or synergy for cooperation between buyers and suppliers (Zaheer and Venkatraman 1995, Das and Teng 2002). We present, below, the theories of transaction cost economics (TCE) and social exchange theory (SET) that provide the theoretical grounds for these two governance mechanisms.

4.2.1 Transaction Cost Economics

Transaction cost economics as a transaction-based (i.e. formal contract) governance mechanism of inter-firm relations and assumes that exchange partners are bounded by rationality and, therefore, may act opportunistically, particularly under environmental uncertainty (Williamson 1979). To minimise the transaction costs resulting from opportunism and bounded rationality, firms are required to consider an appropriate exchange governance mechanism. According to TCE theory, inter-organisational governance mechanisms and financial commitments can be applied to minimise transaction costs and to mitigate the exchange partners' opportunistic behaviour in specific investments. A well-designed complete contract that specifies all possible conditions can be considered a mechanism to eliminate the risks arising from opportunism (Williamson 1985). However, since future contingencies are ambiguous and unforeseen, human-bound rationality suggests that a complete contract may not be possible (Grossman and Hart 1986). Thus, unspecified contractual conditions would provide one exchange party with the opportunity to behave opportunistically, and the other exchange party may not easily observe the potential opportunistic behaviour (Klein et al. 1990). Consequently, this information asymmetry results in an increase in the transaction costs of the exchange. Thus, we argue that the use of a contract mechanism may, to some extent, have limitations regarding mitigating opportunistic behaviour, especially under uncertain scenarios.

Regarding the factors that determine the governance mechanism, asset specificity and environmental uncertainty are highlighted as key dimensions. Asset specificity (i.e. transaction-specific investments) refers to the investments made by one party with respect to a particular transaction (Williamson 1985). The more specific investments made, the higher the dependency between exchange parties and, thus,

the less likely a party is to switch to alternative assets with lower opportunity costs (Heide and John 1988). Thus, this situation may lead to increases in the potential for opportunistic behaviour and the transaction costs of safeguarding investments. Environmental uncertainty refers to unexpected changes resulting from external environmental factors in the exchange (Noordewier et al. 1990). According to TCE theory, exchange parties are assumed to be risk-neutral, such that exchange parties' risk preferences have no influence on the prospects of future outcomes. For example, Aoki (1984) provides evidence that risk-neutral parties have no difference in expected payoffs between certain and uncertain prospects. However, for risk-averse parties, they always prefer certain payoffs over uncertain ones. To gain a comprehensive understanding of attitudes to uncertainty, one must consider ambiguous prospects also as the other dimension, in addition to risk prospects.

Despite contractual agreements contributing to protecting against transactions, they underplay the role of value co-creation through cooperation in exchange relationships (Klein et al. 2007, Williamson 1979). From the relational perspective, TCE theory is inadequate to explain the social factors associated with a relational governance mechanism that can help safeguard transactions and understand supply chain exchange relationships (Klein et al. 2007, Woolthuis et al. 2005). To address these problems, several studies have introduced the concept of relational exchange, which relies heavily on SET (Macneil 1980*b*, Homans 1958). For example, reciprocity is a typical form of social exchange that improves outcomes of cooperation. When reciprocity is embedded in social interactions, exchange parties may be less concerned about opportunistic behaviour, and more likely to enhance cooperative behaviour.

4.2.2 Social Exchange Theory

In relational governance, the success of relational exchange requires a relationship between exchange parties that is embedded in social norms (Heide and John 1992). Social concepts such as reciprocity and other-regarding concerns play a particularly vital role in the social exchange process. During this process, these social characteristics help to reinforce the exchange relationship that develops over

time through repeated interactions between the exchange parties (Heide and John 1992). Social exchange theory focuses on social interactions between exchange parties, highlighting the voluntary actions of individuals or organisations and providing the theoretical grounds for the features of an exchange relationship (Blau 1968). According to SET, individuals are more likely to take voluntary actions that are motivated by their partners' responses in the social exchange (Emerson 1976). A wide number of studies underline SET in the context of interpersonal interactions. However, a few studies indicate that SET can be successfully applied to the analysis of inter-organisational exchange relationships (Son et al. 2005). In this study, we primarily focus on the exchange relationship between manufacturing and supply firms.

The fundamental assumption of SET is that exchange parties become involved in an exchange relationship to expect reciprocal benefits from the other party (Blau 1968, Homans 1958). In a buyer-supplier relationship, the exchange between the buyer and the supplier is viewed as interdependent (Gouldner 1960). The exchange process resembles a form of reciprocity that is driven by social exchange, in which a response by the supply party depends on the behaviour undertaken by the manufacturer party. An underlying feature of reciprocity-based relationship is the other-regarding concern, because the exchange parties with reciprocal interdependence interact often in the expectation of making others better off (Buchan et al. 2006, Itoh 2004). When both parties follow the norms of positive reciprocity, the manufacturer makes decisions with the expectation that the supplier will be rewarding. Building on the social exchange, the supplier's response is, to some extent, shaped by the perception regarding how kind the manufacturer's action is (Charness and Haruvy 2002). The manufacturer's behaviour is kindly rewarded when the supplier perceives the manufacturer's behaviour as kind or favourable, otherwise, the manufacturer will be financially punished (Cropanzano and Mitchell 2005). Thus, reciprocity, as a fundamental element of an exchange relationship, has an important role in encouraging cooperative behaviour, which, in turn, reduces opportunistic behaviour (Fehr and Gächter 2000, Molm 1994).

Overall, social exchange theorists recognise relational mechanisms as useful tools

to safeguard opportunistic behaviour and enhance cooperation in buyer-supplier relationships. The motivation for SET is to seek rewards and avoid punishments (Emerson 1976). Therefore, the attitudes and behaviours of supply chain parties are determined by a trade-off between the benefits of rewards and the costs of punishments. According to SET, the relational norms built into the process of exchange create enduring and long-lasting relationships. In the face of uncertainty, SET suggests that inter-organisational exchanges that are embedded in social relations can help to improve cooperation and, accordingly, reduce unexpected changes over time (Thompson 2017). When two firms interact with each other, particularly in the long-term, the extent of environmental uncertainty is reduced (Das and Teng 2002). In other words, in the positive buyer-supplier relationship that features long-term conditions, both parties commit to lowering the disruption risks.

4.3 Research Hypotheses

The key assumption under TCE is that people are rational and self-interested. In social psychology, researchers have demonstrated that individuals do not always behave out of self-interest but are motivated by social perceptions that are spontaneously and unconsciously activated (Ferguson and Bargh 2004). Regarding supply chain relationships, an interesting question concerns how perceived relational factors influence the role of the manufacturer's kind action in the supplier's reciprocal response. Most studies have provided evidence that individuals' characteristics determine the success of a relationship and, consequently, influence behavioural responses (Beer et al. 2017, Özer et al. 2014, Caliendo et al. 2012). To obtain insights into the evaluation of the relationship by each partner, we pay attention to other-regarding and ambiguity preferences, which relate to self-reported perception, while perpetrator sensitivity is related to felt obligation to care about others, by synthesising theories of TCE and SET. Furthermore, by incorporating the survey-measured data into the experimental data, we provide insights into how suppliers' perceptions of the relationship influence the actual reciprocal behaviour based upon incentives from manufacturers.

4.3.1 Other-regarding Preference and Self-perception of Buyer-Supplier Relationship

In recent research, the relationship between reciprocity and other-regarding preferences has been widely discussed. A stream of literature has categorised reciprocity as a subclass of other-regarding preferences which are conceptually similar to prosocial motivations for altruism (Buchan et al. 2006, Itoh 2004, Batson 1987). Other literature has distinguished reciprocity from other-regarding preferences. For example, research by Cox (2004, 2002) identifies the motivation for other-regarding as unconditional; whereas, the motivation for reciprocity is conditional. Specifically, conditional motivation refers to the type of action taken to reward the other's kindness. Unconditional motivation refers to individuals' concern and is characterised by altruism without expectation of reward. In this study, we follow the notion of Cox (2004, 2002), which distinguishes between reciprocity and other-regarding preferences. Thus, we propose that the self-reported reciprocity-based relationship which is based upon own cognition is closely related to the unconditional other-regarding preferences.

It is generally agreed that relational norms built in supply chain interactions greatly impact the cooperative relationship between exchange parties (Liu et al. 2009, Terpend et al. 2008, Kim 2000). Based on SET, the level of commitment to a relationship is likely to be higher when there exist social concerns such as other-regarding preferences (Heide and John 1992). In an exchange relationship, the more one party is genuinely concerned about the benefits of another, the more likely they intend to endure and maintain a relationship so as to diminish opportunism (Cox 2004). This situation suggests that the exchange parties' unconditional preferences are spontaneously motivated by their own pure altruism, which helps to build a successful relationship. Thus, supply chain partners exhibiting other-regarding preferences are more likely to perceive the relationship as kind and long-term orientated, and, consequently, act using reciprocal behaviour that is necessary to build restoration capability. In line with previously reviewed literature that documented the benefits of unconditional other-regarding preferences and a strong buyer-supplier

cooperative relationship, we expect that subjects will perceive strong cooperative relationships with paired partners. Therefore, we hypothesise the following:

Hypothesis 1. *Other-regarding preference is positively associated with self-perception of the relationship between manufacturers and suppliers.*

4.3.2 Ambiguity Preference and Self-perception of Buyer-Supplier Relationship

Broadly speaking, environment ambiguous uncertainty exists when firms make decisions (Faucheux and Froger 1995, Duncan 1972). According to TCE theory, firms are more likely to free ride under environmental uncertainty. Environmental uncertainty that influences firms' decisions is, in general, related to: (1) unpredictable changes in external environments (e.g. disruption events); (2) ambiguous information regarding external environments (e.g. future recovery outcomes) (Kim et al. 2010, Noordewier et al. 1990). A distinct feature of an ambiguous uncertain environment concerns the probabilities of events or outcomes that are unknown. In other words, under ambiguity uncertainty, exchange parties do not have shared information and, therefore, one party may have difficulty predicting the intention or behaviour of the other party. Thus, the information asymmetry that leads to the potential for opportunistic behaviour is likely to increase transaction costs. As discussed previously, SET suggests that costs caused by an ambiguous uncertain environment can be reduced with the help of a relational governance mechanism that encourages firms to strengthen cooperative relationships. Literature on inter-firm relationships provides evidence that firms are more willing to make a joint effort to strengthen the perceived level of the relationship when ambiguous uncertainty exists (Claro et al. 2003, Gulati 1998). Cai and Yang (2008) indicate that environmental uncertainty positively impacts developing and maintaining cooperative relationships. Noordewier et al. (1990) reveal that relational elements improve performance in buyer-supplier relationships given environmental uncertainty. Cannon et al. (2000) state that firms embedded in relational and social norms perform better in a high level of uncertainty than in a low level of uncertainty.

The effect of ambiguous uncertainty on self-perception of buyer-supplier relationship is fundamentally operated through people's preference for ambiguity. Winkler (1991) stresses that individuals' preferences regarding ambiguity play an important role in their decision behaviours. Much of the research provides evidence that decision-makers generally prefer risky prospects with known probabilities of outcomes over ambiguous prospects with unknown probabilities of outcomes (Keren and Gerritsen 1999, Camerer and Weber 1992, Ellsberg 1961). Considering individuals' future expectations, decision-makers tend to exhibit increased ambiguity aversion with pessimistic expectations when faced with an unknown probability of future outcomes (Abdellaoui et al. 2015). This preference may be because people with pessimistic beliefs feel less confident, and thus are more likely to make conservative decisions in response to ambiguity (Pulford and Colman 2007). In contrast, people who have higher ambiguity tolerance are more likely to display optimistic expectations about positive future outcomes (Pulford 2009). Here, we follow the notion of ambiguity tolerance defined as the 'tendency to perceive ambiguous situations as desirable' (Stanley Budner 1962) (see p.29). Therefore, we suggest that those who hold a high degree of ambiguity tolerance with optimism may be more confident in prosocial attitudes/behaviour than others and, thus, are willing to place more emphasis on building a successful relationship to provide assurance against opportunism.

