DOI 10.7603/s40570-015-0001-2

Volume 17, Number 1 – March 2015
China Accounting and Finance Review
中国会计与财务研究
2015 年 3 月　第 17 卷　第 1 期

企业研发类型与管理控制系统设计 – 基于上市公司的实地研究*

王悦[1]　潘飞[2]　周琳[3]　赵成功[4]

投稿日：2014 年 9 月 2 日　　录用日：2015 年 2 月 11 日

摘要

管理控制系统对于研发活动的顺利进行具有重要影响，而企业往往对其功能认识不清，从而影响了研发管理控制系统的科学设计。有鉴于此，我们根据权变理论和资源基础理论总结了研发成功关键因素的研究成果，提出了一个有效贯彻研发成功关键因素的 MCS 控制机制的框架，该框架不仅将研发过程分为三个阶段，而且还区分了控制机制的功能不同，分析了对不同类型研发活动产生的差异性影响，最后通过实地研究验证了该理论框架的合理性，从而完善了现有研发管理控制系统的设计，使企业更好地认识了管理控制系统的作用，为企业研发活动的成功提供了宝贵的理论基础和经验证据。

关键词：革命式研发、渐进式研发、管理控制系统、资源基础观

---

* 本论文是国家自然科学基金重点项目（项目批准号：71032005）、国家自然科学基金青年项目（项目批准号：71402086）、国家自然科学基金面上项目（项目批准号：71272013、71272218 和 71172143）、教育部重点研究基地重大项目（项目批准号：10JJD630005 和 12JJD790037）和教育部人文社会科学青年基金项目（项目批准号：11YJC790072）的阶段性研究成果。本研究同时得到上海财经大学创新团队支持计划资助。感谢 2013 年会计学会管理会计年会和 2014 年商业会计会议上评论人给与的宝贵意见，文责自负。
[1] 联系作者：王悦，博士，上海财经大学会计与财务研究院，上海市武川路 111 号会计学院大楼 323；邮箱：wang.yue@mail.shufe.edu.cn。
[2] 潘飞，博士，上海财经大学会计与财务研究院。
[3] 周琳，博士，河南财经政法大学讲师。
[4] 赵成功，许继电气股份有限公司研发处处长。

Published online: 20 April 2015

一、 引言

研发活动（Research and Development）既是企业追求技术创新、提升竞争优势的重要手段（Cardinal, 2001），也是企业价值管理的关键环节。研究表明，新产品创利占企业总利润的 30%以上（Booz Allen Hamilton, 1982），技术类公司新产品带来的利润超过 40%（Zirger and Maidique, 1990）。作为价值链管理的起点和重点，研发活动对企业的价值创造至关重要。为了保证研发活动的顺利进行，企业需要建立专门的管理控制系统（Management Control System, 简称 MCS）对其进行计划与控制。MCS 由一系列正式和非正式的控制机制组成（Ouchi, 1979），它们通过组织结构、控制程序、组织文化和人力资源等各种制度和手段实施组织战略。恰当的 MCS 有利于降低代理成本（Fisher and Govindarajan, 1992）、贯彻组织意图、提高经营活动的效率和效果、减少管理失误以及提高学习能力（Lawrence and Lorsch, 1967）。对研发活动来说，设计良好的 MCS 有助于提高研发效率和效果，从而提升企业的创新能力与竞争优势。因此，建立科学的研发管理控制系统极其重要。

MCS 对研发活动的影响存在两种不同的观点：一种观点认为 MCS 扼杀组织创新（Ouchi, 1979; Amabile, 1998; Shalley *et al.*, 2004）。因为传统的 MCS 主要是指正式的控制机制，适合管理稳定和常见的组织行为，而创新活动面临较大的不确定性，例外事项较多，难以明确投入产出之间的关系，也难以对产出做出正确评价，如果 MCS 无法应对不确定性，它就会限制跨功能的组织互动和交流模式，惩罚偏差行为（Davila *et al.*, 2009）。因此，MCS 反而限制了组织的创新活动（Rockness and Shields, 1988; Abernethy and Brownell, 1997）。

另外一种观点认为 MCS 对于研发活动有积极的影响（Koga and Davila, 1999; Nixon, 1998; Cardinal, 2001）。因为 MCS 可以作为在高度不确定性环境下的有效管理工具，它作为信息系统可以在新产品创新过程中弥补“任务所需的信息与现有信息”之间的差距（Tushman and Nadler, 1978; Davila, 2000），因此特别适合需要大量信息的创新活动。这类研究倾向于在各种具体的环境下揭示 MCS 对于研发活动的影响（Chapman, 1998; Ditillo, 2004）。

综上所述，现有的研究未能提供一致的经验证据证明 MCS 对不同研发活动的差异性影响（Bisbe and Otley, 2004），这是非常令人遗憾。我们认为原因有两个：首先，未能区分 MCS 的不同功能对研发活动的影响（Keller, 1994），目前的研究几乎都把 MCS 作为一个整体考虑，并未区分 MCS 功能上的差异对研发活动的影响。实际上，MCS 具有两种不同的功能，监控功能和支持功能（Simons, 1990, P128; Turner and Makhija, 2006; Speklé, 2001; Mundy, 2010），这两种功能对研发活动起着不同甚至是相反的作用。监控功能是对员工实现组织目标的行为进行监控和奖惩（Turner and Makhija, 2006），代理理论认为这是 MCS 最重要的功能（Jensen and Meckling, 1976; Baiman, 1990）；支持功能是在人们逐渐认识到组织面临的不确定性后提出的，它反映了信息处理（Simons, 1994; Makhija and Ganesh, 1997）、计划和协调（Zirger and Maidique, 1990; Cooper, 1995）的共同作用，主要体现了信息处理观（Galbraith, 1974）。

其次，以往研究大多未区分研发项目的创新程度，而研发活动根据对新知识需求和不确定性的程度可分为两类：渐进式研发和革命式研发，革命式研发面临的风险和信息需求度都远高于渐进式研发（Dewar and Dutton, 1986; Roussel *et al.*, 1991）。而组织资源是有限的，MCS 应该区分组织活动的类型进行管理（March, 1991; Schermann *et al.*, 2012）。Cardinal（2001）认为可以依据风险、模糊程度和例外性来划分任务类型，然后根据任务类型区别对待研发活动。由于创新程度较低的渐进式研发主要依赖组织内部已有的技术和信息，而创新程度较高的革命式研发却极需组织外部的技术和信息，对新知识的需求和获取远远多于渐进式研发（Cardinal, 2001），[5] 因此我们认为，革命式研发更依赖 MCS 的支持功能（Enabling）；而监控功能（Controlling），因其特别适合管理稳定且例行化的工作事项（Ouchi, 1977），对渐进式研发更加有效。

综上所述，如果研发活动是分项目进行管理的，那么组织层面的控制机制对于不同类型的研发活动会产生差异性影响（Cardinal, 2001），而且同一控制机制在不同阶段还会对研发活动存在不同的影响。MCS 的不同功能适合解决不同类型的组织活动（Schermann *et al.*, 2012），加之组织的资源有限，同时都做好这两种功能是不现实的（Marginson, 2002; March, 1991），这就需要在研发过程中区分研发活动的类型进行相应的管理。由于这方面的理论和经验证据还十分匮乏，我们采用实地研究的方法，构建了一个 MCS 关键控制机制的不同功能对不同类型研发活动产生差异性影响的研究框架（见图 1），该框架表明：对于渐进式研发项目，MCS 的监控功能更加重要；对于革命式研发项目，MCS 的支持功能更加重要。实地研究的结果也证明了这一框架的合理性。

本文不是第一篇关于 MCS 与研发类型关系的实地研究，但却是第一篇明确区分 MCS 功能与不同类型研发活动关系的论文。首先，我们不是研究整个 MCS 的内容和框架，而是根据现有文献并结合案例企业的实际情况提出了适合研发活动的五种关键控制机制（Montoya-Weiss and Calantone, 1994; Brown and Eisenhardt, 1995; Henard and Szymanski, 2001; Ernst, 2002），这样做的原因是因为组织资源有限，不需要面面俱到，关注研发中的主要矛盾解决好关键问题即可；其次，我们基于资源基础观（Resource-based perspective, RBP, Henri, 2006），区分这些关键控制机制的功能不同来研究它们对不同类型研发活动的影响，强调组织应该在研发过程中平衡好 MCS 的支持功能和监控功能，区分研发活动类型进行管理，这才能提升组织的能力和实现竞争优势（Mundy, 2010）。最后，通过大量的文献回顾和实地数据，我们为研究框架提供了理论和经验上的支持。

本文的结构如下：首先是对管理控制系统与研发活动的关系、研发活动的类型以及管理控制系统的功能进行文献回顾，进而提出本文的理论框架；然后是基于案例企业的实地研究；最后提出本文的研究结论和局限性。

---

[5] Cardinal（2001）以医药行业为例将药品复方作为渐进式研发，认为此类研发主要是依据企业自身知识的积累；而新药品的研发却是革命式研发，必须更多的利用外部知识和信息。

二、 文献回顾和理论框架

2.1 管理控制系统与研发活动

2.1.1 MCS 阻碍研发活动

一些研究认为 MCS 阻碍研发活动或者与研发活动无关（Amabile, 1998; Shalley *et al.*, 2004）。Damanpour（1991）对创新影响因素的经验研究进行了回顾，发现创新与正式的控制系统负相关。Amabile（1998）认为在较高的创新环境中，MCS 会降低创新的内在动机和所需的自由。更具体的研究发现，由于无法准确预期和了解研发过程，归集研发活动的成本和及时计量产出是极为困难的（Rockness and Shields, 1988; Nixon, 1998）。例如预算很难作为产品创新的有效控制机制，因为研发活动缺乏可规划性和明确的投入产出关系，导致预算的功能难以发挥（Rockness and Shields, 1988; Ray and Schlie, 1993; Abernethy and Brownell, 1997），但是预算在任务确定性强和产出能够准确计量的条件下却很有效（Bruns and Waterhouse, 1975; Merchant, 1981; Brownell and Dunk, 1991）。于是人们开始考虑任务类型的不同和 MCS 的关系，Abernethy and Brownell（1997）通过 Perrow（1970）的模型将控制类型与任务的可分析性、例外性程度联系起来，他们认为当任务的不确定性最低的时候，会计控制对业绩具有积极的影响，而行为控制在任何情况下对于业绩都无影响，[6] 这一证据表明 MCS 在产品开发活动中起不了重要的作用（Davila, 2000）。因此，人们认为 MCS 很难对研发活动进行有效管理（Hill *et al.*, 2000），同样 Kim *et al.*（2003）发现正式的和集权的控制系统无法有效地协调和控制研发活动，因为研发活动的异质性使行为控制和结果控制的实施非常困难（Ecker *et al.*, 2013）。[7] 因此，Merchant and van der Stede（2007）提出研发活动更适合由研发专家而非正式的控制系统来管理。同样，Keller（1994）认为信息处理的需求随着项目的复杂性或例行化程度的不同而不同。因此，Cardinal（2001）提出当项目的例行化程度与信息处理量之间存在匹配关系时对研发业绩有积极影响。Davila *et al.*（2009）也认为正式的 MCS 特别支持周期性且例行化的企业活动，但无法判定与研发活动的关系，因为研发活动具有不确定性、未知的投入产出关系以及产出难以评价。总而言之，MCS 通过规则制定和行为限制抑制了研发活动的创造力，从而给业绩带来了负面影响（Amabile, 1998）。

2.1.2 MCS 促进研发活动

另一种观点认为 MCS 对研发活动有积极的作用（Nixon, 1998; Cardinal, 2001）。这方面的研究分为两类：一类是研究 MCS 不同阶段与不同类型研发活动的关系，例如 Cardinal（2001）将 MCS 分为投入、行为和产出三个阶段，认为它们对不同的研发项

[6] 行为控制与过程控制同义（Rowe and Wright, 1997; Cardinal, 2001; Turner and Makhjia, 2006）。同样，后果控制也是产出控制的代名词（Snell, 1992; Cardinal, 2001; Turner and Makhjia, 2006）。所以在本文中，我们使用过程控制、产出控制的表述方法。

[7] 一般认为过程（或行为）控制和产出（或结果）控制属于正式的控制系统，投入控制属于非正式的控制系统（Cardinal, 2001; Davila *et al.*, 2009）。

目存在差异性影响，但是实证结果总体上并没有发现这三个阶段的 MCS 对不同研发项目的影响有显著的差别，而且他提出 MCS 在行为阶段和产出阶段对渐进式研发是正面影响，对革命式研发是负面影响的假设并未得到有说服力的证据。这表明只是按照投入、行为和产出三个阶段来研究 MCS 与研发活动之间的关系在逻辑上还不完全清晰；另外一类是研究 MCS 或者其子系统与研发活动之间的关系，例如 Nixon（1998）采用案例研究描述了财务控制对于产品研发过程的积极影响。Abernethy and Brownell（1997）、Bisbe and Otley（2004）认为如果预算作为计划机制，那么产品创新对于组织业绩具有正面影响。计划机制包括资源的决策制定、目标设定、后果预期以及行动计划（Lin and Vasarhelyi, 1980; Horngren *et al.*, 2000），此时的预算作为计划机制，由管理层制定和讨论，通过对结果进行预期来改进组织的解决方案（Samuelson, 1986）。因此，当预算作为计划工具的时候，产品创新对于组织业绩会有积极影响（Dunk, 2011）。进一步研究发现，MCS 在较高的环境不确定下是一种有效的管理控制工具（Davila, 2000），例如 Khandwalla（1972）发现竞争越激烈，组织对正式的控制机制需求越高。同样，Simons（1987）发现执行开拓者战略的企业需要依赖适时更新信息的正式控制系统来推动组织的学习。其他学者也认为管理者感知到高度不确定性就会更需要广泛的和及时的信息（Chenhall and Morris, 1986）以及更多外部的、非财务的和事前的信息（Gordon and Narayanan, 1984）。Kren（1992）发现预算参与在高度不确定的环境下会有更好的业绩，因为预算参与会增加工作信息的交流。Chenhall and Langfield-Smith（1998）也发现不同的战略强调不同的正式控制系统。因此，学者们认为应该区分研发活动的不确定性和复杂性，权变地管理研发活动（Duncan, 1976; McDonough and Leifer, 1983; Dewar and Dutton, 1986; Keller, 1994），这也是本文的观点。综上所述，MCS 对研发绩效的影响是权变的，如果 MCS 的功能与研发活动类型匹配，那么会给研发后果带来积极的影响（Simons, 1990; Koga and Davila, 1999）。

2.2 研发项目的分类

MCS 和研发后果之间的关系依赖于研发项目的特征，即研发项目的创新程度（Cardinal, 2001; Bonner *et al.*, 2002）。Bonner *et al.*（2002）认为研发活动根据创新程度的不同可以分为：

1、世界首创：即产品是完全创新的，没有任何公司生产过类似产品，消费者也从未见过类似产品；

2、公司首创：产品对公司而言是首创，但是市场上至少存在一个竞争者拥有类似的产品；

3、后续产品：该项目是对本公司现有产品的进一步扩展；

4、产品改进：是对公司现有产品的改进；

5、工艺改造：采用新的工艺生产现有的产品。

可以看出，前两种产品的创新程度是最高的，而后三种产品创新程度较低，因此在研发风险上有显著的差异（Bonner *et al.*, 2002）。

Dewar and Dutton（1986）明确提出了革命式研发（Radical Innovation）和渐进式

研发（Incremental Innovation）的概念，革命式研发是指在技术上有根本的变化，与现有的产品或技术完全不同的研发活动，包括新知识的发现，较多的技术风险、时间和成本投入（Roussel *et al.*, 1991）。渐进式研发是指对现有技术和知识较少改变的研发活动（Roussel *et al.*, 1991）。

我们结合 Cardinal（2001）和 Bonner *et al.*（2002）的方法来区分研发项目类型，将世界首创和公司首创归于革命式研发，后续产品、产品改造和工艺改造归为渐进式研发。

2.3 管理控制系统的功能

Merchant and Otley（2006）认为 MCS 的目标就是为决策制定、计划和考评提供有用的信息。它通过正式的、基于信息基础的规则和程序来支持和修正组织的行为（Simons, 1995），从而控制组织目标的实现、帮助员工寻找机会以及解决问题（Simons, 1995; Ahrens and Chapman, 2004; Zimmerman, 2005）。因此，Mundy（2010）总结了 MCS 两种既互补又竞争的功能：支持功能（Enabling）和监控功能（Controlling），这两种功能既有助于组织目标的实现，又给与员工足够的决策自治权，组织需要在两种功能之间寻求平衡（Roberts, 1990; Sprinkle, 2003; Mundy, 2010），这种平衡取决于组织面临的问题与解决问题的方式是否匹配（Speklé, 2001）。如果所遇问题与解决方式相匹配，两种功能恰当结合，MCS 就会创造出独特的组织能力和竞争优势（Henri, 2006; Widener, 2007）。我们认为研发活动更是应该取得两种功能的恰当融合以提升组织能力和竞争优势，所以从 MCS 功能的角度研究研发活动是极其有意义的。

实际上，MCS 双重功能的说法并非是 Mundy（2010）首次提出的，之前的文献已多有涉及，例如 Mintzberg（1976, 1979, 1994）强调 MCS 应该划分为计划和管理两种功能，计划功能由非正式的控制机制实现，管理功能由正式的控制机制实现。类似的，Simons（1990）也认为 MCS 不仅用来监督组织计划是否实现，还用以激励组织充分考虑当前的和预期的战略不确定性，进而他提出 MCS 不仅体现监控功能，而且还具有使用各种信息支持或纠正组织行为的功能。另外，Sprinkle（2003）认为管理会计信息系统应具备两种功能：决策促进功能（decision-facilitating）和决策影响功能（decision-influencing）。决策促进功能是指管理会计系统应该提供有助于员工做出符合组织利益决策的信息，即提供计划和决策的必要信息，类似于我们所说的支持功能；决策影响功能是指管理会计系统提供的信息有助于协调员工和所有者之间的利益，即激励员工（Zimmerman, 2005），类似于我们说的监控功能。Massaro *et al.*（2011）认为 MCS 有三种功能：第一是学习功能（Learning），第二是问题解决功能（Problem Solving），第三是监控功能（Surveillance）。我们认为学习功能和问题解决功能都属于支持功能。由于支持功能和监控功能适合解决的问题类型不同，而且组织资源有限，在所有研发活动上同时做好这两种功能是不现实的（March, 1991; Marginson, 2002）。这就需要在研发过程中区分研发活动的类型进行相应的管理。MCS 两种功能的理论依据分别是代理理论观和信息处理观（Baiman, 1982; Narayanan and Davila, 1998），我们将依据这两种观点详细阐述 MCS 的功能。

2.3.1 监控功能 － 体现代理理论观

第一种 MCS 的功能是对员工实现组织目标的行为进行监控和奖惩（Turner and Makhija, 2006）。监控作为一种控制功能可以通过降低委托人与代理人之间的信息不对称来减少代理人的机会主义行为，从而避免对组织目标的偏离，这是代理理论认为 MCS 最重要的功能（Jensen and Meckling, 1976; Baiman, 1990）。如 Eisenhardt（1989, p. 60）所述"MCS 可以使委托人知晓代理人的真实行为，从而抑制代理人的机会主义行为"。这实际上就体现了 MCS 的监控功能。这类控制机制包括预算系统、汇报制度、直接监督和内部审计（Jensen and Meckling, 1976; Eisenhardt, 1989）。Sprinkle（2003）认为监控功能是指对员工的行为和业绩进行监督、计量、评价以及报偿。例如，公司可以将成本预算的完成情况与员工薪酬挂钩来激励员工控制成本；又比如公司利用成本分配来激励员工互相监督与合作，或者有效地使用资源（Zimmerman, 1979, 2000）。更普遍地来说，监控功能用以控制员工行为符合组织利益（Merchant, 1985; Sunder, 1997; Sprinkle, 2003）。因此，此种功能的主要作用就是缓和员工和所有者之间的利益冲突从而最大化公司的价值（Indjejikian, 1999）。Massaro *et al.*（2011）也提出了 MCS 应具有监控功能（Surveillance）。

另外，MCS 监控功能和研发的关系也值得深入地研究。Ouchi（1979）认为如果能够充分了解生产或服务相关的投入产出关系（即技术），那么 MCS 的监控功能就能实现有效的控制。Cardinal（2001）和 Bonner *et al.*（2002）认为监控的程度其实也体现了研发团队自行处理研发任务和采取相关行动的自由度，即分权程度。Damanpour（1991）采用经验研究报告了组织创新和 MCS 正式控制机制之间存在负向关系，还发现集权程度与产品创新负相关，但结果并不显著。Perrow（1970）也认为 MCS 正式的控制机制对于可分析性高和例外事项少的任务特别有效，而创新活动又恰恰是可分析性低且例外事项多的任务，因此我们认为监控功能适合创新程度低的研发项目，它的主要作用是减少组织目标和个人目标的分歧。目前还需要进一步的经验证据证明两者之间的关系。

2.3.2 支持功能 － 体现信息处理观

产品研发是一个充满了不确定性的过程，需要组织提供有用的信息进行决策，从而实现研发活动的计划和协调。Gupta and Wilemon（1990）对项目经理的问卷调查发现 58%的研发项目停滞是由于技术的不确定性。因此，组织需要充分的信息来解决新产品开发过程中出现的各种问题（Davila, 2000）。MCS 需要收集和处理各种信息来弥补任务执行所需的信息和现有信息之间的差距以消除研发过程的不确定性（Galbraith, 1974），这就是 MCS 支持功能的理论依据（Tushman and Nadler, 1978; Davila, 2000）。

类似的，许多文献讨论了控制机制具有固有的信息处理功能（Tushman and Nadler, 1978; Ouchi, 1979; Nelson and Winter, 1982; Egelhoff, 1991），这类控制机制包含影响组织内部信息分享和知识传递的组织规章、协调机制以及个人和团队之间的关系（Simons, 1994; Makhija and Ganesh, 1997），从而减少决策的不确定性（Demski and Feltham, 1976）。Sprinkle（2003）、Tiessen and Waterhouse（1983）、Baiman（1982）以及 Simon *et al.*（1954）都指出了此种功能是通过利用信息，尤其是管理会计的信息解决问题。Sprinkle（2003）更是提出管理会计系统的支持功能（decision-facilitating）有助于增进员工的知识，有助于他们做出符合组织利益的判断、决策以及充分了解信息的行动选择。例如公司提供产品成本的信息帮助经理做出正确的定价决策；又例如公司提供经理人标准成本差异以确定计划偏离实际的程度和改进措施等等。Massaro *et al.*（2011）认为 MCS 的学习功能（Learning）主要是用来支持创新过程，包括研发团队内部讨论改进措施以及关注问题。而他还提出了使用 MCS 来管理创新过程的复杂性、减少决策时间以及提高关注问题的态度，即问题解决功能（Problem Solving），这两种功能属于我们所说的支持功能。Sprinkle（2003）也强调支持功能主要是帮助组织进行经济判断和决策。

