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Under What Conditions Do CEO Career Horizons Influence Firm R&D Investment Strategies? Prospect theory, Behavioural Agency Model and the Role of Managerial incentives

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Under What Conditions Do CEOs' Career Horizons Influence Firm R&D Investment Strategies?
Evidence of Chinese Manufacturing Firms

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Abstract

This study develops a conceptual model of CEOs' career horizon problem and its implications on firm risk taking, specifically in the engagement in innovation initiatives. We propose that, depending on their expected tenure in the managerial labour market, CEOs show various levels of loss aversion and thus employ diverse strategies regarding long-term R&D projects. We argue that compared to CEOs with longer career horizons, CEOs with shorter career horizons are less inclined to make R&D investments owing to their considerations in preserving personal wealth and enhancing labour market evaluation. In addition, the horizon problem is mitigated by the level of institutional ownership but reinforced by CEOs' compensation incentives from within-firm pay disparity and personal wealth. Based on the prospect theory and the behavioural agency model, this study incorporates the construct of temporal focus in explaining managerial risk taking and thus extends the agency perspectives and behavioural research. We also offer insights for stakeholders interested in enhancing firm innovation capabilities by showing that a more holistic executive evaluation system is needed.

Keywords: career horizons; R&D investment; prospect theory; behavioural research; pay disparity; institutional ownership.

1. Introduction

Research and development (R&D) investment is critical for firms to develop a continuous stream of innovative products, services, and technologies (Kafouros et al., 2015; Oh and Barker, 2018; Zona, 2016). This is particularly true of technologically intensive industries, where R&D investment has become a major source of competitive advantage, differentiation, and productivity (Audretsch and Belitski, 2020; Baumann and Kritikos, 2016; Coccia, 2009; Gharbi et al., 2014). However, despite its fundamental importance, firms differ in their R&D investment strategy. Prior research has shown that differences in R&D intensity persist even after controlling for industry and firm characteristics (Kor, 2006). Firm-level heterogeneity in R&D strategy has thus been the subject of many studies (Alessandri and Pattit, 2014; Manso, 2011; Rodrigues et al., 2020).

Drawing on insights from the upper-echelons and prospect theories, this paper attempts to explain why firms differ in R&D investment, focusing particularly on the role of CEOs' career horizons. The upper-echelons perspectives (Hambrick and Mason, 1984) direct our attention to the role of managerial characteristics in R&D investment, suggesting that managers' firm-specific knowledge, cognition, and preferences shape their behavioural tendencies and firms' strategic choices (Hambrick, 2007; Maitland and Sammartino, 2015; Wang et al., 2016). Prospect theory (Kahneman and Tversky, 2013) represents another major paradigm in the field of behavioural research, linking managers' risk-specific preferences with R&D investment strategies. In particular, based on the assumption of 'bounded rationality', the prospect theory hypothesises that managers can be either risk averse or risk seeking, depending on how they frame the decision contexts (Barberis, 2013). Given the inherent risk of innovation initiatives (Gharbi et al., 2014), the behavioural research literature shows a dynamic view of risk that allows for varied risk preferences and R&D decisions of managers with different cognitive characteristics (Desjardine and Shi, 2021; Zona, 2016).

Using multi-theoretical lenses, this study incorporates individual cognitive factors into prospect theory's propositions and examine whether managers' temporal orientations, i.e., career horizons, shape their risk preferences and affect firm's R&D intensity. Career horizon is a cognitive

characteristic that is primarily determined by managers' expected time left in the firm (Lee et al., 2018). The nearer the CEO is to departure, the shorter is the career horizon. Using retirement as a reference point, Matta and Beamish (2008) advance the prospect theory and find that managers with horizon problems place greater emphasis on loss aversion than realising gains, leading to a greater tendency to avoid risk. The agency theory, while holding different assumptions about managerial risk taking with prospect theory, also finds that CEOs with horizon problem exhibit heightened short-termism and risk aversion and try to maximize self-interests even if it is suboptimal for the firms (Antia et al., 2010; Marinovic and Varas, 2019). In line with the above arguments, studies find that CEOs with horizon problems are likely to reduce investments in long-term strategic choices such as international acquisitions (Matta and Beamish, 2008) and corporate social responsibility (CSR) (Kang, 2016; Oh et al., 2016) or induce greater agency costs and lower firm value (Antia et al., 2010; Marinovic and Varas, 2019). However, the influence of horizon on R&D investment, a critical determinant of firms' innovation capabilities and long-term profitability, has received limited attention (Cho and Kim, 2017).

To fill this research gap, this study examines whether and how career horizons of CEOs influence corporate R&D investments. Drawing on the prospect theory, we propose that career horizons shape executives' risk and loss perceptions in the decision contexts of R&D. Given the inherent high risk of R&D investments, we hypothesize that long career horizons enhance CEOs' proclivity towards innovation investment; short career horizons, on the other hand, lead to loss and risk aversion and avoidance of R&D initiatives (Antia et al., 2010; Lee et al., 2018; Matta and Beamish, 2008).

This study also goes a step further by investigating how corporate governance parameters shape the R&D decisions of CEOs with different career horizons. We first examine two specific dimensions of compensation-related CEO incentives – within-firm pay disparity and personal wealth – and suggest that these factors can increase managers' loss aversion, thereby exacerbating short-horizon CEOs' risk aversion in R&D spending (Desjardine and Shi, 2021; Larrazakintana et al., 2007). Moreover, this study suggests that institutional ownership as a monitoring mechanism can buffer top managers from downside risks of R&D investment, thus mitigating the influence of career horizons

on R&D decisions. The empirical analysis using a sample of Chinese manufacturing firms provide support for the hypothesized effects.

This research provides the following contributions. First, this study adds to the literature of the determinants of R&D. The prior research has long recognized the critical role of top managers especially CEOs in firms' strategic choices and activities (Chen et al., 2020; Maitland and Sammartino, 2015; Wang et al., 2016). In the R&D literature, scholars have examined how R&D can be affected by CEOs' characteristics such as demographic background (Barker and Mueller, 2002), cognitive bias (S. S. Chen et al., 2014; Wang et al., 2018), past or present experiences (Jiang and Liu, 2020; Oh and Barker, 2018), and compensation incentives (Ederer and Manso, 2013; Lin et al., 2011). However, the influence of CEOs' temporal focus, i.e., career horizon (Lee et al., 2018) has received less attention. Based on the assumptions of prospect theory that timeframe influences individuals' behavioural preferences (Kahneman and Tversky, 2013), this study recognizes that career horizon as an important characteristic of CEOs would have a significant influence on the risky and long-term R&D investments of firms. This research thus contributes to the literature of CEO characteristics and corporate R&D.

