

**Public–Private Partnerships for the Management of  
Agricultural Innovation Systems**

**A Thesis Submitted to the  
College of Graduate Studies and Research  
In Partial Fulfillment of the Requirement  
For the Degree of Doctor of Philosophy  
In the Department of Political Studies  
University of Saskatchewan**

**By  
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## ABSTRACT

Over the past 30 years, there has been a marked proliferation of the use of public–private partnerships (P3s) for the management of agricultural innovation systems. This is part of a larger worldwide trend of using P3s in the provision of public goods and services. Despite the large number of agricultural P3s in operation, a literature review demonstrated paucity of both case studies and of theory, meaning that the study of these emerging business models has not kept pace with practice. Over the last 30 years, only 38 peer-reviewed articles have been published. The objective of this dissertation is to advance the theory, analysis, and policy review of agricultural P3s. There are four independent investigations in this dissertation that advance the knowledge of agricultural P3s in seven specific ways. First, these investigations introduce two quantitative methodologies to empirically demonstrate the critical role P3s occupy in research and development (R&D) innovation networks and in the development, dissemination and commercialization of new technologies that enhance global food security. Second, this analysis suggests that the key variable influencing the formation of these organizations is people, rather than public policy or market incentives. Third, agricultural P3s require large up-front investments and they have extended gestation periods; therefore, they are dependent upon public support. Fourth, P3s are not a means of privatizing public functions; rather, they represent a new and emerging process of collaboration that transcends the public–private dichotomy. Fifth, agricultural P3s appear to operate in “orphan spaces,” sectors that, for a variety of reasons, are ignored by the public and private sectors. Sixth, there is evidence to suggest that many P3s require the services of P3 experts of which there is a shortage, particularly in the developing world. Seventh, each agricultural P3 is novel because each is the result of sector-specific challenges and has a structure that is dependent upon the types and number of partners and their objectives, limiting the ability to transfer explicit lessons from existing models to new P3s.

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## TABLE OF CONTENTS

Permission To Use .....	i
Abstract .....	ii
Acknowledgements .....	iii
List of Tables .....	vii
List of Figures .....	viii
List of Charts .....	ix
LIST OF ABBREVIATIONS .....	x
<b>Chapter One Introduction .....</b>	<b>1</b>
1.1 Problem Statement and Introduction .....	1
1.2 Literature Review .....	3
1.3 Theoretical Perspectives and Limitations of Theory .....	5
1.4 Organization and Purpose of this Study .....	8
1.5 Contribution to Knowledge .....	10
References .....	13
<b>Chapter Two The Origins of Agricultural P3s.....</b>	<b>15</b>
2.1 Intellectual and Theoretical Origins of P3s.....	15
2.2 The Theory of Goods and the Institutional Structure of P3s.....	18
2.3 Intellectual and Policy Origins of Agricultural P3s .....	20
2.4 A Lineage of Agricultural P3s.....	23
2.5 Conclusion.....	27
References .....	28
<b>Chapter 3 Public–Private Partnerships for the Management of National, Regional and International Innovation Systems: A Social Network Analysis of Knowledge Translation Systems.....</b>	<b>30</b>
<b>3.1 Introduction .....</b>	<b>30</b>
<b>3.2 Theory.....</b>	<b>31</b>
3.2.1 P3s Defined and Contextualized .....	31
3.2.2 The Network Society and the Challenge of Governance .....	32
3.2.3 Collaboration, the New Production of Knowledge and the P3.....	33
3.2.4 Innovation and Knowledge .....	34
<b>3.3 Methodology.....</b>	<b>36</b>
<b>3.4 Research Focus: Global Pulse Breeding System .....</b>	<b>39</b>
3.4.1 Pulse Breeding R&D .....	39
3.4.2 Composition of Global Pulse R&D System .....	39
<b>3.5 Data and Analysis .....</b>	<b>40</b>