而 MCS 支持功能和研发活动的关系也有文献涉及，例如研究发现注重计划和协调的研发项目会获得成功（Zirger and Maidique, 1990; Cooper, 1995）。Davila（2000）也发现管理会计信息和产品研发业绩之间具有正向关系，他认为 MCS 的信息处理功能因为能够消除产品研发过程中的不确定性而对创新活动更加重要。因此我们认为，支持功能包含了信息处理、计划、交流和协调的作用，而且对于革命式研发尤为重要。

2.4 本文的研究框架

2.4.1 研发活动成功的关键控制机制

资源基础理论（Resource-based Theory）认为组织应该建立可持续的竞争优势（Barney, 1991），组织的竞争能力是其特长、专家开发能力、利用特定的内部资源以及组织能力的函数。为实现竞争优势，MCS 必须与组织能力相协调、与战略选择相一致（Henri, 2006），那么如何应用 MCS 来实施组织战略就显得尤为重要。

MCS 是由一系列的控制机制组成（Perrow, 1970; Ouchi, 1979; Abernethy and Brownell, 1997）。Perrow（1970）认为 MCS 是包括正式的和非正式的控制机制。Ouchi（1979）将控制机制划分为市场控制、层级控制和社会控制，[8] 认为市场控制和层级控制属于正式的控制机制，社会控制属于非正式的控制机制。Abernethy and Brownell（1997）在 Perrow（1970）的基础上研究了正式控制机制中的会计控制和行为控制，以及非正式控制机制中的人员控制。Rockness and Shields（1984）认为 Ouchi（1979）所说的社会控制也可被称作投入控制，具体的控制机制包括人员的选择、培训过程和制定支出预算；行为控制是由正式的规则和经营过程组成的，包括规则和程序（例如标准经营流程）以及技术调度控制；产出控制是指依据转移定价建立的内部市场。[9] 他们认为组织需要区分任务类型来考虑上述控制机制的使用。但是不论 Abernethy and Brownell（1997）还是 Rockness and Shields（1984）都未发现一致的经验证据证明控制机制与研发活动之间明确的关系，原因主要是他们未能考虑控制机制的不同功能。

---

[8] 在后续文献中也将市场控制、层级控制和社会控制定义为产出控制、行为控制和投入控制（Rockness and Shields, 1984; Abernethy and Brownell, 1997; Cardinal, 2001）。

[9] 因为研发活动并不直接与外界市场签约，所以研发活动的成果只能是内部使用，可以建立转移定价系统来模拟外部市场的作用（Rockness and Shields, 1984）。

Ittner and Larcker（2001）认为研究 MCS 实施战略的关键之处就是发掘导致战略成功的控制机制。Cardinal（2001）认为可以分阶段对研发活动中相关的控制机制进行管理，他将研发活动划分投入、过程和产出三个阶段。投入阶段的控制机制包括：专家多元化（Specialist Diversity）和专业化（Professionalisation）；过程阶段的控制机制包括：集权程度（Centralisation）、正式程度（Formalisation）和高管评价业绩的频率（Frequency of Performance Appraisal）；产出阶段的控制机制包括：目标明确（Goal Specificity）、强调产出（Emphasis on Output）、报偿和认可（Rewards and Recognition），以及对专业性产出的重视（Emphasis on Professional Output）。他的研究关注到了对研发活动重要的控制机制，实证结果比前人更加清楚，但是他并未区分具体控制机制的功能，所以没有得到与假设完全一致的经验证据。

在上述研究的基础上，我们认为研发活动必须考虑关键因素的作用（Blindenbach-Driessen and van den Ende, 2006），如果组织能够关注到这些关键因素，并采取相应的控制机制实施之，那么定能提升研发活动的效率和效益（Rubenstein *et al.*, 1976）。

根据现有文献我们认为有五种控制机制对研发成功至关重要，它们体现了获取研发成功必须的关键因素的作用（Ziger and Maidique, 1990; Montoya-Weiss and Calantone, 1994; Brown and Eisenhardt, 1995; Cardinal, 2001; Henard and Szymanski, 2001; Ernst, 2002; Blindenbach-Driessen and van den Ende, 2006），这五种控制机制在研发活动的不同阶段中发挥了不同的功能，组织特别需要关注（文献依据见附录 A）。

（1）高层领导参与 － 支持功能和监控功能

由于研发活动面临较大的不确定性和工作压力，因此，高层领导参与对研发成功的重要性不言而喻（Rubenstein *et al.*, 1976; Brown and Eisenhardt, 1995; Bonner *et al.*, 2002; Turner and Makhjia, 2006; Felekoglu and Moultrie, 2013）。首先，帮助克服研发活动中面临的组织内部障碍（Souder and Chakrabarti, 1979; Felekoglu and Moultrie, 2013），以及为研发活动提供支持和保障，这方面的控制机制体现为支持功能（Blindenbach-Driessen and van den Ende, 2006; Evanschitzky *et al.*, 2012; Felekoglu and Moultrie, 2013）；其次，高层领导还会通过考核研发项目的进度和预算执行情况来监控研发活动的进展，这方面的控制机制体现为监控功能（Felekoglu and Moultrie, 2013）。我们结合许继的实际情况并参考文献从五个方面计量该机制的内容（Rubenstein *et al.*, 1976; Brown and Eisenhardt, 1995; Cardinal, 2001; Evanschitzky *et al.*, 2012; Felekoglu and Moultrie, 2013）：

① 拥有权力和权威的高层领导支持该项目；

② 企业对开发的项目从发起到市场阶段都有高层领导的支持；

③ 高层领导对研发人员活动和研发成本的评价是否非常频繁；

④ 高层领导是否经常了解 / 评价研发活动的预算和成本；

⑤ 高层领导是否经常提供对预算执行以及成本考核的非正式反馈意见。

Jensen and Meckling（1976）和 Eisenhardt（1989）认为 MCS 体现监控功能的控制

机制包括预算系统、汇报制度、直接监督和内部审计。由于③④⑤涉及到成本、预算的评价和考核，因此都属于监控功能。体现组织内部信息分享和知识传递的规章制度、计划和协调机制、个人和团队之间的关系的机制体现了支持功能（Simons, 1994; Makhija and Ganesh, 1997; Henard and Szymanski, 2001），①②体现了高层领导对于研发项目的帮助和支持，因此属于支持功能。

（2）项目经理的能力 － 支持功能

许多学者强调研发项目经理的重要性（Rothwell *et al.*, 1974; Wheelwright and Clark, 1992; Brown and Eisenhardt, 1995; Blindenbach-Driessen and van den Ende, 2006），他们认为一个有能力的项目经理对于克服部门之间的障碍和推动研发极为有效。有能力的项目经理能够理解市场信息、掌握各个部门的交流方式、做好内外部沟通的工作以及引领研发过程并解决冲突，而缺乏能力的项目经理对于革命式研发尤为不利，因为他只是一个传令兵而非管理者（Wheelwright and Clark, 1992）。并且，有资历有权威的项目经理能够吸引高层领导、研发团队成员和顾客方面的信任与支持（Rothwell *et al.*, 1974; Rubenstein *et al.*, 1976），而且能为研发活动争取到充分的资源，且有助于团队间的合作与交流，对革命式研发的作用尤为重要（Booz Allen Hamilton, 1982），所以这一关键控制机制主要为研发活动提供服务，体现了支持功能（Simons, 1994; Makhija and Ganesh, 1997; Henard and Szymanski, 2001）。我们结合文献和许继的实际情况从两个方面计量该机制（Rubenstein *et al.*, 1976）：

① 在整个开发和引进过程中，项目经理在高层、其他职能部门和顾客方面的协调程度很强；

② 负责该项目开发的经理人员有较高的职位和权威。

（3）研发团队的构成 － 支持功能

许多文献强调了研发活动中跨功能团队的重要性（Brown and Eisenhardt, 1995; Cooper *et al.*, 2001; Ernst; 2002; Blindenbach-Driessen and van den Ende, 2006）。

该控制机制是指研发团队的专业化水平和多元化程度（Cardinal, 2001; Ernst; 2002）。专业化水平是指企业可以通过选择专业化的研发人员来营造良好的知识环境，有利于获取核心的研发知识、技术、经验以及正确的研究态度（Mintzberg, 1983），从而使研发人员接触到最新技术并形成科学的研发计划，这不仅为创新带来了直接投入，而且增加了企业吸收和开发新技术的能力，对研发成功有重要影响（Cohen and Levin, 1989）。团队多元化是指研发团队至少包括三类成员：研发、制造和营销人员，这样的团队会带来两方面的好处（Cooper and Kleinschmidt, 1986）：首先，多元化的研发团队使得研发过程能够结合市场信息，联系制造环节，为研发成功提供保证；其次，多元化的人才有助于创新型思维的产生（Wiersema and Bantel, 1992），在研发团队中需要具有不同背景和各种知识的专家互相交流合作，才能有助于研发人员形成正确的思路和观点（Dougherty, 1992）。这样的团队增强了功能间的渗透，提高了信息处理能力，因此特别有助于革命式研发的成功（Cardinal, 2001; Ernst; 2002）。

综上所述，我们结合文献和案例企业的实际情况从两方面计量该项控制机制（Cardinal, 2001）：

① 团队中研发人员的专业化程度和涉及领域；

② 研发团队内部能够很好地协调沟通、更新收集的数据、分析和实施研发项目。

这两个项目为研发活动创造了良好的基础和条件，因此属于支持功能（Simons, 1994; Brown and Eisenhardt, 1995; Cardinal, 2001）。

（4）项目管理与资源分配 － 支持功能和监控功能

SAPPHO（1972）[10]认为研发成功取决于研发活动是真正有效率和效益的，Rubenstein *et al.*（1976）对美国公司进行的 103 个研发项目的调查发现企业内部的控制机制极大地影响了研发的成功，而政府政策、行为和管制的作用相对次要。他们认为组织应该集中精力改进研发数据的收集、分析和决策过程，并且针对研发活动进行详细的计划，以及提供必要的资源保证，这些控制机制体现了项目管理与资源分配的作用（SAPPHO, 1972; Cooper, 1979; Brown and Eisenhardt, 1995），既有支持功能，也有监控功能，具体包括（1）立项前对产品缺陷的认识（SAPPHO, 1972; Cooper, 1979）；（2）评价项目可行性，选择正确的项目（SAPPHO, 1972; Brown and Eisenhardt, 1995）；（3）恰当分配资本和人力资源（SAPPHO, 1972; Ziger and Maidique, 1990）；（4）有效使用资源（SAPPHO, 1972; Ziger and Maidique, 1990）。我们结合文献和许继的实际情况从十个方面计量这一控制机制的功能（Rubenstein *et al.*, 1976; Cooper, 1979; Ziger and Maidique, 1990; Brown and Eisenhardt, 1995; Cardinal, 2001; Davila *et al.*, 2009）：

① 立项评审会议的专业化程度；

② 在立项之前，有专门的评估程序对项目的缺陷进行把关，尤其是对前期相关的经验教训进行总结；

③ 有专门的情报部门提供关于用户需求、营销和宣传方面的信息，项目团队非常了解该产品的顾客群体和市场；

④ 立项之前，财务部门和技术部门会同研发部门共同商讨研发项目人、财、物资源的分配；

⑤ 任何支出都有严格的审批程序；

⑥ 研发项目的预算目标非常具体明确；

⑦ 成本管理的清晰和健全会得到奖励；

⑧ 预算的节约会得到奖励；

⑨ 与研发项目相关的论文发表和著作出版会得到奖励；

⑩ 与研发项目相关的专利申请会得到奖励。

根据 Jensen and Meckling（1976）、Eisenhardt（1989）、Zirger and Maidique（1990）、Simons（1994）、Cooper（1995）以及 Makhija and Ganesh（1997）的定义，由于①②

[10] 英国在70年代初期进行的启发性起源模式的科学行为预测研究（The Scientific Activity Predictor from Patterns of Heuristic Origins, SAPPHO）首次关注产品成功和失败的比较类研究（Rothwell, 1972; Rothwell *et al.*, 1974）。

③④有助于交流、传递各种信息从而进行计划和降低研发活动的风险，因此属于支持功能，⑤⑥⑦⑧⑨⑩则是通过监督和考评来保证组织目标的实现，因此属于监控功能。[11]

（5）内外部交流与合作 － 支持功能

成功的研发依赖于项目设计和开发阶段中良好的交流与合作（Gupta *et al.*, 1985; Brown and Eisenhardt, 1995; Henard and Szymanski, 2001; Ernst; 2002; Evanschitzky *et al.*, 2012），团队内外信息的交流有助于顾客需求、产品定价以及市场信息的传递（Rothwell, 1972; Evanschitzky *et al.*, 2012），从而保证研发目标的顺利实现。SAPPHO（1972）认为有效利用外部技术和学术交流是研发成功的重要因素。Cardinal（2001）认为当研发团队能够与外部进行交流时，研发活动更容易取得成功。Ancona and Caldwell（1990）发现研发团队如果进行外部交流，既可以使他人了解团队工作的重要性，还能够有助于协调、协商和获取外方的反馈意见，从而有助于快速推进研发预算和进程以及生产出最具有创新特征的产品。我们结合文献和案例企业的实际情况从两方面计量该项控制机制的作用（Rubenstein *et al.*, 1976; Davila *et al.*, 2009）：

① 研发、生产和营销部门能够很好地协调沟通、更新收集的数据、分析和做出研发项目的决策；

② 研发工作能有效利用外部技术和学术交流。

该项控制机制都体现了支持功能（Ernst; 2002; Blindenbach-Driessen and van den Ende, 2006）。

上述体现了研发成功关键因素的控制机制表明组织的 MCS 对研发成功关键因素的执行情况，这些控制机制在研发的不同阶段发挥了不同的功能，对不同研发活动的影响也不相同，研究这一问题有助于组织有的放矢地完善 MCS，从而集中宝贵的资源更好地进行研发活动，实现产品和服务的创新（Ziger and Maidique, 1990）。

2.4.2 研究框架

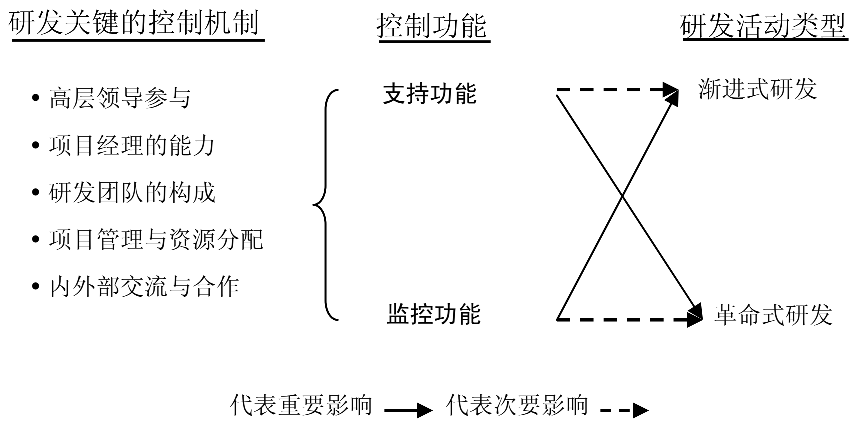

图 1 MCS 不同功能对研发活动差异性影响的研究框架图

[11] 许继电气并没有把研发业绩考核与市场业绩联系在一起，对研发活动直接成果做了相应的考评，考评内容包括预算执行、成本节约以及学术成果的发表和专利申请。

综合上述文献，研发的效果其实是不同类型的研发项目与不同功能的控制机制恰当结合的结果（Duncan, 1976; McDonough and Leifer, 1983; Dewar and Dutton, 1986; Keller, 1994）。而以往的研究未能关注 MCS 控制机制的功能不同对研发活动的差异性影响，导致这类研究缺乏与假设相一致的经验证据，而且大多数研究对于研发活动的类型也较少区分（如 Abernethy and Brownell, 1997），只是认为研发活动不同于其他组织活动，却忽略了研发活动本身也是有差异的。而我们根据文献和案例企业的实际情况将研发活动划分为投入、过程和产出三个阶段，体现研发成功关键因素的五种控制机制贯穿了这三个阶段，并且在不同阶段发挥了不同的功能，[12] 因此需要区分各个阶段研究控制机制的不同功能对于不同类型研发活动（革命式 vs.渐进式）的差异性影响，这才能清晰地揭示了 MCS 与研发活动之间的关系，发掘出 MCS 对研发活动有积极影响的内在原因，这是我们的贡献。具体而言，由于 MCS 的监控功能适合于管理周期性且例行化的组织活动（Davila *et al.*, 2009），而渐进式研发由于创新程度较低，例外程度较少，对新知识的需求不高，所以监控功能对渐进式研发更加有效；而革命式研发由于具有较大的不确定性，对新知识和技术的要求更高，需要更多有用的信息和相对宽松的研发环境和较高的分权程度（Cardinal, 2001），因此，MCS 的支持功能对革命式研发更加有效（见图 1）。

三、 实地研究

3.1 案例企业的MCS

3.1.1 案例企业的选择

我们选择许继电气作为案例企业是出于以下考虑：第一，许继电气的集团公司坚持技术创新战略，许继电气作为高新技术企业，高起点、超前开发高科技产品，确保产品领先战略的实施。这说明研发活动在许继电气是非常重要的工作，有利于我们进行相关研究。加之集团有专门的科研管理机构即科研处，且能做到科研管理工作的务实高效。同时，科研处还加强和研发业务相关接口单位之间的协作，为上下游客户做好服务支撑工作。有这样一个综合管理研发工作的机构对于我们获取相关信息和数据极为有利。并且，许继电气的公司治理结构完善，透明度较高，十年以来与我们合作了不少研究项目，因此我们与各层级的管理人员十分相熟，这种信任与融洽的合作关系十分有利于我们获取第一手的资料，有利于本研究的进行。另外，二十年来许继电气坚持围绕“高科技创新”，不断推动产品升级换代、产业延伸扩张，使产品的科技含量不断提高，形成了一个互补的产业格局，成为业内唯一一家一次设备和二次设备并驾齐驱的企业集团。因此，许继电气十分适合作为我们实地研究的对象。

3.1.2 数据来源和问卷调查

[12] 比如高层领导参与这项控制机制在投入阶段体现了支持功能，但是在过程阶段却同时具有两种功能，所以有必要划分研发的三个阶段来更好的研究具体控制机制的作用。

我们对案例企业研发 MCS 的实地研究一共经历了 23 个月，从 2011 年 10 月份到 2013 年 7 月份，先后 6 次深入许继访谈、观察和调研。为了提高案例研究结论的效度，本文从多个数据来源分析案例。数据来源主要包括：上市公司正式披露的信息、新闻媒体的报道、公司网站披露的信息、对许继电气研发活动各层级人员的深度访谈以及公司内部资料和问卷调查（见表 1）。

表 1 实地研究数据特征概览

数据类型	文件类型	数据来源	说明
1.公开数据	2007-2012 年的研发数据	上市公司披露的年报数据、新闻报道以及公司网站发布相关信息	在年报中将最近六年许继披露的研发数据进行整理，包括研发投入的绝对值和趋势值，发明、实用新型和外观设计的新增数量，以了解许继自身研发情况和在行业中的地位。
2.深度访谈录音	许继的研发管理控制系统概况	来自与许继研发人员和其管理团队的现场访谈	对许继管理控制系统的三个阶段的介绍和总结，对本文中涉及的四个项目的定性说明和介绍。
3.内部资料	许继现有的研发管理控制系统资料	许继内部管理人员提供以及内部刊物	许继研发项目预算表（模版）、研发项目计划变更申请表（模版）、研发项目立项申请书（模版）等等。
4.问卷调查	四个研发项目的问卷评分	由许继电气的 4 个项目经理分别提供	对相关项目的风险水平、研发类型、管理控制系统内容和研发后果均作了定量的评分。

（1）公开数据

我们先后整理了许继电气近 6 年的年报，对它公开披露的研发数据进行了汇总整理，包括研发费用投入、研发人员数量和比重以及专利、实用新型和外观设计的数量。对这些数据进行了趋势分析，结果发现许继研发投入的绝对值和比例都是逐年增加的，研发活动保持着良好的势头，选择这样的公司作为研究对象对其他公司能起到标杆作用。

（2）现场访谈和访谈对象信息

经过文档资料收集和阅读，课题组与许继电气总经理、常务副总经理、财务总监，尤其是主管研发工作的各层级人员逐一进行深度访谈。被访者在不同程度上对公司的研发活动都有了解。课题组事先与被访者进行电话沟通，预约访谈时间，邮件发送访谈目的和内容，提供访谈提纲。在访谈开始前，明确说明访谈是开放式的，以获得尽可能真实、全面的信息。在访谈过程中，课题组所有成员同时记录，并在征得被访者同意的情况下，使用录音笔全程录音。在访谈结束前，课题组适当提出一些有针对性的问题，以确认和补充某些重要的内容。根据 Eisenhardt（1989）的建议，课题组在

24 小时内对访谈笔记进行整理和核对，并将笔记和录音内容全部输入到电子文档中。对于其中不确定或者缺失的信息，还通过电话和邮件与被访者进一步沟通和补充，保证获取足够的信息（具体访谈内容见附录 B）。

（3）内部资料

为了对许继电气研发活动有一个全面的了解，课题组收集了大量的文档资料。例如，许继电气的电子报纸以及研发管控系统的内部资料（见表 1）。这些材料帮助我们直观上了解许继现有的研发管理控制系统的内容和特点，做到有的放矢地研究问题。

（4）问卷调查的内容

我们主要根据 Cardinal（2001）和 Abernethy and Brownell（1997）的研究设计了问卷内容，大体包括以下三个方面:

① 研发项目的分类

研发类型划分为渐进式研发和革命式研发两种，两者的根本区别在于所用技术的新颖程度不同，以及使用新知识的程度不同（Dewar and Dutton, 1986）。如前文所述，我们根据现有文献对两种研发类型进行计量（Cardinal, 2001; Bonner *et al.*, 2002）。

② 管理控制系统的计量

根据案例企业的实际情况，我们按照大多数文献的划分方法将研发管控系统分为：投入阶段、过程阶段和产出阶段（Abernethy and Brownell, 1997; Cardinal, 2001）。投入阶段的管控主要是对资源进行配置，为研发活动提供支持，包括 8 项控制机制；过程阶段的管控主要通过设定规则来管理标准经营过程以及监控个人行为，包括 8 项控制机制，其中 4 项属于支持功能，4 项属于监控功能；产出阶段的管控主要是 5 项控制机制，计量和考核经营活动和员工个人业绩，属于监控功能。我们按照文献提供的计量方法（Cardinal, 2001），结合案例企业的实地情况对 MCS 所包含的内容进行计量（见表 2）。

③ 研发项目后果的计量

对于研发项目后果的计量，我们分为两类：财务业绩（Atuahene-Gima and Li, 2004）和非财务业绩（Davila, 2000; Bonner *et al.*, 2002）。财务业绩包括 4 项，非财务业绩包括 12 项（见表 2）。