In supply chain settings, supply chain disruptions are generally unforeseen and thereby may lead to ambiguity regarding recovery outcomes (Ambulkar et al. 2015). Given environmental uncertainty, firms that are more ambiguity tolerant are more confident in cooperating with others to enhance recovery outcomes (Pulford 2009). Accordingly, such firms are likely to feel comfortable engaging in relationship improvement, such that they may perceive themselves having relationships with partners, in particular under uncertain environments, as value added. Thus, we propose that a firm's ambiguity preferences may play a vital role in shaping their self-perception of the relationship.

Hypothesis 2. *Ambiguous preference is positively associated with self-perception of the relationship held between manufacturers and suppliers.*

4.3.3 Perpetrator Justice Sensitivity and Felt Obligation within the buyer-Supplier Relationship

As mentioned previously, the feelings of obligation to reciprocate within an exchange relationship can motivate the supplier's behaviours that correspond to this obligation. Drawing upon the theory of reciprocity, which places more emphasis on rewarding kind actions and punishing unkind ones, the obligation for reciprocity is fulfilled by fairness. (Falk and Fischbacher 2006, Buunk and Schaufeli 1999, Fehr et al. 1997, Berg et al. 1995, Fehr et al. 1993). Some recent literature has proposed dividing the theory of reciprocity into two dimensions: consequence-based and intention-based (Falk and Fischbacher 2006, Cooper and Kagel 2016). In other words, people's reciprocal behaviour is not purely determined by the distributional outcome, but also by their concern for the behavioural intention. Consequence-based reciprocity emphasises people's evaluation of kindness towards an action as being shaped by the distributional outcomes (Bolton and Ockenfels 2000, Fehr and Schmidt 1999). On the other side, evidence from several researchers indicates that intention is significantly related to the question of how kind the action being perceived is and how strong the reciprocal response is (Falk and Fischbacher 2006, Dufwenberg and Kirchsteiger 2004, McCabe et al. 2003). These scholars provide evidence that a good perception that signals a positive reciprocity induces a stronger reciprocal response.

Reciprocity within exchange relationships is motivated by the exchange parties' perceived fairness (Das and Teng 2002). With a concern for perceived fairness, people reward fair others but sacrifice their own money to punish unfair others (Falk et al. 2008, Bolton and Ockenfels 2000, Fehr and Schmidt 1999, Camerer and Thaler 1995, Güth and Tietz 1990). The existing literature on organisational justice suggests that perceptions of justice (i.e. fairness) within SET play a vital role in prosocial behaviour (Gollwitzer et al. 2009, Schmitt et al. 2005, Fetchenhauer and Huang 2004). In social psychology, people's concerns for justice are expressed via justice sensitivity (Schmitt et al. 2005). Justice sensitivity that shapes people's behaviour and their reaction to perceived fairness differs between individuals (Schmitt

et al. 2010, Lovaš and Wolt 2002, Schmitt et al. 1995). A 2005 study conducted by Schmitt et al. categorised justice sensitivity into three dimensions: (1) victim sensitivity; (2) observer sensitivity; (3) beneficiary sensitivity. The victim, observer and beneficiary sensitivities respectively represent the feelings of being unfairly treated, the feelings of observing unfair events, and the feelings of benefiting from injustice. To differentiate between the passive and the active role of benefiting from injustice, Schmitt et al. (2010) extended their research and developed an additional justice construct perpetrator sensitivity as a measure of justice sensitivity. They identified beneficiary sensitivity as passive; whereas, perpetrator sensitivity is actively benefiting from injustice.

The relationship between individual differences in justice sensitivity perspectives and prosocial attitude/behaviour has received increased attention. Fetchenhauer and Huang (2004) provide experimental evidence that individuals differ in making strategic decisions subject to different dimensions of justice sensitivity. For example, subjects with strong feelings of benefiting from injustice are more concerned about treating others fairly; whereas, those with strong feelings of being unfairly treated are more likely to behave selfishly. Gollwitzer et al. (2009) indicate that other-related (observer, beneficiary and perpetrator) sensitivity has a positive relationship with prosocial attitude/behaviour and other-regarding concerns, but self-related (victim) sensitivity has been found to positively associate with antisocial behaviour. Baumert et al. (2014) distinguish the effect of beneficiary sensitivity on reciprocity from that of perpetrator sensitivity. They state that perpetrator sensitivity is significantly associated with positive reciprocity; whereas, beneficiary sensitivity is not correlated with it. Thus, from a social perspective, the perpetrator perspective appears to reflect more general reciprocal concerns for justice.

According to the theory of TCE, in exchange relationships, individuals may behave opportunistically and thereby benefit themselves by taking an active commitment to injustice (perpetrator sensitivity). In this case, individuals' moral emotions may link with feelings of guilt. Emotions of guilt are grouped into two aspects: one, resulting from immoral beliefs or actions, is labelled 'actional guilt' (Hoffman 1984, Gollwitzer 2004); the other, resulting from taking advantage of objective unfairness,

is called 'existential guilt' (Montada et al. 1986). In decision-making processes, individuals' feelings of guilt may be more closely associated with actional guilt. Subsequently, such individuals are more likely to be motivated to take prosocial actions (Konoske et al. 1979). Therefore, we hypothesise that individuals with higher perpetrator sensitivity are more likely to have reciprocal concerns for others.

Hypothesis 3. *Perpetrator justice sensitivity is positively associated with felt obligation for reciprocity within the relationship between manufacturers and suppliers.*

4.3.4 The Moderating Role of Perceived Relational Factors in the relationship between Incentive and Investment Decisions

Results from our previous experiment highlight that suppliers are more likely to invest more in restoration capability towards a more generous incentive by manufacturers when they repeatedly interact. Previous studies have revealed that people with high perception levels of relationships are more likely to engage in cooperative relationships and to take actions that strengthen those relationships (Kim et al. 2010, Wilson 1995, Heide and John 1992). Two streams of research provide insights into the exchange process from different perspectives. The first stream, from the fields of supply chains, marketing and business, examines the buyer-supplier relationship through the lens of exchange parties' self-reported measures (Ambrose et al. 2010, Powers and Reagan 2007, Narayandas and Rangan 2004). The second stream explores the relationship between buyers and suppliers through the perspective of social exchange (e.g. reciprocity), which is conditioned by the attitudes and behaviour of others (Falk and Fischbacher 2006, Cox 2004, Gouldner 1960). Based on this literature, this study provides insights into the two perception variables as moderators of the relationship between manufacturer incentives and supplier investment decisions.

In our previous experiment, incentives offered by manufacturers consisted of two dimensions: (1) type, (2) value. We are motivated by research on cognitive psy-

chology to distinguish between those two constructs as independent variables when performing a moderation analysis. Kahneman (2003) demonstrated that people most often rely on two functions of cognitive systems, comprising intuitive and reasoning processing systems, when making decisions. When faced with different types of questions, a person's processes of decision-making may vary depending on the cognitive system used. For example, a person may make decisions using logic and rational systems to process information for normative questions; whereas, they may use personal perceptions or preferences for descriptive questions (Kahneman and Tversky 2013). Philosophically, normative questions refer to subjective statements about how to value things, while descriptive questions refer to objective statements about types of beliefs or preferences (Kahneman and Tversky 2013).

To answer questions such as, 'How much incentive value would you like to offer?', subjects need to use methods other than intuitive judgements (Kahneman 2003). Since the operations of analytical reasoning system are largely rational-based, individuals using this function to solve problems may be less sensitive to social attitudes or preferences. However, with the operations of an automated intuitive system, when only two simple choices occur to people, they are likely to use this function to choose between the options without much effort. Intuitive judgements are more emotion-driven and are most often governed by people's own attitudes or preferences (Kahneman 2003). Thus, we suppose that the answer to the question, 'Which option would you like to choose between Direct and Indirect incentive?' is likely to be driven by emotion, such that individuals may behave less self-interestedly with their bounded rationality compared with the question concerning incentive value.

Incentive Type and Incentive Value Moderated by Self-Perception of Buyer-Supplier Relationship

As mentioned previously, the question regarding incentive type represents a simple categorical description between two options that involve the intuitive cognitive system. Specifically, the intuitive system is similar to the operating process of perception (Kahneman 2003). When the view of intuition is held, individuals' preferential choices occur spontaneously (Higgins 1996). According to SET, it is likely

that individuals' reciprocal behaviours are governed by cognitive processing in exchange relationships (Blau 1968). In other words, people's internalised perceptions are important to the exhibition of reciprocal behaviour.

Drawing upon research on cognitive psychology (Plous 1993, Anderson and Gerbing 1988), the effect of incentive type on supplier investment decision that signals reciprocity may vary given various perception levels of relationship. For example, suppliers who perceive high levels of relationship with manufacturers are more likely to display reciprocal behaviour when incentives by manufacturers are viewed as prosocial (Kim et al. 2010). In contrast, suppliers with low perceptions are less likely to be motivated to make decisions that benefit others. That is, low perceptual more likely to be concerned with their own interests and, accordingly, choose an option that benefits themselves. Thus, Direct incentive would have a weak effect on reciprocal behaviour for suppliers with low perceptions of their relationship with manufacturers. Therefore, we hypothesise that when Direct incentive is offered, the more that suppliers perceive their relationships with manufacturers as being good, the more likely that suppliers will exhibit reciprocal behaviour via investing more in restoration capability.

Hypothesis 4a. *Self-perception of buyer-supplier relationship moderates the relationship between manufacturer incentive type offered and supplier reciprocal behaviour, such that the positive relationship between incentive type and reciprocal behaviour is stronger among suppliers with high perception levels of relationship.*

The cognitive system that drives human reasoning plays an important role in asking and answering questions such as *how much* (Graesser et al. 1996). The process of question-answering involves a conscious, deliberate and analytical thinking process (Kahneman 2003). In social exchange relationships, supplier reciprocal behaviour may be motivated only when they perceive the incentive value offered to be considerable, depending upon the rational cognitive processing (Blau 1968). Therefore, we predict that the effect of incentive value offered on supplier reciprocal behaviour may vary according to different perceived levels of the relationships the

suppliers have with the manufacturers. Suppliers who perceive high levels of relationships with their manufacturers are more likely to engage in prosocial behaviour and, thus, may be motivated to invest more towards the manufacturers' generous incentive value offered. In contrast, suppliers with low perception levels of the relationships with their manufacturers may have a weak sense of cooperating and, thus, may be less likely to invest more in restoration capability (Kim et al. 2010). Thus, we hypothesise that the stronger suppliers perceive their relationships to be with manufacturers, the more likely they will exhibit reciprocal behaviours towards the manufacturers' generous incentive value.

Hypothesis 4b. *Self-perception of buyer-supplier relationship moderates the relationship between manufacturer incentive value offered and supplier reciprocal behaviour, such that the positive relationship between incentive value and reciprocal behaviour are stronger among suppliers with high perception levels of the relationship.*

As noted previously, the judgements of incentive type and incentive value have been distinguished between two cognitive mechanisms: intuitive and deep reasoning. Differing from categorical questions, numerical question-answering requires the adoption of deep reasoning and logic processes to evaluate a reasonable value to offer. From this perspective, the judgement of the incentive value is processed with a relatively slower and more conscious cognitive system. Based upon research on TCE, the rational cognitive system is more likely to encourage self-regarding behaviour, but less motivate prosocial behaviour (Williamson 1979). This result suggests that analytical processing that involves bound rationality motivates suppliers to deliberately evaluate the value offered by manufacturers with less concern about others' benefits. In contrast, the judgement of an incentive type that adopts an unconscious, intuitive and heuristic thinking process most often involves emotional processing, which is more relevant to social cognition (Evans 2008). If suppliers hold high perception levels of the relationship with manufacturers, they are more likely to cohere with reciprocity norms based on the manufacturers' generous incentive offer and, accord-

ingly, behave in prosocial ways. Taking account of social considerations, we propose that subjects' sense of an incentive type that involves more social cognition has a stronger effect on reciprocal behaviour than that of an incentive value that relies more on rational reasoning when those variables are moderated by self-perception of buyer-supplier relationships.