Second, this study contributes to the literature of career horizons by taking a contingent view of the effects of career horizons on firm strategies and outcomes. Scant research on the horizon problem and R&D has examined the moderating role of firm-level factors such as organisational behaviour (Cho and Kim, 2017) and TMT characteristics (Heyden et al., 2017). However, few studies have considered how the horizon – R&D relationship can be moderated by corporate governance parameters such as compensation incentives (pay disparity and CEO personal wealth) and institutional ownership. By examining the moderating role of these governance mechanisms, we account for the complex relationships inherent in the horizon problem and provide a more comprehensive view regarding the influence of career horizons on R&D investment.

2. Literature review

2.1. Risks of R&D investment

R&D plays a critical role in determining long-run competitive advantages of firms. Investment in R&D can increase absorptive capacity and the stock of knowledge, allowing for enhanced technological innovation in a firm (Kafourous et al., 2015; Wu et al., 2016). It offers possibilities for the generation of new technologies, products, and processes, which in turn leads to long-term growth of the firm's productivity and performance (Audretsch and Belitski, 2020; Baumann and Kritikos, 2016). Nevertheless, the 'time' element is central to R&D investment. The generation of favourable outcomes is more likely in the long term since good innovation results are the outcome of a gradual improvement in innovation, which is slow, uncertain and time-consuming (Kor, 2006). In the short term, firms must endure huge irreversible financial sacrifices by committing resources to R&D (Czarnitzki and Toole, 2011; Lach and Schankerman, 1989). Furthermore, due to the rapidly evolving technologies and competitive conditions, the investment payoffs from R&D often cannot be predicted and possibilities of failure or loss are high (Czarnitzki and Toole, 2011; Schuhmacher et al., 2016). Therefore, commitment to R&D does not guarantee immediate profits; rather, the investment will impair near-term profit generation by diverting limited firm resources from other practical investments (e.g., manufacturing).

In addition to jeopardizing short-term cash flows, the announcements of R&D projects do not always generate positive market reactions. R&D is often associated with high levels of information asymmetry between managers and shareholders (Aboody and Baruch, 2000; Gharbi et al., 2014) because the former generally have a better understanding of the likelihood of success or tend to maintain technological competitiveness of firms by withholding relative information (Cheng, 2004). As a result, the profitability and characteristics of R&D initiatives may not be fully reflected in the stock markets (Abdoh and Liu, 2021; Chan et al., 2001). Also, because R&D expenditures are expensed as incurred, the stock markets may temporarily undervalue firms based on their short-term accounting earnings (Cheng, 2004).

In sum, R&D investments can be costly, post uncertainty to the firm's short-term income stream,

and can jeopardize immediate market returns. To the extent that CEOs are made accountable for firms' accounting and stock performance and the outcomes of R&D decisions, a temporary undervaluation of R&D can impinge on the assessment of CEOs' performance and threaten their job security, even when they may not be fully responsible for the observed results. This threat is of particular concern to CEOs with horizon problems as they are sensitive to labour market evaluation and focus more on minimizing any losses to the current situations (Desjardine and Shi, 2021; Matta and Beamish, 2008). Therefore, despite its long-term value creation to the firms, R&D investment can be perceived by top managers with short horizons as a significant 'downside risk' instead of 'upward potential' to their career (Abdoh and Liu, 2021; Brasch et al., 2022; Wu and Tu, 2007). Studies in managerial risk verify the above arguments by showing that CEOs who are concerned about short-term performance tend to opportunistically reduce firms' R&D investment and other long-term strategic choices (Kang, 2016; Lee et al., 2018; Liu and Schmidt, 2022; Oh et al., 2016).

2.2. CEO career horizons under prospect theory

Different from agency theory that assumes that agents' risk orientations are stable over time (i.e., agents are always risk averse) (Kumeto, 2015), prospect theory takes a more dynamic view about managerial risk taking (Zona, 2016). Drawing from the assumption of bounded rationality, prospect theory (Kahneman and Tversky, 1979; Thaler et al., 1997) developed the concept of 'loss aversion', whereby individuals are risk averse when framing situations as gain, and risk seeking when framing situations as loss. In a positively framed current situation, loss-averse individuals can become risk-averse to protect the current gains they have already possessed, whereas in a negatively framed situation, loss-averse individuals tend to bet on risky choices to potentially increase future benefits (Martin & Davis, 2010; Wiseman & Gomez-Mejia, 1998).

Although prospect theory originally emerged from laboratory studies on individuals' decision making under risk, management research has applied the theory's propositions to the organizational level to account for the risk preferences of top executives (Holmes et al., 2011; Zona, 2016). According to the prospect theory, firm-level actions are manifestations of the risk preferences for

executives because their problem framing influences how organizational resources are used (Bromiley, 2009). For example, Larraza-kintana et al. (2007) find that as the value of the CEOs' stock options increases, firms take less risk in organizational behaviours such as new market entries and capital investments. It indicates that CEOs use the exercise price of stock options as a reference point, where those with positively valued stock options adopt gain frames and thus promote risk-averse behaviours at the firm level (Holmes et al., 2011).

The concept of loss aversion has also been applied to understand the intertemporal preferences of managers. Identified within the prospect theory, Martin et al. (2016) suggests that longer evaluation periods reduce managers' aversion to future losses. Since they are more concerned about potential losses in the short term than those in the distant future, managers' aversion to future losses would decline as the timeline extends (Marginson & McAulay, 2008; Martin et al., 2016). Similarly, Matta & Beamish (2008) argue that as CEOs approach retirement (the evaluation period is short and the decision horizon is limited), they tend to overemphasize career stability and legacy conservation, leading to increased risk aversion in long-term investments such as international acquisitions. Following this line of research, we suggest that CEOs' career horizons, defined as the expected amount of time left before a CEO leaves the position (Lee et al., 2018), will have implications on managerial risk-taking and investment choices. Specifically, longer career horizons of top executives indicate longer evaluation periods and less aversion to future loss, potentially leading to risk-seeking decisions; shorter career horizons indicate imminent labour market evaluation and heightened loss aversion of managers, thus inducing risk-averse behaviour.