（5）问卷调查过程

我们首先将问卷调查的内容告知科研处处长，建议他为我们选择成功的和失败的革命式研发项目各一项，成功和失败的渐进式研发项目各一项，以此来观察 MCS 的功能与研发类型匹配情况对于研发后果的影响，从而验证我们的研究框架。科研处长随机为我们选择了成功和失败的革命式研发项目与渐进式研发项目各两项，并联系了负责这四个项目的经理，他们均表示愿意参与我们的问卷调查（附录 C），我们在问卷填写前与 4 位项目经理进行交谈，确保他们了解我们所要询问的问题，之后把问卷发放给他们填写。此类问卷调查虽受到样本量和横截面的限制，但是可以深入了解研究问

题，是实地研究中常用的一种方法。

这四位项目经理在许继的工作时间平均在 11.75 年以上，担任研发项目经理的年限也在 6.25 年以上，学历也均在本科以上，对研发活动和相应的 MCS 较为熟悉和了解（见附录 C）。问卷填写之后，这四位经理就项目的具体情况还和我们做了深入的交谈（见“3.2 研发项目分析”），因此保证我们获取四个研发项目的定量信息和定性信息。

3.1.3 许继的研发管理控制系统概况[13]

作为国内业绩良好的制造型上市公司，许继电气在公司治理以及管理理念上都是业内楷模。许继研发分为四个层次：基础研究、技术开发、产品设计和系统集成。[14] 每个层面都包含革命式研发和渐进式研发，管理控制分项目进行。数量上来看，渐进式研发项目居多，但是投入资金上，革命式研发更大。[15] 从时间上来看，许继的研发管控系统可以划分为三个阶段：

（1）许继研发管控的投入阶段

投入阶段主要包括各种资源配置机制，它是组织获取业绩的前提条件（Turner and Makhjia, 2006），Cardinal（2001）认为投入阶段包括研发团队的专业化程度和多元化水平。Rockness and Shields（1984）认为投入阶段应该包括社会控制，即团队成员的选择（Ouchi, 1979）、对行业的了解和交流以及预算支出的安排。许继电气的研发活动在这一阶段 MCS 的主要内容有：

首先，通过立项评审会邀请市场、技术、工艺和财务部门的专家共同参与项目评审。包括“评审会的专业化程度”、“是否对项目的缺陷进行把关”、“对前期相关的经验教训进行总结”、“有专门的情报部门提供关于用户需求、营销和宣传方面的信息”等控制机制的作用都在这一阶段实现，因此属于“项目管理与资源分配”控制机制的内容。

其次，所有项目都建立跨部门团队，任命合适的项目经理，包括考量项目经理的职位、威信以及与组织内外各方协调的能力，同时考量研发团队的专业化程度和多元化程度，体现了“研发团队的构成”和“项目经理的能力”两类控制机制的内容。

最后，子公司根据自身盈利水平，采用预算参与的形式，自下而上的申报研发项目，集团公司自上而下拨款，专款专用：主要指财务部门和技术部门会同研发部门共同商讨研发项目人、财、物资源的分配，属于“项目管理与资源分配”控制机制的内容。

“我们在投入阶段通过项目立项书确定研发团队的负责人和人员构成，包括他们各自的专业特长和承担的工作；然后通过立项评审会考察研发项目的可行性，即要进

[13] 该部分的内容来自于许继电气研发处处长和 3 位工作人员和 4 位研发经理的现场访谈录音和笔录的整理。4 位研发经理来自于 4 个不同的子公司。

[14] 考虑到基础研究和技术设计还不能直接对应到研发的市场业绩，我们选择的研发项目只包括产品设计和系统集成。

[15] “项目数量上，渐进式研发与革命式研发是 7：3，但是资金投入上却是 3：7”（许继电气研发处处长）。

行顾客分析、竞争对手分析和市场分析，阐述该项目的内外部需求；另外会同财务处科研处确定拟投资的金额和详细的预算编制，一般是自下而上报预算，然后由财务处统一管理，科研处负责预算执行过程的审批。一般来说受到高层领导关注的项目比较受到各方的重视，结果也相对较好；而各个子公司研发项目经理的能力的确存在差异，所以负责的项目在重要性和研发效益上也有差别。越是重大的研发项目越是看重这一阶段的安排”。[16]

根据如上所述，投入阶段的控制机制体现了支持功能，包括“高层领导参与”、“项目经理的能力”、“研发团队的构成”以及“项目管理与资源分配”，这些控制机制为研发活动顺利进行提供了坚实的知识基础和资源保障，并且降低了研发过程中的技术风险和需求风险。

（2）许继研发管控的过程阶段

过程阶段是明确规定员工必须从事的行为和过程的机制，包括持续监督员工行为到工作的完成（Snell, 1992）。至于过程阶段的管控设计，Cardinal（2001）认为，过程管控应该关注集权程度、报告制度和业绩评价的频率。许继电气在这一阶段管控的主要内容有：

① 高层考核进度：项目统一管理，跟踪计划、执行和变更事项。就研发进度的完成情况、预算执行情况和各类相关问题对高层进行项目汇报，周期分周报、月报、季报、半年报、年报。这属于“高层领导参与”的内容。

② 组织内部信息沟通以及对外部技术的利用：对进度上出现的问题上下级之间、团队成员之间以及组织内外之间要进行相应的信息交流与沟通，及时调整研发项目进度和配套资源，保证研发项目的顺利进行。这体现了“研发团队构成”和“内外部交流与合作”控制机制的作用。

“由于研发活动都是分项目进行管理，在立项时就设定有研发周期的计划，所以科研处会在执行阶段跟踪项目的执行和变更，大项目汇报的频率快、信息多，小项目汇报的频率慢、信息少。同一个项目在不同的阶段汇报的频率不同、内容不同，一般技术层面的信息多，重大项目要上报每周计划完成情况，遇到的问题等，做到‘远粗近细、快速推进’；对研发执行过程中预算支出一般都要经过审批，超预算过多的项目会有关注，具体由财务部提供预算执行信息，科研处会同管理；由于研发活动最重要的就是技术的可实现性，失败的项目往往是技术无法实现所致，所以团队内部信息的交流和协调很重要，一般来说有项目经验的团队交流和协调做得较好，同时善于利用外部技术和信息的项目更易获得成功。”[17]

该阶段体现了高层领导参与、研发团队构成、项目管理与资源分配以及内外部交流与合作四种关键控制机制的作用，既有支持功能，又有监控功能。

---

[16] 来自许继电气研发处处长和工作人员的现场访谈内容。
[17] 来自许继电气研发处处长和工作人员的现场访谈内容。

（3）许继研发管控的产出阶段

产出控制是指产出管控是对工作结果进行的管理和调节（Eisenhardt, 1985），计量和监控企业经营以及员工的工作（Langfield-Smith and Smith, 2003），对员工工作有明确的产出要求（Eisenhardt, 1985），规定预期的产出标准，协调产出与标准设定，提出奖惩方式（Merchant, 1985）。一般认为产出阶段的管控应该包括目标明确性、对产出的重视与奖惩（Cardinal, 2001）。但是研发的产出控制很难设计，因为研发风险越高，这一阶段的控制更容易使得员工倾向于易于完成的渐进式项目而非能够带来长期回报的革命式项目（Cardinal, 2001）。这就导致对研发产出的奖惩对于渐进式项目更加有效，而对革命式项目却是不利的（Cardinal, 2001）。许继电气这一阶段管控的主要内容有：

① 目标明确性：最初设定的预算目标要明确详细，如市场占有率、与竞争对手对比业绩、目标利润等。

② 业绩评价：即鉴定考评阶段，考评预算和成本的执行情况以及论文著作发表和专利的申请。

“目前许继内部的研发、工程和销售责任分开，费用预算的核定、报销由科研处统一集中管控，研发投入统一由财务部门管理。科研处全程参与管控和评估，直接影响研发团队的收入。对研发人员的经济奖励依据获奖证书、专利、论文和研究成果及市场业绩，但是这方面的制度还不够完善，存在不足之处，尤其是市场业绩，我们一般设定产品上市三年的销售业绩作为奖励基础，但是有些研发项目的效益显现在三年之后，例如有些革命式研发项目，前期可能并不成功，需要后期转型或者继续投入才能完成，那么奖励时限已经失效，所以大家从心里更希望做一些产出快，短期内更容易出成果的项目。这也是我们正在希望解决的问题”。[18]

这一阶段的控制机制反映了资源使用的效率，发挥了“项目管理与资源分配”这一关键控制机制的作用，因为该阶段研发活动已经基本结束，处于收尾阶段，主要通过公平的奖惩促进下一阶段正确选择研发项目和激励研发人员努力工作，所以，该阶段的控制机制体现监控功能。

我们发现许继电气研发管理控制系统的实际内容与本文提出的研发框架极为契合，非常适合本文的研究主题，因此，我们选择了许继自主研发的四个项目进一步验证本文的理论框架。

3.2 研发项目分析

3.2.1 项目 A－ 渐进式研发

A 项目经理：“贵广 II 回直流输电工程是行业内第一个以中方为主建设的大型工程，国家发改委确定的直流自主化依托工程，实现‘以我为主，联合设计，自主生产，全面实现直流系统设计、换流站设备成套设计和直流工程设计自主化和设备制造自主

[18] 来自许继电气研发处处长和工作人员的现场访谈内容，由于市场业绩考评存在一定的问题，许继目前的考评重点不在市场业绩上，因此，我们在设计考评相关的控制机制（“项目管理与资源分配”中的“有效使用资源”）中不考虑市场业绩。

化，综合自主化率达到 70%以上’的目标。该项目起点为贵州兴仁换流站，终点为广东深圳，线路全长 1,255 千米，输电容量 300 万千瓦，电压等级为±500 千伏。2005 年 6 月 28 日该工程启动，至 2007 年 12 月 3 日双极成功投运，历时两年半时间。该项目的技术风险和需求风险都较低，属于渐进式研发项目，相关技术对许继而言很成熟，所以投入阶段按照例行化的程序进行，并未进行广泛动员和较多的技术会议进行论证。过程阶段，领导对项目的监控较为频繁，且项目支出审核也较为严格。因为该项目的影响大，对许继的发展至关重要，所以整个研发团队无论是项目进度还是汇报周期都抓得较紧，最后在产出阶段，由于预期的成果都已实现，因此考核也很明确到位，最后实现的项目绩效也比较理想。”

3.2.2 项目 B－ 革命式研发

B 项目经理：“该项目依托供货合同同步实施，是公司第一次涉及风电技术，该项目从创新水平上来说属于革命式研发项目。技术上采取风冷方式设计，通过样机试制、厂内试验、现场运行试验验证设计原型，并确立定型版本。项目计划 2006 年初立项，周期 2 年完成现场运行验证，由于在投入阶段对风电技术的掌握不够成熟，缺乏对该技术的运用基础，没有以往的经验可以借鉴，所以项目评审对产品缺陷把关的作用不大。虽然有对用户需求、营销和宣传方面的信息，但因为首次涉及该领域，项目团队并不十分了解该产品的顾客群体和市场。项目经理也缺乏相应的经验，未能发挥足够的领导作用，结果技术和试验都不理想，导致项目 2 次技术调整推迟到 2009 年初交付。在过程阶段，该项目的拖延虽然引起了高层的重视，但是由于前期技术上的问题未能解决，导致后期该项目工期较为缓慢。在 2008 年 5 月，项目通过专家组的中期检查评审后，由于现场操作不当和运行环境差等原因，样机在运行中故障破损而停止现场试验，最后被处理他用，项目宣告失败。之后随着风电行业发展迅速，风电厂家和年装机容量都逐年递增，风冷方式已很难满足 1.5MW 以上级变流器的需求，风电机组采用水冷变流器是未来的发展趋势。公司反思了风冷项目的经验教训，及时调整研发方向，2009 年转接、重新立项开发水冷技术的研究，成果较为理想，尤其是研发团队对前期的失败经验认真总结，队伍得到了很好的锻炼，这为后期研发的成功打下了良好的基础。”

3.2.3 项目 C－ 渐进式研发

C 项目经理：“ECVT800-35 电子式互感器采用电流电压组合式结构，取代原传统电磁式电流和电压互感器，减少了互感器安装尺寸，降低了生产成本。同时可以使每个出线间隔相对独立，方便了现场检修和问题的分析。该电子式互感器的研制，便于用户在许继实现 35kV 系统的一站式采购，将提高许继电气在数字化变电站建设中的综合竞争能力。该项目属于渐进式研发项目，技术风险和需求风险都较低，在投入阶段，由于初始投入成本较高，因此受到高层领导的关注很大，所有可以动用的资源都在其中，但是在过程阶段并没有持续得到高层的监督，对项目支出的监管也不十分严格。对技术信息的关注也不多，原因是该项目对许继而言技术十分成熟，市场上更

新换代也比较慢，产品的替代性较差，许继拥有较强的市场地位，所以过程管控没有做的很强，最后的效果属于中等水平。”

3.2.4 项目 D－ 革命式研发

D 项目经理：“是中国第一个真正意义上社会化运营的电动汽车充换电站，是在国网公司‘换电为主、插充为辅、集中充电、统一配送’的战略方针指导下，推动国网充换电站标准运营模式实施的示范工程，对许继而言是机遇也是风险。该项目作为许继集团在充换电站领域的第一个 EPC 总包项目，承担的责任可谓重大。随着城市规模增加和工业开发区的发展，居民多数居住在青岛，而工作地点却在黄岛，从而促使青岛充电公交车的快速发展，引领了未来的公交车发展的趋势。薛家岛公交车标准充换电站项目，历时时间短，从项目启动到项目结束，要用 80 天实现可为 120 辆公交车同时充电，或为 360 辆乘用车充电。在换电方面，公交车每次换电时间为 6-8 分钟，每天可更换 540 车次。这个项目属于革命式研发，技术风险和需求风险都很高，计划工期只有 100 多天，得到了国家电网高度关注，政治意义很重大，所以在最初的投入阶段任命了许继电气的总经理作为项目负责人，立项评审会议专业化很强，而且对于市场需求进行了充分的了解和论证，高层领导全体动员，给予了极大的支持，可以说不惜成本。在过程阶段我们十分重视沟通和交流环节，对项目进展的督促并未过多，主要是考虑到研发团队所处的压力不宜过大，所以项目进度还是按照正常的水平进行，项目支出也有较大的空间。对于产出阶段，由于属于研发周期较短的项目，所以我们并未对项目的预算和成本节约给予严格的要求，相反希望员工卸下包袱，努力工作即可，最后的项目结果还是非常成功的。”

3.3 问卷调查分析

3.3.1 控制功能对研发活动的影响

渐进式研发项目 A 的创新程度较低，不需要特别强调支持功能（三个阶段支持功能机制 12 项平均 3.4 分）；而应该把注意力集中在监控功能上（三个阶段监控功能机制共 9 项，平均 5.44 分）。许继对待此项目的战略比较正确，因此取得的项目业绩较好（财务业绩平均 5.5 分，非财务业绩平均 5.67 分）。

革命式研发项目 B 是许继第一次涉及风电技术的项目，却不够重视支持功能。由于项目风险较高，项目经理又缺乏经验，研发团队专业性也不够强，前期各种信息的了解也不充分，整个投入阶段的支持功能较为薄弱（8 项平均 4.6 分），因此最后的业绩很不理想（财务业绩平均 1.5 分，非财务业绩平均 3.67 分）。

渐进式研发项目 C 较为重视支持功能，尤其是投入阶段的团队构成、项目经理的能力以及高层领导参与的作用很大（8 项平均 6.1 分）。相对而言，过程阶段中的监控功能（4 项平均 4.5 分）和产出阶段的监控功能（5 项平均 4 分）重视度不够，导致业绩并未达到预期的水平（财务业绩平均 4.5 分，非财务业绩平均 5 分）。所以该项目属于没有做好监控功能而导致研发不够理想的典型案例。

许继对革命式研发项目 D 在过程阶段的监控功能处于中等水平（4 项平均 4.25 分），

表 2 许继研发项目管理控制系统内容和评分[19]

Panel A		研发关键控制机制				
阶段	功能		项目评分 A	B	C	D
投入阶段	支持功能	***高层领导参与***				
		• 拥有权力和权威的高层领导支持该项目	1	6	6	6
		项目经理的能力				
		• 在整个开发和引进过程中，项目经理在高层、其他职能部门和顾客方面的协调程度很强	1	3	7	6
		• 负责该项目开发的经理人员有较高的职位和权威	1	4	6	6
		研发团队的构成				
		• 你对团队中研发人员的专业化程度和涉及领域十分满意	2	4	6	6
		项目管理与资源分配				
		• 立项评审会议的专业化程度很高	2	5	6	6
		• 在立项之前，有专门的评估程序在投产前对项目的缺陷进行把关，尤其是对前期相关项目的经验教训进行总结	3	4	5	5
		• 有专门的情报部门提供关于用户需求、营销和宣传方面的信息，项目团队非常了解该产品的顾客群体和市场	3	4	6	3
		• 立项之前，财务部门和技术部门会同研发部门共同商讨研发项目人、财、物资源的分配	2	7	7	7
		小计	15	37	49	45
过程阶段	支持功能	***高层领导的参与***				
		• 企业对开发的项目从发起到市场阶段都有高层领导的支持	7	5	5	7
		研发团队的构成				
		• 研发团队内部能够很好地协调沟通、更新收集的数据、分析和实施研发项目	7	4	6	7
		内外部交流与合作				
		• 研发、生产和营销部门能够很好地协调沟通、更新收集的数据、分析和做出研发项目的决策	6	5	6	7
		• 研发工作能有效利用外部技术和学术交流	6	7	5	6
		小计	26	21	22	27
	监控功能	***高层领导参与***				
		• 高层领导对研发人员活动和研发成本的评价是否非常频繁？(1)超过半年一次，(2)半年两次，(3)每季度一次，(4)每月一次，(5)每月两次，(6)每周一次，(7)每周多次	5	4	4	4

[19] Panel A 中所有问题均采取 Likert 7 分制，除了过程阶段关于高层领导参与的三个问题之外，其它问题 1=完全不赞同，4=中立，7=完全赞同；Panel B 中的问题全部采取 Likert 7 分制，1=远低于行业其它竞争者，4=等于行业其他竞争者，7=远高于行业其它竞争者。问卷填写对象为许继电气的 4 个研发项目经理，他们根据自己负责的最重要的一个研发项目进行评分。

		• 高层领导是否经常了解 / 评价研发活动的预算和成本？(1)超过半年一次，(2)半年两次，(3)每季度一次，(4)每月一次，(5)每月两次，(6)每周一次，(7)每周多次	5	4	4	4
		• 高层领导是否经常提供对预算执行以及成本考核的非正式反馈意见？(1)超过半年一次，(2)半年两次，(3)每季度一次，(4)每月一次，(5)每月两次，(6)每周一次，(7)每周多次	4	4	4	6
		项目管理与资源分配				
		• 任何支出都有严格的审批程序	7	5	6	3
		小计	21	17	18	17
产出阶段	监控功能	***项目管理与资源分配***				
		• 研发项目的预算目标非常具体明确	6	6	4	4
		• 预算的节约会得到奖励	5	4	4	1
		• 成本管理的清晰和健全会得到奖励	5	4	4	3
		• 与研发项目相关的论文发表和著作出版会得到奖励	6	4	4	4
		• 与研发项目相关的专利申请会得到奖励	6	5	4	4
		小计	28	23	20	16

Panel B		研发项目后果				
	财务业绩	• 相对于竞争者的销售收入增长率	6	2	5	6
		• 相对于竞争者的市场份额增长率	5	2	6	6
		• 相对于竞争者的投资回报率	6	1	4	7
		• 相对于竞争者的利润增长率	5	1	3	5
		小计	22	6	18	24
	非财务业绩	• 实现了产品的性能	5	3	7	6
		• 实现了单位成本目标	4	3	4	4
		• 实现了及时性目标	6	2	7	7
		• 实现了项目的预算目标	5	3	5	4
		• 满足了顾客的需求	6	2	6	7
		• 获得了商业成功	7	2	5	7
		• 获得了较高的市场份额	5	2	4	6
		• 开拓了新的市场	6	5	3	6
		• 开拓了一条新的产品线	6	6	5	6
		• 开发了新技术	6	6	4	6
		• 提升了处理新技术的能力	6	5	6	6
		• 锻炼出了一只高素质的研发团队	6	5	4	6
		小计	68	44	60	71
		合计	90	50	78	95

产出阶段的监控功能也较为放松（5 项平均 3.2 分）。而投入阶段和过程阶段的支持功能水平较高（12 项平均 6 分），因此，由于支持功能做的较好，监控功能较为放松，

该项目研发的效果还是较为理想的（财务业绩平均 6 分，非财务业绩平均 5.9 分）。

3.3.2 研发MCS对不同研发活动的影响

从研发 MCS 对革命式研发和渐进式研发的影响效果看（表 3），革命式研发更应该注重控制机制的支持功能：项目 B 由于未能很好地执行控制机制的支持功能，最终研发并不成功；而项目 D 由于较大力度地执行了控制机制的支持功能，并且适当放松了产出阶段的监控功能，而取得了良好的研发绩效。

相对而言，渐进式研发更注重监控功能：项目 A 由于重视了控制机制的监控功能，实际业绩基本符合理论预期；而项目 C 对控制机制的监控功能投入不够，导致研发绩效处于中等水平。

上述四个研发项目基本验证了我们的研究框架，即不同类型的研发活动对于不同阶段的管控系统的功能需求有所不同，只有对研发活动进行分类管理，正确发挥管控系统在不同阶段的不同功能，才能得到良好的研发后果。

表 3　案例项目分析结果汇总表

项目号	研发类型	投入阶段	过程阶段		产出阶段	理论预期	实际业绩	实际与预期的比较
		支持功能	支持功能	监控功能	监控功能			
项目 A	渐进式	低水平	高水平	较高	较高	较高	较高	符合
项目 B	革命式	中等	中等	中等	中等	中等	较低	基本符合
项目 C	渐进式	高水平	中等	中等	中等	中等	中等	符合
项目 D	革命式	较高	高水平	中等	较低	高/较高	较高	基本符合

四、 研究结论和局限性

4.1　研究结论

我们通过实地 / 案例研究调查了许继电气研发管理控制系统的设计和实施情况，结果发现 MCS 对研发活动具有重要影响，而组织对于不同类型的研发活动针对性地使用 MCS 的控制机制，才能起到事半功倍的效果。具体而言，对革命式研发应该看重控制机制的支持功能；而对于渐进式研发更应该看重控制机制的监控功能。并非所有阶段所有功能的管控都做到无懈可击才有利于研发活动，只有抓住主要矛盾才能真正做好研发。

另外，传统的研究认为革命式研发看重投入阶段（Cardinal, 2001），其实是因为该阶段的控制机制体现支持功能，而该功能对革命式研发尤为重要；并且以往研究无法辨明过程阶段对不同类型研发活动的差异性影响是因为该阶段的控制机制既有支持功能也有监控功能，如果不区分功能，势必难以得出预期的结论。我们的一大贡献就是分功能考察控制机制对研发活动的影响，从而更好地剖析了 MCS 在研发活动中的作用。

4.2　局限性

由于本文是实地 / 案例研究，研究结论不具有普遍性，但是为大样本研究提供了一个很好的框架。并且，我们关注的只是与研发成功的关键因素相对应的 MCS 控制机制，而非 MCS 的所有内容。而控制功能方面我们总结了两种功能 — 支持和监控，这并非说明 MCS 没有其它的功能和价值，需要未来进一步研究提供证据。另外，对于研发项目的选择也可能存在偏差，未来的研究方需要扩大研究样本，从普遍性上验证该框架的合理性，我们的发现只是一个开始，而不是结束。

参考文献

Abernethy, M. A. and Brownell, P. (1997), ‘Management control systems in research and development organizations: The role of accounting, behavior and personnel controls’, *Accounting, Organizations and Society* 22 (3-4): 233-248.