Hypothesis 4c. *Incentive type more strongly impacts supplier investment decisions when it is moderated by self-perception of the buyer-supplier relationship compared with that of incentive value.*

Incentive Type and Incentive Value Moderated by Felt Obligation to Reciprocity within the Buyer-Supplier Relationship

In social psychology, the understanding of attitudinal factors that influence people's prosocial behaviour, such as reciprocity, is very important (Ajzen 1991, Ajzen and Fishbein 1977, 1980). A previous study supports the view that people's behaviour is consistently guided by their attitudes towards the other (Kim and Hunter 1993). According to the theory of reciprocity, the attitude or behaviour of manufacturers is the premise of suppliers' obligations for reciprocity, which, in turn, shape their behaviours (Falk and Fischbacher 2006). More specifically, in buyer-supplier relationships, suppliers respond to favourable actions by manufacturers with strong senses of obligation to reciprocate are more likely to engage in prosocial behaviours. Winter and Uleman (1984) provide evidence that individual preferences such as reciprocity and altruism are not perceived *per se*, but formalise the social perceptions that may ultimately reinforce social behaviours. Thus, we predict that the felt obligation for reciprocity that is conditioned on the other's behaviour has a moderating role in the effects of the manufacturer incentive decisions on the supplier's restoration investment.

Based on SET, we propose that suppliers with high felt obligations are more likely to behave in prosocial ways and, thus, may be more responsive to manufacturers' generous incentives by investing more. In contrast, suppliers with low felt obligations may appreciate manufacturers' generous incentives less, and, thus, are

less likely to cohere to the reciprocity norm. Drawing on the explanations for the moderating effect of self-perception of the buyer-supplier relationship, the moderating effect of felt obligation for reciprocity on the relationship between incentive type, incentive value and reciprocal behaviour is theoretically similar. Accordingly, we hypothesise that the higher perception level the subjects scored, the more likely they are to exhibit reciprocal behaviour, whether in decisions regarding incentive type or regarding incentive value.

Hypothesis 5a. *Felt obligation to reciprocate within the buyer-supplier relationship moderates the relationship between manufacturer incentive type offered and supplier reciprocal behaviour, such that the positive relationship between incentive type and reciprocal behaviour is stronger among suppliers with high feelings of obligation for reciprocity.*

Hypothesis 5b. *Felt obligation to reciprocate within the buyer-supplier relationship moderates the relationship between manufacturer incentive value offered and supplier reciprocal behaviour, such that the positive relationship between incentive type and reciprocal behaviour is stronger among suppliers with high feelings of obligation for reciprocity.*

Hypothesis 5c. *Incentive type more strongly impacts supplier investment decisions when it is moderated by the felt obligation to reciprocate within the buyer-supplier relationship compared with that of incentive value.*

4.4 Method

The importance of buyer-supplier relationships has been widely explored in both experimental and empirical studies. In experimental studies, the researcher manipulates the buyer-supplier relationship and, thus, the effects of imposed control in buyer-supplier relationships can be ascertained. Our experimental results reveal that long-term orientation that signals a strong buyer-supplier relationship positively im-

pacts supplier investment decision towards the manufacturer incentive (i.e. type and value) offered. However, we cannot observe how suppliers' own perceptions of their relationship with manufacturers influence their investment decisions on a subjective level. Research on the perception-behaviour link indicates that individuals' characteristics that spontaneously elicit the social perceptions are positively associated with prosocial behaviour (Dijksterhuis and Bargh 2001, Dijksterhuis and Van Knippenberg 1998). Thus, we used a post-experimental survey based upon experimental approaches to investigate how perceived buyer-supplier relationships influence the relationship between incentives by manufacturers and supplier reciprocal behaviour.

4.4.1 Sampling and Data Collection

The hypotheses were tested using the data collected from the post-experimental questionnaires. Both supplier and manufacturer players were asked to answer attitudinal questions after finishing the main experiment. In general, a survey approach is a typical way to understand the subjects' attitudes or intentions on a subjective level. By testing the attitudinal questions in a survey, we can understand whether subjects' personal attitudes are significantly correlated with their actual behaviours in the main experiment. In many cases, to impress others or maintain self-image, subjects may provide a desirable answer about their attitudes that is inconsistent with their actual behaviour. Drawing from Maximiano (2012), we use the post-experimental survey to examine whether subjects' answers to perception-based questions correlate with their actual reciprocal behaviour in a controlled environment. Specifically, we investigate the individual differences in the perception levels of the relationship with their paired partner on the link between incentives by manufacturers and reciprocal behaviour and the factors influencing perceptions by each partner. A total of 122 subjects completed the post-experimental questionnaire, half of whom were manufacturer players and the other half supplier players. On average, the subjects took about 10-15 minutes to complete the questionnaire.

4.4.2 Measures

The questionnaire design was based on questions adopted in previous research on social psychology. We covered the following five categories of questions: (1) self-perception of relationship; (2) ambiguity preference; (3) other-regarding preference; (4) felt obligation to reciprocate; (5) justice sensitivity. The details of the items measured for the above constructs are in Appendix C.

To measure self-perception of the relationship between manufacturers and suppliers, the subjects were asked to rate how much they agree with the statements about their relationships with their paired partners. This question was followed by a seven-point Likert scale ranging from 1 (extremely weak) to 7 (extremely strong). The question concerning ambiguous uncertainty primarily captured subjects' preferences for a known/unknown probability of an event. The test that we used is similar to Erev et al. (2017)'s replicated version of Ellsberg (1961)'s measure of ambiguity aversion. The subjects were asked to select their preference from two options: (A) 100 with probability 0.5; 0 otherwise; (B) 100 with probability 'x'; 0 otherwise; ('x' is an unknown constant between 0 and 1). For other-regarding preferences that featured as procial motivations for altruism, we measured this using four items adapted from Grant (2008). The subjects were asked to rank their level of agreement with statements related to a question concerning, 'Why are you motivated to do the task?', answering on a seven-point scale from 1 (not at all applies to me) to 7 (perfectly applies to me). Specifically, the statements about prosocial motivation can be considered as alternative interpretations that underlying other-regarding preferences. The four statements assessing other-regarding preferences were: (1) 'Because I care about benefiting others through my work'; (2) 'Because I want to help others through my work'; (3) 'Because I want to have a positive impact on others'; (4) 'Because it is important to me to do good for others through my work'.

To assess subjects' felt obligations to reciprocate within the buyer-supplier relationship, three items that were evaluated using scales from 1 (does not apply to me at all) to 7 (applies to me perfectly) were adapted from Caliendo et al. (2012), for example, the subjects were asked to rate the statement, 'If someone does me a favour, I am prepared to return it.' The measure of justice sensitivity was adapted from

Schmitt et al. (2010), who used ten-item scales for each type of justice sensitivity. Specifically, considering the relevance of our experimental scenarios, we focused on perpetrator justice sensitivity and adopted five items with great factor loadings from the measure of perpetrator justice sensitivity. The subjects were asked to choose the point that best expresses their own opinion regarding the statements (see Appendix C for statements of all items). A six-point scale was adopted to measure the items, with 0 representing 'strongly disagree', and 5 representing 'strongly agree'.

The perceived buyer-supplier relationship in this study may be influenced by other factors. In addition to the main variables demonstrated above, we measured the following three control variables: experimental buyer-supplier relationship, age and gender. The buyer-supplier relationship in the main experiment was a dummy variable equal to 1 if the relationship is in long-term orientation, and 0 otherwise. The relationship orientation is a good indication of how good a relationship is between two parties. In a long-term orientation, people generally have a sense of a good relationship with their partners over time. Thus, we additionally controlled the imposed relationship to examine whether the focal variables have the same effect on perceptions of buyer-supplier relationships. To distinguish the main experiment from other measures of buyer-supplier relationship, we refer to it as 'exp-relationship'. Table 1 illustrates the correlation matrix of all the variables. Age was a dummy variable equal to 1 if the subject was either a young undergraduate or postgraduate student, and 0 otherwise. As for gender variable, we assigned the variable as male subjects being equal to 1, and female subjects being equal to 0.

4.4.3 Data Analysis

To test the overall fitness of the measurement model, the reliability and validity of all the constructs relevant to our study have been assessed. Specifically, self-perception of relationship and ambiguity preference are measured using only single-item measures. The statistics related to other three constructs that contain multiple items are shown in Table 4.1, which include the factor loading of each item, the Cronbach's α and composite reliability of each construct and the value of average variance extracted (AVE).

Table 4.1: Reliability and validity of constructs

Measurement items	Factor loading	Cronbach's α	AVE	CR
Felt obligation for reciprocity		0.71	0.5	0.75
PR1: If someone does me a favour, I am prepared to return it.	0.54			
PR2: I go out of my way to help somebody who has been kind to me before.	0.83			
PR3: I am ready to undergo personal costs to help somebody who helped me before.	0.73			
Justice Perpetrator		0.869	0.58	0.87
JP1: It gets me down when I take someone else I don't deserve.	0.73			
JP2: I cannot stand the feeling of exploiting someone.	0.74			
JP3: It takes me a long time to forget when I allow myself to be careless at the expense of someone else.	0.79			
JP4: I feel guilty when I enrich myself at the cost of others.	0.86			
JP5: I feel guilty when I treat someone worse than others.	0.69			
Other-regarding preference		0.927	0.77	0.93
OP1: Because I care about benefiting others through my work.	0.91			
OP2: Because I want to help others through my work.	0.92			
OP3: Because I want to have positive impact on others.	0.92			
OP4: Because it is important to me to do good for others through my work.	0.74			

Note: AVE = Average Variance Extracted, CR = Composite Reliability.
Model Fit statistics: $\chi 2 = 62.07$, df = 51, $p = 0.138$, GFI = 0.93, CFI = 0.98, RMSEA = 0.042;

Cronbach's α over 0.7 is considered to be an acceptable threshold of internal consistency for each variable (Nunnally and Bernstein 1994). In our study, the Cronbach's α of each multi-item scale exceeds the acceptable value of 0.7, indicating high internal consistency and reliability of the variables. In addition, we conducted a confirmatory factor analysis (CFA) to test the validity of the multi-item focal variables including 'felt obligation for reciprocity', 'justice perpetrator', and 'other-regarding preference'. According to the CFA results, we have a good fit of model for the data ($\chi^2 = 62.07$, df = 51, $p = 0.14$, GFI = 0.93, CFI = 0.98, RMSEA = 0.04). The estimates of squared multiple correlation for each item were between 0.30 and 0.90, and all factor loadings were significant at $p < 0.01$. These results support the convergent validity and unidimensionality of the constructs (Anderson and Gerbing 1988). Furthermore, an assessment of discriminant validity of each construct was conducted to examine the constructive distinctiveness of the variables used in this study. As indicated in Table 4.2, all constructs' square root of AVE values are higher than the inter-construct correlations, which provides support for the discriminant validity of the measured variables (Fornell and Larcker 1981).

Table 4.2: Discriminant validity assessment

Variables	1	2	3
1 Self-perception relationship	0.71		
2 Felt obligation for reciprocity	0.37	0.76	
3 Other-regarding preference	0.24	0.21	0.88

Notes: Square root of AVE of each construct is shown on the diagonal; the values of inter-construct correlations are presented below the diagonal.