<b>3.6 Comparative analysis</b> .....	<b>42</b>
3.6.1 System Structure and the Critical Role of the P3 .....	42
3.6.2 The Export System .....	43
3.6.3 The EU System .....	49
3.6.4 The Developing World System .....	53
3.6.5 The Global System.....	56
<b>3.7 Conclusion</b> .....	<b>60</b>
<b>References</b> .....	<b>63</b>
<b>Chapter Four Collaboration and the Generation of New Knowledge in Networked Innovation Systems: a Bibliometric Analysis</b> .....	<b>68</b>
<b>4.1 Introduction</b> .....	<b>68</b>
<b>4.2 Theory</b> .....	<b>69</b>
4.2.1 Triple Helix of Innovation.....	69
4.2.2 Research Focus: The Political Economy of Canola R&D.....	73
4.2.3 Research Question .....	75
<b>4.3 Methodology</b> .....	<b>76</b>
<b>4.4 Analysis</b> .....	<b>77</b>
<b>4.5 Conclusion</b> .....	<b>82</b>
<b>4.6 Policy Implications</b> .....	<b>83</b>
<b>4.7 Directions for Further Research</b> .....	<b>84</b>
<b>References</b> .....	<b>85</b>
<b>Chapter Five A Typology of Research and Development Agricultural Public-Private Partnerships Common to the Developing World Bio-economy</b> .....	<b>88</b>
<b>5.1. Introduction</b> .....	<b>88</b>
<b>5.2 Methodology</b> .....	<b>89</b>
<b>5.3 Theory</b> .....	<b>90</b>
<b>5.4 Summary and Analysis of the Responses to the Questions</b> .....	<b>96</b>
5.4.1 The Incentives to Join or Form a P3 .....	96
5.4.2 Constraints in Joining or Forming a P3.....	99
5.4.3 How Have P3s Overcome the Constraints? .....	100
5.4.4 The Hidden Costs Associated with Working with P3s.....	101
5.4.5 The Key Enablers of P3s .....	104
5.4.6 The Most Important Lessons Learned by Practitioners of P3s .....	107
<b>5.5 Analysis</b> .....	<b>108</b>
<b>5.6 Strategic Implications</b> .....	<b>112</b>
<b>References</b> .....	<b>115</b>
<b>Chapter Six Public-Private-Producer Partnerships (P4s) in Canada</b> .....	<b>119</b>
<b>6.1 Introduction</b> .....	<b>119</b>
<b>6.2 Methodology</b> .....	<b>120</b>
<b>6.3 Case Study 1: Saskatchewan Pulse Growers</b> .....	<b>121</b>

6.3.1 P4 Inputs .....	121
6.3.2 P4 Processes.....	122
6.3.3 P4 Outputs .....	124
<b>6.4 Case Study 2: Centre de Développement du Porc du Québec .....</b>	<b>125</b>
6.4.1 P4 Inputs .....	125
6.4.2 P4 Processes.....	126
6.4.3 P4 Outputs .....	128
<b>6.5 Case Study 3: Okanagan Plant Improvement Corporation .....</b>	<b>129</b>
6.5.1 P4 Inputs .....	129
6.5.2 P4 Processes.....	130
6.5.3 P4 Outputs .....	133
<b>6.6 Case Study 4: Vineland Research and Innovation Centre .....</b>	<b>134</b>
6.6.1 P4 Inputs .....	134
6.6.2 P4 Processes.....	136
6.6.3 P4 Outputs .....	138
<b>6.7 Analysis.....</b>	<b>139</b>
<b>6.8 Conclusion.....</b>	<b>141</b>
<b>References .....</b>	<b>142</b>
<b>Chapter Seven Conclusion .....</b>	<b>144</b>
7.1 What Was Known .....	144
7.2 What We Have Learned .....	145
7.3 Policy Implications.....	149
7.4 Limitations .....	151
7.5 Directions for Future Research .....	152
<b>Appendices .....</b>	<b>153</b>
<b>Appendix A: List of and coding for organizations in Chapter Three .....</b>	<b>153</b>
<b>Appendix B: Formulation of the negative binomial distribution .....</b>	<b>159</b>
<b>Appendix C: Questionnaire for Chapter Six.....</b>	<b>161</b>
I. Background Information (P4 Inputs).....	161
II. P4 Processes.....	161
III. P4 Outputs .....	162
<b>Appendix D: A Discussion on the Provenance of Each Article/Chapter.....</b>	<b>164</b>