Ahrens, T. and Chapman, C. S. (2004). ‘Accounting for flexibility and efficiency: A field study of management control systems in a restaurant chain’, *Contemporary Accounting Research* 21 (2): 271-301.

Amabile, T. M. (1998). ‘How to kill creativity’, *Harvard Business Review* 76 (5): 76-87.

Ancona, D. G. and Caldwell, D. F. (1990). ‘Beyond boundary spanning: Managing external dependence in product development teams’, *Journal of High Technology Management Research* 1 (2): 119-135.

Atuahene-Gima, K. and Li, H. (2004), ‘Strategic Decision Comprehensiveness and New Product Development Outcomes in New Technology Ventures’, *The Academy of Management Journal* 47 (4): 583-597.

Baiman, S. (1982), ‘Agency research in management accounting: A survey’, *Journal of Accounting Literature* 1: 154-213.

Baiman, S. (1990), ‘Agency Research in Managerial Accounting: A Second Look’, *Accounting, Organizations and Society* 15 (4): 341-371.

Barney, J. B. (1991), ‘Firm resources and sustained competition advantage’, *Journal of Management* 17 (1): 99-120.

Birnberg, J. G. and Snodgrass, C. (1988), ‘Culture and control: A field study’, *Accounting, Organizations and Society* 13 (5): 447-464.

Bisbe, J. and Otley, D. (2004), ‘The Effects of Interactive Use of Management Control Systems on Product Innovation’, *Accounting, Organizations and Society* 29 (8): 709-737.

Blindenbach-Driessen F. and van den Ende, J. (2006). ‘Innovation in project-based firms: The context dependency of success factors’, *Research Policy* 35 (4): 545-561.

Bonner, J. M., Ruekert, R. W., and Walker, O. C. Jr. (2002), ‘Upper Management Control of New Product Development Projects and Project Performance’, *Journal of Product Innovation Management* 19 (3): 233-245.

Booz Allen Hamilton (1982), *New Products Management for the 1980s*, Booz Allen Hamilton, New York.

Brown S. L. and Eisenhardt, K. M. (1995), ‘Product development: Past research, present findings and future directions’, *Academy of Management Review* 20 (3): 343-378.

Brownell, P. and Dunk, A. S. (1991), ‘Task uncertainty and its interaction with budgetary participation and budget emphasis: Some methodological issues and empirical investigation’, *Accounting, Organizations and Society* 16 (8): 693-703.

Bruns, W. J. and Waterhouse, J. H. (1975), ‘Budgetary control and organization structure’, *Journal of Accounting Research* 13 (2): 177-203.

Cardinal, L. B. (2001), ‘Technological Innovation in the Pharmaceutical Industry: The Use of Organizational Control in Managing Research and Development’, *Organization Science* 12 (1): 19-36.

Chapman, C. S. (1998), ‘Accountants in organizational networks’, *Accounting, Organizations and Society* 23 (8): 737-766.

Chenhall, R. and Langfield-Smith, K. (1998), ‘The relationship between strategic priorities, management techniques and management accounting: An empirical investigation using a systems approach’, *Accounting, Organizations and Society* 23 (3): 243-264.

Chenhall, R. H. and Morris, D. (1986), ‘The impact of structure, environment, and interdependence on the perceived usefulness of management accounting systems’, *The Accounting Review* 61 (1): 16-35.

Cohen, W. M. and Levin, R. C. (1989), ‘Empirical studies of innovation and market structure’, in Schmalensee, R. and Willig, R. (eds), *Handbook of Industrial Organization*, Vol. 2, Elsevier Science, New York, 1060-1107.

Cooper, R. G. (1979), ‘The dimensions of industrial new product success and failure’, *Journal of Marketing* 43 (3): 93-103.

Cooper, R. G. (1995), ‘Developing new products on time, in time’, *Research-Technology Management* 38 (5): 49-57.

Cooper, R. G., Edgett, S., and Kleinschmidt, E. (2001), ‘Portfolio management for new product development: Results of an industry practices study’, *R&D Management* 31 (4): 361-381.

Cooper, R. G. and Kleinschmidt, E. J. (1986), ‘An Investigation into the New Product Process: Steps, Deficiencies, and Impact’, *Journal of Product Innovation Management* 3 (2): 71-85.

Damanpour, F. (1991), ‘Organizational innovation: A meta-analysis of effects of determinants and moderators’, *Academy of Management Journal* 34 (3): 555-590.

Davila, A., Foster G., and Li, M. (2009), ‘Reasons for management control systems adoption:

Insights from product development systems choice by early-stage entrepreneurial companies', *Accounting, Organizations and Society* 34 (3-4): 322-347.

Davila, T. (2000), 'An empirical study on the drivers of management control systems' design in new product development', *Accounting, Organizations and Society* 25 (4-5): 383-409.

Demski, J. S. and Feltham, G. A. (1976), *Cost Determination: A Conceptual Approach*, Ames, IA: Iowa State University Press.

Dewar, R. D. and Dutton, J. E. (1986), 'The Adoption of Radical and Incremental Innovations: An Empirical Analysis', *Management Science* 32 (11): 1422-1433.

Ditillo, A. (2004), 'Dealing with uncertainty in knowledge-intensive firms: The role of management control systems as knowledge integration mechanisms', *Accounting, Organizations and Society* 29 (3-4): 401-421.

Dougherty, D. (1992), 'Interpretive barriers to successful product innovation in large firms'. *Organization Science* 3 (2): 179-202.

Duncan, R. (1976), 'The ambidextrous organization: Designing dual structures for innovation', in Kilmann, R. H., Pondy, L. R., and Slevin, D. P. (eds), *The Management of Organization Design* Vol. 1, New York: North-Holland, 167-188.

Dunk, A. S. (2011), 'Product innovation, budgetary control, and the financial performance of firms', *The British Accounting Review* 43 (2): 102-111.

Ecker, B., van Triest, S., and Williams, C. (2013), 'Management Control and the Decentralization of R&D', *Journal of Management* 39 (4): 906-927.

Egelhoff, W. (1991), 'Information-processing theory and the multinational enterprise', *Journal of International Business Studies* 22 (3): 341-368.

Eisenhardt, K. M. (1985), 'Control: Organizational and economic approaches', *Management Science* 31 (2): 134-149.

Eisenhardt, K. M. (1989), 'Agency Theory: An Assessment and Review', *Academy of Management Review* 14 (1): 57-71.

Ernst, H. (2002), 'Success factors of new product development: A review of the empirical literature', *International Journal of Management Reviews* 4 (1): 1-40.

Evanschitzky, H., Eisend, M., Calantone, R. J., and Jiang, Y. (2012), 'Success Factors of Product Innovation: An Updated Meta-Analysis', *Journal of Product Innovation Management* 29 (S1): 21-37.

Felekoglu, B. and Moultrie, J. (2013), 'Top Management Involvement in New Product Development: A Review and Synthesis', *Journal of Product Innovation Management* 31 (1): 159-175.

Fisher, J. and Govindarajan, V. (1992), 'Profit Center Manager Compensation: An Examination of Market, Political and Human Capital Factors', *Strategic Management Journal* 13 (3): 205-217.

Galbraith, J. R. (1974), 'Organization design: An information processing view', *Interfaces* 4 (3): 28-36.

Gordon, L. A. and Narayanan, V. K. (1984), 'Management accounting systems, perceived environmental uncertainty and organizational structure: An empirical investigation', *Accounting, Organizations and Society* 9 (1): 33-47.

Gupta, A. K., Raj, S. P., and Wilemon, D. L. (1985), 'The R&D-Marketing Interface in High Technology Firms', *Journal of Product Innovation Management* 2 (1): 12-24.

Gupta, A. K. and Wilemon, D. L. (1990), 'Accelerating the development of technology-based new products', *California Management Review* 32 (2): 24-44.

Henard, D. H. and Szymanski, D. M. (2001), 'Why some new products are more successful than others', *Journal of Marketing Research* 38 (3): 362-375.

Henri, J.-F. (2006), 'Management control systems and strategy: A resource-based perspective', *Accounting, Organizations and Society* 31 (6): 529-558.

Hill, S., Martin, R., and Harris, M. (2000), 'Decentralization, integration and the post-bureaucratic organization: The case of R&D', *Journal of Management Studies* 37 (4): 563-586.

Horngren, C. T., Foster, G., and Datar, S. M. (2000), *Cost Accounting: A Managerial Emphasis*, Upper Saddle River, NJ: Prentice Hall.

Indjejikian, R. J. (1999), 'Performance evaluation and compensation research: An agency perspective', *Accounting Horizons* 13 (2): 147-157.

Jaeger, A. M. and Baliga, B. R. (1985), 'Control systems and strategic adaptation: Lessons from the Japanese experience', *Strategic Management Journal* 6 (2): 115-134.

Jensen, M. and Meckling, W. (1976), 'Theory of the firm: Managerial behavior, agency costs, and ownership structure', *Journal of Financial Economics* 3 (4): 305-360.

Keller, R. T. (1994), 'Technology-information professing fit and the performance of R&D project groups: A test of contingency theory', *The Academy of Management Journal* 37 (1): 167-179.

Khandwalla, P. (1972), 'The Effect of Different Types of Competition on the Use of Management Controls', *Journal of Accounting Research* 10 (2): 275-285.

Kim, K., Park, J. H., and Prescott, J. E. (2003), 'The global integration of business functions: A study of multinational businesses in integrated global industries', *Journal of International Business Studies* 34 (4): 327-344.

Koga, K. and Davila, A. (1999), 'What is the role of performance goals in product development? A study of Japanese camera manufacturers', in Hitt, M. A., Clifford, P. G., Nixon, R. D., and Coyne, K. P. (eds), *Dynamic Strategic Resources: Development, Diffusion and Integration*, New York: Wiley, 403-431.

Langfield-Smith, K. and Smith, D. (2003), 'Management control systems and trust in outsourcing relationships', *Management Accounting Research* 14 (3): 281-307.

Lawrence, P. R. and Lorsch, J. W. (1967), *Organization and Environment*, Boston, MA: Division of Research, Harvard Business School.

Lebas, M. and Weigenstein, J. (1986), 'Management control: The roles of rules, markets, and culture', *Journal of Management Studies* 23 (3): 259-272.

Lin, W. T. and Vasarhelyi, M. A. (1980), 'Accounting and financial control for R&D expenditure', in Dean, B. V. and Goldhar, J. D. (eds), *Management of Research and*

Innovation (TIMS Studies in the Management Sciences), Vol. 15, New York: North-Holland, 199-213.

Makhija, M. V., and Ganesh, U. (1997), 'The relationship between control and partner learning in learning-related joint ventures', *Organization Science* 8 (5): 508-527.

March, J. G. (1991, 'Exploration and exploitation in organizational learning', *Organization Science* 2 (1): 71-87.

Marginson, D. E. W. (2002), 'Management control systems and their effects on strategy formation at middle-management levels: Evidence from a UK organisation', *Strategic Management Journal* 23 (11): 1019-1031.

Massaro, M., Bardy, R., and Zanin, F. (2011), 'Innovation Strategy and Management Control: The Link Between Knowledge Management and Management Control Systems', *Proceedings of the 3rd European Conference on Intellectual Capital*, 231-239.

McDonough, E. F., III, and Leifer, R. (1983). 'Using simultaneous structures to cope with uncertainty', *The Academy of Management Journal* 26 (4): 727-735.

Merchant, K. A. (1981), 'The design of the corporate budgeting system: Influences on managerial behavior and performance', *The Accounting Review* 56 (4): 813-829.

Merchant, K. A. (1985), *Control in Business Organizations*, Pitman, Boston, MA.

Merchant, K. A. and Otley, D. T. (2006), 'A review of the literature on control and accountability', in Chapman, C., Hopwood, A., and Shield, M. (eds), *The Handbook of Management Accounting Research*, Elsevier Press, 785-802.

Merchant, K. A. and van der Stede, W. A. (2007), *Management Control Systems: Performance Measurement, Evaluation and Incentives* (2nd ed.), Harlow, UK: Prentice Hall.

Mintzberg, H. (1976), 'Planning on the left side and managing on the right', *Harvard Business Review* 54 (4): 49-58.

Mintzberg, H. (1979), *The Structuring of Organizations*, Upper Saddle River NJ: Prentice Hall.

Mintzberg, H. (1983), *Structure in Fives: Designing Effective Organizations*, Englewood Cliffs: Prentice-Hall, Inc.

Mintzberg, H. (1994), *The Rise and Fall of Strategic Planning*, New York, NY: Free Press.

Montoya-Weiss, M. M. and Calantone, R. (1994), 'Determinants of New Product Performance: A Review and Meta-Analysis', *Journal of Product Innovation Management* 11 (5): 397-417.

Mundy, J. (2010). 'Creating dynamic tensions through a balanced use of management control systems', *Accounting, Organizations and Society* 35 (5): 499-523.

Narayanan, V. G. and Davila, A. (1998), 'Using delegation and control systems to mitigate the tradeoff between the performance-evaluation and belief-revision uses of accounting signals', *Journal of Accounting and Economics* 25 (3): 255-282.

Nelson, R. R. and Winter, S. G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Belknap Press of Harvard University Press.

Nixon, B. (1998), 'Research and development performance measurement: A case study', *Management Accounting Research* 9 (3): 329-355.

Ouchi, W. (1977), 'The Relationship between Organizational Structure and Organizational Control', *Administrative Science Quarterly* 22 (1): 95-113.

Ouchi, W. (1979), 'A Conceptual Framework for the Design of Organizational Control Mechanisms', *Management Science* 25 (9): 833-847.

Perrow, C. (1970), *Organizational Analysis: A Sociological View*, New York, NY: Tavistock Publications.

Ray, M. and Schlie, T. (1993), 'Activity-based management of innovation and R&D operations', *Journal of Cost Management* (Winter): 16-22.

Rockness, H. O. and Shields, M. D. (1984), 'Organizational Control Systems in Research and Development', *Accounting, Organizations and Society* 9 (2): 165-177.

Rockness, H. O. and Shields, M. D. (1988), 'An empirical analysis of the expenditure budget in research and development', *Contemporary Accounting Research* 4 (2): 568-581.

Rothwell, R. (1972), *Factors for Success in Industrial Innovations from Project SAPPHO – A Comparative Study of Success and Failure in Industrial Innovation*, Brighton, Sussex, England: S.P.R.U.

Rothwell, R., Freeman, C., Horley, A., Jervis, V. I. P., Robertson, A. B., and Townsend, J. (1974), 'SAPPHO Updated – Project SAPPHO, Phase II', *Research Policy* 3 (3): 258-291.

Roussel, P. A., Saad, K. N., and Erickson, T. J. (1991), *Third Generation R&D: Managing the Link to Corporate Strategy*, Harvard Business School Press, Boston, MA.

Rowe, W. G. and Wright, M. (1997), 'Related and unrelated diversification and their effect on human resource management controls', *Strategic Management Journal* 18 (4): 329-338.

Rubenstein, A. H., Chakrabarti, A. K., O'keffe, R. D., Souder, W. E., and Young, H. C. (1976), 'Factors Influencing Innovation Success at the Project Level', *Research Management* (May): 15-20.

Samuelson, L. A. (1986), 'Discrepancies between the roles of budgeting', *Accounting, Organizations and Society* 11 (1): 35-45.

Schermann, M., Wiesche, M., and Krcmar, H. (2012), 'The Role of Information Systems in Supporting Exploitative and Exploratory Management Control Activities', *Journal of Management Accounting Research* 24 (1): 31-59.

Shalley, C. E., Zhou, J., and Oldham, G. R. (2004), 'The effects of personal and contextual characteristics on creativity: Where should we go from here?', *Journal of Management* 30 (6): 933-958.

Simon, H. A., Kozmetsky, G., Guetzkow, H., and Tyndall, G. (1954), *Centralization vs. Decentralization in Organizing the Controller's Department*, New York: Controllership Foundation, Inc.

Simons, R. (1987). 'Accounting control systems and business strategy: An empirical analysis'. Accounting, Organizations and Society, 12(4): 357-375.

Simons, R. (1990), 'The Role of Management Control Systems in Creating Competitive Advantage: New Perspectives', *Accounting, Organizations and Society* 15 (1-2): 127-143.

Simons, R. (1994), 'How New Top Management Use Control Systems as Levels of Strategic Renewal', *Strategic Management Journal* 15 (3): 169-189.

Simons, R. (1995), *Levers of Control: How Managers Use Innovative Control Systems to Drive Strategic Renewal*, Boston, MA: Harvard Business School Press.

Snell, S. A. (1992), 'Control theory in strategic human resource management: The mediating effect of administrative information', *The Academy of Management Journal* 35 (2): 292-327.

Souder, W. E. and Chakrabarti, A. K. (1979), 'Industrial Innovations: A Demographical Analysis', *IEEE Transactions on Engineering Management* 26 (4): 101-109.

Speklé, R. F. (2001), 'Explaining management control structure variety: A transaction cost economics perspective', *Accounting, Organizations and Society* 26 (4-5): 419-441.

Sprinkle, G. B. (2003), 'Perspectives on experimental research in managerial accounting', *Accounting, Organizations and Society* 28 (2-3): 287-318.

Sunder, S. (1997), *Theory of Accounting and Control* Cincinnati, OH: South-Western Publishing Company.

Tiessen, P. and Waterhouse, J. H. (1983), 'Towards a descriptive theory of management accounting', *Accounting, Organizations and Society* 8 (2-3): 251-267.

Tushman, M. L. and Nadler, D. A. (1978), 'Information Processing as an Integrating Concept in Organizational Design', *The Academy of Management Review* 3 (3): 613-624.

van der Panne, G., van Beers, C., and Kleinknecht, A. (2003), 'Success and Failure of Innovation: A Literature Review', *International Journal of Innovation Management* 7 (3): 309-338.

Veryzer, R. W. (2005), 'The Roles of Marketing and Industrial Design in Discontinuous New Product Development', *Journal of Product Innovation Management* 22 (1): 22-41.

Wheelwright, S. C. and Clark, K. B. (1992), *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency and Quality*, New York: Free Press.

Widener, S. K. (2007), 'An empirical analysis of the levers of control framework', *Accounting, Organizations and Society* 32 (7-8): 757-788.

Wiersema, M. F. and Bantel, K. A. (1992), 'Top management team demography and corporate strategic change', *The Academy of Management Journal* 35 (1): 91-121.

Ziger, B. J. and Maidique, M. A. (1990), 'A model of new product development: An empirical test management science', *Management Science* 36 (7): 867-883.

Zimmerman, J. L. (2005), *Accounting for Decision Making and Control* (4th ed.), New York: Irwin.

附录 A　研发活动关键控制机制的文献依据

研发成功的关键控制机制	文献依据	控制机制的具体内容	控制功能
高层领导的参与	Brown and Eisenhardt (1995); Ernst (2002); Felekoglu and Moultrie (2013); Henard and Szymanski (2001); Evanschitzky *et al.* (2012); Montoya-Weiss and Calantone (1994); van der Panne *et al.* (2003)	① 拥有权力和权威的高层领导支持该项目	支持
		② 企业对开发的项目从发起到市场阶段都有高层领导的支持	支持
		③ 高层领导对研发人员活动和研发成本的评价是否非常频繁	监控
		④ 高层领导是否经常了解 / 评价研发活动的预算和成本	监控
		⑤ 高层领导是否经常提供对预算执行以及成本考核的非正式反馈意见	监控
项目经理的能力	Bisbe and Otley (2004); Brown and Eisenhardt (1995); Ernst (2002)	① 在整个开发和引进过程中，项目经理在高层、其他职能部门和顾客方面的协调程度很强	支持
		② 负责该项目开发的经理人员有较高的职位和权威	支持
研发团队的构成	Bisbe and Otley (2004); Brown and Eisenhardt (1995); Ernst (2002); Henard and Szymanski (2001); Evanschitzky *et al.* (2012); van der Panne *et al.* (2003)	① 你对团队中研发人员的专业化程度和涉及领域十分满意	支持
		② 研发团队内部能够很好地协调沟通、更新收集的数据、分析和实施研发项目	支持
项目管理与资源分配			
1、评价项目可行性，选择正确的项目	Bisbe and Otley (2004); Brown and Eisenhardt (1995); Evanschitzky *et al.* (2012); Veryzer (2005)	① 立项评审会议的专业化程度很高 ② 有专门的情报部门提供关于用户需求、营销和宣传方面的信息，项目团队非常了解该产品的顾客群体和市场	支持
2、立项前对产品缺陷的认识	Zimmerman (2005)	③ 在立项之前，有专门的评估程序在投产前对项目的缺陷进行把关，尤其是对前期相关项目的经验教训进行总结	支持

3、恰当分配资本和人力资源	Henard and Szymanski (2001); Zimmerman (2005)	④ 立项之前，财务部门和技术部门会同研发部门共同商讨研发项目人、财、物资源的分配	支持
4、有效使用资源	Zimmerman (2005)	⑤ 任何支出都有严格的审批程序	监控
		⑥ 研发项目的预算目标非常具体明确	监控
		⑦ 成本管理的清晰和健全会得到奖励	监控
		⑧ 预算的节约会得到奖励	监控
		⑨ 与研发项目相关的论文发表和著作出版会得到奖励	监控
		⑩ 与研发项目相关的专利申请会得到奖励	监控
内外部交流与合作	Brown and Eisenhardt (1995); Ernst (2002; Henard and Szymanski (2001); Evanschitzky *et al.* (2012)	① 研发、生产和营销部门能够很好地协调沟通、更新收集的数据、分析和做出研发项目的决策	支持
		② 研发工作能有效利用外部技术和学术交流	支持

附录 B 访谈对象和内容统计表

访谈对象	人数	访谈次数和形式	级别	访谈内容
总经理	1	1 次面谈	高层管理者	公司发展战略、研发活动的整体情况
常务副总经理	1	1 次面谈	高层管理者	研发工作的思路
财务总监	1	2 次面谈	高层管理者	研发活动相关的财务制度
科研处处长	1	3 次面谈，3 次电话访谈	中层管理者	研发管理控制系统和管理流程
财务处工作人员	1	1 次面谈	员工	研发预算的制定、执行和考核情况
科研处工作人员	4	3 次面谈 / 人，其中一人 3 次电话访谈	员工	研发活动具体管理制度
研发项目经理	4	2 次面谈/人	中层管理者	研发项目具体信息

附录 C 问卷填写人的信息

项目经理	工作年限	担任研发项目经理的年限	最终学历
A	14	10	硕士及以上
B	8	4	硕士及以上
C	10	5	硕士及以上
D	15	6	本科

Volume 17, Number 1 – March 2015
China Accounting and Finance Review
中 国 会 计 与 财 务 研 究
2015年3月 第17卷 第1期

Research on the Management Control Systems in Different R&D Activities − A Field Study of a Listed Company[1]

Yue Wang, Fei Pan, Lin Zhou, and Chenggong Zhao[2]

Received 2nd of September 2014 Accepted 11th of February 2015

Abstract

Management control systems (MCS) are fundamental to the progress of research and development (R&D) activities. However, misunderstanding the functions of MCS impedes their scientific design. In view of this, we assess the literature on the key mechanisms of MCS in an R&D context according to the contingency and resource-based theories, and propose a framework which effectively demonstrates these mechanisms. The framework divides the progress of R&D into three stages and analyses the effects of control mechanisms on different R&D activities by distinguishing between their different functions. Finally, we verify the rationality of our framework, with a view to improving current MCS design, using a field study. Our work can help organisations to recognise the role of MCS and provides valuable theoretical and empirical evidence to support their R&D activities.