Table 4.3: Descriptive statistics and correlation matrix (N=122)

Variables	1	2	3	4	5	6	7	8
1 Self-perception relationship	1							
2 Felt obligation for reciprocity	0.17**	1						
3 Other-regarding preference	0.20**	0.24***	1					
4 Ambiguity preference	0.16**	0.06	-0.11	1				
5 Justice perpetrator	0.04	0.37***	0.21***	-0.07	1			
6 Exp-relationship	0.29***	0.12	-0.23***	0.08	0.12	1		
7 Gender	0.01	0.11	0.00	-0.03	-0.13	-0.09	1	
8 Age	0.10	0.10	0.11	-0.02	0.17	-0.08	0.15	1
Mean	3.78	5.98	5.03	0.32	3.76	0.51	0.35	1.14
S.D.	1.54	0.87	1.33	0.47	0.97	0.5	0.48	0.35

[1] $^{**}p < 0.05$; $^{***}p < 0.01$;

Table 4.3 above presents descriptive statistics and correlation matrix for all the variables including both focal and control variables. Notably, the self-perception of buyer-supplier relationship was significantly related to other-regarding preference (r=0.20, $p < 0.05$) and ambiuity preference (r=0.16, $p < 0.05$). The felt obligation for reciprocity was significantly related to perpetrator justice sensitivity (r=0.37, $p < 0.01$).

4.4.4 Hypotheses Testing

Hypotheses 1 and 2 were tested using multiple regression analysis. The regression model captures the dependent variable 'self-perception of buyer-supplier relationship' as a function of other-regarding preference, ambiguity preference and control variables. In addition, we conducted tests for multicollinearity by using the variance inflation factor (VIF). All tolerance values were above 0.85 and VIF values were below 10, indicating acceptable levels of multicollinearity (Neter et al. 1996). Table 4.4 displays the results of the regression analyses that were conducted to examine these hypotheses.

Table 4.4: Regression analysis for self-perception of buyer-supplier relationship

Independent Variables	**Standardized Coefficients (β)**	***t***	**Sig.**	**Multicollinearity**	
				Tolerance	**VIF**
(Constant)		1.26	0.21		
Other-regarding preference	0.29	3.32	0.00***	0.85	1.17
Ambiguity preference	0.17	2.02	0.05**	0.98	1.02
Exp-relationship	0.36	4.16	0.00***	0.90	1.12
Gender	0.04	0.43	0.67	0.95	1.05
Age	0.09	1.09	0.28	0.96	1.04
$R^2 = 0.20$					

[1] Dependent Variable: Self-perception of buyer-supplier relationship;
[2] $^{**}p < 0.05$; $^{***}p < 0.01$;

To examine the determinants of felt obligations for reciprocity, the regression model was developed to capture the dependent variable 'felt obligation for reciprocity' as a function of justice perpetrator and the control variables. We show the results of regression for Hypothesis 3 in Table 4.5 below.

Table 4.5: Regression analysis for felt obligation for reciprocity within the buyer-supplier relationship

Independent Variables	**Standardized Coefficients Beta (β)**	***t***	**Sig.**
(Constant)		12.41	0.00
Justice Perpetrator	0.38	4.34	0.00***
Exp-relationship	0.09	1.04	0.30
Gender	0.16	1.06	0.06
Age	0.02	0.20	0.85
$R^2 = 0.17$ F-value = 6.03***			

[1] Dependent Variable: Felt obligation for reciprocity;
[2] $^{**}p < 0.05$; $^{***}p < 0.01$;

Taking together the survey-based and experimental measures of reciprocity, we first tested whether the data regarding subjects' self-reported measures of buyer-supplier relationship and felt obligations for reciprocity in the survey correlate with experimentally observed reciprocal behaviour data. We measured the subjects' extent of reciprocity, which was observed from the experiment by aggregating the return rate of investment amount to incentive value at an individual level. We call this extent 'exp-reciprocity' in the interpretation of results. Table 4.6 presents the correlation matrix of felt obligation for reciprocity, exp-reciprocity and self-perception of relationship.

In order to test Hypotheses 4a, 4b and 4c, we develop the regression model to capture investment amount (F), signalling reciprocal behaviour and obtained in the previous experimental study, as the dependent variable. Preferential incentive type and value (I) (also experimentally obtained), self-perception of buyer-supplier rela-

Table 4.6: Correlation matrix for the survey and experiment data

Variables	**Mean**	**S.D.**	**1**	**2**	**3**
1 Felt obligation for reciprocity	5.97	0.91	1		
2 Exp-reciprocity	0.33	0.18	0.18**	1	
3 Self-perception	3.79	1.54	0.11	0.33***	1

[1] $^{**}p < 0.05$; $^{***}p < 0.01$;

tionship, the interaction variables of self-perception of buyer-supplier relationship, incentive type or incentive value, and the imposed exp-relationship as independent variables. In this study, the moderation effect of self-perception of buyer-supplier relationship is modelled using an interaction variable in the regression equation. With the moderation effect, the relationship between incentive type or value offered by manufacturers and supplier investment amounts varies according to perceptions about the level of the buyer-supplier relationship. The results of the regression analyses are displayed in Table 4.7.

Table 4.7: The moderation effect of incentive type on investment amount

Independent Variables	**Standardized Coefficients Beta (β)**	***t***	**Sig.**
Incentive value	0.02	20.50	0.00***
Incentive type	0.54	9.48	0.00***
Self-perception relationship	0.08	1.07	0.29
Incentive value × Self-perception	0.00	1.78	0.08
Incentive type × Self-perception	0.10	2.47	0.01**
Exp-relationship	0.16	2.75	0.01***
$R^2 = 0.35$			
F-value = 105.88***			

[1] Dependent Variable: Investment amount;
[2] $^{**}p < 0.05$; $^{***}p < 0.01$;

To examine Hypotheses 5a, 5b and 5c, the regression model was further developed to replace self-perception of buyer-supplier relationship with the felt obligation to reciprocate within buyer-supplier relationship as independent variables. Similar to self-perception of buyer-supplier relationship, the moderation effect of the felt obligation for reciprocity is modelled using the interaction variable in the regression equation. With the moderation effect, felt obligation for reciprocity modifies the relationship between incentive type or value offered by manufacturers and supplier investment amounts. The results of regression for Hypotheses 5a, 5b and 5c are in Table 4.8.

Table 4.8: The moderation effect of incentive value on investment amount

Independent Variables	**Standardized Coefficients Beta (β)**	***t***	**Sig.**
Incentive value	0.02	19.86	0.00***
Incentive type	0.54	9.43	0.00***
Felt obligation for reciprocity	0.06	1.31	0.19
Incentive value × Felt obligation for reciprocity	0.00	1.06	0.29
Incentive type × Felt obligation for reciprocity	0.16	2.67	0.01***
Exp-relationship	0.26	4.63	0.01***
$R^2 = 0.35$			
F-value = 107.36***			

[1] Dependent Variable: Investment amount;
[2] **$p < 0.05$; ***$p < 0.01$;

As is evident from Table 4.4, other-regarding preferences ($\beta = 0.27, p < 0.01$) and ambiguity preferences ($\beta = 0.17, p < 0.1$) exert significant and positive effects on self-perception of buyer-supplier relationship. Thus, Hypotheses 1 and 2 are supported. The results of the regression on felt obligation for reciprocity within the buyer-supplier relationship indicate that justice perpetrator ($\beta = 0.33, p = 0.00$) had positive and significant relationships with the felt obligation for reciprocity, supporting Hypothesis 3. The interaction effects between incentive type and self-perception of buyer-supplier relationship ($\beta = 0.11, p < 0.05$), and between incentive value and self-perception of buyer-supplier relationship ($\beta = 0.001, p = 0.05$), on supplier investment amount were positive and significant. These results support Hypotheses 4a and 4b. Consistent with our expectation, the effect of incentive type moderated by self-perception of buyer-supplier relationship was stronger than that of incentive type moderated by self-perception of buyer-supplier relationship. This result supports Hypothesis 4c. Combining the subjects' felt obligation for reciprocity with actual reciprocal behaviour in the experiments, their feelings of obligation to reciprocate positively strengthens the relationship between incentive type or incentive value and investment decisions, as predicted in Hypotheses 5a and 5b. Furthermore, we found a stronger relationship between incentive type and investment amount than between incentive value and investment amount when felt obligation for reciprocity is considered as a moderator, supporting Hypothesis 5c. Regarding the type of relationship imposed in the experiment (i.e. exp-relationship), we controlled this variable in our moderator analyses. It was found to be positive and significantly related to self-perceptions of buyer-supplier relationship and felt obligations for reciprocity ($\beta = 0.35, p < 0.01$). This result confirms the important role of the types of buyer-supplier relationship on self-perceptions regarding how good the relationships subjects have with their partners are.

4.5 Discussion

4.5.1 Summary of Results

Our motivation for this study was to investigate how differences in the perceptions of the relationship between manufacturers and suppliers correlate with actually observed reciprocal behaviour in incentive-investment experimental games. To provide insights into the effects of incentive type or value offered by manufacturers on supplier investment amount, we used the lens of two distinct perceptions of the buyer-supplier relationship that serve as moderator variables. We distinguish between the self-perception of the relationship, which reflects people's own internal perceptions, and, on the other hand, the felt obligation to reciprocate within the relationship, which is conditioned by the attitude or behaviour of others through social exchanges.

Three key findings are illustrated. First, our results confirm that the relationships between manufacturer incentive type, value, and supplier reciprocal behaviour are moderated by perceived relational factors. The results indicate that high self-perception levels of a buyer-supplier relationship significantly strengthen the link between those relationships. In other words, suppliers who perceive the relationship with their manufacturers to be strong are more likely to be motivated to invest more towards the manufacturers' decisions for either type or value of incentive offered. In addition, we found that the results for the moderation effects of the felt obligation for reciprocity on the link between incentives and reciprocal behaviour are similar to those for self-perception of buyer-supplier relationship.

Second, we distinguished the effects of incentive type and value on supplier reciprocal behaviour when moderated by perceived relational factors. Our results reveal that incentive type has a stronger effect on investment amount than incentive value when they are moderated by either self- or other- perception of buyer-supplier relationship. In line with Kahneman (2003), the preferential choice of incentive type as a simple description may spontaneously occur to suppliers, and, thus, involves more social cognition in their investment decisions. In contrast, responding to questions of incentive value requires suppliers to adopt a logic cognitive system to evaluate

whether the incentive value offered is acceptable and, thus, there may be fewer social considerations involved.

Third, at individual levels, our findings suggest that a high self-perception level of the buyer-supplier relationship is closely related to ambiguity preference and unconditional other-regarding preference. In addition, we demonstrated that strong feelings of perpetrator justice sensitivity are associated with high felt obligations for reciprocity within the buyer-supplier relationship.

4.5.2 Theoretical Contributions

This study contributes to the existing literature in several ways. First, we advance the existing research on behavioural operations by analysing the data with respect to subjects' personal attitudes or perceptions and providing evidence for the correlation between post-experimental survey-based measures of perception-based buyer-supplier relationships and actual reciprocal behaviour observed in a controlled experiment. Most previous research on behavioural operations provides experimental evidence on the effects of reciprocity on supply chain performances in supply chain relationships (Wu 2013, Loch and Wu 2008). However, supply chain partners have differences in perceptions about the level of buyer-supplier relationships, and thereby may have different behavioural responses to the relationships (Ambrose et al. 2010). These differences led to us addressing the question of the extent to which the subjectively perceived buyer-supplier relationships can explain the effect of incentives offered by manufacturers on supplier reciprocal behaviour from dimensions of perceived relational factors. We provide evidence that suppliers who perceive high levels of buyer-supplier relationships are more likely to exhibit reciprocal behaviour towards manufacturers' generous actions.

Second, we make a methodological contribution to the research on BOM through the development of combined experimental and survey-based approaches applicable to supply chain relationships. Our previous experimental results suggest that the relationships between manufacturers and suppliers play an important role in supplier reciprocal behaviour towards different types of incentives offered by manufacturers. To understand the moderating role of subjects' perceptions of the strength of

buyer-supplier relationships on the link between incentives by manufacturers and supplier reciprocal behaviour, we methodologically correlated the survey measures of self-reported buyer-supplier relationships with the observed behavioural decisions in the experiment. We found that the survey-based measures consistently confirm the experimental measures of the role of buyer-supplier relationships in motivating supplier reciprocity for restoration capability investment.