## LIST OF TABLES

Table 1.1.	P3 Publications.....	4
Table 2.1.	Typology by Good and Attribute.....	20
Table 3.1.	Typology of Centrality Measures.....	38
Table 3.2.	Production and exports of pulses, 2003–07, million tonnes.....	39
Table 3.3.	The Four Pulse Innovation Networks.....	41
Table 3.4.	Export System Actors & Centrality.....	43
Table 3.5.	An estimate of the vulnerability of the Export System.....	46
Table 3.6.	EU System Actors & Centrality.....	50
Table 3.7.	An Estimate of the Vulnerability of the EU System.....	52
Table 3.8.	Developing World System Actors & Centrality.....	53
Table 3.9.	An Estimate of the Vulnerability of the Developing World System.....	55
Table 3.10.	Global System Actors & Centrality.....	57
Table 3.11.	An Estimate of the Vulnerability of the Developing World System.....	60
Table 4.1.	AAFC Peer-Reviewed Canola Paper Citation Rates.....	75
Table 4.2.	Collaborative Funding Descriptive Statistical Comparison.....	78
Table 4.3.	Producer P3s and MII Descriptive Statistical Comparison.....	79
Table 4.4.	Regression Results.....	81
Table D.1.	Provenance of Each Article/Chapter.....	164
Table D.1.	Dissemination of Thesis Chapters.....	164



## LIST OF FIGURES

Figure 2.1 Picciotto Model.....	21
Figure 3.1. The Export System.....	44
Figure 3.2. The Export System minus CDC/SPG and ICARDA.....	45
Figure 3.3 The Export System.....	46
Figure 3.4 EU System.....	51
Figure 3.5 EU System less GLIP.....	51
Figure 3.6 Developing World System.....	54
Figure 3.7 Developing World System less ICARDA, ICRISAT and CLAN.....	54
Figure 3.8 The Global System.....	58
Figure 3.9 The Global System less GLIP, CDC/SPG, ICARDA and ICRISAT.....	59

## LIST OF CHARTS

Chart 1.	Total peer-reviewed agricultural P3 publications.....	4
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## LIST OF ABBREVIATIONS

### CHAPTER 1:

Organization for Economic Development and Cooperation (OECD)

International Union for the Protection of New Varieties of Plants (UPOV)

Social network analysis (SNA)

Canadian Agricultural Innovation and Research Network (CAIRN)

International Development Research Centre (IDRC)

International Consortium on Applied Bio-Economy Research (ICABR)

Agrifood and Agriculture Canada (AAFC)

### CHAPTER 2:

New public management (NPM)

Alternative Service Delivery (ASD)

Private Finance Initiative (PFI)

Intellectual property rights (IPR)

Consultative Group on International Agricultural Research (CGIAR)

Fédération des producteurs de porcs du Québec (FPPQ)

Centre de développement du porc du Québec (CDPQ)

Okanagan Plant Improvement Company (PICO)

Federal Partners in Technology Transfer (FPTT)

Saskatchewan Pulse Growers (SPG)

Grains Research and Development Corporation (GRDC)

Cooperative Research Centers (CRCs)

CRC for Sugar Industry Innovation through Biotechnology (CRCSIIB)

Value Added Wheat CRC (VAWCRC)

CRC for Molecular Plant Breeding (MRBCRC)

Center for Legumes in a Mediterranean Area (CLIMA)

Pulse Crop Genetic Improvement Network (PCGIN)

John Innes Center (JIC)

Processors and Growers' Research Organization (PGRO)

National Institute of Agricultural Botany (NIAB)

#### CHAPTER 3:

Non-governmental organizations (NGOs)

Plant genetic resource (PGR)

International Center for Agriculture Research in the Dry Areas (ICARDA)

Pulse Breeders Australia (PBA)

Center for Innovative Legume Research (CILR)

Grains Council of Australia (GCA)

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

Council of Grain Growing Organizations (COGGO)

Grain Legumes Integrated Project (GLIP)

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)

#### CHAPTER 4:

Matching Investment Initiative (MII)

Incident-rate ratios (IRR)

#### CHAPTER 5:

Public Sector Intellectual Property Resource for Agriculture (PIPRA)

Corporate Social Responsibility (CSR)

Bill and Melinda Gates Foundation (BMGF)

Acquisition of Agri-Biotechnology Applications (ISAAA)

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

International Development Centre (IDRC)

CHAPTER 6:

Public-private-producer partnership (P4)

Vineland Research and Innovation Centre (VRIC)

Crop Development Centre (CDC)

Variety Release Agreement (VRA)

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ)

British Columbia Fruit Growers' Association (BCFGA)

Pacific Agri-Food Research Centre (PARC)

Developing Innovative Agricultural Products (DIAP)

Horticulture Research Institute of Ontario (HRIO)

Ontario Ministry of Food and Agriculture (OMARFRA)

Federal- Canadian Agricultural Adaptation Program (CAAP)

Federal Development Agency for Southern Ontario (FeDev)

# CHAPTER ONE

## INTRODUCTION

### **1.1 Problem Statement and Introduction**

Despite high social and economic returns on investment (ROIs) from agricultural research and development (R&D), which is critical to global food security, investments have been declining for decades. Several factors are responsible for this decline, including cutbacks to public R&D expenditures and the growth of privatization programs. As a result, neither the public nor the private sector has been able to supply the required R&D to support the technological innovation necessary for the development of long-term solutions to food security. In response to the combined shortfalls in both public and private investments, there has been a marked rise in the use of public-private partnerships to generate R&D for agricultural innovation. Agricultural public-private partnerships impart a hybridized organizational structure to the management, finance and generation of agricultural R&D, representing a solution that is ahead of current theory, analysis and policy. The study of these hybrid agricultural R&D partnerships, in which practice has overtaken theory and analysis, remains an emerging and important field.

The objective of this dissertation is to advance the theory, analysis and policy relevance of these agricultural public-private partnerships (P3s). The large-scale uptake and unprecedented proliferation of the use of P3s in agricultural innovation systems began with the advent of a number of new paradigms regarding the role of government and the use of public funds and facilities to support the economy, including but not limited to agricultural R&D. Beginning in the late 1970s and continuing to the present day, a number of interrelated factors have precipitated re-conceptualization of the parameters governing relations between the state and society. First, the advent of ideologies such as neo-liberalism and new public management (NPM) have challenged the traditional role of government by advocating for the privatization of public services and the application of market-based reforms to the management and administration of government services. Second, austerity measures have limited both the scale and scope of governments, leading to a long-term decline in expenditures related to agricultural R&D which has forced users to develop new ways and new sources for financing their technology and

innovation requirements. Third, the public-private dichotomy that formerly characterized both society and the agricultural R&D system has been challenged by the growth of distributed governance and the rise of a network society characterized by the inclusion of new actors that do not conform to the public-private spectrum (Rhodes, 1995: 1). Additionally, globalization has intensified the impact and intensity of distributed governance. Lastly, the above transformations have collectively changed R&D the route to developing and commercializing new agricultural technologies from a linear, mostly public-private process to a horizontal process involving heterogeneously organized networks operating on a global basis (Phillips and Khachatourians, 2001: 21). These new paradigms have jointly provided the impetus for the growth in the use of these new organizations.

A full explanation of the above transformations requires recognition that there has been a growth of international political economy (IPE) as a unique research discipline within political science. Beginning in the 1970s, the traditional approach of separating analysis of international politics from the operations of the international economy became incapable of explaining changes to the global political-economic order itself. Susan Strange's (1970) article entitled "International Economics and International Relations: A Case of Mutual Neglect" and follow-up publications by Robert Cohen and Robert Gilpin, among others, noted this phenomenon. The intellectual foundations of IPE are formed on the premise that the economic, power and social changes affecting national economies and domestic politics are global in nature, the ongoing results of a "compression in time and space" caused by unprecedented advancements in communication, distribution and transportation systems which have led to global economic and political integration and interdependence (Gilpin, 2001: 8). IPE is grounded on the assumption that policy change is the result of interactions between states, multinational corporations, interest groups and international political and trade regimes that then render the traditional state-market and international-domestic dichotomies insufficient frameworks for analysis.