***Keywords*:** Radical R&D, Incremental R&D, Management Control Systems, Resource-based Theory

---

1 We gratefully acknowledge financial support from the following projects under the National Natural Science Foundation of China: Key Programme (Approval no. 71032005), Youth Research Project (Approval no. 71402086), and general programmes (Approval nos. 71272013, 71272218, and 71172143). This paper is also part of the research sponsored by the Key Research Institutes of Humanities and Social Science in Chinese Universities (Approval nos. 10JJD630005 and 12JJD790037) and Youth Research of Humanities and Social Science in Chinese Universities (Approval no. 11YJC790072) within the Ministry of Education. We also thank the programme for innovative research teams of the Shanghai University of Finance and Economics (IRTSHUFE) for financial support. We appreciate the helpful comments and suggestions made by participants in the Annual Management Accounting Conference 2013 of the Accounting Society of China and the Commercial Accounting Conference 2014.

2 Corresponding author: Yue Wang, PhD, Institute of Accounting and Finance, Shanghai University of Finance and Economics; email: wang.yue@mail.shufe.edu.cn. Fei Pan, PhD, Institute of Accounting and Finance, Shanghai University of Finance and Economics. Lin Zhou, PhD, Henan University of Economics and Law. Chenggong Zhao, Director of Scientific Research Department, XJ Electric Co., Ltd.

I. Introduction

Research and development (R&D) activities have become increasingly critical for firms. Not only are they used for achieving and maintaining competitive advantage (Cardinal, 2001), but they are also a key part of the value management of organisations. Research shows that new product introductions are vital to most manufacturing firms' growth and prosperity and contribute more than 30% of profits. For technology-driven industries, the contribution of new products to profits is over 40% (Booz Allen Hamilton, 1982). As the starting point and core of value chain management, R&D is very important to a firm's value creation. It is therefore necessary for firms to build special management control systems (MCS) in order to plan and control their R&D activities. MCS consist of the formal and informal control mechanisms (Ouchi, 1979) through which firms implement organisational strategies by means of various systems and methods, such as the organisational structure, control programme, organisational culture, and human resources. Use of appropriate MCS can reduce agency costs (Fisher and Govindarajan, 1992), enable organisational strategies to be successfully implemented, increase the efficiency and effectiveness of operations management, reduce management errors, and improve learning ability (Lawrence and Lorsch, 1967). Scientific MCS will help to improve the effectiveness and efficiency of R&D activities and enhance firms' innovation capability and competitive advantage. Therefore, it is very important to build scientific MCS for R&D activities.

There are two different views of the effects of MCS on R&D activities. The first suggests that MCS can stifle innovation (Ouchi, 1979; Amabile, 1998; Shalley *et al.*, 2004). This arises because traditional MCS mainly refers to formal control mechanisms, which are best suited to managing stable and normal organisational behaviour. However, innovation contains so many uncertainties and exceptions that it is difficult to confirm the relationship between input and output and evaluate the output correctly. If MCS are not designed to deal with uncertainty, they may constrain cross-functional interactions, limit communication to established patterns, penalise deviations, and diffuse leadership (Davila *et al.*, 2009). Therefore, MCS may limit a firm's innovation capacity (Rockness and Shields, 1988; Abernethy and Brownell, 1997).

An alternative point of view is that MCS have a positive effect on R&D activities (Koga and Davila, 1999; Nixon, 1998; Cardinal, 2001). MCS in new product development are viewed as sources of information that can be used to close the gap between what is already known and the information required to perform a task. For example, Tushman and Nadler (1978) argue that MCS are effective tools to manage uncertainty and can therefore be very useful for managing innovation activities that need a lot of information. This line of research has explored the effects of MCS on R&D activities in a number of specific environments (Chapman, 1998; Ditillo, 2004).

It is unfortunate that research to date has not provided consistent empirical evidence to verify the effects of MCS on different R&D activities (Bisbe and Otley, 2004). There are two reasons for this. Firstly, a very large body of research has been unable to distinguish between the different effects of MCS functions on R&D activities (Keller, 1994) because MCS are considered as a whole. In fact, MCS have two different functions; controlling and enabling (Simons, 1990; Speklé, 2001; Turner and Makhija, 2006; Mundy, 2010), which have different or even opposing effects on R&D activities. The controlling function monitors and rewards employees' behaviour in order to realise organisational goals (Turner and Makhija, 2006). According to the agency theory, monitoring is the most important function of MCS (Jensen and Meckling, 1976; Baiman, 1990). The enabling function refers to providing information to reduce pre-decision uncertainty, reflecting the common role of MCS in information processing (Simons, 1994; Makhija and Ganesh, 1997), planning, and coordination (Zirger and Maidique, 1990; Cooper, 1995). This perspective embodies the information processing view (Galbraith, 1974).

Secondly, studies have also tended to neglect differences in innovation levels among R&D activities. R&D activities can be divided into two types – incremental and radical – according to the demand for new knowledge and level of uncertainty. Radical R&D involves much more risk and demands more information than incremental (Dewar and Dutton, 1986; Roussel *et al.*, 1991). The challenge for management is to achieve sustainable trade-offs to resolve the tension between different types of organisational activities, because they have to compete for scarce organisational resources. As a result, organisations make explicit and implicit choices between the two types of R&D (March, 1991; Schermann *et al.*, 2012). Cardinal (2001) suggests that across R&D projects, teams should not be managed in the same ways due to different project characteristics such as riskiness, ambiguity, nonroutineness, and radicalness. Radical R&D projects require external sources of information that are dependent upon disciplinary knowledge and publicly available science, while incremental R&D projects require internal sources of information that are specific to the firm (Cardinal, 2001).[3] Therefore, it may be proposed that radical R&D activities need to make more use of the enabling function of MCS, whereas the controlling function is more useful to incremental R&D activities because it can regulate stable and routine tasks (Ouchi, 1977).

In summary, if R&D activities should be managed according to the type of project involved, organisational control mechanisms will affect them differently (Cardinal, 2001); furthermore, even the same control mechanisms will have different effects at different R&D

[3] In the case of the pharmaceutical industry, radical innovations represent major changes in technology involving the discovery of new knowledge and substantial technical risk, time, and cost. Incremental innovations represent minor changes to existing technology involving small advances based on an established foundation of knowledge (Cardinal, 2001).

stages. So, the functions of MCS can be applied differently to manage different types of organisational activities (Schermann *et al.*, 2012). However, it is unrealistic for MCS to fulfil both functions at the same time, because organisational resources are scarce (Marginson, 2002; March, 1991). This means that the functions of MCS should be properly directed to managing R&D activities. Because both theory and empirical evidence in this area are still scarce, we use a case study method to propose a research framework which describes the effect of the two functions of MCS on different R&D activities (Figure 1). The framework shows that the controlling function of MCS is more important to incremental R&D activities, while the enabling function is more vital to radical projects. Furthermore, the results of our field study verify that the framework is reasonable.

This study is not the first to examine the relationship between MCS and R&D activities, but it is the first to do so by differentiating clearly the functions of MCS. Firstly, we do not investigate all elements of the whole MCS, but propose five types of key control mechanisms of R&D activities on the basis of a literature review and field study (Montoya-Weiss and Calantone, 1994; Brown and Eisenhardt, 1995; Henard and Szymanski, 2001; Ernst, 2002). Our reasons are as follows. Firstly, organisational resources are scarce, so companies should focus on the key control mechanisms in the R&D process. Secondly, from the resource-based perspective (Henri, 2006), we study the effects of key control mechanisms on the two types of R&D activities by distinguishing between their functions, and emphasise that the organisation should balance the controlling and enabling functions of MCS in the R&D process and distinguish types of R&D activities so as to manage them more effectively. This will enhance organisational ability and competitive advantage (Mundy, 2010). Finally, we verify our research framework on the basis of a literature review and field evidence.

The rest of this paper is set out as follows. The next section comprises the literature review on the relationship between MCS and R&D, the types of R&D activities, and the functions of MCS, leading to the development of our research framework. Section III describes the research methods and the analysis of measures used. The final section sets out our conclusions and discusses the limitations of our study.

II. Literature Review and Research Framework

2.1 MCS and R&D Activities

2.1.1 MCS stifling R&D activities

Some studies consider that MCS either impedes or does not affect R&D activities (Amabile, 1998; Shalley *et al.*, 2004). Damanpour (1991) reviews empirical studies on the determinants of innovation and find that innovation is negatively related to formal MCS.

Amabile (1998) considers that MCS may diminish the intrinsic motivation and freedom that innovation requires. Specifically, it is very difficult to accumulate the cost of R&D activities and measure their output timeously (Rockness and Shields, 1988; Nixon, 1998). For instance, it is difficult to use budgets as an effective control tool because R&D activities lack programmability and an obvious input-output relationship, which prevents the budget from playing its role (Rockness and Shields, 1988; Ray and Schlie, 1993; Abernethy and Brownell, 1997). However, a budget can be an effective control tool when the task is clear and output can be measured accurately (Bruns and Waterhouse, 1975; Merchant, 1981; Brownell and Dunk, 1991). Therefore, scholars have begun to consider the relationship between different types of tasks and MCS. Following Perrow's (1970) model, Abernethy and Brownell (1997) relate control types with task analysability and routines. They propose that accounting controls have significant positive effects on corporate performance only where task uncertainty is low, and behaviorbehavioural controls have no effect on performance under any circumstances,[4] showing that MCS cannot play an important role in R&D activities (Davila, 2000). Hill *et al.* (2000, p. 565) claim that R&D activities are "difficult to incorporate into organizationisational control systems", while Kim *et al.* (2003, p. 336) find that "formalizationisation and centralizationisation are not effective in coordinating and controlling R&D". The idiosyncratic nature of R&D means that the application of result controls or action controls is difficult (Ecker *et al.*, 2013). Therefore, Merchant and van der Stede (2007, p. 183) state that "many organizationisations operate on the belief that research scientists are highly professional and will control themselves better than the organizationisation could by implementing formal controls". In addition, Keller (1994) considers that the demands of information processing vary with a project's complexity and routines. Therefore, Cardinal (2001) proposes that a fit between the routines and information processing of projects will have a positive effect on R&D performance. Davila *et al.* (2009) also consider that the formal mechanisms of MCS will particularly support the periodic and routinely activities of enterprises, but cannot be used to judge the relation between MCS and R&D activities because the latter are associated with uncertainty, unknown relations between input and output, exceptions, and an output that is hard to evaluate. Generally speaking, MCS restrain the creation of R&D activities and have negative effects on firm performance via rule formulation and behaviour limitation (Amabile, 1998).

2.1.2 MCS driving R&D activities

Two key streams of literature provide insights on the positive effects of MCS on R&D

---

[4] In the MCS literature, the terms behaviour control and process control are often used interchangeably (Rowe and Wright, 1997; Cardinal, 2001; Turner and Makhjia, 2006). Likewise, outcome control and output control are used synonymously (Snell, 1992; Cardinal, 2001; Turner and Makhjia, 2006). For clarity, we use the terms process control and output control in this paper.

activities (Nixon, 1998; Cardinal, 2001). The first studies the relationship between different stages of MCS and different R&D activities. For example, Cardinal (2001) divides MCS into three controls, namely input, process, and output, and considers that each has a different effect on different R&D projects. However, the empirical evidence does not support this hypothesis in general. Moreover, he finds that process and output controls have neither a positive effect on incremental R&D nor a negative effect on radical R&D. His research indicates that the relationships between the three stages of controls and R&D activities lack logical precision.

The second stream of research focuses on the relation between MCS or its components and R&D activities. For example, Nixon (1998) describes how financial controls can have positive effect on the R&D process in a case study. Abernethy and Brownell (1997) as well as Bisbe and Otley (2004) suggest that if budgets are used primarily as a planning mechanism, product innovation is likely to have a positive effect on firm performance. Planning involves making resource decisions, setting objectives, predicting outcomes under alternative ways of achieving those objectives, and then deciding on a course of action (e.g. Lin and Vasarhelyi, 1980; Horngren *et al.*, 2000). When budgets are used as a planning mechanism, they are prepared and discussed across managerial levels, and forecasts of likely outcomes are made in order to develop improved organisational solutions (Samuelson, 1986). Therefore, when budgets are used primarily as a planning mechanism, product innovation will be more likely to enhance firms' financial performance (Dunk, 2011). In later studies, MCS have been shown to be useful tools in environments characterised by a high level of uncertainty (Davila, 2000). For example, Khandwalla (1972) finds that reliance on formal control systems increases with the intensity of competition. Similarly, Simons (1987) reports that high-performing prospectors rely on the information provided by frequently updated formal control systems to drive organisational learning. Managers who perceive a higher level of environmental uncertainty tend to use a broader scope and more timely information (Chenhall and Morris, 1986) as well as more external, nonfinancial, and *ex ante* information (Gordon and Narayanan, 1984). Kren (1992) finds that participation in the budgeting process is related to better performance for tasks with high uncertainty because it increases the communication of job information. Chenhall and Langfield-Smith (1998) also report that different strategic priorities place emphasis on different formal control systems regardless of the uncertainty faced by the organisation. Therefore, researchers have suggested that because of the different levels of uncertainty and complexity, a contingency approach should be taken to organising innovation activities (Duncan, 1976; McDonough and Leifer, 1983; Dewar and Dutton, 1986; Keller, 1994). This is also the view taken in this work. In conclusion, MCS have contingent effects on R&D performance, and if MCS functions match with the types of R&D projects, the fit will contribute positively to R&D performance (Simons, 1990; Koga and Davila, 1999).

2.2 Categories of R&D Projects

The relationship between MCS and R&D outcomes is dependent on the characteristics of R&D projects, that is, the degree of innovation (Cardinal, 2001; Bonner *et al.*, 2002). Bonner *et al.* (2002) divides R&D activities into five types according to this dimension; (1) New to the World. These products create entirely new markets. No firm has ever developed similar products. Potential customers have never seen such a product before. (2) New to the Firm. This is a new product to the firm but at least one competitor has something comparable to it on the market. Customers have some knowledge of this type of product. (3) Line extension. The product is an extension of an existing line or related products already being produced by the firm. (4) Product modification. The product is an improvement to an existing product the firm already manufactures. (5) Process modification. The product is being manufactured in a new way. It can be seen that the first two of these display more innovation while the latter three show less, so they are different in terms of the uncertainty of innovation (Bonner *et al.*, 2002).

Dewar and Dutton (1986) propose the concepts of "radical innovation" and "incremental innovation". Radical innovations represent major changes in technology involving the discovery of new knowledge and substantial technical risk, time, and cost (Roussel *et al.*, 1991). Incremental innovations represent minor changes to existing technology involving small advances based on an established foundation of knowledge (Roussel *et al.*, 1991).

Following this line of research (Cardinal, 2001; Bonner *et al.*, 2002), we group "new to the world" and "new to the firm" as radical R&D, and "line extension", "product modification", and "process modification" as incremental R&D.

2.3 Functions of MCS

Merchant and Otley (2006) consider that the goal of MCS is to provide information for decision making, planning, and evaluation. Managers use MCS as a set of formal and information-based routines and procedures to maintain or alter patterns in organisational activities (Simons, 1995), so as to control the attainment of organisational goals and enable employees to search for opportunities and solve problems (Simons, 1995; Ahrens and Chapman, 2004; Zimmerman, 2005). Accordingly, Mundy (2010) summarises the complementary and interdependent functions of MCS into two types; enabling and controlling. These necessitate a balance between taking actions that are congruent with the organisation's goals while also giving employees sufficient autonomy to make decisions (Roberts, 1990; Sprinkle, 2003; Mundy, 2010). This balance is determined by a match between the problems faced by the organisation and the problem-solving abilities available (Speklé, 2001). When such a match is achieved, the controlling and enabling functions of MCS will create dynamic tensions that produce unique organisational capabilities and competitive advantage (Henri, 2006; Widener, 2007). We consider that R&D should balance the two functions correctly to improve organisational ability and competitive advantage, so it is important to study R&D activities from the perspective of MCS functions.

In fact, Mundy (2010) was not the first to propose the two functions of MCS. A large body of literature refers to this. For example, Mintzberg (1976, 1979, 1994) emphasises the separation of **planning** and **managing** within MCS. Planning refers to informal and managing to formal control mechanisms. Similarly, Simons (1990) considers that MCS are used not only to monitor the congruence of outcomes with plans, but also to motivate the organisation to be fully informed about the current and expected state of strategic uncertainties. Furthermore, he proposes that MCS not only embody the monitoring function, but also support or correct organisational behaviour by using many kinds of information.

Sprinkle (2003) considers that a management accounting information system serves two important roles: decision-facilitating and -influencing. The former provides some of the necessary information for employees to make decisions in the organisation's interests (that is, the enabling function in our framework) whereas the latter provides management accounting information to mitigate the conflict of interest between employees and owners and motivate employees to maximise firm value (Zimmerman, 2000); that is, the controlling function. Massaro *et al.* (2011) consider that MCS have three important roles; learning, problem solving, and surveillance. The first two of these can be viewed as the enabling function. Since the enabling and controlling functions try to answer different kinds of questions, and organisational resources are scarce, it is unrealistic for both functions to be fulfilled at the same time in R&D activities (March, 1991; Marginson, 2002). This means that the R&D process should be managed according to the types of activity involved. The arguments for the two functions of MCS are the agency theory and the information processing view, respectively (Baiman, 1982; Narayanan and Davila, 1998). We will now elaborate these two functions on the basis of these views.

2.3.1 Controlling function based on the agency theory

Controlling means monitoring and rewarding employees' actions taken to realise organisational goals (Turner and Makhija, 2006). It can reduce the information asymmetry between principal and agent to constrain the latter's opportunistic behaviour so that it will not diverge from organisational goals. This is the most important function of MCS (Jensen and Meckling, 1976; Baiman, 1990). As pointed out by Eisenhardt (1989, p. 60), "since the MCS inform the principal about what the agent is actually doing, they are likely to curb agent opportunism because the agent will realise that he or she cannot deceive the principal". This manifests the controlling function of MCS. The controlling mechanisms include the budgeting system, reporting principles, direct monitoring, and internal auditing (Jensen and Meckling, 1976; Eisenhardt, 1989). Sprinkle (2003) proposes that the use of MCS for controlling purposes is intended to influence employee behaviour via the effects of monitoring, measuring, evaluating, and rewarding actions and performance on motivation. For example, to motivate employees to control costs, firms might link compensation to performance by providing financial incentives that encourage managers to achieve an actual cost that is less than the budgeted or standard cost. Additionally, firms might use cost allocation to motivate mutual monitoring, cooperation, or the efficient use of a resource (Zimmerman, 1979, 2000). Generally speaking, the controlling function is used to keep employees' behaviour consistent with organisational interests (Merchant, 1985; Sunder, 1997; Sprinkle, 2003). Therefore, the primary function of MCS is to mitigate the inherent conflict of interest between employees and owners and motivate the former to maximise firm value (Indjejikian, 1999). Massaro *et al.* (2011) also propose that MCS are used mainly as surveillance tools.

In addition, the relationship between the controlling function and R&D is worthy of further investigation. Ouchi (1979) suggests that if the means-ends relationships involved in basic production or service activities (that is, the technology) are well understood, then the controlling function can be effective simply by having someone watch over the behaviour of the employees and the workings of the machines. Both Cardinal (2001) and Bonner *et al.* (2002) consider that the degree of control reflects the freedom of R&D teams to manage tasks and take actions; that is, decentralisation. In an empirical study, Damanpour (1991) reports that the relationship between organisational innovation and the formal control mechanisms of MCS is negative, and between centralisation and product innovation is also negative, but that the results are insignificant. Perrow (1970) also considers that the formal mechanisms of MCS are especially effective in tasks with higher analysability and few exceptions. However, innovation activities are always tasks with lower analysability and more exceptions, so we propose that the controlling functions of MCS are effective when dealing with less innovative tasks and are mainly intended to reduce the divergence of goals between organisations and individuals. Currently, there is little empirical evidence for the relationship between controlling mechanisms and innovation tasks.

2.3.2 Enabling function based on the information processing view

Product development is an uncertain process and the information provided by organisations is needed to make decisions. Gupta and Wilemon (1990) report that according to 58% of the project managers they surveyed, technological uncertainty is a reason for delays in R&D projects. Therefore, organisations require enough information to resolve the many questions arising in the new product R&D process (Davila, 2000). MCS have to collect and deal with many kinds of information to close the gap between the information required to perform a task and the amount of information already known, so as to reduce the uncertainties in the R&D process (Galbraith, 1974). This is consistent with the work of

Tushman and Nadler (1978) and Davial (2000), who argue that MCS are effective tools to manage uncertainty because they supply the data needed to reduce any information gaps.

Similarly, a great deal of literature discusses the inherent information processing properties of control mechanisms (Tushman and Nadler, 1978; Ouchi, 1979; Nelson and Winter, 1982; Egelhoff, 1991). Such mechanisms, which encompass routines, coordination mechanisms, and organisational norms, mandate specific relationships between individuals and groups that influence how information is shared and knowledge disseminated within the firm (Simons, 1994; Makhija and Ganesh, 1997). This decreases decision uncertainty (Demski and Feltham, 1976). Such a function refers to the provision of information, especially about management accounting, to resolve questions (Simon *et al.*, 1954; Baiman, 1982; Tiessen and Waterhouse, 1983; Sprinkle, 2003). Sprinkle (2003) proposes that the use of managerial accounting information to facilitate decision making is intended to improve employees' knowledge, thereby enhancing their ability to make desirable judgments and decisions and better-informed choices. For example, firms supply managers with product cost data to help ensure appropriate pricing decisions which emphasise the product. They also provide standard cost variances so that managers can determine the source of deviation from planned performance and take corrective action. According to Massaro *et al.* (2011), the learning function of MCS means that enterprises use MCS to support innovation processes, including debating development measures within research teams and brainstorming problems. They also propose the problem-solving function of MCS, which means that enterprises use MCS to manage the complexity linked to innovation processes, reduce decision times, and to increase employees' concern about problems. Both the learning and problem-solving aspects belong to the enabling function. Sprinkle (2003) also emphasises that the enabling function can help enterprises to make economic judgments and decisions.