3. Hypotheses development

3.1. CEO career horizons and R&D investment

A CEO's decision horizon is limited to their tenure within the firm, whereas a firm's lifespan can be much longer (Antia et al., 2010; Marginson and McAulay, 2008). As such, the agency theory indicates that the time-based agency problem occurs when there is a horizon mismatch between managers and the shareholders, in a way that the agency costs are greater if a firm's CEO has a short decision

horizon (Antia et al., 2010). The upper echelons theory also suggests that managers are less willing to take proactive decision making when they are empowered with tenure in the firm (Kor, 2006). As career horizon relates mainly to the stage of the career of a CEO, we argue that CEOs with shorter career horizons are primarily concerned about risk minimization, leading to reduced R&D investment in firm strategy.

The prospect theory indicates that decision-makers are generally loss averse: they are more interested in protecting current gains than in attracting additional wealth and suffering uncertainty (Kahneman and Tversky, 2013). In a positive situation, loss-averse individuals are risk-averse to protect the current gains they have already possessed, whereas in a negative situation, they tend to bet on risky choices to increase future benefits (Larrazakintana et al., 2007; Martin and Davis, 2010; Wiseman and Gomez-Mejia, 1998). Based on the assumptions of prospect theory, we argue that CEOs with relatively short career horizons tend to regard current timeframe as gain, and try hard to avoid any losses to current favourable situations. Short-horizon CEOs tend to possess a history of satisfactory performance because otherwise, it is unlikely that they would reach current career stages (Heyden et al., 2017). They have already accumulated wealth, power and reputation in the firm as well as in the labour market. After early success, they increasingly believe in the correctness of their view of the world, leading to passiveness in decision-making approach and resistance to change (Kor, 2006). Short-horizons also lead to a subjective feeling of ‘endowment’ – CEOs spend more time thinking about current wealth and success and become more psychologically attached to it (Martin et al., 2016). Therefore, short-horizon CEOs may not only count current situation as a gain, but also try to avoid any fluctuation in their current benefits. Their behaviours tend to become increasingly risk averse, focusing on risk minimization rather than prospect maximization, to preserve their legacy and reputation (Desjardine and Shi, 2021; Matta and Beamish, 2008). The future consequences of their actions, on the other hand, are less considered because short-horizon CEOs are less likely to enjoy the payoffs or suffer the losses occurring after their employment time horizon.

The aversion of losses and risks by managers with short career horizons is prominent under the imminent pressure of labour market evaluation. The managerial labour market, either internal or

external to the firm, monitors firm accounting and stock market performance and adjusts the ‘price’ of CEOs accordingly (Brickley et al., 1999; He et al., 2017). CEOs with better on-the-job performance generally enjoy higher compensation and reputations in the market and can be provided with better offers in their future career (Kang, 2016). In contrast, receiving a weak performance appraisal if targets are not met would negatively influence their current wealth and reputation and even future employment opportunities. As short-horizon CEOs are close to departure, they are under imminent evaluation of the managerial labour market. The risk of a bad appraisal can be detrimental as they are given limited time to reverse any performance downfall (Kang, 2016; Matta and Beamish, 2008). Any loss of current and future income stream can jeopardize their career safety. Therefore, as their career horizons shorten, CEOs are subject to increased vulnerability to loss regarding current wealth and reputation, leading to heightened risk aversion in decision-making.

Despite its positive influence on firm long-term competitiveness, R&D investment is considered as a risky endeavour because of its uncertain and delayed payoffs (Czarnitzki and Toole, 2011). The irreversible R&D spending may harm the firm’s short-term stock and accounting results, suggesting downside risk that can compromise the value of current CEO wealth (Matta and Beamish, 2008). CEOs whose companies underperform due to risky R&D projects would be blamed for incompetence and mismanagement, potentially threatening their job opportunities and reputation. Considering that managers with short career horizons are sensitive to labour market evaluation and attempt to myopically protect their current gains, they tend to take a more risk averse approach to R&D investment, for fear that the uncertainty of R&D spending would jeopardize their career safety and reputation. The long-term payoffs (if any) of innovation are less of a concern, as they are less likely to enjoy the payoffs occurring after their employment time.

CEOs with longer career horizons, on the other hand, are more future-oriented. They exhibit less caution to current income stream and are risk-seeking at the prospect of obtaining larger future gains (Desjardine and Shi, 2021). As such, CEOs with longer career horizons may be more willing to invest heavily in R&D. By increasing the likelihood of developing innovative products in the future, they can prove their competency in the position to stakeholders. This argument is supported by the notion

that longer evaluation periods reduce decision makers' aversion to potential future losses (Martin et al., 2016; Thaler et al., 1997). In sum, we suggest that:

Hypothesis 1: There is a positive relationship between CEOs' career horizons and firm R&D investment.

3.2. The moderating role of CEO pay disparity

According to the prospect theory, CEOs frame a situation as a gain or loss based on a reference point that they subjectively determine, which is particularly relevant to the compensation contexts (Pepper and Gore, 2015). Given the premise that most CEOs are cognizant of the pay levels of executives in the firm, CEOs may compare their compensation with others and consider the pay gap as large or small (Lee et al., 2019). We argue that, although short-horizon CEOs are generally loss averse regarding the current welfare they possess, a large pay disparity is an enhanced gain context that indicates significant managerial power, making them more loss averse in R&D decisions.

A large pay disparity represents a favourable context for CEOs. The managerial power perspective has recognized that CEOs have significant influences on their own pay (Bebchuk and Fried, 2003) and attempt to 'exploit their power to capture the pay process and extract excessive compensation', potentially 'creating a large gap between their pay and that of other executives' (Vo and Canil, 2019, p. 170). That is to say, a higher level of pay disparity suggests greater motivation and ability of CEOs to extract rents for their own interests (Bebchuk et al., 2011; Bebchuk and Fried, 2003) and indicates greater influence of CEOs on firm decisions (Pathan, 2009). Recent scholars find supportive evidence showing that CEOs with large executive pay disparity are more capable of protecting themselves from being dismissed for poor performance and are involved with higher succession risk (Bebchuk et al., 2011; Chen et al., 2013).