## 1.2 Literature Review

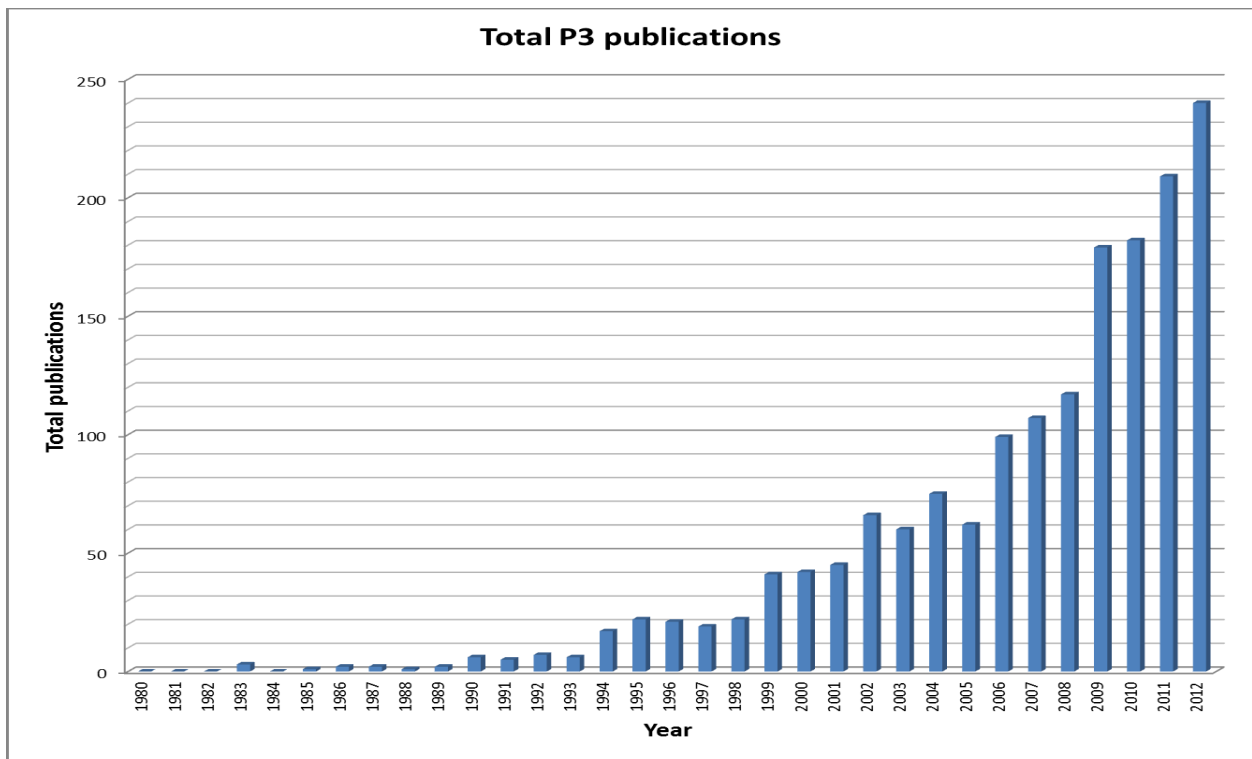
A literature review confirms that the use of P3s in both the agricultural space and in general is a recent phenomenon, as the majority of the scholarly articles and books covering both fields have been published in the last five years. A keyword search using the ISI Web of Science identified all relevant peer-reviewed articles published between the beginning of 1980 to the end of 2012 relating to P3s in order to contextualize how they apply to agriculture and to identify trends that may influence the present research. The reason for the selection of this time frame is that the concept of P3s gained prominence in Great Britain during the early years of the Prime Minister Margaret Thatcher's government. The process was driven by both ideological preferences and contemporary fiscal pressures, as governments sought to privatize functions and services by downloading to both the for-profit and not-for-profit sectors.

From an agricultural perspective, 1980 also marks the end of the golden era when the public sector transformed global agriculture through targeted R&D efforts and investments. In the preceding decades modern improved varieties came to dominate global markets and high yielding 'green revolution' varieties of wheat and rice largely resolved long-term food insecurity in India and China. Again in Great Britain, the Thatcher government privatized all publicly funded breeding activities by selling public facilities to the private sector (Heisley et al., 2002: 8). In the United States, laws governing intellectual property rights (IPRs) and technology transfer were drafted to provide near-monopolistic control over new biological products and technologies developed in both public and private facilities. This created incentives for private investors to fund R&D, which went partway to compensating declining public investments in agriculture (Knudson, 2000: 175). Within the Organization for Economic Development and Cooperation (OECD), the advent of IPRs, beginning in the 1970s in the form of plant breeders' rights (PBRs) from the International Union for the Protection of New Varieties of Plants (UPOV), facilitated the privatization of many aspects of agricultural R&D (Flugie and Schimmelpfenning, 2000: 3–5). This institutional transformation was mirrored in the animal sciences, as IPRs and new collaborative methods of financing R&D diminished the role of the public sector beginning in the 1980s (Flugie et al., 2000: 136–145). Put simply, 1980 marks the end of the era in which the public sector dominated in the provision of agricultural R&D and the