Third, our study provides new insights into the research on psychological cognition by comparing the effects of incentive value and type when they are moderated by various types of perceptions of buyer-supplier relationships through the lens of human cognitive processing systems (Kahneman 2003). We advance the existing literature by revealing that suppliers who perceive a high level of buyer-supplier relationship are more responsive to incentive type, which allows them to behave more reciprocally compared with incentive value.

Finally, we extend the research on buyer-supplier relationships by providing insights into the understanding of determinants of various types of perceived buyer-supplier relationships, which complements previous relationship literature regarding supply chains. Specifically, we contribute to the line of research on justice and social preference by examining the role of perpetrator justice sensitivity in the felt obligation to reciprocate. Our results align with the findings in the literature (Baumert et al. 2014, Gollwitzer et al. 2009), which emphasises the importance of perpetrator justice in reciprocal behaviour. In addition, we extend this line of research by synthesising TCE theory and SET, which strengthens our understanding of the role of the perceptions of buyer-supplier relationships when buyers and suppliers interact.

4.5.3 Managerial Implications

Our findings have several managerial implications in supply chain relationship management. First, both the type and the value of incentives are revealed to be positively associated with supplier reciprocal behaviour. Comparison of incentive type and value indicated that suppliers with a high perception level of the buyer-supplier relationship are more responsive to an incentive type that provides a sense of confidence in the manufacturers' incentive decisions by exhibiting reciprocal be-

haviour. Thus, managers of manufacturing firms should place more emphasis on the patterns of incentives, which allows changing investment decisions by suppliers.

Second, an effective interaction is desirable for both parties in a supply chain. Our findings suggest that manufacturing firms can benefit from insights into perceived relational factors, which contribute to the reinforcement of reciprocal behaviour. Suppliers with a high level of relationship perceptions are more likely to follow the reciprocity norm and, thus, may behave more prosocially. For manufacturers, those who place more emphasis on relationship-building can be more effective in motivating supplier reciprocal behaviour. Therefore, the advantage of how relationship partners perceive the relationship allows managers to develop more effective supply chain collaborative strategies.

Finally, the comprehensive understanding of self-aware and other-related perceptions of the buyer-supplier relationship is key for driving relationship success. We suggested that the ambiguity preference and other-regarding preference are positively related to self-perception of the buyer-supplier relationship; whereas, perpetrator justice sensitivity is positively related to the felt obligation for reciprocity. Thus, there is a need for supply chain partners to focus on the characteristics of these two types of perception regarding the relationship between them. Both manufacturers and suppliers should pay attention to the other's preferences, which allows the cultivation of a strong buyer-supplier relationship.

4.5.4 Limitations and Future Research

This study has some limitations. First, several issues regarding sampling should be addressed for future research. Due to time and cost constraints, we used a post-experimental survey to measure differences in the perceptions of relationships between manufacturers and suppliers in a laboratory environment. To enhance the external validity of our findings, further research should focus on field experiments and investigate whether the findings based on laboratory experiments are the same in the real world. Also, our subject pool was limited to students as participants due to resource constraints. Although the existing research on subject-pool effects supports the use of students as participants when examining social preferences in

lab experiments, such a sample still has limited generalisability (Falk et al. 2013). A comparison of the behaviour of student and nonstudent participants in the experiment should be performed. In addition, our sample in the experiment is UK based. Future studies should emphasise sampling from multiple countries, which would contribute to a wider generalisation of the findings.

Second, our experimental design's primary focus was on supplier reciprocal behaviour. As such, the effect of perceptions of the buyer-supplier relationship on the link between manufacturer incentives and supplier reciprocal behaviour was only measured through the lens of suppliers. Future research should explore the perpetual differences between manufacturers and suppliers. Furthermore, we suggest that future studies focus on the prosocial behaviour of manufacturers. For manufacturers, their decisions regarding incentives may be motivated by trust attitudes. Thus, future research could extend investigations on the effect of the perceptions of the relationship on trust behaviour from the perspective of manufacturers.

Third, one limitation in the conceptual model is concerning. We measured subjects' self-perceptions of the relationship with paired partners by asking them about their perceptions of the strength of the relationship directly. In contrast, the felt obligations for reciprocity was measured by drawing upon a valid survey developed by Caliendo et al. (2012), which allows for a measure of positive reciprocity through three measurement items. Future research should explore the measurement items underlying the self-perception of relationships, which would allow for a comprehensive comparison between these two perceived relational factors. Moreover, the determinants used for the perceptions of the buyer-supplier relationship were constrained by the context of our study. For example, we only predicted perpetrator justice sensitivity that involves a two-sided nature of perception as a characteristic of the felt obligation to reciprocate in a dyadic relationship. We suggest that a broader range of factors applicable to a wider generalisation should be explored in the future.

4.6 Conclusions

This paper examined the effects of survey-measured perceived relational factors on the link between experimentally observed manufacturer incentives and supplier investment decisions. Regarding manufacturer incentive decisions, we specifically distinguished between incentive type and incentive value to explain the moderating roles. Taken together, both perceived relational factors were revealed to positively moderate the relationship between incentives by manufacturers and supplier reciprocal behaviour. In particular, suppliers who are more responsive to incentive type, rather than incentive value, are more likely to exhibit reciprocal behaviour. In addition, we provide evidence that although the experimental relationship was manipulated to reflect long-term and short-term conditions, the survey-measured perceptions of the buyer-supplier relationship nevertheless confirm the influence of these perceptions on the relationship between manufacturers' incentive and suppliers' investment decisions. We further provide insights into an understanding of the underlying determinants that drive the perceived relational factors within an exchange relationship.

Chapter 5

Conclusions and Future Research

5.1 Conclusions

This thesis contributes to the field of BOM by incorporating the theory of reciprocity into supply-chain disruption contexts to study how reciprocity impacts supply chain decisions. Supply chain disruptions are unpredictable and, most often, have detrimental economic consequences on supply-chain performance. When a disruption occurs, the manufacturer generally suffers greatly. Thus, building a cooperative relationship between supply-chain partners is critical to strengthen restoration capability and, thus, improve supply-chain recovery outcomes and efficiency. Inducing the supplier to jointly contribute to restoration capability investment raises the question of under what circumstances can incentives play a more effective role. We are interested in how the incentives offered by the manufacturer can motivate supplier reciprocity when making investment decisions regarding capability restoration. In our setting, both the manufacturer and the supplier are decision-makers. The manufacturer decides the type and value of incentive offered; whereas, the supplier decides whether or not to invest in restoration capability depending on the manufacturer's decisions, and, if so, what amount to invest. In this thesis, we begin by analytically interpreting the processes and consequences of their decisions in the context of supply chain disruption through treemaps. Using our analytical results, we investigate whether the subjects' behaviour deviates from the theoretical predictions in a laboratory environment. Following the experiment, we evaluate the subjects'

own perceptions of relationships in supply chains by employing a post-experiment survey approach.

In Chapter 2, we develop analytical models to investigate the effects of two incentive mechanisms on supplier restoration-capability investment that signals their concerns for reciprocity. In a traditional economy, decision-makers are assumed to be self-interested. Based on this assumption, suppliers are likely to free ride when manufacturers make decisions that benefit them. However, behavioural studies in economics have revealed that people have concerns about others' benefits in addition to their own interests. Thus, the need for emotion-based incentives is a matter of concern also. Compared with a conditional incentive that is realised after a disruption, an unconditional incentive offered prior to disruption is recognised as more generous and pragmatic. Assuming both incentives are economically equivalent, the unconditional incentive that involves the proactive and unconditional attributes serves as a more effective mechanism to induce higher levels of investment by suppliers. In addition to the types of incentive, the modelling of reciprocal behaviour is also based on the types of uncertainty about future recovery outcomes. The probabilities of disruption recovery outcomes are classified into two categories: known and unknown. Recent studies in behavioural economics indicate that people differ regarding future decisions based on subjective attitudes towards future outcomes. We discuss four types of beliefs based upon different degrees of recovery outcomes, including optimistic, pessimistic, most likely and neutral. However, the unconditional incentive mechanism is more effective at motivating reciprocity, especially when an ambiguous prospect for recovery outcomes is anticipated with less optimism.

Following Chapter 2, we further investigate supplier investment decisions that reflect reciprocal behaviour towards the incentives offered by the manufacturer in a laboratory environment. The experimental study refers to an incentive-investment sequential move game that involves two human players. Our design of decision-variables is innovative, in which we give each group of manufacturer-players an option to select between the two incentive types, rather than imposing a treatment on them. We observe that a Direct incentive condition strengthens the supplier's investment level towards a higher incentive offered by the manufacturer. In addition,

our design involves a further two manipulations: the types of manufacturer-supplier relationship and the uncertainty regarding future recovery outcomes. In a long-term exchange relationship that strengthens the preference for reciprocity, offering an unconditional incentive prior to disruption can lead to a synergistic effect in motivating the supplier's desire to reciprocate, and, thus, invest more in restoration capability. Moreover, in repeated interactions, people in labour relations tend to imitate reciprocity (Gächter and Falk 2002). Our results echo the arguments that supply-chain parties adjust their strategies when they repeatedly interact. The parties learn to adjust their behaviours towards equilibrium outcomes that are motivated by their intrinsic reciprocity. Accordingly, the parties' selfish motives of maximising their own benefits can be restrained. The results of our investigations on subjects' behaviour under known vs. unknown uncertainties provide evidence that manufacturer-players who choose Direct incentive are ambiguity averse to offering the incentive value when the probability of the future recovery outcome is unknown.

In fact, reciprocity is interpreted as a process of exchange relationship. Our experimental study emphasises the importance of successful relationships in social interactions. Using our experimental design, the relationship treatment is deliberately imposed on subjects. However, people are psychologically revealed to be heterogeneous in relationship perceptions and, accordingly, their decisions may vary with their own perceptions or attitudes towards the other party's behaviour. Thus, the understanding of the subjects' own perceptions of the relationship plays a vital role. In a laboratory environment, we failed to obtain further insights into how subjects' own perceptions of the relationship affect their emotion-based behaviour and decision-making. To address this problem, each subject was asked a set of questions regarding emotional characteristics at the end of the main experiment. Chapter 4 furthers the experimental study by considering the subjects' individual differences about relationship perceptions, as well as the factors influencing their perceptions. We incorporate the experimental data into the post-experiment survey data and investigate the moderating roles of these buyer-supplier relationship perceptions in the relationship between manufacturer incentive and supplier investment decisions. The survey-based measure provides some perceptive insights by distinguishing be-

tween the roles of self- and other-perceptions of buyer-supplier relationships in the relationship between behavioural decisions made by both parties. We illustrate that both moderators strengthen the effects of an unconditional incentive mechanism on supplier investment decisions regarding restoration capability.

We further advance the existing research on social psychology by extending the understanding of the factors that affect subjects' perceptions of a successful buyer-supplier relationship. Under an environmental uncertainty, people with higher ambiguity tolerance are more likely to have optimistic expectations of future outcomes and, accordingly, are more willing to contribute to a successful buyer-supplier relationship. An explanation for the role of other-regarding motivation, which interprets subjects' altruism in benefiting others, can serve as a signal of spontaneous motivation for a strong buyer-supplier relationship. However, these factors are more related to subjects' self-perception. On the other hand, subjects' relationship perceptions are closely tied to other-perception, in which the subjects shape their perceptions by observing others. The other-perception that involves a two-sided interaction provides an explanation for positive reciprocity that governs social relationships. To achieve a better understanding of exchange parties' sense of positive reciprocity in supply-chain relationships, the reactions that both parties present after having perceived fairness is important to investigate. We highlight the importance of perpetrator justice sensitivity, which interprets people's sensitivity to benefit from treating others unfairly in shaping relationship perceptions.