Some of the literature explores the relation between the enabling function and R&D activities. For example, both Zirger and Maidique (1990) and Cooper (1995) find that R&D projects which focus on planning and coordinating will succeed. Davila (2000) also finds that management accounting information has a positive effect on R&D performance. He suggests that MCS have an important role in product development because they can reduce the uncertainty in R&D processes. Therefore, we propose that enabling functions consist of information processing, planning, communication, and coordination, all of which are particularly important to radical R&D activities.

2.4 Research Framework of this Study

2.4.1 Key control mechanisms for successful R&D activities

According to the resource-based view, organisations should create sustainable competitive advantage (Barney, 1991). This competitiveness is a function of the strength, expert exploitation, and leveraging of specific internal resources and capabilities controlled by a firm. To realise it, MCS must be aligned with firm capabilities so as to be effective and consistent with strategic choices (Henri, 2006). Hence, implementing organisational strategy using MCS is a very important issue for firms.

MCS consist of control mechanisms (Perrow, 1970; Ouchi, 1979; Abernethy and Brownell, 1997). Perrow (1970) suggests that these include formal and informal elements. Ouchi (1979) divides control mechanisms into market, bureaucracy, and social control.[5] Market and bureaucracy control are viewed as formal, and social control as informal. Following Perrow (1970), Abernethy and Brownell (1997) investigate formal control, including accounting and behaviour, and personnel control which is informal. Rockness and Shields (1984) view social control as defined by Ouchi (1979) as a specific input control, which refers to personnel selection, training processes, and expenditure budgeting; behaviour control consists of a set of formal rules, operating procedures (such as standard operating procedures), and technical scheduling. Output control refers to internal markets based on transfer pricing.[6] They consider that the role of control mechanisms is associated with the characteristics of tasks, such as complexity and inter-dependence. However, neither Abernethy and Brownell (1997) nor Rockness and Shields (1984) find consistent empirical evidence to prove the relationship between control mechanisms and R&D activities, because they do not uncover the key control mechanisms of successful R&D.

As suggested by Ittner and Larcker (2001), one key element in studying implementation strategies for MCS is to identify the specific control mechanisms that lead to strategic success. Cardinal (2001) divides control mechanisms into three stages; input, process, and output control to manage R&D activities. The mechanisms of input control include specialist diversity and professionalisation; process control is exercised through centralisation, formalisation, and frequency of performance appraisal; and the mechanisms of output control include goal specificity, emphasis on output (including professional), rewards and recognition. Cardinal’s research focuses on the most important control mechanisms in R&D activities, so his empirical evidence contributes to the literature. However, he fails to generate evidence consistent with his hypothesis because he does not distinguish between the functions of control mechanisms.

On the basis of these studies, we believe that the key determinants of successful R&D activities need to be identified (Blindenbach-Driessen and van den Ende, 2006). If organisations focus on these and implement them using control mechanisms, they can enhance the effectiveness and efficiency of R&D activities (Rubenstein *et al.*, 1976).

---

[5] In the later literature, market, bureaucratic, and social control are termed output, behaviour, and input control (Rockness and Shields, 1984; Abernethy and Brownell, 1997; Cardinal, 2001).

[6] Since many R&D subunits do not have contact with external markets, the outcomes of R&D activities are used internally. Transfer pricing can be used to imitate external markets (Rockness and Shields, 1984).

According to the current literature, we therefore propose five kinds of control mechanisms, all of which are important to the success of R&D and embody its key determinants (Ziger and Maidique, 1990; Montoya-Weiss and Calantone, 1994; Brown and Eisenhardt, 1995; Cardinal, 2001; Henard and Szymanski, 2001; Ernst, 2002; Blindenbach-Driessen and van den Ende, 2006). These five kinds of control mechanisms play different roles at different stages of R&D activities and should be a particular focus of organisations (see also the literature sources in Appendix A).

1. Involvement of Top Management − Enabling and Controlling Functions

The influence of top management is obviously important to the success of R&D, because R&D activities involve great uncertainties and pressures (Rubenstein *et al.*, 1976; Brown and Eisenhardt, 1995; Bonner *et al.*, 2002; Turner and Makhjia, 2006; Felekoglu and Moultrie, 2013). Firstly, top managers can help overcome internal obstacles in the organisation (Souder and Chakrabarti, 1979; Felekoglu and Moultrie, 2013) as well as supporting and safeguarding R&D activities. These roles encompass control mechanisms (Blindenbach-Driessen and van den Ende, 2006; Evanschitzky *et al.*, 2012; Felekoglu and Moultrie, 2013). Secondly, top management monitors the progress of R&D projects by evaluating the rate of progress and budgeting schedules, which work embodies the controlling mechanism (Felekoglu and Moultrie, 2013). We measure this according to five criteria identified with reference to the case study of the XJ Electric Co., Ltd. (stock code: 000400) and the literature (Rubenstein *et al.*, 1976; Brown and Eisenhardt, 1995; Cardinal, 2001; Evanschitzky *et al.*, 2012; Felekoglu and Moultrie, 2013):

(1) Do powerful top management support the project?
(2) Does the firm provide a high level of top management support for the project from the development stage through its launch to the marketplace?
(3) Do top management evaluate R&D professionals' actions and R&D costs?
(4) How frequently do top management understand/evaluate the budgeting and cost of R&D activities?
(5) How frequently do top management provide informal feedback on budget execution and cost evaluation?

Both Jensen and Meckling (1976) and Eisnhardt (1989) consider that the controlling mechanisms of MCS include the budgeting system, reporting principles, direct monitoring, and internal auditing. Since criteria (3), (4), and (5) refer to the evaluation of cost and budgets, they are the controlling mechanisms. The enabling mechanisms, encompassing routines, coordination mechanisms, and organisational norms, mandate specific relationships between individuals and groups that influence how information is shared and knowledge disseminated within the firm (Simons, 1994; Makhija and Ganesh, 1997; Henard and Szymanski, 2001). Since criteria (1) and (2) measure the help and support given by top management for R&D projects, they are part of the enabling mechanisms.

2. Ability of Project Managers − Enabling Function

Many scholars emphasise the importance of project managers (Rothwell *et al.*, 1974; Wheelwright and Clark, 1992; Brown and Eisenhardt, 1995; Blindenbach-Driessen and van den Ende, 2006). They consider heavyweight project managers to be important in overcoming department silos and holding a development project together. They consider a lightweight leader to be ineffective for more radical projects, because he or she is more of a messenger than a manager (Wheelwright and Clark, 1992). Furthermore, project managers who have experience and authority are very important to radical R&D activities (Booz Allen Hamilton, 1982), because they can gain the trust and support of top management, R&D team members, and customers (Rothwell *et al.*, 1974; Rubenstein *et al.*, 1976). They can also help R&D teams to compete for available resources and improve communication and cooperation between teams. This control mechanism therefore to provides services for R&D activities, which embodies the enabling function (Simons, 1994; Makhija and Ganesh, 1997; Henard and Szymanski, 2001). On the basis of the literature and the case study of XJ, we measure the ability of project managers according to two criteria (Rubenstein *et al.*, 1976):

(1) In the process of project development and deployment, the project manager coordinates very well with top management, other functional divisions, and customers;
(2) The project manager who is responsible for the R&D project holds a high position and has high authority.

3. Composition of R&D Teams − Enabling Function

Much of the literature emphasises the importance of cross-functional teams in R&D activities (Brown and Eisenhardt, 1995; Cooper *et al.*, 2001; Ernst; 2002; Blindenbach-Driessen and van den Ende, 2006).

This control mechanism refers to the professionalisation and scientific diversity of R&D teams (Cardinal, 2001; Ernst; 2002). R&D professionals can be used to create the type of “knowledge environment” desired by firms by manipulating the degree and variety of the core knowledge, skills, experiences, and attitudes displayed on the job (Mintzberg, 1983). Not only that, but they can also provide direct input to innovation and increase the firm’s capacity to adopt and exploit new technologies. Therefore, professionalisation is fundamental to R&D success (Cohen and Levin, 1989). Scientific diversity in R&D teams should include at least three kinds of members; R&D, manufacturing, and marketing employees. Such diversity has two advantages (Cooper and Kleinschmidt, 1986). Firstly, it ensures that R&D activities integrate marketing information with the manufacturing function to deliver success, and secondly it assists with general creativity and brainstorming processes. Diversity in terms of perspectives, backgrounds, and training facilitates the generation of new ideas (Wiersema and Bantel, 1992). Innovation requires collective action and effort to bring together different perspectives. The availability of multiple areas of scientific expertise can help R&D professionals develop new knowledge and expand the existing knowledge bases through cross-fertilisation of ideas (Dougherty, 1992). A team with diverse expertise on board can increase the penetration between functions and improve information processing ability. Therefore, this mechanism is very helpful to the success of radical R&D projects.

In summary, we measure this mechanism according to two criteria on the basis of the literature and the case study of XJ (Cardinal, 2001):

(1) The level of professionalisation and areas of expertise of employees in R&D teams;

(2) Whether or not R&D teams can coordinate internally, update their collected data, and analyse and execute projects successfully.

These two criteria embody a good foundation and working conditions and hence characterise the enabling function (Simons, 1994; Brown and Eisenhardt, 1995; Cardinal, 2001).

4. Project Management and Resource Allocation − Enabling and Controlling Functions

SAPPHO[7] (1972) advocates that the success of R&D activities depends on their efficiency and effectiveness. A study of 103 projects developed by US industrial firms was conducted by Rubenstein *et al.* (1976). They conclude that internal management factors are primary influences on product success and that government policy, actions, and regulation are secondary. They suggest that organisations concentrate on improving communication, particularly between functional groups, upgrading data collection, analysis and decision-making processes for projects, making detailed planning, and providing the necessary resources. These control mechanisms embody the role of project management and resource allocation (SAPPHO, 1972; Cooper, 1979; Brown and Eisenhardt, 1995), which have both enabling and controlling qualities. These include: (1) identifying product defects prior to launch (SAPPHO, 1972; Cooper, 1979); (2) assessing the feasibility of projects and selecting the most promising (SAPPHO, 1972; Brown and Eisenhardt, 1995); (3) appropriately allocating both capital and labour resources (SAPPHO, 1972; Ziger and Maidique, 1990); and (4) efficiently utilising the available resources (SAPPHO, 1972; Ziger and Maidique, 1990). On the basis of the literature and the case study of XJ, we measure this kind of control mechanism − project management and resource allocation − according

[7] The Scientific Activity Predictor from Patterns of Heuristic Origins (SAPPHO) study, the first comparative study of product success and failure, was conducted during the early 1970s in the UK (Rothwell, 1972; Rothwell *et al.*, 1974).

to 10 criteria (Rubenstein *et al.*, 1976; Cooper, 1979; Ziger and Maidique, 1990; Brown and Eisenhardt, 1995; Cardinal, 2001; Davila *et al.*, 2009):

(1) The level of professionalisation of the project approval board is very high;

(2) There is a specific review process to identify product defects prior to launch which includes in particular a summary of the experience and lessons of prior, related projects;

(3) There are specific intelligence departments providing information about users' demands, marketing, and advertising, so the R&D team has an in-depth understanding of the target customers and market for the product;

(4) The Finance Department communicates with the technology and R&D departments to discuss the R&D projects' allocation of human, capital, and material resources;

(5) Any expenditure has strict review procedures;

(6) The budgeted goals of R&D projects are very clear and specific;

(7) Clear and sound cost management is reflected in the rewards received;

(8) Favourable variances in the budget are reflected in the rewards received;

(9) The quantity of publication of papers and books related to R&D projects is reflected in the rewards received; and

(10) The quantity of patent applications related to R&D projects is reflected in the rewards received.

According to Jensen and Meckling (1976), Eisenhardt (1989), Zirger and Maidique (1990), Simons (1994), Cooper (1995), and Makhija and Ganesh (1997), criteria (1) to (4) embody the enabling function, which are helpful in communications and information transmission, so that the risks of R&D activities can be planned and reduced. Criteria (5) to (10) embody the controlling function because they involve monitoring and evaluating the achievement of organisational goals.[8]

5. Internal and External Communication and Cooperation − Enabling Function

R&D success depends on sound communication and cooperation in the project design and development stages (Gupta *et al.*, 1985; Brown and Eisenhardt, 1995; Henard and Szymanski, 2001; Ernst; 2002; Evanschitzky *et al.*, 2012). Internal and external group communications are useful for transmitting customer demands, product pricing, and market information (Rothwell, 1972; Evanschitzky *et al.*, 2012), all of which ensure R&D activities achieve their goals. SAPPHO (1972) advocates the effective use of outside technology and external scientific communications as very important to R&D successes. Cardinal (2001)

[8] The market performance of R&D projects is never reflected in their performance evaluation, which is based on R&D results such as budget enforcement, cost savings, publication of papers and books, and patent applications.

considers that radical projects are more successful when members of the team are able to communicate with outside parties. Ancona and Caldwell (1990) show that external communication by R&D teams can help others to understand the importance of teamwork as well as to coordinate, negotiate with, and get feedback from outsiders. This enables the R&D budget and process to be pushed through so the firm can manufacture the most innovative products. On the basis of the literature and the case study of XJ, we measure this mechanism according to two criteria (Rubenstein *et al.*, 1976; Davila *et al.*, 2009):

(1) The firm's R&D, production, and marketing functions are well coordinated and able to update the data collected and analyse and make decisions about R&D projects;

(2) The R&D work makes effective use of external technology and academic exchanges.

This mechanism embodies the enabling function (Ernst; 2002; Blindenbach-Driessen and van den Ende, 2006).

The control mechanisms described above show how organisations implement these key determinants of R&D success. They play different roles at different stages of the R&D process and have different effects on different activities. Researching these questions can help organisations to improve the functions of MCS and use scarce resources more efficiently to conduct R&D activities and hence realise the innovation of products and services (Ziger and Maidique, 1990).

2.4.2 Research framework

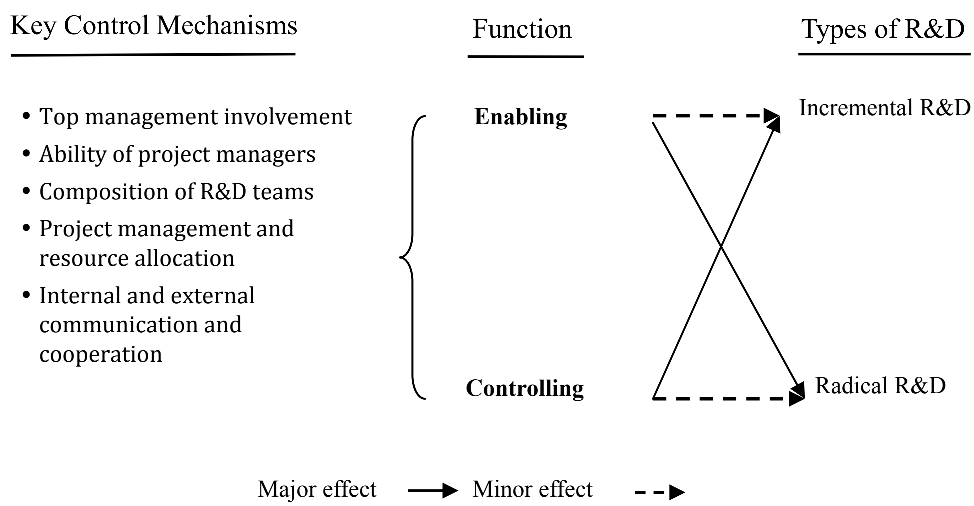

Figure 1 Research Framework for Different Functions of MCS Having Different Effects on R&D Activities

In summary, as shown by the literature review, the effectiveness of R&D activities depends on the fit between the type of R&D projects and the control functions of MCS (Duncan, 1976; McDonough and Leifer, 1983; Dewar and Dutton, 1986; Keller, 1994). So far, research has not focused on the different effects of MCS control mechanisms on R&D activities, leading to a lack of empirical evidence that can support the hypotheses. Furthermore, little of the research distinguishes between, or recognises the inherent diversity of, types of R&D activities (e.g., Abernethy and Brownell, 1997), instead simply defining them as different from other organisational activities. We divide the process of R&D activities into three stages; input, process, and output control, on the basis of the literature and the case study of XJ. The five types of control mechanisms, which embody the key determinants of the success of R&D activities, play different roles at each of the three stages.[9] Therefore, it is necessary to differentiate the stages in order to study the effects of control mechanisms on different R&D activities (radical vs. incremental).

Our contribution to the literature is partly found in our investigation of the relationship between MCS and R&D activities and the internal reasons why the former has a positive effect on the latter. In particular, the controlling function of MCS is more effective in periodic and routine activities (Davila *et al.*, 2009), and so more useful to incremental R&D activities that have a lower level of innovation, fewer routines, and less demand for new knowledge. On the contrary, radical R&D activities that have more uncertainty and a higher demand for new knowledge and technology require much more useful information, a relatively loose R&D environment, and a higher level of decentralisation (Cardinal, 2001). Therefore, the enabling function of MCS is more effective to radical R&D activities (see Figure 1).

III. Field Study

3.1 MCS of Field Site

3.1.1 Field site

XJ Electric Co. Ltd. (XJ) employs a strategy of technological innovation. We consider XJ as a suitable firm for our field study for the following reasons. Firstly, as a high-tech enterprise, XJ has had the foresight to develop high-tech products to ensure the implementation of its leading production strategy, resulting in a strong emphasis on R&D activities. This makes it a suitable environment for our research. In addition, XJ has a special research administration department, the Scientific Research Department, which manages scientific research projects efficiently and pragmatically. The Scientific Research

[9] It is necessary to study the roles of control mechanisms by dividing R&D activities into three stages. For example, top management involvement plays the enabling role in input control, but both the enabling and controlling roles in process control.

Department strengthens coordination between related R&D business units and provides services to support up- and downstream customers. As a comprehensive management department for R&D activities, the Scientific Research Department was able to help us to obtain relevant information and data.

Secondly, the corporate governance structure of XJ is very sound and transparent. We have been cooperating with XJ in many research projects over the last decade and are very familiar with its management personnel at all levels. This trusted and friendly cooperative relationship is very useful in enabling us to get first-hand data and facilitate our research processes. Furthermore, XJ insists on the policy of high-tech innovation, constantly promotes product upgrading and industry extension, and improves production technologies in order to establish a complementary business model in the industry. Therefore, XJ is a unique company that has both primary and secondary equipment and is very suitable as the object of our field study.

3.1.2 Data sources and survey investigation

The field study was conducted over a period of 23 months from October 2011 to July 2013 through 6 formal rounds of interview, participant observation, and investigation. To improve the validity of our conclusions, this paper analyses the case study by using data from multiple sources, including information disclosed formally by XJ, media news reports, information disclosed on the company's website, in-depth interviews with XJ employees at all levels, company internal data, and questionnaire surveys (see Table 1).

Table 1 Feature Overview of Field Study Data

Data types	Document types	Data sources	Description
Public information	R&D data from 2007 to 2012	Annual reports, news reports, and company website	The statistics of R&D data disclosed by XJ in the last six years, including the absolute value and trends of R&D input and the increments of invention, utility models, and appearance designs, reflecting the R&D situation of XJ and its position in the industry.
In-depth interviews and recordings	Profile of XJ's R&D MCS	Individual interviews with R&D personnel and management teams	Elaboration and summary of XJ's MCS in three stages; qualitative illustration and introduction of four R&D projects.
Authorisation documents	Documentation of XJ's R&D MCS	Internal periodicals	Budget sheets, schedule change request forms, and project applications of R&D projects
Survey	Questionnaires about four R&D projects	Responses of four project managers from XJ	Quantitative scores on the risk level, types of R&D, MCS content, and R&D outcomes of related projects.

1. Public data

We examined XJ's annual financial reports for the last six years to obtain publicly disclosed R&D data, including R&D expenditure; the quantity and proportion of R&D personnel; and the quantity of patents, utility models, and appearance designs. We analyse the trend of these data and find that both the absolute value and proportion of XJ's R&D input has increased year by year, showing that R&D activities maintain a good growth momentum. Therefore, it is suitable to choose XJ as the research site because it can play the role of benchmark for other companies.

2. Information from on-the-spot interviews and interviewees

After collecting documents and reviewing the data contained within them, we conducted in-depth interviews with the Chief Executive Officer (CEO), deputy general manager, Chief Financial Officer (CFO), and individual employees at various levels. All the interviewees had varying levels of knowledge of XJ's R&D activities. Before starting the formal interviews, we communicated with the interviewees by telephone to schedule appointments. We also emailed them an outline of the purpose and content of the interviews, and indicated that the interview would be open-ended to ensure that comprehensive and accurate information could be obtained. During the interviews, all members of our research team made notes as well as recording the interviews on a digital voice recorder with the participants' agreement. Following the suggestion of Eisenhardt (1989), our research team sorted and checked the interview records within 24 hours of the session and input all the notes and records as electronic documents. We communicated with the interviewees by telephone and email *ex post* to clarify uncertain and missing information so as to obtain enough data (see Appendix B).

3. Internal data

We collected a lot of documents in order to comprehensively understand XJ's R&D activities, such as the company' online newsletters and internal data about the MCS (see Table 1). The aim of this was to help us understand intuitively the current components and characteristics of XJ's R&D MCS, so that we can investigate issues of concern with a well-defined objective in mind.

4. Questionnaire content

Following Cardinal (2001) and Abernethy and Brownell (1997), we designed a questionnaire with three parts as follows.

(a) Types of R&D project

R&D projects can be divided into two types: incremental and radical. The fundamental difference is the degree of technological innovation and new knowledge used (Dewar and Dutton, 1986). As mentioned above, we measure these two types of R&D projects according to the current literature (Cardinal, 2001; Bonner *et al.*, 2002).

(b) Content of MCS

With the specific situation of XJ in mind, we divide the R&D MCS into three stages; input, process, and output control (Abernethy and Brownell, 1997; Cardinal, 2001). The input control mainly allocates resources to, and supports, R&D activities, including the eight controlling mechanisms. Process control regulates activities and behaviour and is most often implemented in the form of rules and procedures, including four enabling and four controlling mechanisms. Output control regulates outcomes and results as opposed to the means by which they are achieved, and comprises five controlling mechanisms. We measure the content of the R&D MCS in XJ following Cardinal (2001) and on the basis of XJ's actual situation (see Table 2).

(c) Outcomes of R&D projects

We measure the outcomes of R&D on the basis of financial (Atuahene-Gima and Li, 2004) and nonfinancial performance (Davila, 2000; Bonner *et al.*, 2002). Financial performance measurement includes 4 items, and nonfinancial performance measurement 12 items (see Table 2).

5. Process of survey research

Firstly, we told the director of the Scientific Research Department about the questionnaire and suggested that he select one successful radical R&D project, one failed radical R&D project, one successful incremental R&D project, and one failed incremental R&D project for us. This was intended to enable us to observe the effect of the match between the functions of the MCS and R&D activities on R&D performance to verify our research framework. The department director then randomly selected four R&D projects that met our requirements and contacted their managers. All four managers were willing to participate in our investigation (Appendix C). Before sending them the questionnaire, we talked to them to ensure that they understood the questions. Although this method is restricted by the small sample size used, it is a very popular approach in field studies, and enabled us to carry out in-depth research in a single company.