beginning of a new institutional environment characterized by collaboration between the public, private, academic and volunteer (producer organization) sectors.

The ISI keyword<sup>1</sup> search identified 1,660 peer-reviewed articles on P3s during the 1980-2012 timeframe. As noted in Table 1 below, 927 of these articles (56%) were published in 2008-12, suggesting the study of P3s is an emerging field. A total of 58 unique research areas were identified, each with a minimum of five publications. In agriculture, a total of 38 peer-reviewed articles on P3s have been published since 1980. Again, mirroring the general trend in P3s, 17 (45%) were published in 2008-12, as Table 1.1 below indicates.



**Chart 1.** Total P3 Publications

<sup>1</sup> The keyword used was public-private partnership.

**Table 1.1.** Total Peer-Reviewed P3 and Agricultural P3 Publications

Period in 5-Year Segments	Total P3 Publications	Agricultural P3 Publications	Ag P3 as a Percentage of Total
1983-87	8	0	0%
1988-92	21	4	.190%
1993-97	85	1	.012%
1998-02	216	8	.037%
2003-07	403	8	.020%
2008-12	927	17	.018%

### **1.3 Theoretical Perspectives and Limitations of Theory**

As the study of P3s in general and agricultural P3s in particular, is an emerging field, practice has overtaken study. This presents challenges for researchers, as the absence of a unifying theory of P3s has led to a paucity of both methodologies and case studies for organizing the study of this phenomenon. This gap is especially pronounced in the agricultural literature base, as the case studies conducted to date have used interviews, surveys and record analysis as means of examination. This research is descriptive by nature and conducted on an isolated basis, making it impossible to extrapolate explicit lessons that can be transferred to support the formulation and implementation of specific policies for agricultural P3s. In place of a single theory of agricultural P3s, the present study relies on a number of divergent perspectives to both ground the research and to provide the research trajectory for the four articles that constitute the core of this dissertation. Three independent theoretical perspectives guide this research. The first is based on public administration literature, generally focused on new public management; the second draws on the disparate theories and prior case studies in the agricultural literature; and the third tests various theories of innovation.

In the public administration literature, the P3 represents a process and institution that bridges the gap between public- and private-sector practices in order to make government more efficient and accountable to stakeholders. Essentially, P3s are a new space for democratic engagement. They link community stakeholders in networks of shared interests with policy makers, creating new procedures and norms to facilitate legitimacy and consent (Skelcher et al., 2005: 20–21). P3s permit governments a semblance of control over policy while allowing the development of new methods of financing and managing the provision of public goods, such as infrastructure and

services. Specifically, the P3 is a vehicle for leveraging public assets in order to acquire private financing while enhancing public accountability (McQuaid and Scherrer, 2010: 8). There is a tendency to view P3s according to a public-private dichotomy, in which the public sector seeks to adopt private-sector practices to enhance efficiency and the private sector seeks new areas in which to operate and search for profits. However, P3s actually represent an innovative organizational model designed to maximize the comparative advantages of the competencies of all partners—public, private and volunteer—by developing self-organizing networks constructed upon the need for coordinated and integrated responses to problems that are beyond the control of any sector acting in isolation. The P3, rather than being a vehicle for achieving public efficiency, is a new paradigm of public governance in an environment characterized by the need for citizen engagement, transparency and accountability (Bovaird, 2004: 12–13).