5.2 Future Research

This thesis provides a number of directions for future research. First, in our model development, for simplicity, we follow a study by Hu et al. (2013) that assumes that market demand is determinant. In fact, an uncertain demand may be closer to the practice. Therefore, a future study could employ stochastic demand to investigate how the uncertainty of order quantity affects both the manufacturer's and the supplier's decisions and social behaviour. Regarding the assumptions of market price and order quantity, we set the same values before and after disrup-

tions. In a future study, we could relax this assumption and further investigate supplier reciprocity towards the manufacturer's incentive offered with the changes of price and quantity.

Second, the existing research on the reciprocity factor has no universal measurement. In our experiment, we assigned a set of various multipliers for reciprocity to capture supplier reciprocal behaviour under different treatment conditions. In particular, we assigned ambiguous uncertainty with an unconditional incentive the highest multiplier. Nevertheless, the experimental results provide evidence for the opposite, that suppliers continue to be ambiguity- averse and, accordingly, exhibit less reciprocity when an unconditional incentive is offered. Thus, a future study could explore the dynamics of the multiplier towards different scenarios.

Third, we could extend our experiment conducted in a laboratory environment by testing whether the results can be applied in the field. In this experimental study, we used student pools as our subjects due to time and cost constraints. Although the use of student subject pools has been widely acknowledged in most experimental studies, such pools may not be representative for the entire population. Thus, the extent to which experimental results from student subject pools can be generalised to non-student pools is important to consider. A further study should contain non-students from different backgrounds as the subject pools. Also, the sample of this study is UK based. As Özer et al. (2014) documented, individuals from different countries have different patterns of trust behaviour regarding information-sharing in supply chains. This observation suggests that, for a future study, samples from different countries should be incorporated.

Methodologically, we used the Wilcoxon rank-sum test to compare results between two independent groups with the data at an individual level. However, this method is insufficient to consider both the number of rounds and choice of incentive offered. A future study should focus on how the frequency of the incentive type chosen impacts supplier reciprocity. In our experimental design, we offered the manufacturer-player a choice of incentive type, rather than treat the incentive type as an extraneous variable. Further investigations on how reciprocity works for suppliers under imposed incentive conditions should provide a clear contrast between

these two treatment designs.

Finally, this thesis primarily focused on supplier reciprocal behaviour following the manufacturer's incentive offer. Manufacturer behaviour, such as trust and trustworthiness, also exert an important role in eliciting supplier reciprocity. Thus, it would be worthwhile to study social behaviour from the perspectives of both the manufacturer and the supplier. Also, the existing literature classified reciprocity into two categories: positive and negative. This thesis emphasises supplier positive reciprocity more. In our experimental design, we mainly focused on the aspect of positive reciprocity. Specifically, we considered supplier reciprocity to be positive if they invest towards the manufacturer incentive. However, it may be likely that, under an incomplete contract, the supplier would free ride on the manufacturer's offered incentive. A possible punishment for supplier opportunistic behaviour could be considered in future study.

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Appendix A

Proofs and Figures for Chapter 2

A.1 Decision approach description

A.1.1 Manufacturer's decision

In the Manufacturer's Decision Tree (See Figure 2.2), the primary decision is to determine whether to provide an incentive prior to or after disruptions. The 'Direct incentive' branch is denoted by S_1, while the 'Indirect incentive' branch is denoted by S_2. Following the initial stage decision, there are two possible sequential outcomes for restoration capability investment: 'Invest' and 'Do not invest'. These two possibilities are decisions made by the supplier, while for the manufacturer they are chance events. For both choices, two states are then considered: Normal Status and Disrupted Status. If the supplier chooses to invest, the manufacturer faces three possible recovery outcomes: full recovery, partial recovery, no recovery. The probability of each recovery outcome can be either known or unknown. With regard to the beliefs about either known or unknown likelihood of recovery outcomes, there exist four possible scenarios which refer to pessimistic, optimistic, most likely and neutral.

A.1.2 Supplier's decision

Following the manufacturer's first stage decision, the supplier needs to decide whether to invest in restoration capability or not. In the Supplier's Decision Tree

(See Figure 2.3), 'Invest' or 'Do not invest' in restoration capability are considered as decision events, while in the Manufacturer's Decision Tree they are considered as chance events. From the social preference perspective, the supplier's decision to invest in restoration capability and the cost of the investment F can be considered as a proxy of reciprocity exerted by the supplier. The reciprocity is either not straightforwardly observable or, even if it can be observed, it is difficult to measure *per se*. To better understand how the supplier's reciprocal behaviour works, this study measures it by comparing the supplier's investment value in restoration capability to the manufacturer's incentive offered. We use a Bayesian approach to demonstrate how the supplier's investment decision influences the outcomes of supply chain disruption recovery.

A.2 Proof of Lemma 1

As shown in (8) above, the manufacturer's total expected value under Direct incentive Π_m^D is equal to the difference between the weighted sum of Π_1^D and Π_2^D by α^D and the incentive value I^D. Under Direct incentive, the profit function of 'Do invest in restoration capability', Π_1^D, is the weighted sum of Π_{N} and π_E^D by the disruption probability, β, where

$$\Pi_1^D = (1-\beta)\Pi_{\text{N}} + \beta\pi_E^D$$

The profit function of 'Do not invest in restoration capability', Π_2^D, is represented as

$$\Pi_2^D = (1-\beta)\Pi_{\text{N}} + \beta L$$

In the Manufacturer's Decision Tree, the monetary values of the branches marked 'Normal Status' are

$$\Pi_{\text{N}} = (p_1 - w_1)q_1$$

The expected value of the branch marked 'Disrupted Status' under Direct incen-

tive is given as

$$\pi_E^D = \sum_{i=1}^{N} \mu_i \pi_i^b = \mu_1(p_2 - w_1)q_1 + \theta\mu_2(p_2 - w_1)q_1 - \mu_3(p_2 - w_1)q_1$$

$$\begin{cases} \pi_1^b = (p_2 - w_1)q_1 & \text{full recovery} \\ \pi_2^b = \theta(p_2 - w_1)q_1 \ (0 < \theta < 1) & \text{partial recovery} \\ \pi_3^b = -(p_2 - w_1)q_1 & \text{no recovery} \end{cases}$$

Let $K = \mu_1 + \theta\mu_2 - \mu_3$, the the above equation can be written as $\pi_E^D = K \cdot (p_2 - w_1)q_1$.

Under Indirect incentive, as shown in (5), the manufacturer's total expected value is calculated in the same way as in the Direct incentive condition. Likewise, the profit function of 'Do invest in restoration capability' under Indirect incentive, Π_1^{I}, is the weighted sum of Π_{N} and π_E^I by the disruption probability, β, where

$$\Pi_1^{\mathrm{I}} = (1 - \beta)\Pi_{\mathrm{N}} + \beta\pi_E^I$$

The profit function of 'Do not invest in restoration capability',Π_{I}^2, is represented as

$$\Pi_2^{\mathrm{I}} = (1 - \beta)\Pi_{\mathrm{N}} + \beta L$$

The expected value of the branch marked 'Disrupted Status' under indirect incentive is given as

$$\pi_E^I = \sum_{i=1}^{N} \mu_i \pi_i^{b'} = \mu_1(p_2 - w_2)q_2 + \theta\mu_2(p_2 - w_2)q_2 - \mu_3(p_2 - w_2)q_2$$

$$\begin{cases} \pi_1^{b'} = (p_2 - w_2)q_2 & \text{full recovery} \\ \pi_2^{b'} = \theta(p_2 - w_2)q_2 \ (0 < \theta < 1) & \text{partial recovery} \\ \pi_3^{b'} = -(p_2 - w_2)q_2 & \text{no recovery} \end{cases}$$

Likewise, the equation can be simplified as $\Pi_1^{I,d} = K \cdot (p_2 - w_2)q_2$. The manufacturer's total expected payoff under Indirect incentive is calculated in terms of the below equation:

$$\Pi_m^I = \alpha^I \Pi_1^I + (1 - \alpha^I)\Pi_2^I \tag{A.2.1}$$

We substitute above mentioned (1) into (17), then we have the following expansion equation.

$$\Pi_m^I = K\beta\alpha^I M_2 q_2 - K\beta\alpha^I q_2^2 - K\beta\alpha^I w_2 q_2 + (1-\beta)(p_1 - w_1)q_1 + (1-\alpha^I)\beta L$$

Taking the derivative of the manufacturer's payoff under Indirect incentive Π_m^I with respect to q_2, it gives

$$\frac{\partial \Pi_m^I}{\partial q_2} = K\beta\alpha^I M_2 - 2K\beta\alpha^I q_2 - K\beta\alpha^I w_2 = 0$$

$$q_2^* = \frac{M_2 - w_2}{2}$$

We can further obtain that

$$p_2^* = \frac{M_2 + w_2}{2}$$

Next, let us substitute (20) into (13) it gives

$$\Pi_s^I = (1-\beta)\Pi_N' + \frac{1}{2}K\beta(M_2 w_2 - M_2 c_2 - w_2^2 + w_2 c_2)$$

Taking the derivative of the supplier's payoff under Indirect incentive Π_s^I with respect to w_2, it gives

$$\frac{\partial \Pi_s^I}{\partial w_2} = \frac{1}{2}K\beta M_2 - K\beta w_2 + \frac{1}{2}K\beta c_2$$

$$w_2^* = \frac{M_2 + c_2}{2}$$

A.3 Proof of Lemma 3

Based on the proof of lemma 1, the manufacturer's total expected payoff under Direct incentive can be expressed as

$$\Pi_m^D = \alpha^D \Pi_1^D + (1 - \alpha^I)\Pi_2^D$$

To simplify the Inequality $\Pi_m^D > \Pi_m^I$, it can yield the result that

$$0 < I^D < \beta[\alpha^D(\sum_{i=1}^{N} \mu_i \pi_i^b - L) - \alpha^I(\sum_{i=1}^{N} \mu_i \pi_i^{b'} - L)]$$

It is clear that the upper value of I^D must follow $I^D > 0$, which induces the relationship between α^D and α^I through a comparison between $\sum_{i=1}^{N} \mu_i \pi_i^{b'}$ and $\sum_{i=1}^{N} \mu_i \pi_i^b$. If $\alpha^D > \alpha^I$, the sizes of $\sum_{i=1}^{N} \mu_i \pi_i^{b'}$ and $\sum_{i=1}^{N} \mu_i \pi_i^b$ depend on the value of w_i and q_i, for $i = 1, 2$. When $q_2 > q_1, w_1 = w_2$, then we have $\sum_{i=1}^{N} \mu_i \pi_i^{b'} > \sum_{i=1}^{N} \mu_i \pi_i^b$. When $q_2 = q_1, w_2 > w_1$, then it follows $\sum_{i=1}^{N} \mu_i \pi_i^{b'} < \sum_{i=1}^{N} \mu_i \pi_i^b$. When $q_2 > q_1, w_2 > w_1$, the relationship of $\sum_{i=1}^{N} \mu_i \pi_i^{b'}$ and $\sum_{i=1}^{N} \mu_i \pi_i^b$ depends on the product value of $w_i q_i$. To sum up, we see that the upper value of I^D can be satisfied without restricted comparison in boundary between $\sum_{i=1}^{N} \mu_i \pi_i^{b'}$ and $\sum_{i=1}^{N} \mu_i \pi_i^b$. By contrast, if $\alpha^D < \alpha^I$, it suggests that $\frac{\sum_{i=1}^{N} \mu_i \pi_i^{b'}}{\sum_{i=1}^{N} \mu_i \pi_i^b} < 1$ and thereby satisfying $I^D > 0$.