On average, the four project managers had worked in XJ for more than 11.75 years and held the position of R&D project manager for more than 6.25 years. All held a bachelor degree or above and were very familiar with R&D activities and MCS (see Appendix C). After they had completed the questionnaires, we discussed the projects with them in detail to ensure that we had obtained sufficient qualitative and quantitative information about all four (see "Analysis of R&D Projects").

3.1.3 Profiles of R&D MCS in XJ[10]

As a well-performing manufacturing listed company, XJ Electric Co. Ltd. is a leading model company in the industry in terms of corporate governance and management philosophy. Four types of R&D activities are carried out in XJ; basic research, technology development, product design, and system integration.[11] Each type includes incremental and radical R&D activities which are managed in the form of projects. The number of incremental R&D projects is greater than that of radical R&D projects, but the latter needs more capital input.[12] The MCS of R&D can be divided into three stages as follows.

1. Input control of R&D MCS

Input control can be considered as a form of resource allocation because it regulates the antecedent conditions of organisational performance (Turner and Makhjia, 2006), including professionalisation and specialist diversity (Cardinal, 2001). Rockness and Shields (1984) consider that input control should include social control, which has its core a rigorous personnel selection (Ouchi, 1979), peer interaction and professional association, and expenditure budgeting. We therefore consider that the input control of XJ mainly comprises the following content.

First of all, the project review board invites experts from the marketing, technology, process, and financial departments to take part in a project review. This engages the input control mechanisms, including professionalisation of the project review board; identifying product defects prior to launch; putting in place special evaluation programs to review defects, consider prior related experiences, and reflect on lessons learnt; and having a special intelligence department to provide information on user demands, marketing, and advertising. Accordingly, the mechanisms of project management and resource allocation are manifested.

Secondly, cross-functional teams are built for all R&D projects and put under the command of suitably capable project managers. Activities here include considering the position and prestige of project managers and their ability to coordinate internal and external parties, as well as the degree of professionalisation and specialist diversity of R&D teams. These steps belong under the mechanisms of project management ability and the composition of the R&D team.

Finally, subsidiaries apply for project approval through a bottom-top approach, via

[10] The content in this section was sourced from the recordings and notes of interviews with the director, three employees of the Scientific Research Department, and four R&D project managers in XJ (drawn from four different subsidiaries of XJ).

[11] Considering that basic research and technology development cannot directly correspond to the market performance of R&D, the R&D projects we chose included only product design and system integration.

[12] Comparing incremental R&D with radical R&D projects, the quantity ratio was 7:3, while the ratio of capital input was 3:7, as confirmed by the director of the Scientific Research Department.

budget participation, on the basis of their own profitability. The group company provides the necessary scientific research facilities and funds for special use, in a top-down approach. The finance department discusses the allocation of human resources, capital, and materials with the technology department and R&D teams. All these are project management and resource allocation mechanisms.

"In the input control stage, the managers and members of R&D teams are designated and specified in the approval form, including their professional expertise and tasks. Afterwards, the project review board will assess the feasibility of R&D projects by reviewing the analyses of the customers, competitors, market, and internal and external demands. In addition, the Financial Department will participate in deciding the amounts of invested capital and in the detailed preparation of budgets. The budgetary preparation takes the bottom-up approach and is managed by the Financial Department, while the Scientific Research Department approves the budget execution. Generally speaking, the projects advocated by top management will get more support and perform better. Because the abilities of project managers in different subsidiaries are quite different, the projects they are responsible for are very different in terms of importance and effectiveness. The more important R&D projects are, the more attention is paid in the input control stage."[13]

In summary, the mechanisms in the input control phase embody the enabling functions, including top management involvement, ability of project managers, composition of R&D teams, and project management and resource allocation. This provides solid knowledge and resources to support the smooth development of R&D activities and reduce the technology and demand risks.

2. Process control of R&D MCS

Process control clearly defines the behaviour and processes in which employees must engage, including monitoring ongoing activities and behaviour and regulating how work gets done (Snell, 1992). Regarding the design of process control, Cardinal (2001) suggests that centralisation, formalisation, and frequency of performance appraisal should be included. XJ's process control involves:

(1) Top management assessing R&D progress. R&D projects are centrally managed and these activities include tracking their planning, execution, and modification. The process of R&D project completion, budget implementation, and other related issues should be reported to top management at weekly, monthly, quarterly, half-yearly, and annual intervals. These are the mechanisms for top management involvement.

[13] The content in quotation marks in this section was taken from interviews with the director and employees of the Scientific Research Department.

(2) The communication of internal organisational information and the utilisation of external technology. Communication about project progress takes place between superiors and subordinates, peer team members, and the inside and outside of the organisation. To ensure that R&D projects progress smoothly, the schedule of R&D projects and allocated resources should be updated on a timely basis. These are functions of the mechanisms of the composition of R&D teams and internal and external communication and cooperation.

"Because the R&D activities are managed as projects, the R&D schedule will be planned at the time of project approval. The Scientific Research Department will track the implementation and alteration of projects. Generally speaking, reports on the process of major projects are provided frequently and give more information; reports on the process of minor projects are provided infrequently and give less information. Even for the same project, the process in different stages will be reported at different frequency and with different content, most of which focuses on the technical information. Weekly reports about implementation of plans and problems encountered are provided for major projects. The budget expenditures in R&D implementation are reviewed, and any unfavourable variances in budgets will be scrutinised. The Financial Department provide budgetary execution information, while the Scientific Research Department will review and manage the execution. Because the key to success of R&D activities is the realisation of technology, the failure of projects is usually due to the nonfulfillment of technology. So the communication and coordination of information within the organisation is very important. Generally speaking, teams with a lot of experience can communicate and coordinate well. The projects good at using external technology and information are more likely to succeed."

Such process control embodies top management involvement, the composition of the R&D team, project management and resource allocation, and internal and external communication and cooperation. These processes include both enabling and controlling functions.

3. Output control of R&D MCS

Output control regulates outcomes and results, as opposed to the means by which they are achieved (Eisenhardt, 1985). Outcome controls measure and monitor the output of operations or employees (Langfield-Smith and Smith, 2003), and require explicit output from employees' work (Eisenhardt, 1985). In applying output control, firms define the dimensions of the desired results, measure how well output aligns with the set standards, and provide reward or punishment in response to success or failure in goal attainment (Merchant, 1985). Cardinal (2001) also suggests that output control should include goal specificity and an emphasis on output and rewards. Output controls in R&D activities are difficult to design because the risks are high, leading staff to put too much emphasis on incremental projects with more predictable outcomes and faster returns even if these returns are smaller in the long run (Cardinal, 2001). XJ's control mechanisms in this stage include:

(1) Goal specificity. The budget goal initially set should be specific and detailed, such as market share, performance compared with competitors, target profit, and so on.
(2) Performance evaluation. In the appraisal stage, the execution of budget and cost, the publications of papers and books, and patent applications will be reflected in the performance evaluation framework.

"Currently, the responsibilities of R&D, engineering, and marketing are managed separately. The review and reimbursement of budget expenditure is managed centrally by the Scientific Research Department, while the input of resources in R&D is managed by the Financial Department. The Scientific Research Department is responsible for the management and appraisal of R&D projects, which directly determines the income of R&D research teams. The economic rewards for R&D employees are based on reward certifications, patents, research papers and results, and market performance. But the principles of reward have some drawbacks, especially for market performance. Generally, we set the sales performance of a product introduced to the market in the first three years as the basis for reward. However, the effectiveness of many R&D projects is not good in the first three years; for example, some radical R&D projects may not be successful in their early stages and will be profitable only by virtue of continued input or transformation at a later stage, but the time limit for rewards has expired by then. As a result, employees are more willing to conduct incremental projects with more predictable outcomes and faster returns. We hope these problems can be solved as soon as possible."[14]

The control mechanisms used at this stage reflect the efficiency of resource utilisation and play a role in project management and resource allocation. Because the R&D activities are almost completed at this stage, the main tasks include encouraging the correct choice of future projects by means of fair rewards and penalties and motivating R&D employees to work hard. Therefore, the control mechanisms at this stage embody the controlling function.

We find that the essential features of XJ's MCS in the context of R&D activities accord with the research framework we have proposed, so XJ is a very suitable setting for our study. We accordingly selected four specific R&D projects within XJ to further verify the theoretical framework discussed in this paper.

[14] Because evaluation based on market performance has drawbacks, evaluation of R&D projects in XJ excludes this measure. We therefore take no account of market performance in designing related control mechanisms (the related mechanisms are included in "efficiently utilising the available resources" under project management and resource allocation).

3.2 Analysis of R&D Projects

3.2.1 Project A: Incremental R&D project

Project Manager: “The DC transmission lines project between Guizhou and Guangdong was the first large-scale project to be constructed primarily by Chinese companies. The National Development and Reform Commission (NDRC) defined it as the leading project for proving China’s independency in DC transmission technology. It achieved the goal of ‘independence rate above 70% in terms of the design and construction of DC transmission system, flow station equipment and DC transmission equipment mainly by domestic companies’. The transmission lines started at the Xingren converter station in Guizhou Province and ended at Shenzhen, Guangdong Province. The total transmission distance was 1,255 kilometres with a 3 million kilowatt capacity at a voltage level ± 500 kilovolts. The project began on 28 June 2005, and it took about 2.5 years, successfully beginning operations on 3 December 2007. In terms of both technology and demand, the project was at a low-risk level, so it was an incremental R&D project. As XJ was already familiar with the relevant technologies, the project just followed the routine process during the feasibility study. It did not involve too many parties nor many discussions of the technical details. The leadership team conducted frequent monitoring and strict audits during implementation. Since the project would have a big impact and was very important to the development of XJ, the whole R&D team was dedicated to the project to speed up progress and follow each reporting period tightly. As a result, the expected results were achieved and the performance evaluation also reached the desired level. The final output of the whole project was very good too.”

3.2.2 Project B: Radical R&D project

Project Manager: “This project was the first time that XJ had entered the wind power industry. In terms of innovation, it was a radical R&D project. We originally adopted the air-cooling design. Then, the design was evaluated and finalised after prototype building, experimental tests, and field tests. The original plan was to start the project at the beginning of 2006 and finish the field running tests within two years. However, the project delivery was postponed to the beginning of 2009 after two big design changes due to the following difficulties. We lacked knowledge of wind power and had less experience of applying the technology. As a result, some defects were found by project auditing. The project team did not understand the customers and the market because they did not have any experience in this industry. Although the delay in the project was noticed by the high-level leadership team, the unsolved technical problems caused the slow progress of project construction. Even though the project was able to pass its mid-term audit and inspection by a team of expert consultants, the poor running environment, improper onsite operations, and other issues led to fatal damage to the prototype equipment. Finally, the project was judged to be a failure and the damaged equipment was removed to be used for other purposes. Since then, with the rapid development of the wind power industry, the number of manufacturers and the annual installed capacity of wind power have increased. Air-cooling technology has become obsolete as it cannot meet the demands of converters over 1.5MW capacity. XJ adjusted its direction after reflecting on the lessons learnt from the failure of this project. In 2009, the project technology was adapted for use in water-cooling technology and has achieved good results. In particular, the R&D team has matured a lot after this failure and is more ready for future success."

3.2.3 Project C: Incremental R&D project

Project manager: "The ECVT800-35 electronic instrument transformer adopted a combined voltage and current structure. Compared to traditional electromagnetic current and voltage instrument transformers, it reduced the installation size and lowered manufacturing costs. Additionally, its independent outgoing line bays made troubleshooting and repair easier. The availability of this electronic instrument transformer enabled users to do a one-stop shop at XJ for a 35kV system, giving XJ a better position in a competitive market. The project was an incremental R&D project with low technology and demand risks. During the investment stage, it was one of the top priorities for the high-level leadership team because of the large initial cost. All available resources were involved. However, the project was not continuously overseen by the leadership during the implementation stage. The cost control was not strict, nor did the details of the technology attract much attention. The reasons for this were that XJ was already quite familiar with the technology involved, and the evolution of existing products was so slow that there was almost no replacement on the market. Therefore, XJ had a dominant position in the market. Owing to weak control in implementation, the final project result was not very good, just at the medium level."

3.2.4 Project D: Radical R&D project

Project manager: "The project was the first attempt to operate electric vehicle charging power stations open to the public in China. It was the model project for promoting the operation of the State Grid's standard for charging stations. The project was a great opportunity but carried risks. It was XJ's first EPC (Engineering, Procurement, and Construction) turnkey project involving charging stations and had a big impact on the company. Due to the growth in the city's population and the development of the industrial zone, most residents live in Qingdao but work in Huangdao. This situation has caused the rapid development of public transportation, and the electric bus has led the trend of future development. Charging stations in Xujiadao faced a tight schedule. We had to finish the project within 80 days in order to meet the power demand of 120 buses or 360 cars.

Regarding battery exchange, an electric bus takes 6 to 8 minutes, and the total number of exchanges reached 540 per day. This was a radical R&D project with high technical and demand risks. The planned construction time covered only 100+ days. As State Grid paid a lot of attention to it, the project was also of great political importance. As a result, XJ's general manager was assigned to lead the project. The project review board was very professional, and we also conducted comprehensive feasibility studies to understand market demand. The whole leadership team gave the project full support, almost without considering the costs. During the implementation stage, we attached great importance to communication. However, we did not push hard for progress because we did not want the R&D team to be under too much stress. Finally, the project was delivered on time and the costs were well controlled. Because of the tight schedule, we did not strictly control the budget and costs. Instead, we hoped that the employees could work diligently with reduced stress. Fortunately, we achieved very successful results with the project."

3.3 Survey Analysis

3.3.1 Effects of control functions on R&D activities

The incremental Project A involved less innovation and did not need to emphasise the enabling function (the average score of the 12 enabling mechanisms in the 3 stages was 3.4). The controlling mechanisms were concentrated in Project A (the average score of the 9 controlling mechanisms in the 3 stages was 5.44). The strategy XJ used for these control mechanisms was quite correct, so Project A's performance was better (the average score for financial performance was 5.5, and for nonfinancial performance 5.67).

The radical Project B was XJ's first foray the wind power industry, but it lacked enabling mechanisms. Owing to its high-risk nature, an inexperienced project manager, unprofessional R&D teams, less understanding of related information in the earlier stages, and weak enabling mechanisms in the input control stage (the average score of the 8 enabling mechanisms was 4.6), final performance was not good (the average score for financial performance was 1.5, and for nonfinancial performance 3.67).

The incremental Project C paid more attention to enabling mechanisms. In particular, top management involvement, composition of the R&D team, and the ability of project managers played significant roles (the average score for the 8 mechanisms was 6.1). Comparatively speaking, the controlling mechanisms for process control (the average score of the 4 mechanisms was 4.5) and output control (the average score of the 5 mechanisms was 4) were not strongly valued, and thus the project failed to deliver the target performance (the average score for financial performance was 4.5, and for nonfinancial performance 5). In conclusion, Project C represents the quintessential example of project underperformance caused by poorly run controlling mechanisms.

The controlling mechanisms in the process control of Project D were at the medium level (the average score of the 4 mechanisms was 4.25), while the controlling mechanisms of output control were also weak (the average score of the 5 mechanisms was 3.2). However, the enabling mechanisms in input control and process control were strong (the average score of the 12 mechanisms was 6). Therefore, the effectiveness of Project D was good, as a result of the strong enabling function and less rigid controlling function (the average score for financial performance was 6, and for nonfinancial performance 5.9).

Table 2 Content and Scores of the R&D MCS in XJ[15]

Panel A		Key Controlling Mechanisms of R&D				
Stage	Function		Project Score			
			A	B	C	D
Input control	Enabling	***Top management involvement***				
		• Very powerful top management support the project.	1	6	6	6
		Ability of project managers				
		• In the process of project development and deployment, the project manager coordinates very well with top management, other functional divisions, and customers.	1	3	7	6
		• The project manager responsible for the R&D of this project holds a higher position and has higher authority.	1	4	6	6
		Composition of R&D teams				
		• I am satisfied with the professionalisation and expertise areas of the employees in the R&D teams.	2	4	6	6
		Project management and resource allocation				
		• The level of professionalisation of the project approval board is very high.	2	5	6	6
		• There is a specific review process to identify product defects prior to launch, particularly to summarise the experience and lessons of prior related projects.	3	4	5	5
		• There are specific intelligence departments to provide information about user demand, marketing, and advertising, so the R&D team has an in-depth and focused understanding of the customers and market for the product.	3	4	6	3
		• The finance department communicates with the technology and R&D departments to discuss the allocation of human resources, capital, and materials to R&D projects.	2	7	7	7
		Subtotal	15	37	49	45

[15] All the items in Panel A were rated using a 7-point Likert scale ranging from 1= strongly disagree to 7= strongly agree, except the three items covering top management involvement. All the items in Panel B were also rated using a 7-point Likert scale ranging from 1 = much lower than other industry competitors to 7 = much higher than industry competitors. The respondents were the four R&D projects' managers, each of whom filled in the questionnaire on the basis of the most important R&D project for which they were responsible.

Process control	Enabling	***Top management involvement***				
		• The firm provides a high level of top management support for the product from the development stage through to its launch on the marketplace.	7	5	5	7
		Composition of R&D teams				
		• The R&D teams coordinate well internally, update the data collected, and analyse and execute projects.	7	4	6	7
		Internal and external communication and cooperation				
		• The firm's R&D, production, and marketing functions are well coordinated, update the data collected, and analyse and make decisions on R&D projects.	6	5	6	7
		• The R&D work uses external technology and academic exchange effectively.	6	7	5	6
		Subtotal	26	21	22	27
	Controlling	***Top management involvement***				
		• How frequently do top management evaluate R&D professionals' actions and R&D costs? (1) less than twice a year, (2) twice a year, (3) once a quarter, (4) once a month, (5) twice a month, (6) once a week, (7) many times a week.	5	4	4	4
		• How frequently do top management understand/ evaluate the budget and costs of R&D activities? (1) less than twice a year, (2) twice a year, (3) once a quarter, (4) once a month, (5) twice a month, (6) once a week, (7) many times a week.	5	4	4	4
		• How frequently do top management provide informal feedback on budget execution and cost evaluation? (1) less than twice a year, (2) twice a year, (3) once a quarter, (4) once a month, (5) twice a month, (6) once a week, (7) many times a week.	4	4	4	6
		Project management and resource allocation				
		All expenditure has strict review procedures.	7	5	6	3
		Subtotal	21	17	18	17
Output control	Controlling	***Project management and resource allocation***				
		• The budgeted goals of R&D projects are very clear and specific.	6	6	4	4
		• Favourable variances in the budget are reflected in rewards received.	5	4	4	1
		• Clear and sound cost management is reflected in rewards received.	5	4	4	3
		• The quantity of research papers and book publications related to R&D projects is reflected in rewards received.	6	4	4	4
		• The quantity of patent applications related to R&D projects is reflected in rewards received.	6	5	4	4
		Subtotal	28	23	20	16

Panel B		Outcomes of R&D Activities				
Financial Performance	•	Sales growth relative to competitors.	6	2	5	6
	•	Market share growth relative to competitors.	5	2	6	6
	•	Return on investment relative to competitors.	6	1	4	7
	•	Growth in profit relative to competitors.	5	1	3	5
		Subtotal	22	6	18	24
Nonfinancial Performance	•	Meets product specifications.	5	3	7	6
	•	Meets unit cost objectives.	4	3	4	4
	•	Meets timing goals.	6	2	7	7
	•	Meets budget goals of the project.	5	3	5	4
	•	Fulfils customers' needs.	6	2	6	7
	•	Achieves business success.	7	2	5	7
	•	Captures a high market share.	5	2	4	6
	•	Creates a new market.	6	5	3	6
	•	Creates a new product line.	6	6	5	6
	•	Develops new technology.	6	6	4	6
	•	Enhances skills to handle new technology.	6	5	6	6
	•	Maturity of the R&D team grows.	6	5	4	6
		Subtotal	68	44	60	71
		Total	90	50	78	95

3.3.2 Effects of MCS on different R&D activities

In comparing the effects of MCS on radical and incremental R&D projects, we see that radical R&D activities should pay more attention to enabling mechanisms. For example, Project B failed to perform because it did not execute these mechanisms properly. In contrast, Project D did make good use of the enabling mechanisms well while also placing less emphasis on the controlling mechanisms of output control. Accordingly, it achieved good performance.

However, incremental R&D projects should pay more attention to controlling mechanisms. For example, Project A almost reached its performance target as a result of emphasising these mechanisms; while they were not properly used in Project C, leading to a moderate level of performance.

The four projects described above verify the framework of our research; that is, different R&D activities make different demands on the functions of MCS. The two types of control functions in the different stages of R&D can only play a positive role when R&D activities are managed according to type.

Table 3 Summary of Analyses of R&D Projects

Project	Type of R&D	Input control	Process control		Output control	Expectation of performance	Actual performance	Comparing actual performance with expectations
		Enabling	Enabling	Controlling	Controlling			
A	Incremental	Low	High	Above medium	Above medium	Above medium	Above medium	Consistent
B	Radical	Moderate	Moderate	Moderate	Moderate	Moderate	Below medium	Almost consistent
C	Incremental	High	Moderate	Moderate	Moderate	Moderate	Moderate	Consistent
D	Radical	Above medium	High	Moderate	Below medium	High/above medium	Above medium	Almost consistent

IV. Conclusions and Limitations

4.1 Conclusions

This field study has extended the body of work on the design and implementation of MCS by investigating the R&D activities of the company XJ. It has shown that MCS have significant effects on R&D activities. Different control mechanisms are better suited to different R&D activities. Organisations should classify their R&D activities before applying the control mechanisms of MCS to manage them. Doing so will enhance the effectiveness and efficiency of MCS. In particular, radical R&D activities should pay more attention to enabling mechanisms, while incremental R&D activities should emphasise controlling mechanisms. It is not necessary to conduct all the control mechanisms well for R&D activities to succeed; the key is to ensure the appropriate mechanisms play an effective role in R&D.

Traditional research advocates that radical R&D should focus more attention on input control (e.g. Cardinal, 2001). The underlying reason for this is that the controlling mechanisms of input control embody the enabling function, which is more effective for radical R&D activities. In addition, research has failed to clarify that process control includes both enabling and controlling mechanisms, leading to the result that the effects of process control on R&D activities depends on the fit between control mechanisms and project type. It is hard to predict the effects of control mechanisms on R&D activities if their functions are not differentiated. Our contribution is that we identify the effects of control mechanisms on R&D activities by considering their different functions, thus identifying the important roles of MCS in R&D.

4.2 Limitations

This paper has used a case study method, which is unable to provide generalisable conclusions. The advantage of such a field study is that it can bridge the gap between theoretical research and practice. Furthermore, we have concentrated on the control mechanisms that embody the key determinants of successful R&D projects, not all the mechanisms of MCS. In addition, we focus on two functions, enabling and controlling, but this does not mean that there are no other possible functions of MCS. More evidence is required from future research. Finally, there may have been bias in selecting the R&D projects studied here. Future research should expand the research sample and verify our framework from a generalisable perspective. Our findings are the start, not the end point, of this research stream.