As the literature count demonstrated in Table 1.1, above, shows, there is a rather small collection of peer-reviewed publications related to P3s in the agricultural space. As such, there is no true agricultural theory or group of theories pertaining to P3s. Instead, there are a range of concepts and a small number of case studies that attempt to describe the growing use of P3s in agricultural R&D and in agricultural supply chains in both the developed and developing world. Three concepts are important to this dissertation. The first is the role that P3s occupy in R&D networks. Specifically, P3s have been labelled “innovation brokers,” as they anchor networks due to their unique ability to link the public, private and producer (volunteer) sectors into horizontally configured systems (Klerkx et al., 2009: 2–4). P3s act as intermediaries between the disparate partners by facilitating trust, communication and collaboration—all essential components of the innovation process. The second theme concerns the incentives that draw partners into P3s. The private sector engages in P3s to lower the cost of developing new technologies and markets, as P3s are by design well suited for developing new value and supply chains, since collaboration lowers the costs and risks associated with new technologies and markets. The third concept focuses on the constraints that inhibit the development of P3s. Engaging in P3s can result in the undesirable transfer of proprietary technologies to competitors, or to producer groups, which then inadvertently transfer them to competitors. This includes the transfer of confidential practices and financial information that can harm a firm’s market position vis-à-vis its competitors.

A number of theories of innovation attempt to contextualize the proliferation of P3s. One perspective, known as the triple helix model, posits that innovation has become complex, requiring the collaboration of all sectors to develop the economies of scale and scope needed to accelerate innovation. Here, the development of science-based knowledge becomes dependent on the use of organic hybrid organizations that incorporate the institutional characteristics of each sector—public, private and academic (Etzkowitz and Ranga, 2010: 5). A second perspective suggests that innovation depends on the connection to global flows of ideas and technologies, requiring the use of novel institutions that link local capabilities and needs with these global flows. Bathelt et al. (2004: 31–33) characterize the challenge of linking global pipelines to local buzz. A third view suggests that innovation-based P3s are best understood using a number of interrelated economic theories that view collaboration as a means of institutional design, which lowers the cost of R&D and generates economies of scale that exceed the capability of either the public or the private sector alone.

There are a number of limitations associated with the above theories. First, from a generalized viewpoint on P3s, there is a paucity of models to evaluate the P3s and generate empirical evidence. Specifically, most of the theories are largely descriptive and do not provide any specific causal relationship which can be quantified and assessed in terms of input and outputs. The current primary tools for evaluating generic P3s are qualitative, based on interviews, surveys and observations (Brinkerhoff, 2002: 5). Second, the primary public administration literature views the P3 as a process for achieving efficiencies in the provision of public goods by collaborating with the private sector to finance and manage infrastructure projects. Agricultural P3s as discussed in this dissertation are of a different order than infrastructure projects: in place of the design, building and management of such projects, agricultural P3s are organic organizations developed to create something new in the form of technological innovation. Therefore, they move away from contract management into the creation of social and scientific capital, operating on long-term horizons characterized by uncertainty. Additionally, agricultural P3s include a wide variety of partners (e.g., producer groups, NGOs, foundations) that do not fit into the strict public-private dichotomy of the literature. Third, the agricultural literature base

contains a limited number of discrete case studies, making it difficult to draw explicit lessons that can be transferred systematically into policy and into future agricultural P3s.

#### **1.4 Organization and Purpose of this Study**

In addition to the Introduction and Conclusion this thesis consists of four discrete articles that have been presented at peer-reviewed conferences. The four articles in this dissertation are designed to advance the theory, analysis and policy review of agricultural P3s. The first article, “Centerless Governance and the Management of Global R&D: Public–Private Partnerships and Plant-Genetic Resource Management,” uses social network analysis (SNA) to empirically evaluate the role of P3s at the national, regional and global levels of operations in the pulse R&D sector. The pulse sector provides fertile ground for research: pulses are sometimes characterized as an “orphan crop,” as their R&D needs are largely ignored by both the public and private sectors. Consequently, there exist opportunities for innovative financing and management business models; a large number of P3s operate in this sector. This article graphically and statistically demonstrates through SNA that P3s are the central actors that provide the structural nucleus for the horizontally configured innovation systems that dominate in this research space. Moreover, they are vital for linking the various national systems into larger regional/continental systems and ultimately into the global system. A sensitivity analysis helps to define the central role of P3s in this process. Furthermore, the operational configuration of each P3 depends upon the R&D and governance needs of each national or regional network. Specifically, each P3 is tailored to the technology-transfer characteristics of each system. This article also demonstrates that the use of P3s can confer competitive advantages to users at the macro level of operations.