A.4 Proof of Lemma 4

When Direct and Indirect incentives are economically equivalent for the manufacturer, the less incentive value offered the more efficient for the corresponding incentive type. We make a comparison between Direct and Indirect incentive. The comparative value ratio depends on the loss suffered by the manufacturer in case the supplier does not invest.

$$\Theta = \frac{\hat{I^D}}{\hat{I^I}} = \frac{\beta[\alpha^D(\sum_{i=1}^{N} \mu_i \pi_i^b - L) - \alpha^I(\sum_{i=1}^{N} \mu_i \pi_i^{b'} - L)]}{(w_2 q_2 - w_1 q_1)}$$

Let $\Theta < 1$, the loss value that satisfying $I^D < I^I$ can be categorised into three different conditions:

(a) if $\alpha^D > \alpha^I$*, then* $\frac{\beta(\alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b - \alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'}) - I^I}{\beta(\alpha^D - \alpha^I)} < L < 0$*;*

(b) if $\alpha^D < \alpha^I$*, then* $\frac{\alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'} - \alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b}{\alpha^I - \alpha^D} < L < 0$*;*

(c) if $\alpha^D = \alpha^I$*, then the loss value* L *has no effect on* Θ*.*

As for the condition that $\alpha^D > \alpha^I$, we see that the denominator $\beta(\alpha^D - \alpha^I) > 0$. Thus, to satisfy $L < 0$ it requires $\beta(\alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b - \alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'}) - I^I > 0$. Then we have $\beta < \frac{I^I}{\alpha^D \sum_{i=1}^{N} \mu_i \pi_i^b - \alpha^I \sum_{i=1}^{N} \mu_i \pi_i^{b'}}$.

A.5 Proof of Theorem 1

The supplier's upper value of F^D and F^I is the difference in payoff between two investment decisions under Direct and Indirect incentive, respectively, with risky certainty, while the upper value of $F^{D'}$ and $F^{I'}$ denote those with ambiguous uncertainty.

$$\begin{cases} \hat{F^D} = \Pi_1^{\mathrm{D}'} - \Pi_2^{\mathrm{D}'} + \lambda I^D - I^D \\ \hat{F^I} = \Pi_1^{\mathrm{I}'} - \Pi_2^{\mathrm{I}'} \\ \hat{F^{D'}} = \Pi_1^{\mathrm{D}''} - \Pi_2^{\mathrm{D}'} + \lambda I^D - I^D \\ \hat{F^{I'}} = \Pi_1^{\mathrm{I}''} - \Pi_2^{\mathrm{I}'} \end{cases}$$

The profit function of 'Do invest in restoration capability' under Direct incentive with risky certainty, $\Pi_1^{\mathrm{D}'}$, is the weighted sum of Π_{N}' and $\pi_{\mathrm{E}}^{\mathrm{D}'}$ by the disruption probability, β, where

$$\Pi_1^{\mathrm{D}'} = (1-\beta)\Pi_{\mathrm{N}}' + \beta\pi_{\mathrm{E}}^{\mathrm{D}'}$$

The profit function of 'Do not invest in restoration capability' under Direct incentive, $\Pi_2^{\mathrm{D}'}$, is represented as

$$\Pi_2^{\mathrm{D}'} = (1-\beta)\Pi_{\mathrm{N}}' + \beta L$$

While under Indirect incentive, the above profit functions are expressed respectively as

$$\Pi_1^{\mathrm{I}'} = (1-\beta)\Pi_{\mathrm{N}}' + \beta\pi_{\mathrm{E}}^{\mathrm{I}'}$$
$$\Pi_2^{\mathrm{I}'} = \Pi_2^{\mathrm{D}'}$$

In the Supplier's Decision Tree, the monetary values of the branches marked 'Normal Status' are the same where,

$$\Pi_{\mathrm{N}}' = (w_1 - c_1)q_1$$

If the supplier invests, the expected payoff when disruption occurs under Direct incentive with risky certainty is

$$\pi_{\mathrm{E}}^{\mathrm{D}'} = \sum_{i=1}^{N} \mu_i \pi_i^s$$

The payoff under Direct incentive with ambiguous uncertainty is

$$\pi_{\mathrm{E}}^{\mathrm{D}''} = \sum_{i=1}^{N} \delta\mu_i \pi_i^s$$

Specifically, the expected payoffs of the three types of disruption recovery degree are respectively represented as

$$\begin{cases} \pi_1^s = (w_1 - c_2)q_1 \\ \pi_2^s = \theta \cdot (w_1 - c_2)q_1 \quad (0 < \theta < 1) \\ \pi_3^s = -(w_1 - c_2)q_1 \end{cases}$$

Likewise, the expected payoff of working with the contractual supplier under Indirect incentive is

$$\pi_{\mathrm{E}}^{\mathrm{I}'} = \sum_{i=1}^{N} \mu_i \pi_i^{s'}$$

The payoff under Indirect incentive with ambiguous uncertainty is

$$\pi_{\mathrm{E}}^{\mathrm{I}''} = \sum_{i=1}^{N} \delta\mu_i \pi_i^{s'}$$

In this case, the expected payoffs of the three types of disruption recovery degree are respectively expressed as

$$\begin{cases} \pi_1^{s'} = (w_2 - c_2)q_2 \\ \pi_2^{s'} = \theta \cdot (w_2 - c_2)q_2 \quad (0 < \theta < 1) \\ \pi_3^{s'} = -(w_2 - c_2)q_2 \end{cases}$$

The supplier's upper investment value under each of four situations can be simplified as

$$\begin{cases} \hat{F^D} = \beta(\sum_{i=1}^{N} \mu_i \pi_i^s - L) + (\lambda - 1)I^D \\ \hat{F^{D'}} = \beta(\delta\lambda \sum_{i=1}^{N} \mu_i \pi_i^s - L) + (\lambda + \delta - 1)I^D \\ \hat{F^I} = \beta(\sum_{i=1}^{N} \mu_i \pi_i^{s'} - L) \\ \hat{F^{I'}} = \beta(\delta \sum_{i=1}^{N} \mu_i \pi_i^{s'} - L) \end{cases}$$

Notably, in the case that the profit functions of the supplier's decision to invest are negative, we limit the value of F^D and F^I to 0.

By considering the impact of ambiguous uncertainty on the supplier reciprocity, we derive the parameter δ which satisfies $\frac{F^{D'}}{I^D} > \frac{F^{I'}}{I^I}$. Let $I^D = I^I$, then we have the following result

$$\beta(\delta\lambda \sum_{i=1}^{N} \mu_i \pi_i^s - L) + (\lambda + \delta - 1)I^D > \beta(\delta \sum_{i=1}^{N} \mu_i \pi_i^{s'} - L)$$

Accordingly, we can obtain a lower bound of δ

$$\underline{\delta} \equiv \frac{(1-\lambda)I^D}{\beta(\lambda \sum_{i=1}^{N} \mu_i \pi_i^s - \sum_{i=1}^{N} \mu_i \pi_i^{s'}) + I^D} < \delta < 1$$

A.6 Proof of Theorem 2

Based on the lower bound $\underline{\delta}$, we see that $\underline{\delta}$ needs to satisfy $0 < \underline{\delta} < 1$. When $\underline{\delta} < 1$, we have the below result:

$$(1-\lambda)I^D < \beta(\lambda \sum_{i=1}^{N} \mu_i \pi_i^s - \sum_{i=1}^{N} \mu_i \pi_i^{s'}) + I^D$$

Accordingly, we can derive a lower bound of λ as follows

$$\lambda > \frac{\beta \sum_{i=1}^{N} \mu_i \pi_i^{s'}}{\beta \sum_{i=1}^{N} \mu_i \pi_i^{s} + I^D}$$

On the other hand, taking account of the supplier reciprocity in incentive type dimension, we derive another lower bound of λ that satisfies $F^D > F^I$ by letting $I^D = I^I$.That is

$$\beta(\sum_{i=1}^{N} \mu_i \pi_i^{s} - L) + (\lambda - 1) I^D > \beta(\sum_{i=1}^{N} \mu_i \pi_i^{s'} - L)$$

Thus another lower bound of λ is

$$\lambda > \frac{\beta(\sum_{i=1}^{N} \mu_i \pi_i^{s'} - \sum_{i=1}^{N} \mu_i \pi_i^{s})}{I^D} + 1$$

We compare the two lower bounds of λ and find that the latter bound clearly supports our assumption that $\lambda > 1$. Thus the latter one is used as the lower bound of λ in Theorem 2.

Refer back to the lower bound of δ, let $\underline{\delta} > 0$, as $\lambda > 1$, it requires to simultaneously meet

$$\begin{cases} (1-\lambda) I^D < 0 \\ \beta(\lambda \sum_{i=1}^{N} \mu_i \pi_i^{s} - \sum_{i=1}^{N} \mu_i \pi_i^{s'}) + I^D < 0 \end{cases}$$

Accordingly, we can derive a range of λ

$$\frac{\beta(\sum_{i=1}^{N} \mu_i \pi_i^{s'} - \sum_{i=1}^{N} \mu_i \pi_i^{s})}{I^D} + 1 < \lambda < \frac{\beta \sum_{i=1}^{N} \mu_i \pi_i^{s'} - I^D}{\beta \sum_{i=1}^{N} \mu_i \pi_i^{s}}$$

A.7 Notation

Table A.1: Notation of parameters in Manufacturer's Decision Tree

$\Pi_{\mathrm{m}}^{\mathrm{D}}$	Manufacturer's expected payoff under Direct incentive
$\Pi_{\mathrm{m}}^{\mathrm{I}}$	Manufacturer's expected payoff under Indirect incentive
I^D	direct incentive value
I^I	indirect incentive value
Π_1^{D}	Manufacturer's expected payoff of 'Invest' in restoration capability under Direct incentive
Π_2^{D}	Manufacturer's expected payoff of 'Do not Invest' in restoration capability under Direct incentive
Π_1^{I}	Manufacturer's expected payoff of 'Invest' in restoration capability under Indirect Incentive
Π_2^{I}	Manufacturer's expected payoff of 'Do not Invest' in restoration capability under Indirect incentive
α^D	Probability of 'Invest' in restoration capability under Direct incentive
α^I	Probability of 'Invest' in restoration capability under Indirect incentive
β	Disruption probability
L	loss arising from 'Not Invest' in restoration capability
Π_{N}	Manufacturer's expected payoff when no disruption occurs
$\pi_{\mathrm{E}}^{\mathrm{D}}$	Manufacturer's expected payoff of working with the existing supplier under Direct incentive
$\pi_{\mathrm{E}}^{\mathrm{I}}$	Manufacturer's expected payoff of working with the existing supplier under Indirect incentive
π_1^b	Manufacturer's expected payoff of full disruption recovery under Direct incentive
π_2^b	Manufacturer's expected payoff of partial disruption recovery under Direct incentive
π_3^b	Manufacturer's expected payoff of no recovery under Direct incentive
$\pi_1^{b'}$	Manufacturer's expected payoff of full disruption recovery under Indirect incentive
$\pi_2^{b'}$	Manufacturer's expected payoff of partial disruption recovery under Indirect incentive
$\pi_3^{b'}$	Manufacturer's expected payoff of no recovery under Indirect incentive

Table A.2: Notation of parameters in Supplier's Decision Tree

Π_s^D	Supplier's expected payoff under Direct incentive
Π_s^I	Supplier's expected payoff under Indirect incentive
F^D	Value of investment in restoration capability under Direct incentive
F^I	Value of investment in restoration capability under Indirect incentive
$\Pi_1^{D'}$	Supplier's expected payoff of 'Invest' in restoration capability under Direct incentive
$\Pi_2^{D'}$	Supplier's expected payoff of 'Do not Invest' in restoration capability under Direct incentive
$\Pi_1^{I'}$	Supplier's expected payoff of 'Invest' in restoration capability under Indirect incentive
$\Pi_2^{I'}$	Supplier's expected payoff of 'Do not Invest' in restoration capability under Indirect incentive
$\Pi_{N'}$	Supplier's expected payoff when no disruption occurs
$\pi_E^{D'}$	Supplier's expected payoff of working with contractual supplier under Direct incentive
$\pi_E^{I'}$	Supplier's expected payoff of working with contractual supplier under Direct incentive
π_1^s	Supplier's expected payoff of full disruption recovery under Direct incentive
π_2^s	Supplier's expected payoff of partial disruption recovery under Direct incentive
π_3^s	Supplier's expected payoff of no recovery under Direct incentive
$\pi_1^{s'}$	Supplier's expected payoff of full disruption recovery under Indirect incentive
$\pi_2^{s'}$	Supplier's expected payoff of partial disruption recovery under Indirect incentive
$\pi_3^{s'}$	Supplier's expected payoff of no recovery under Indirect incentive
μ_1	Probability of full disruption recovery under Direct incentive
μ_2	Probability of partial disruption recovery under Direct incentive
μ_3	Probability of no recovery under Direct incentive
θ	Proportion of partial disruption recovery
λ	Reciprocity loading factor for the type of incentive offered
δ	Reciprocity loading factor for the type of uncertainty about future recovery outcomes
w_1	Regular wholesale price
w_2	Disruption wholesale price
q_1	Regular order quantity
q_2	Disruption order quantity
p_1	Marketing price with no disruption
p_2	Marketing price with disruption
c_1	Regular production cost
c_2	Disruption production cost