References

Abernethy, M. A. and Brownell, P. (1997), 'Management control systems in research and development organizations: The role of accounting, behavior and personnel controls', *Accounting, Organizations and Society* 22 (3-4): 233-248.

Ahrens, T. and Chapman, C. S. (2004). 'Accounting for flexibility and efficiency: A field study of management control systems in a restaurant chain', *Contemporary Accounting Research* 21 (2): 271-301.

Amabile, T. M. (1998). 'How to kill creativity', *Harvard Business Review* 76 (5): 76-87.

Ancona, D. G. and Caldwell, D. F. (1990). 'Beyond boundary spanning: Managing external dependence in product development teams', *Journal of High Technology Management Research* 1 (2): 119-135.

Atuahene-Gima, K. and Li, H. (2004), 'Strategic Decision Comprehensiveness and New Product Development Outcomes in New Technology Ventures', *The Academy of Management Journal* 47 (4): 583-597.

Baiman, S. (1982), 'Agency research in management accounting: A survey', *Journal of Accounting Literature* 1: 154-213.

Baiman, S. (1990), 'Agency Research in Managerial Accounting: A Second Look', *Accounting, Organizations and Society* 15 (4): 341-371.

Barney, J. B. (1991), 'Firm resources and sustained competition advantage', *Journal of Management* 17 (1): 99-120.

Birnberg, J. G. and Snodgrass, C. (1988), 'Culture and control: A field study', *Accounting, Organizations and Society* 13 (5): 447-464.

Bisbe, J. and Otley, D. (2004), 'The Effects of Interactive Use of Management Control Systems on Product Innovation', *Accounting, Organizations and Society* 29 (8): 709-737.

Blindenbach-Driessen F. and van den Ende, J. (2006). 'Innovation in project-based firms: The context dependency of success factors', *Research Policy* 35 (4): 545-561.

Bonner, J. M., Ruekert, R. W., and Walker, O. C. Jr. (2002), 'Upper Management Control of New Product Development Projects and Project Performance', *Journal of Product Innovation Management* 19 (3): 233-245.

Booz Allen Hamilton (1982), *New Products Management for the 1980s*, Booz Allen Hamilton, New York.

Brown S. L. and Eisenhardt, K. M. (1995), 'Product development: Past research, present findings and future directions', *Academy of Management Review* 20 (3): 343-378.

Brownell, P. and Dunk, A. S. (1991), 'Task uncertainty and its interaction with budgetary participation and budget emphasis: Some methodological issues and empirical investigation', *Accounting, Organizations and Society* 16 (8): 693-703.

Bruns, W. J. and Waterhouse, J. H. (1975), 'Budgetary control and organization structure', *Journal of Accounting Research* 13 (2): 177-203.

Cardinal, L. B. (2001), 'Technological Innovation in the Pharmaceutical Industry: The Use of Organizational Control in Managing Research and Development', *Organization Science* 12 (1): 19-36.

Chapman, C. S. (1998), 'Accountants in organizational networks', *Accounting, Organizations and Society* 23 (8): 737-766.

Chenhall, R. and Langfield-Smith, K. (1998), 'The relationship between strategic priorities, management techniques and management accounting: An empirical investigation using a systems approach', *Accounting, Organizations and Society* 23 (3): 243-264.

Chenhall, R. H. and Morris, D. (1986), 'The impact of structure, environment, and interdependence on the perceived usefulness of management accounting systems', *The Accounting Review* 61 (1): 16-35.

Cohen, W. M. and Levin, R. C. (1989), 'Empirical studies of innovation and market structure', in Schmalensee, R. and Willig, R. (eds), *Handbook of Industrial Organization*, Vol. 2, Elsevier Science, New York, 1060-1107.

Cooper, R. G. (1979), 'The dimensions of industrial new product success and failure', *Journal of Marketing* 43 (3): 93-103.

Cooper, R. G. (1995), 'Developing new products on time, in time', *Research-Technology Management* 38 (5): 49-57.

Cooper, R. G., Edgett, S., and Kleinschmidt, E. (2001), 'Portfolio management for new product development: Results of an industry practices study', *R&D Management* 31 (4): 361-381.

Cooper, R. G. and Kleinschmidt, E. J. (1986), 'An Investigation into the New Product Process: Steps, Deficiencies, and Impact', *Journal of Product Innovation Management* 3 (2): 71-85.

Damanpour, F. (1991), 'Organizational innovation: A meta-analysis of effects of determinants and moderators', *Academy of Management Journal* 34 (3): 555-590.

Davila, A., Foster G., and Li, M. (2009), 'Reasons for management control systems adoption: Insights from product development systems choice by early-stage entrepreneurial companies', *Accounting, Organizations and Society* 34 (3-4): 322-347.

Davila, T. (2000), 'An empirical study on the drivers of management control systems' design in new product development', *Accounting, Organizations and Society* 25 (4-5): 383-409.

Demski, J. S. and Feltham, G. A. (1976), *Cost Determination: A Conceptual Approach*, Ames, IA: Iowa State University Press.

Dewar, R. D. and Dutton, J. E. (1986), 'The Adoption of Radical and Incremental

Innovations: An Empirical Analysis', *Management Science* 32 (11): 1422-1433.
Ditillo, A. (2004), 'Dealing with uncertainty in knowledge-intensive firms: The role of management control systems as knowledge integration mechanisms', *Accounting, Organizations and Society* 29 (3-4): 401-421.
Dougherty, D. (1992), 'Interpretive barriers to successful product innovation in large firms'. *Organization Science* 3 (2): 179-202.
Duncan, R. (1976), 'The ambidextrous organization: Designing dual structures for innovation', in Kilmann, R. H., Pondy, L. R., and Slevin, D. P. (eds), *The Management of Organization Design* Vol. 1, New York: North-Holland, 167-188.
Dunk, A. S. (2011), 'Product innovation, budgetary control, and the financial performance of firms', *The British Accounting Review* 43 (2): 102-111.
Ecker, B., van Triest, S., and Williams, C. (2013), 'Management Control and the Decentralization of R&D', *Journal of Management* 39 (4): 906-927.
Egelhoff, W. (1991), 'Information-processing theory and the multinational enterprise', *Journal of International Business Studies* 22 (3): 341-368.
Eisenhardt, K. M. (1985), 'Control: Organizational and economic approaches', *Management Science* 31 (2): 134-149.
Eisenhardt, K. M. (1989), 'Agency Theory: An Assessment and Review', *Academy of Management Review* 14 (1): 57-71.
Ernst, H. (2002), 'Success factors of new product development: A review of the empirical literature', *International Journal of Management Reviews* 4 (1): 1-40.
Evanschitzky, H., Eisend, M., Calantone, R. J., and Jiang, Y. (2012), 'Success Factors of Product Innovation: An Updated Meta-Analysis', *Journal of Product Innovation Management* 29 (S1): 21-37.
Felekoglu, B. and Moultrie, J. (2013), 'Top Management Involvement in New Product Development: A Review and Synthesis', *Journal of Product Innovation Management* 31 (1): 159-175.
Fisher, J. and Govindarajan, V. (1992), 'Profit Center Manager Compensation: An Examination of Market, Political and Human Capital Factors', *Strategic Management Journal* 13 (3): 205-217.
Galbraith, J. R. (1974), 'Organization design: An information processing view', *Interfaces* 4 (3): 28-36.
Gordon, L. A. and Narayanan, V. K. (1984), 'Management accounting systems, perceived environmental uncertainty and organizational structure: An empirical investigation', *Accounting, Organizations and Society* 9 (1): 33-47.
Gupta, A. K., Raj, S. P., and Wilemon, D. L. (1985), 'The R&D-Marketing Interface in High Technology Firms', *Journal of Product Innovation Management* 2 (1): 12-24.
Gupta, A. K. and Wilemon, D. L. (1990), 'Accelerating the development of technology-based new products', *California Management Review* 32 (2): 24-44.
Henard, D. H. and Szymanski, D. M. (2001), 'Why some new products are more successful than others', *Journal of Marketing Research* 38 (3): 362-375.
Henri, J.-F. (2006), 'Management control systems and strategy: A resource-based perspective', *Accounting, Organizations and Society* 31 (6): 529-558.
Hill, S., Martin, R., and Harris, M. (2000), 'Decentralization, integration and the post-bureaucratic organization: The case of R&D', *Journal of Management Studies* 37 (4): 563-586.
Horngren, C. T., Foster, G., and Datar, S. M. (2000), *Cost Accounting: A Managerial Emphasis*, Upper Saddle River, NJ: Prentice Hall.
Indjejikian, R. J. (1999), 'Performance evaluation and compensation research: An agency

perspective', *Accounting Horizons* 13 (2): 147-157.
Jaeger, A. M. and Baliga, B. R. (1985), 'Control systems and strategic adaptation: Lessons from the Japanese experience', *Strategic Management Journal* 6 (2): 115-134.
Jensen, M. and Meckling, W. (1976), 'Theory of the firm: Managerial behavior, agency costs, and ownership structure', *Journal of Financial Economics* 3 (4): 305-360.
Keller, R. T. (1994), 'Technology-information professing fit and the performance of R&D project groups: A test of contingency theory', *The Academy of Management Journal* 37 (1): 167-179.
Khandwalla, P. (1972), 'The Effect of Different Types of Competition on the Use of Management Controls', *Journal of Accounting Research* 10 (2): 275-285.
Kim, K., Park, J. H., and Prescott, J. E. (2003), 'The global integration of business functions: A study of multinational businesses in integrated global industries', *Journal of International Business Studies* 34 (4): 327-344.
Koga, K. and Davila, A. (1999), 'What is the role of performance goals in product development? A study of Japanese camera manufacturers', in Hitt, M. A., Clifford, P. G., Nixon, R. D., and Coyne, K. P. (eds), *Dynamic Strategic Resources: Development, Diffusion and Integration*, New York: Wiley, 403-431.
Langfield-Smith, K. and Smith, D. (2003), 'Management control systems and trust in outsourcing relationships', *Management Accounting Research* 14 (3): 281-307.
Lawrence, P. R. and Lorsch, J. W. (1967), *Organization and Environment*, Boston, MA: Division of Research, Harvard Business School.
Lebas, M. and Weigenstein, J. (1986), 'Management control: The roles of rules, markets, and culture', *Journal of Management Studies* 23 (3): 259-272.
Lin, W. T. and Vasarhelyi, M. A. (1980), 'Accounting and financial control for R&D expenditure', in Dean, B. V. and Goldhar, J. D. (eds), *Management of Research and Innovation (TIMS Studies in the Management Sciences*), Vol. 15, New York: North-Holland, 199-213.
Makhija, M. V., and Ganesh, U. (1997), 'The relationship between control and partner learning in learning-related joint ventures', *Organization Science* 8 (5): 508-527.
March, J. G. (1991, 'Exploration and exploitation in organizational learning', *Organization Science* 2 (1): 71-87.
Marginson, D. E. W. (2002), 'Management control systems and their effects on strategy formation at middle-management levels: Evidence from a UK organisation', *Strategic Management Journal* 23 (11): 1019-1031.
Massaro, M., Bardy, R., and Zanin, F. (2011), 'Innovation Strategy and Management Control: The Link Between Knowledge Management and Management Control Systems', *Proceedings of the 3rd European Conference on Intellectual Capital*, 231-239.
McDonough, E. F., III, and Leifer, R. (1983). 'Using simultaneous structures to cope with uncertainty', *The Academy of Management Journal* 26 (4): 727-735.
Merchant, K. A. (1981), 'The design of the corporate budgeting system: Influences on managerial behavior and performance', *The Accounting Review* 56 (4): 813-829.
Merchant, K. A. (1985), *Control in Business Organizations*, Pitman, Boston, MA.
Merchant, K. A. and Otley, D. T. (2006), 'A review of the literature on control and accountability', in Chapman, C., Hopwood, A., and Shield, M. (eds), *The Handbook of Management Accounting Research*, Elsevier Press, 785-802.
Merchant, K. A. and van der Stede, W. A. (2007), *Management Control Systems: Performance Measurement, Evaluation and Incentives* (2nd ed.), Harlow, UK: Prentice Hall.

Mintzberg, H. (1976), 'Planning on the left side and managing on the right', *Harvard Business Review* 54 (4): 49-58.
Mintzberg, H. (1979), *The Structuring of Organizations*, Upper Saddle River NJ: Prentice Hall.
Mintzberg, H. (1983), *Structure in Fives: Designing Effective Organizations*, Englewood Cliffs: Prentice-Hall, Inc.
Mintzberg, H. (1994), *The Rise and Fall of Strategic Planning*, New York, NY: Free Press.
Montoya-Weiss, M. M. and Calantone, R. (1994), 'Determinants of New Product Performance: A Review and Meta-Analysis', *Journal of Product Innovation Management* 11 (5): 397-417.
Mundy, J. (2010). 'Creating dynamic tensions through a balanced use of management control systems', *Accounting, Organizations and Society* 35 (5): 499-523.
Narayanan, V. G. and Davila, A. (1998), 'Using delegation and control systems to mitigate the tradeoff between the performance-evaluation and belief-revision uses of accounting signals', *Journal of Accounting and Economics* 25 (3): 255-282.
Nelson, R. R. and Winter, S. G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Belknap Press of Harvard University Press.
Nixon, B. (1998), 'Research and development performance measurement: A case study', *Management Accounting Research* 9 (3): 329-355.
Ouchi, W. (1977), 'The Relationship between Organizational Structure and Organizational Control', *Administrative Science Quarterly* 22 (1): 95-113.
Ouchi, W. (1979), 'A Conceptual Framework for the Design of Organizational Control Mechanisms', *Management Science* 25 (9): 833-847.
Perrow, C. (1970), *Organizational Analysis: A Sociological View*, New York, NY: Tavistock Publications.
Ray, M. and Schlie, T. (1993), 'Activity-based management of innovation and R&D operations', *Journal of Cost Management* (Winter): 16-22.
Rockness, H. O. and Shields, M. D. (1984), 'Organizational Control Systems in Research and Development', *Accounting, Organizations and Society* 9 (2): 165-177.
Rockness, H. O. and Shields, M. D. (1988), 'An empirical analysis of the expenditure budget in research and development', *Contemporary Accounting Research* 4 (2): 568-581.
Rothwell, R. (1972), *Factors for Success in Industrial Innovations from Project SAPPHO – A Comparative Study of Success and Failure in Industrial Innovation*, Brighton, Sussex, England: S.P.R.U.
Rothwell, R., Freeman, C., Horley, A., Jervis, V. I. P., Robertson, A. B., and Townsend, J. (1974), 'SAPPHO Updated – Project SAPPHO, Phase II', *Research Policy* 3 (3): 258-291.
Roussel, P. A., Saad, K. N., and Erickson, T. J. (1991), *Third Generation R&D: Managing the Link to Corporate Strategy*, Harvard Business School Press, Boston, MA.
Rowe, W. G. and Wright, M. (1997), 'Related and unrelated diversification and their effect on human resource management controls', *Strategic Management Journal* 18 (4): 329-338.
Rubenstein, A. H., Chakrabarti, A. K., O'keffe, R. D., Souder, W. E., and Young, H. C. (1976), 'Factors Influencing Innovation Success at the Project Level', *Research Management* (May): 15-20.
Samuelson, L. A. (1986), 'Discrepancies between the roles of budgeting', *Accounting, Organizations and Society* 11 (1): 35-45.
Schermann, M., Wiesche, M., and Krcmar, H. (2012), 'The Role of Information Systems in

Supporting Exploitative and Exploratory Management Control Activities', *Journal of Management Accounting Research* 24 (1): 31-59.

Shalley, C. E., Zhou, J., and Oldham, G. R. (2004), 'The effects of personal and contextual characteristics on creativity: Where should we go from here?', *Journal of Management* 30 (6): 933-958.

Simon, H. A., Kozmetsky, G., Guetzkow, H., and Tyndall, G. (1954), *Centralization vs. Decentralization in Organizing the Controller's Department*, New York: Controllership Foundation, Inc.

Simons, R. (1987). 'Accounting control systems and business strategy: An empirical analysis'. Accounting, Organizations and Society, 12(4): 357-375.

Simons, R. (1990), 'The Role of Management Control Systems in Creating Competitive Advantage: New Perspectives', *Accounting, Organizations and Society* 15 (1-2): 127-143.

Simons, R. (1994), 'How New Top Management Use Control Systems as Levels of Strategic Renewal', *Strategic Management Journal* 15 (3): 169-189.

Simons, R. (1995), *Levers of Control: How Managers Use Innovative Control Systems to Drive Strategic Renewal*, Boston, MA: Harvard Business School Press.

Snell, S. A. (1992), 'Control theory in strategic human resource management: The mediating effect of administrative information', *The Academy of Management Journal* 35 (2): 292-327.

Souder, W. E. and Chakrabarti, A. K. (1979), 'Industrial Innovations: A Demographical Analysis', *IEEE Transactions on Engineering Management* 26 (4): 101-109.

Speklé, R. F. (2001), 'Explaining management control structure variety: A transaction cost economics perspective', *Accounting, Organizations and Society* 26 (4-5): 419-441.

Sprinkle, G. B. (2003), 'Perspectives on experimental research in managerial accounting', *Accounting, Organizations and Society* 28 (2-3): 287-318.

Sunder, S. (1997), *Theory of Accounting and Control* Cincinnati, OH: South-Western Publishing Company.

Tiessen, P. and Waterhouse, J. H. (1983), 'Towards a descriptive theory of management accounting', *Accounting, Organizations and Society* 8 (2-3): 251-267.

Tushman, M. L. and Nadler, D. A. (1978), 'Information Processing as an Integrating Concept in Organizational Design', *The Academy of Management Review* 3 (3): 613-624.

van der Panne, G., van Beers, C., and Kleinknecht, A. (2003), 'Success and Failure of Innovation: A Literature Review', *International Journal of Innovation Management* 7 (3): 309-338.

Veryzer, R. W. (2005), 'The Roles of Marketing and Industrial Design in Discontinuous New Product Development', *Journal of Product Innovation Management* 22 (1): 22-41.

Wheelwright, S. C. and Clark, K. B. (1992), *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency and Quality*, New York: Free Press.

Widener, S. K. (2007), 'An empirical analysis of the levers of control framework', *Accounting, Organizations and Society* 32 (7-8): 757-788.

Wiersema, M. F. and Bantel, K. A. (1992), 'Top management team demography and corporate strategic change', *The Academy of Management Journal* 35 (1): 91-121.

Ziger, B. J. and Maidique, M. A. (1990), 'A model of new product development: An empirical test management science', *Management Science* 36 (7): 867-883.

Zimmerman, J. L. (2005), *Accounting for Decision Making and Control* (4th ed.), New York: Irwin.

Appendix A Reference Sources of the Key Control Mechanisms in R&D Activities

Key control mechanisms for R&D success	References	Criteria of control mechanisms	Function
Top management involvement	Brown and Eisenhardt (1995); Ernst (2002); Felekoglu and Moultrie (2013); Henard and Szymanski (2001); Evanschitzky *et al.* (2012); Montoya-Weiss and Calantone (1994); van der Panne *et al.* (2003)	(1) Do powerful top management support the project?	Enabling
		(2) Does the firm provide a high level of top management support for the project from the development stage through its launch to the marketplace?	Enabling
		(3) Do top management evaluate R&D professionals' actions and R&D costs?	Controlling
		(4) How frequently do top management understand/evaluate the budgeting and cost of R&D activities?	Controlling
		(5) How frequently do top management provide informal feedback on budget execution and cost evaluation?	Controlling
Ability of project managers	Bisbe and Otley (2004); Brown and Eisenhardt (1995); Ernst (2002)	(1) In the process of project development and deployment, the project manager coordinates very well with top management, other functional divisions, and customers.	Enabling
		(2) The project manager who is responsible for the R&D project holds a high position and has high authority.	Enabling
Composition of R&D teams	Bisbe and Otley (2004); Brown and Eisenhardt (1995); Ernst (2002); Henard and Szymanski (2001); Evanschitzky *et al.* (2012); van der Panne *et al.* (2003)	(1) The level of professionalisation and areas of expertise of employees in R&D teams.	Enabling
		(2) Whether or not R&D teams can coordinate internally, update their collected data, and analyse and execute projects successfully.	Enabling
Project Management and Resource Allocation			
1. Assess the feasibility of projects and select	Bisbe and Otley (2004); Brown and Eisenhardt (1995);	(1) The level of professionalisation of the project approval board is very high.	Enabling

the most promising ones	Evanschitzky *et al.* (2012); Veryzer (2005)	(2) There are specific intelligence departments providing information about users' demands, marketing, and advertising, so the R&D team has an in-depth understanding of the target customers and market for the product.	
2. Identify product defects prior to the product launch	Zimmerman (2005)	(3) There is a specific review process to identify product defects prior to launch which includes in particular a summary of the experience and lessons of prior, related projects.	Enabling
3. Appropriately allocate both capital and labour resources	Henard and Szymanski (2001); Zimmerman (2005)	(4) The Finance Department communicates with the technology and R&D departments to discuss the R&D projects' allocation of human, capital, and material resources.	Enabling
4. Efficiently utilise the available resources.	Zimmerman (2005)	(5) Any expenditure has strict review procedures.	Controlling
		(6) The budgeted goals of R&D projects are very clear and specific.	Controlling
		(7) Clear and sound cost management is reflected in the rewards received.	Controlling
		(8) Favourable variances in the budget are reflected in the rewards received.	Controlling
		(9) The quantity of publication of papers and books related to R&D projects is reflected in the rewards received.	Controlling
		(10) The quantity of patent applications related to R&D projects is reflected in the rewards received.	Controlling
Internal and External Communication and Cooperation	Brown and Eisenhardt (1995); Ernst (2002; Henard and Szymanski (2001); Evanschitzky *et al.* (2012)	(1) The firm's R&D, production, and marketing functions are well coordinated and able to update the data collected and analyse and make decisions about R&D projects.	Enabling
		(2) The R&D work makes effective use of external technology and academic exchanges.	Enabling

Appendix B Summary of Interview Data Used for Analysis

Interviewees	Number of interviewees	Interview frequency	Interview type	Level	Topics
CEO	1	Once	Vis-à-vis	Top management	The corporation's strategies and overviews of R&D activities.
Deputy General Manager	1	Once	Vis-à-vis	Top management	Roadmap of R&D activities.
CFO	1	Twice	Vis-à-vis	Top management	Related financial policies of R&D activities.
Director of Scientific Research Department	1	Thrice	Vis-à-vis	Middle management	Overviews of R&D MCS and managing processes
		Thrice	By phone		
Staff of Financial Department	1	Once	Vis-à-vis	Employee	Overviews of R&D budget formulation, execution and evaluation.
Staff of Scientific Research Department	4	Thrice/person	Vis-à-vis	Employee	Specific regulations of R&D management.
		One of them thrice	By phone		
R&D project manager	4	Twice/person	Vis-à-vis	Middle management	Detailed information of R&D projects.

Appendix C Profiles of Respondents

Project Manager	Years of service	Years serving as an R&D project manager	Highest level of education
A	14	10	Master's degree or above
B	8	4	Master's degree or above
C	10	5	Master's degree or above
D	15	6	Bachelor's degree