We extend the above proposition and argue that the wealth and power reflected in large pay disparity enhances short-horizon CEOs' perceptions of current gain situations, thus intensifying their aversion to losses and risks and the avoidance of R&D investment. Also, compared with those with

smaller pay disparity, short-horizon CEOs who enjoy a large pay disparity are more capable of using their bargaining power to curtail R&D investment and preserve the wealth and status. We thus hypothesize that:

Hypothesis 2: CEO pay disparity with non-CEO executives within a firm positively moderates the positive effects of CEOs' career horizons on firm R&D investment.

3.3. The moderating role of CEO personal wealth

The traditional view of agency theory offers conflicting assumptions about the effects of managers' pay arrangements. While the 'optimal contracting approach' assumes that compensation schemes are designed to effectively motivate managers to maximize shareholder value, the 'managerial power approach' argues that compensation reflects managerial rent-seeking behaviour in pay design process rather than the existence of efficient incentives (Bebchuk and Fried, 2003). We propose that the above studies fail to consider that compensation schemes can have varied influence on managers with different temporal focus, leading to contrary assumptions and conclusions in the literature. In fact, the prospect theory has illustrated that CEOs with horizon problems have strong intentions of wealth preservation before leaving office (Matta and Beamish, 2008), which raises particular considerations about the interactions between CEO horizons and personal wealth.

Developed from the loss aversion assumptions of prospect theory, the behavioural agency model suggests that managers' risk preferences are not only dependent on their problem framing (choices being framed as potential gain or loss contexts), but also on their risk bearing (the extent to which the agent's wealth is at risk) (Wiseman and Gomez-Mejia, 1998). Specifically, it is found that agents with high risk bearing in the form of income or career tend to avoid risk-taking decisions (Martin et al., 2016).

CEOs often accumulate a substantial amount of personal wealth through compensation and ownership of firm shareholdings during the years of tenure. This personal wealth allows them to maintain the same standard of living before and after the departure (Matta and Beamish, 2008).

However, the value of the compensation packages is closely tied to the fluctuation of firm accounting performance and stock prices around departure. Any negative feedback from the labour market in response to firms' poor performance would put CEOs' personal wealth at risk. Therefore, the greater the CEO's endowed equity holdings and compensation, the more vulnerability and risk bearing CEOs suffer.

According to the behavioural agency model, CEOs' risk preference is shaped by their subjective judgement of the probability that the downside outcomes of their decisions lead to losses in endowed wealth (Benischke et al., 2019). Equity holdings and compensation represent an endowed wealth, as they are available for CEOs to sell or use (Miller and Shapira, 2004; Wiseman and Gomez-Mejia, 1998). However, given that R&D activities jeopardize current cash flows and post uncertainty to stock price, R&D investment represents potential loss outcomes that are likely to weigh heavily upon CEOs with significant personal wealth. Therefore, while risk aversion and avoidance of R&D investment are common for all short-horizon CEOs, loss outcomes are likely to be more salient for short-horizon CEOs with more current gains. Consequently, acting in wealth preservation, CEOs with short career horizons and holding large values of personal wealth will be less likely to spend on R&D than CEOs with short career horizons and lower values of wealth. We provide the following hypothesis:

Hypothesis 3: CEO personal wealth positively moderates the positive effects of CEOs' career horizons on firm R&D investment.

3.4. The moderating role of institutional ownership

The agency theory has long argued that close monitoring of managerial behaviour is an important way to lower a CEO's self-seeking motivations. Prior literature finds that, due to the large ownership stakes and relatively low coordination costs, institutional owners can effectively monitor CEOs' actions and have the power to guide them to focus on long-term investments (Aghion et al., 2013). The stakeholder salience (Neville et al., 2011) theory also posits that top managers tend to prioritize the demands of powerful and salient institutional owners who hold significant ownership positions in

their companies (Neubaum and Zahra, 2006). Based on these arguments, we expect institutional ownership to mitigate the negative effects of short career horizons of CEOs on firm R&D investment.

Institutional investors possess significant shareholdings in the firm, and therefore have strong incentives and abilities to actively monitor CEOs and influence their corporate strategic decisions such as R&D investment (Baysinger et al., 1991). From the agency theory, institutional investors with diversified investment portfolios are risk-neutral (Thomsen and Pedersen, 2000) and thus are more likely to accept high-risk investment activities than the agents (H. L. Chen et al., 2014). Also, they tend to have long time horizons (David et al., 2001), suggesting a preference to invest for the long run. Although R&D is associated with uncertain and delayed payoffs, it can also lead to significant future profits (Kafouros et al., 2015). Therefore, institutional investors may view R&D spending as necessary for future competitive advantage and thereby encourage CEOs to pursue R&D investment in favour of the long-term interest of shareholders (Rong et al., 2017).

Large institutional investors, who support investments in the long term, also have substantial power in actively shaping strategic managerial strategic decisions (Kochhar and David, 1996). Institutional investors remain as the shareholders of a firm in the long run to realize future cash flows. During the time of holding the stocks, they form arm's-length relationships with the firms and become informed about managers' operations, which makes it easier for them to influence firm objectives (Thomsen and Pedersen, 2000). Access to management enables institutional investors to pressure CEOs to act in the long run, as otherwise, they can sell their holdings in the firm, which may harm firm performance as well as CEOs' compensation and career (Aghion et al., 2013). Institutional investors are also able to defend their interest against CEO short-termism by exercising voice with campaigning and voting at shareholder meetings (Hoskisson et al., 2002). Although short-horizon CEOs are particularly concerned about their current wealth and reputation, these actions can effectively compel them to balance short- and long-term goals and increase R&D investment (David et al., 2001). We thereby argue that CEOs with longer career horizons (who suffer relatively low agency problems) are relatively unaffected by institutional ownership, whereas the presence of institutional ownership mitigates the short-termism of CEOs with shorter career horizons.

Hypothesis 4: Institutional ownership negatively moderates the positive effects of CEOs' career horizons on firm R&D investment.