Appendix B

Experimental Design, Figures and Tables for Chapter 3

B.1 Experimental Instructions

Welcome to the Experimental Laboratory! Please make sure your mobile phone and all other electronic devices are turned off now! This is an experiment regarding business decision-making between a Manufacturer and a Supplier. Depending on the decisions you made, you will be able to earn a considerable amount of money which will be paid to you in cash at the end of the experiment. You will be given 5GBP show-up fee. During the experiment, your earnings are given in Points. At the end of the experiment, your total points will be converted to CASH value based on the exchange rate, where 1GBP = 1,000 points. It is important that you are strictly not allowed to communicate during the experiments. Please raise your hand if you have any question, an experimenter will come to help you. Non-compliance with this rule will lead to an exclusion from the experiment and your cash earnings will be 0. This experiment consists of 28 rounds, starting with 3 practice rounds to help you get familiar with the experimental mechanism, followed by 25 rounds where your earning will be actually based upon. After the experiment, you will be asked to complete a short questionnaire. It may help you to understand the decision situation if you carefully think about the following scenario. You will then be asked a couple of control questions to make sure you understand the instruction.

B.2 Questions for Manipulation Check

The following control questions are only designed to test subjects' understanding of the experiment as described in the previous instructions.

1. The manufacturer can offer an incentive from two options. Which one is the unconditional incentive?

   (a) Direct incentive

   (b) Indirect incentive

2. Which one is the promise-based incentive that is effective only if the supplier invests in recovery capability?

   (a) Direct incentive

   (b) Indirect incentive

3. Do you play with _____ each round?

   (a) a fixed player

   (b) a different player

4. How likely is the supply chain recoverable with the supplier's investment in recovery capability ?

   (a) Above 50

   (b) It is likely but unsure about probability

5. Both the manufacturer and the supplier initially have 100 points endowment. For example the manufacturer has offered the supplier the Direct incentive with 50 points. Now the supplier has 375 points in total and the supplier decides to invest 190 points. Please calculate payoffs of the manufacturer and the supplier. [Payoff Manufacturer = Endowment - Incentive value offered + Supplier's investment amount; Payoff Supplier = Supplier's total amount available - Investment amount].

(a) Manufacturer: 240 points; Supplier: 185 points

(b) Manufacturer: 185 points; Supplier: 240 points

B.3 The Incentive-Investment Game

In the following, we give a specific example to illustrate how the two players are interacted in the game. We take RU-RG treatment as an example. If the manufacturer offers a Direct incentive with 50 points under risk condition in a long-term relationship, the supplier will receive 375 points in total. The contexts shown on manufacturer and supplier players' screens are described as follows.

B.3.1 Manufacturer Screen

Round No.: 1. You are paired with a fixed player.

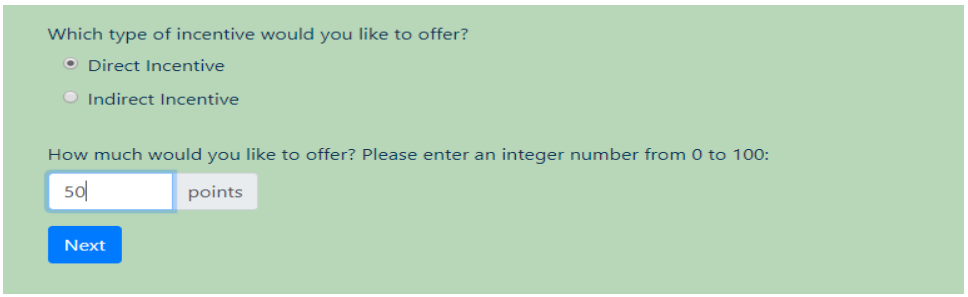
You are the Manufacturer. Your company, competing in high technology industry, produces mobile phone with the high capacity requirements. Due to a fire accident in the past, you are unable to fulfil the order placed by your customers such that you have suffered great financial and reputation losses. You are aware of the importance of securing your supplier's capacity to ensure the uninterrupted flow of production to serve the end customers. Thus you consider offering an incentive to motivate your supplier to invest in a new production site that can be used as a contingency plan to recover capacity from future disruptions (if any). In this experiment, you can choose between Direct incentive and Indirect incentive. The Direct incentive is paid upfront before a disruption occurs without any condition while the Indirect incentive is a promise-based contract which becomes effective only if the supplier invests in recovery capability, via increasing the wholesale price. Depending on the nature of the disruption event, there are three possible outcomes of recovery: (1) full recovery (i.e. leads to highest payoff); (2) partial recovery (i.e. leads to medium payoff); (3) no recovery (i.e. leads to lowest payoff). If your supplier decides to invest in recovery capacity, above 50% chance the supply chain is recoverable. You have 100 points endowment with which you can offer an incentive.

Below are the formulas for payoff calculations:

Manufacturer Payoff = Endowment - Incentive value offered + Supplier's investment amount

Supplier Payoff = Supplier's total amount available - Investment amount

1. Which type of incentive would you like to offer?
   (a) Direct incentive
   (b) Indirect incentive
2. How much would you like to offer? Please enter an integer number from 0 to 100: _____ points



B.3.2 Supplier Screen

Round No.: 1. You are paired with a fixed player.

You are the key Supplier for a mobile phone manufacturer. Due to a fire accident in the past, you are unable to supply products required by your manufacturer such that both of you have suffered great financial and reputation losses. Facing the possibility of disruption risk (i.e. a risk that unable to supply), your manufacturer tries to encourage you to invest in a new production site as a backup capacity plan. Currently, your manufacturer considers offering you one type of incentive, either Direct or Indirect. The Direct incentive is paid upfront before a disruption occurs without any condition while the Indirect incentive is a promise-based contract which becomes effective only if the supplier invests in recovery capability, via increasing the wholesale price. After the incentive offered, you then decide whether to invest in recovery capability. Depending on the nature of the disruption event, there are three

possible outcomes of recovery: (1) full recovery (i.e. leads to highest payoff); (2) partial recovery (i.e. leads to medium payoff); (3) no recovery (i.e. leads to lowest payoff). If you decide to invest, above 50% chance the supply chain is recoverable. The manufacturer has offered you the Direct Incentive with **50** points. Now you will have **375** points and you can decide to invest some, all or none of your points to build up restoration capability.

Below are the formulas for payoff calculations:

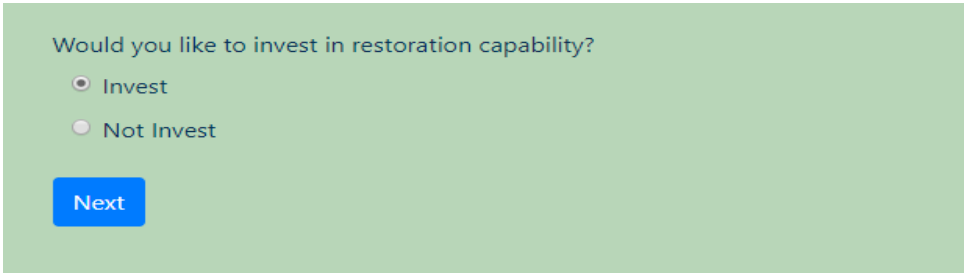
Manufacturer Payoff = Endowment - Incentive value offered + Supplier's investment amount

Supplier Payoff = Supplier's total amount available - Investment amount

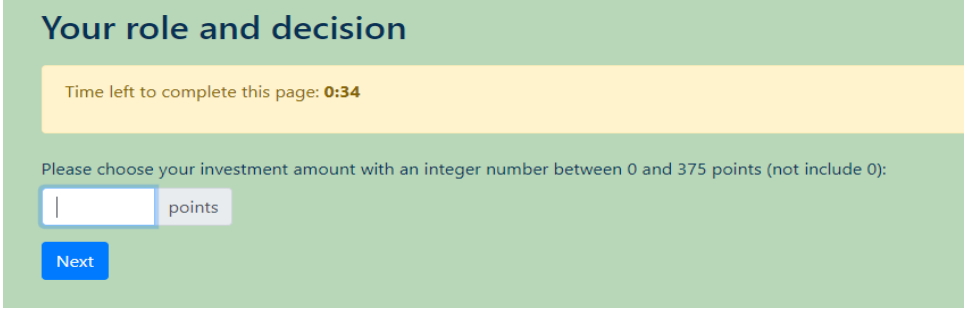
1. Would you like to invest in restoration capability?

   (a) Invest

   (b) Not Invest



2. Please choose your investment amount with an integer number between 0 and 100 points (not include 0): _____ points



Appendix C

Post-experimental Survey for Chapter 3

C.1 Post-experimental Survery

Please fill out this questionnaire completely

Your ID: _____ (as shown on your desk)

1. What is your gender?

   ☐ Male

   ☐ Female

2. What is your age?

   ☐ 17-21 ☐ 22-26 ☐ 27-31 ☐ 32-36 ☐ 37-41

3. Which country are you from? _____

4. What's your programme and subject? _____

5. Please rank on the following scale how much you have a good relationship with your partner in the experiment? [Please rate on a scale of 1'extremely weak' to 7 'extremely strong']

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

6. Please select option 'A' or option 'B'

   ☐ A: 100 with probability 0.5; 0 otherwise;

   ☐ B: 100 with probability 'x'; 0 otherwise; ('x' is an unknown constant)

7. Why are you motivated to do the task? Please rate the reasons on each of the following items: [Please rate on a scale of 1 'not at all apply to me' to 5 'perfectly apply to me']

   Because I care about benefiting others through my work.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   Because I want to help others through my work.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   Because I want to have positive impact on others.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   Because it is important to me to do good for others through my work.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

8. Please rate the following statements on a scale of 1 'does not apply to me at all' to 7 'applies to me perfectly'.

   If someone does me a favour, I am prepared to return it.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   I go out of my way to help somebody who has been kind to me before.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

   I am ready to undergo personal costs to help somebody who helped me before.

   ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

9. Please respond to each of the following statements by circling the number which best expresses your own opinion regarding that statement. [Please rate on a scale of 0 strongly disagree' to 5 'strongly agree']

   It makes me angry when others receive a reward that I have earned.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I cannot easily bear it when others profit unilaterally from me.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I ruminate for a long time when other people are treated better than me.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   It burdens me to be criticized for things that are overlooked in others.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   It makes me angry when I am treated worse than others.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I have a bad conscience when I receive a reward that someone else has earned.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I cannot easily bear it to unilaterally profit from others.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I ruminate for a long time about being treated nicer than others for no reason.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   It bothers me when someone tolerates things with me that other people are being criticize for.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I feel guilty when I treat someone worse than others.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   It gets me down when I take something from someone else that I don't deserve.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

   I cannot stand the feeling of exploiting someone.

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

It takes me a long time to forget when I allow myself to be careless at the expense of someone else.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

I feel guilty when I enrich myself at the cost of others.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

I feel guilty when I treat someone worse than others.

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5