4. Methodology

4.1. Data and Sample

The sample of this study is restricted to Chinese manufacturing firms listed on Shanghai and Shenzhen stock exchanges from 2012 to 2019. As the past two decades have witnessed a remarkable rise in R&D investments from Chinese firms (Kafouros et al., 2015), China can offer an appropriate setting to test our framework. We focus only on manufacturing industries because these firms compete with new products and processes that requires significant and continuous R&D investment (Wang et al., 2020). Specifically, industries are identified according to the 2012 China Securities Regulatory Commission (CSRC) Industry Classification, covering industries in automotive, chemicals, communication, electronics, machinery, pharmaceuticals, etc (see Appendix 1). We select listed firms because they generally have sufficient resources to invest in R&D compared with private firms. A lagged structure is adopted that uses information on CEO career horizons and all other independent variables at year t to predict the R&D intensity of firms at year $t+1$. Firms with ST and PT status are excluded. The final sample consists of 11,111 observations from 2,076 firms.

The data are retrieved from the China Stock Market & Accounting Research (CSMAR) database, which provides detailed information on the target firms, including firm basic information, financial indicators, as well as CEO characteristics and compensation schemes. It provides the most detailed and reliable data on Chinese listed firms and has been widely used in previous studies (Pang & Wang, 2020; Wang et al., 2018).

4.2. Measures

4.2.1. The dependent variable

R&D investment (RD). Following the R&D literature, we use R&D intensity to measure CEOs'

efforts in innovative activities. We use R&D input instead of R&D output to measure the innovation efforts because it is more subject to the direct influence of managerial decision-making and risk preferences than innovation outcomes. R&D intensity is defined as the ratio of annual research and development expenses to net assets (%). Compared to the absolute amount of R&D expenditure, the R&D-to-assets ratio controls for the size effect and allows for better comparison among firms (Chen & Hsu, 2009). Following the existing literature (Lin et al., 2011), we substitute missing R&D expense data with 0. All variable definitions are listed in Table 1.

[Insert Table 1 about here]

4.2.2. The independent variable

Career horizon. CEO career horizon is measured regarding the expected tenure of the CEO within the firm. Considering that CEO career horizons are influenced by industry-level factors, we adopt an industry-adjusted approach combining CEO age and tenure with the industry average CEO age and tenure (Antia et al., 2010; Lee et al., 2018; Oh et al., 2016). It follows the assumption that CEOs' career horizon would be longer if they are younger and newer than their peer CEOs in the same industry (Antia et al., 2010; Lee et al., 2018). Compared with previous studies using CEO age as the proxy for career horizon, this combination of both relative age and relative tenure is more complete as it accounts for the industry effects on CEO horizon (Lee et al., 2018). For example, in infant industries (e.g., internet-related industries), the management teams can be generally younger than those in mature industries (e.g., automobile). It is constructed as follows:

$$\text{CEO career horizon}_{i,t} = (\text{average age}_{\text{ind},t} - \text{age}_{i,t}) + (\text{average tenure}_{\text{ind},t} - \text{tenure}_{i,t})$$

4.2.3. Moderating variables

Pay disparity. Pay disparity is measured with executives' compensation (without bonus). It is operationalized as the ratio of CEO's compensation to the average compensation of top 3 senior executives (Lee et al., 2019; Ridge et al., 2015).

Personal wealth. CEOs' personal wealth is constructed as the value of shareholdings plus CEO compensation (in 10 million Yuan). The value of shareholdings is the number of shares owned by the CEO multiplied by the stock price per share at the year-end (Barker and Mueller, 2002; Sanders, 2001). The data of stock price per share and the number of equity holdings owned by the CEO are collected from the CSMAR database.

Institutional ownership (InstiOwn). Following previous studies (Liu and Mauer, 2011; Lu and Wang, 2018), institutional ownership is measured as the ratio of the number of shares held by all the institutional investors divided by the total number of shares. Institutional investors include mutual funds, securities firms, insurance companies, pension funds, QFIIs and other legal entities (except for government agencies) (Zhu et al., 2022).

4.2.4. Control variables

We control for a series of firm- and CEO-related effects that influence its R&D investment. *Leverage* is defined as the ratio of long-term debt to total assets. *Firm performance* is measured use the market value (in billion) (Martin & Davis, 2010). We also control for *board size*, measured as the natural logarithm of the number of directors on the board to account for the power of board members to influence managers' investment behaviour (Wang et al., 2018). *CEO duality* is a dummy variable that equals 1 if the CEO is also the board chairman, 0 otherwise. *CEO gender* is included as a dummy that takes the value of 1 if the CEO is a female, 0 otherwise. *CEO education* is measured as a dummy variable that equals 1 if the CEO has achieved an undergraduate degree or above, and 0 if not (Lin et al., 2011). Previous scholars find that formal education provide CEOs with greater ability to absorb new ideas and therefore increase firm R&D investment (Barker and Mueller, 2002).

5. Results

5.1. Main results

Table 2 reports the means, standard deviations, and the minimal and maximal values for all variables in the regression models. The results of pairwise correlations are reported in Table 3. It shows modest

correlations between the independent variables, suggesting that multicollinearity is not a serious concern. We also check the Variance Inflation Factors (VIFs) associated with each regression coefficient (Zhang et al., 2007). The VIF ranges from 1.00 to 1.10 and the mean value is 1.04, further confirming that there are no potential problems of multicollinearity in our analyses.

[Insert Table 2 and Table 3 about here]

The model is first estimated using a fixed-effects approach in a firm-year panel data setup to mitigate the concerns about unobserved time-invariant omitted variables that affect both career horizons and R&D intensity. The results of Hausman test reject the null hypothesis that the unobserved individual level effects are uncorrelated with other variables, so that the fixed effects model should be used. Robust standard errors are clustered by firm level in our analyses to correct for heteroskedasticity. We employ a lag structure to make sure that R&D intensity is observed after the CEO career horizon is observed. Specifically, CEO career horizon, the moderating variables, and the control variables are measured in year t ; dependent variable (i.e., R&D intensity) is measured in year $t+1$. To facilitate the interpretation of the main effects, we mean-centred the variables involved in the interactions prior to calculating the interaction effects (David et al., 2001). The results of our regressions are reported in Table 4.

Hypothesis 1 predicts a positive relationship between CEO career horizons and firm R&D investment. This hypothesis is supported by Model 2, which adds control variables to the baseline model. The coefficient for Career horizons in Model 2 is positive and significant ($\beta=0.008$, $p<0.01$), suggesting a significant and positive relationship between CEO career horizon and R&D investment. Hypothesis 2 draws on arguments about prospect theory to predict that CEO pay disparity with non-CEO executives will positively moderate the associations between career horizons and R&D investment. Model 3 includes the interaction term between the CEO career horizon and pay disparity. Consistent with Hypothesis 2, the interaction effect is positive and statistically significant ($\beta=0.007$, $p<0.10$). Hypothesis 3 predicts that CEO equity holdings will positively moderate the associations between career horizons and R&D investment. As shown in Model 4, the estimated coefficient of the interaction term between career horizon and CEO personal wealth is 0.002 ($p<0.01$), supporting

Hypothesis 3. Last, Model 5 includes the interaction term between CEO career horizon and institutional ownership. Consistent with Hypothesis 4, the interaction effect is negative and statistically significant ($\beta=-0.032$, $p<0.01$), supporting the negative moderating effect of institutional ownership on our focal relationship.

5.2. Robustness checks

We performed several robustness tests in the following areas: 1) using industry median values instead of mean values when adjusting for CEO age and tenure, 2) using legal retirement age instead of industry average CEO age in the construction of career horizon, 3) using R&D expenses divided by market value (RD1) as R&D intensity, 4) only accounting for cases in high-tech industries, including chemical, pharmaceutical, aerospace, electric machines, computer, and instruments manufacturing. The results are shown in Table 5. It can be seen that the above alternative measures also support our hypotheses.

[Insert Table 5 about here]

5.3. Endogeneity

While controlling firm fixed effects and employing a lagged structure can address certain concerns with endogeneity issues, it is still possible that the results about the relationship between CEO career horizons and R&D intensity are biased by reverse causality. It is possible that firms invest more in R&D activities are more likely to hire CEOs who are relatively younger or are expected to have longer tenure in the industries, and therefore a long career horizon (Antia et al., 2010). To mitigate the endogeneity concerns, we employ a fixed effects two-stage least squares (2SLS) model that involves two steps of regressions. We use the percentage of firms that are larger than the focal firm in the same industry (ISIZE) as the instrumental variable. ISIZE serves as a proxy for the intensity of better employment opportunities in the industry, which is expected to extend CEOs' career horizons (Antia et al., 2010).

Results obtained using instrumental 2SLS approach are presented in Table 6. The first-stage regression uses CEO career horizon as the dependent variable. It shows that ISIZE is positively

associated with CEO career horizon, suggesting that CEO career horizon increases when there are better employment opportunities in the industry. In the second stage, we find a positive and significant relationship between career horizons and R&D intensity. The control variables in the two stages are the same. The Cragg-Donald Wald F statistic is 72.28 (above 10), rejecting the null hypothesis of weak instrument. We also conduct a Durbin-Wu-Hausman test to determine the endogeneity of CEO career horizons. The test rejects the null hypothesis that career horizon is exogenous, so that 2SLS regressions should be employed.

[Insert Table 6 about here]

6. Discussion

6.1. Implications for theory and practice

This paper examines why firms differ in R&D investment and demonstrates whether and how CEOs' career horizons shape R&D intensity. Based on the prospect theory, we suggest that CEOs with shorter career horizons make less R&D investment due to concerns about maintaining current wealth and reputation. Consistent with these expectations, we find that CEO career horizons are positively associated with firm R&D intensity. This result is consistent with typical agency arguments that CEOs near retirement or departure take more risk-averse behaviours (Kang, 2016). We also find that CEOs' pay disparity and personal wealth intensify the horizon problem, whereas firm institutional ownership that aligns managers' interests with those of shareholders mitigates the relationship between CEO career horizons and R&D investment.

This study has several implications for research. First, it extends the R&D literature by incorporating the construct of CEO horizon in explaining the determinants of firm R&D investments. Prior research in this field has focused on how top executives are motivated by compensation incentives (Ederer and Manso, 2013; Lin et al., 2011), demographic characteristics (Barker and Mueller, 2002), corporate governance factors (Oh and Barker, 2018), and the environment (Alam et al., 2019) to increase or decrease R&D. However, the influence of career horizon as a cognitive characteristic of managers is relatively under-represented. By showing that career horizons influence CEOs'

perceptions of loss in the R&D contexts, this study goes beyond the typical determinants of R&D such as compensation and age to provide a temporal based explanation of how short career horizons motivate CEOs to reduce R&D investments. This study thus advances a reinterpretation of the R&D underinvestment in firms by contextualising CEO' avoidance of R&D investments as a temporal trade-off between current and future gains in later stages of their careers.

Second, this study contributes to the managerial horizon research by linking career horizons with CEOs' R&D investment decisions. Since managers' horizons are limited to their tenure, they become more myopic as their horizons shorten, in the sense that they tend to place less weight on profitability occurring after their employment. This phenomenon of managerial myopia induced by short horizon is shown to have a negative influence on firm performance (Antia et al., 2010). Drawing on the prospect theory, we find that career horizons also induce different preferences of CEOs towards long-term and risky R&D investments by influencing their time and problem framing, thus contributing to current research on CEO horizon. This finding is in line with recent studies that examines how retirement or older age of managers leads to less involvement in firms' long-term strategies (Cazier, 2011; Cho and Kim, 2017; Matta and Beamish, 2008; Oh et al., 2016).

Third, this research contributes to the prospect theory by providing a contingent view on individuals' problem framing and behavioural tendencies. While prior research has recognized that managers are more concerned about potential losses in the short term than those in the distant future and thus show different preferences in long-term strategic decisions (Desjardine and Shi, 2021; Kahneman and Tversky, 2013; Zona, 2016), we suggest that this propensity depends on certain environmental factors (in our case, corporate governance parameters). By theorizing and showing evidence of how the relationship between career horizon and R&D investment is negative moderated by CEO incentives (pay disparity and personal wealth) and positively moderated by institutional ownership, our study furthers the understanding of the mechanisms underlying the relationship between horizon and firm outcomes.

Furthermore, different from the agency theory literature that examines the direct influence of corporate governance factors on firm R&D (Dong and Gou, 2010; Rodrigues et al., 2020), this study

finds that corporate governance factors influence R&D through the moderating effects of career horizons. While the agency theory assumes that compensation contracts are designed to mitigate agency problems and managerial short-termism (Cheng, 2004), we demonstrate that CEOs' pay disparity and personal wealth can have a negative moderating effect on career horizons, motivating short-horizon CEOs to become more averse towards R&D initiatives. Institutional ownership, on the other hand, is shown to be an effective governance mechanism that reduce the negative influence of career horizons on R&D investments (Aghion et al., 2013).

Our findings also provide practical implications for the boards of directors of firms. It is revealed that CEOs with short career horizons may opportunistically forgo R&D investment. Thus, the board members need to account for potential agency conflicts with CEOs of short career horizons, which may lead to underinvestment in R&D. It is also suggested that this problem can be escalated if CEOs enjoy larger pay disparity with other executives or have greater personal wealth. Therefore, when designing CEOs' compensation schemes, the board should take into consideration the potential conflicts between incentives, horizons and firm R&D spending. In addition, it is suggested that institutional shareholders can help monitor CEOs' short-termism and facilitate R&D activities. In sum, we argue that a balance between a CEO's temporal orientations and a firm's effective incentives and monitoring schemes generates greater innovation capabilities.

6.2. Limitations and future research

One limitation of this study is related to the generalizability of our findings. The sample is drawn from CSMAR database and covers only listed manufacturing firms in China. Therefore, the generalisation of results to smaller private firms can be a potential problem. Further, as China is characterised by relatively weak institutions and corporate governance, our findings may only be applicable in other emerging markets but may not apply equally to developed markets whose situations differ significantly from those of China. Second, this study focuses mainly on the innovation inputs, i.e., R&D expenditure, and not innovation outputs such as patent counts or new product sales. While R&D investment is a useful lens to examine how career horizons influence managers' behavioural

tendencies and preferences in R&D strategies, it not necessarily leads to generations of new technologies and products. Future research can examine whether the findings are also applicable to innovation performance. Third, this study focuses on the moderating effects of CEO pay disparity, personal wealth, and firm institutional ownership. However, R&D investment can be influenced by other CEO incentives and corporate governance factors such as CEOs' stock options pay (Wu and Tu, 2007). Therefore, a possible extension can be to examine how CEO career horizons and other incentives and governance variables interact to influence R&D investment.

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Table 1 Definitions of Variables

Variables	Definitions
RD	the ratio of annual R&D expenses to net assets (%)
Career horizon	$(\text{average age}_{\text{ind},t} - \text{age}_{i,t}) + (\text{average tenure}_{\text{ind},t} - \text{tenure}_{i,t})$
Pay disparity	the ratio of CEO's total compensation to the average compensation of top 3 senior executives
Personal wealth	the value of shareholdings plus the compensation of CEOs (in 10 million Yuan)
InstiOwn	the ratio of the number of shares held by institutional investors divided by the total number of shares
Leverage	the ratio of long-term debt to total assets
Firm performance	return on equity (net assets / average balance of shareholders' equity)
Board size	the natural logarithm of the number of board directors
CEO duality	a dummy variable that equals 1 if the CEO is also the board chairman, 0 otherwise
CEO gender	a dummy variable that equals 1 if the CEO is a female, 0 otherwise
CEO education	a dummy variable that equals 1 if the CEO has achieved an undergraduate degree or above, 0 otherwise

Table 2 Descriptive Statistics (Obs=11,228)

Variable	Mean	Std. Dev.	Min	Max
RD (%)	2.877	2.533	0	36.91
Career horizon	-0.159	5.092	-11.50	19.45
Pay disparity	0.631	0.528	0	9.454
Personal wealth	0.165	4.281	0	357.2
InstiOwn	0.373	0.243	0	0.890
Leverage	0.059	0.072	0	0.848
Firm performance	0.048	0.599	-45.55	0.990
Board size	2.228	0.167	1.609	2.890
CEO duality	0.326	0.469	0	1
CEO gender	0.061	0.239	0	1
CEO education	0.861	0.346	0	1

Notes: The mean value of institutional ownership is similar with the results from previous studies that use the same variable definitions (see Zhu et al., 2022). Personal wealth equals 0 when the CEO does not receive compensation (e.g., the CEO may receive compensation from other related companies) and does not own firm stocks.

Table 3 Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) RD	1.000										
(2) Career horizon	-0.030	1.000									
(3) Pay disparity	0.087	-0.014	1.000								
(4) Personal wealth	0.016	0.014	0.015	1.000							
(5) InstiOwn	-0.056	0.005	-0.160	-0.008	1.000						
(6) Leverage	-0.161	0.008	-0.104	-0.009	0.093	1.000					
(7) Firm performance	0.030	-0.022	0.008	0.004	0.031	-0.067	1.000				
(8) Board size	-0.056	-0.015	-0.120	0.007	0.151	0.116	0.004	1.000			
(9) CEO duality	0.084	-0.166	0.122	0.006	-0.133	-0.085	0.017	-0.184	1.000		
(10) CEO gender	-0.027	0.000	0.008	-0.005	-0.021	-0.026	0.010	-0.078	-0.033	1.000	
(11) CEO education	0.057	0.054	-0.054	0.008	0.082	0.072	-0.010	0.036	-0.068	-0.035	1.000

Table 4 Fixed-effects regression results

VARIABLES	(1) RD	(2) RD	(3) RD	(4) RD	(5) RD
Career horizon	0.009*** (0.003)	0.008*** (0.003)	0.009*** (0.003)	0.008*** (0.003)	0.009*** (0.003)
Career horizon * pay disparity			0.007* (0.004)		
Career horizon * personal wealth				0.002*** (0.001)	
Career horizon * InstiOwn					-0.032** (0.013)
Pay disparity		0.001 (0.030)	-0.005 (0.031)	0.004 (0.030)	0.003 (0.030)
Personal wealth		0.002 (0.004)	0.002 (0.004)	-0.007 (0.006)	0.003 (0.004)
InstiOwn		0.076 (0.215)	0.076 (0.215)	0.077 (0.215)	0.095 (0.214)
Leverage		-1.205*** (0.344)	-1.203*** (0.344)	-1.205*** (0.344)	-1.196*** (0.344)
Firm performance		0.003 (0.013)	0.003 (0.013)	0.003 (0.013)	0.003 (0.013)
Board size		0.182 (0.183)	0.182 (0.183)	0.190 (0.183)	0.180 (0.184)
CEO duality		0.016 (0.056)	0.017 (0.056)	0.017 (0.056)	0.016 (0.056)
CEO gender		0.015 (0.107)	0.017 (0.107)	0.013 (0.107)	0.012 (0.107)
CEO education		0.090 (0.080)	0.087 (0.080)	0.090 (0.080)	0.084 (0.081)
Constant	2.973*** (0.043)	2.542*** (0.424)	2.542*** (0.423)	2.523*** (0.424)	2.550*** (0.425)
Year-fixed effects	Yes	Yes	Yes	Yes	Yes
Firm-fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	11228	11228	11228	11228	11228
adj. R2	0.023	0.026	0.026	0.027	0.027

Notes: Standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Robustness checks

	(1) RD	(2) RD	(3) RD1	(4) High-tech
Career horizon (industry median)	0.007** (0.003)			
Career horizon (retirement age)		0.006** (0.003)		
Career horizon			0.005*** (0.002)	0.014** (0.005)
Pay disparity	0.000 (0.030)	0.000 (0.030)	0.003 (0.017)	-0.004 (0.057)
Personal wealth	0.002 (0.004)	0.002 (0.004)	0.001 (0.001)	-0.041** (0.016)
InstiOwn	0.077 (0.216)	0.076 (0.216)	-0.163* (0.096)	-0.003 (0.419)
Leverage	-1.197*** (0.342)	-1.198*** (0.342)	0.032 (0.160)	-1.500** (0.686)
Firm performance	0.003 (0.014)	0.003 (0.014)	0.010 (0.008)	-0.037 (0.052)
Board size	0.181 (0.183)	0.180 (0.183)	0.150* (0.086)	0.332 (0.314)
CEO duality	0.031 (0.058)	0.030 (0.057)	0.012 (0.027)	0.102 (0.091)
CEO gender	0.016 (0.108)	0.047 (0.107)	-0.115** (0.057)	0.053 (0.201)
CEO education	0.072 (0.081)	0.074 (0.081)	0.048 (0.037)	0.108 (0.161)
Constant	2.556*** (0.423)	2.451*** (0.423)	0.885*** (0.198)	2.788*** (0.730)
Year-fixed effects	Yes	Yes	Yes	Yes
Firm-fixed effects	Yes	Yes	Yes	Yes
<i>N</i>	11228	11228	11228	5476
adj. <i>R</i> ²	0.026	0.026	0.224	0.032

Notes: Standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Model (1) reports the regression results when career horizon = (legal retirement age – CEO age) + (industry average CEO tenure – CEO tenure). Model (2) reports the regression results when career horizon = (industry median CEO age – CEO age) + (industry median CEO tenure – CEO tenure). Model (3) uses R&D expenses divided by market value as R&D intensity. Model (4) reduce the sample to firms from high-tech industries, including chemical, pharmaceutical, aerospace, electric machines, computer, and instruments manufacturing.

Table 6 2SLS regressions

VARIABLES	(1) First stage Career horizon	(2) Second stage RD
Career horizon		0.078** (0.037)
Pay disparity	-0.143 (0.142)	0.009 (0.029)
Personal wealth	0.004 (0.010)	0.003 (0.003)
InstiOwn	2.137*** (0.521)	-0.069 (0.214)
Leverage	-0.943 (0.930)	-1.053*** (0.314)
Firm performance	0.019 (0.060)	0.003*** (0.017)
Board size	-1.107* (0.633)	0.279* (0.157)
CEO duality	-2.728*** (0.220)	0.196* (0.114)
CEO gender	0.425 (0.478)	-0.013 (0.108)
CEO education	1.495*** (0.282)	-0.030 (0.079)
ISIZE	3.275*** (0.385)	
Constant	0.438 (0.730)	2.481*** (0.346)
Year-fixed effects	Yes	Yes
Firm-fixed effects	Yes	Yes
<i>N</i>	10,674	10,674
<i>F</i>	72.28***	14.52***

Notes: Standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. R^2 is not reported as it has no statistical meaning in the context of 2SLS. Model (1) reports coefficients from the first-stage regression of the 2SLS model where career horizon is the dependent variable. Model (2) reports the second-stage regression where the fitted value of career horizon is regressed against R&D intensity.

Appendix 1 Sample distribution

Industry	Year								Total
	2012	2013	2014	2015	2016	2017	2018	2019	
Computers, communications and other electronic equipment 39	140	142	150	169	204	251	264	288	1608
Chemical raw materials and chemical product 26	114	115	124	129	146	175	178	187	1168
Electric machinery and equipment 38	110	117	124	138	142	163	166	178	1138
Special-purpose equipment 35	90	86	102	122	143	159	168	188	1058
Pharmaceutical 27	95	99	107	120	133	159	164	176	1053
General equipment 34	64	64	69	76	90	100	100	104	667
Automobile 36	51	54	61	68	75	97	98	99	603
Non-metallic mineral 30	46	47	50	54	54	62	58	61	432
Rubber and plastic products 29	36	36	37	38	51	60	60	66	384
Non-ferrous metal smelting and rolling processing 32	35	40	43	44	46	59	54	50	371
Metal product 33	27	27	27	35	36	49	48	51	300
Instrument and meter manufacturing 40	16	20	22	28	37	42	42	43	250
Railways, ships, aircrafts, spacecrafts and other transportation equipment 37	25	26	24	22	27	33	37	42	236
Food 14	17	20	22	26	29	34	29	38	215
Alcohol, beverage and refined tea 15	22	25	22	22	31	33	31	26	212
Agricultural and sideline food processing 13	23	24	25	25	24	31	30	29	211
Textile 17	26	25	25	24	23	27	26	24	200
Textile garment and apparel 18	20	21	25	24	25	29	31	25	200
Ferrous metal and smelting and rolling processing 31	24	22	22	23	21	23	23	24	182
Papermaking and paper product 22	17	18	16	16	17	20	21	21	146
Chemical fibre 28	15	17	15	15	16	17	19	18	132
Petroleum processing, coking, and nuclear fuel processing 25	10	11	10	10	11	13	12	13	90
Other manufacturing 41	6	8	9	11	11	13	14	14	86
Furniture 21	3	2	3	6	10	19	19	19	81
Stationery, industrial arts, sports and entertainment supplies 24	5	5	5	6	6	10	10	10	57
Printing and recording media reproduction 23	3	3	5	5	8	10	10	10	54
Wood processing and wood, bamboo, rattan, palm fibre, and straw 20	6	6	6	6	7	7	7	6	51
Leathers, furs, feathers and related products and footwear 19	2	2	2	2	4	5	5	5	27

Comprehensive utilization of waste resources 42	1	2	2	2	1	2	2	4	16
Total	1049	1084	1154	1266	1428	1702	1726	1819	11228