The second article, “Collaboration and the Generation of New Knowledge in Networked Innovation Systems: a Bibliometric Analysis,” merges two methodologies to develop an innovative analytic model to measure how collaboration improves technology transfer and knowledge dissemination in the Canadian canola sector. Both regression and citation analyses are merged into a single analytical model to demonstrate that collaboration, centered around P3s, creates economies of scale and scope in demand-driven networks, which are replacing supply-push linear systems of innovation in agricultural R&D. This paper suggests that traditional models of agricultural R&D based on a public-private dichotomy are being replaced by multi-

sectoral and transient networks organized around P3s, which are governed and financed by the users—generally producers—of the resultant technologies. Therefore, innovation is becoming a bottom-up and organic process in which pluralistic funding and governance processes are challenging the traditional, hierarchically structured systems of technology transfer. The results of the regression suggest that there are optimal configurations for these partnerships—producers, academics and industry partners generate differential synergies, as does government (albeit not if two or more government engage).

The third article, “A Typology of Research and Development: Agricultural Public-Private Partnerships Common to the Developing World Bio-economy,” is a comparative analysis of a number of P3s in the developing world, grounded in the agricultural P3 literature. This article advances the theory and policy relevance of agricultural P3s in the developing world in five ways. First, it develops a working typology by delineating two models of P3s (R&D and value-chain), illuminating how the utilization of proprietary knowledge, the requirement for networks at different stages of their life cycle and the need for P3 specialists differentiate the two models. Second, this paper suggests that individuals responding to intractable problems related to food security are the key drivers of the formation of P3s—not policies. Third, it argues that the successful formation and operation of these new business models is limited by a shortage of P3s specialists, researchers and scientists. Fourth, it reveals previously unknown variables—related to complexity, financial reporting and gestation periods—that hinder success. Fifth, it demonstrates how, as the problems of food security in the developing world exceed the capacity of both the private and public sectors to produce and distribute sufficient food, P3s represent the leading edge of an emerging global system of institutions dedicated to addressing the growing challenge of food security.

The last article, “Public–Private–Producer Partnerships (P4s) in Canada,” is a case-study analysis on four P4s currently in operation in Canada. The term public–private–producer partnership represents a relatively new concept in agriculture and is a subset of agricultural P3s that has not yet been researched. This article examines the growing role that self-organizing producer organizations occupy in the financing and management of the R&D process in Canada in collaboration with the public sector and academia using P4s. P4s are an emerging business

model that permits producers to use production-based levies to finance the development and commercialization of new technologies. P4s have developed in response to a variety of factors including public austerity measures and the advent of intellectual property rights regimes that have engendered new economic spheres that have neither the public nor the private sectors have adequately responded to. There are four case studies based on primary and secondary sources that illuminate the growing role of P4s in Canadian agriculture.

As each of the four above chapters/articles is by design a discrete probe of the concept of P3s that has been presented at peer-reviewed conferences and, in two cases, published, there is no single, overarching specific theory and methodology chapter to this dissertation. The reason for this is each article uses a methodology unique to that particular investigation. Therefore, a number of theories and concepts central to the understanding of agricultural P3s are repeated and refined in each article.

Including the introduction, there are a total of seven chapters to this dissertation. The second chapter discusses the genesis of the contemporary conceptualization and theorizing of P3s and the multiple factors underscoring the growth of agricultural P3s. This framework is used to develop the lineage of agricultural R&D P3s. Chapters three to six contain the four individual articles, and chapter seven discusses the findings, implication, possible extensions and limitations of this research.

### **1.5 Contribution to Knowledge**

This summarizes the discussion in chapter 7. Agricultural R&D is being transformed from a vertical process characterized by a public-private dichotomy to a horizontal process characterized by collaboration. Agricultural P3s are a new business model that due to its collaborative structure centres R&D networks by performing the role of gatekeepers by controlling the flow of ideas, people, money and technologies. As this dissertation demonstrates, agricultural P3s are critical to the generation and commercialization of technologies needed to enhance global food security. P3s originally emerged to replace public R&D spending lost to austerity but have since evolved into highly-specialized business models that accelerate the R&D process by linking dissimilar organizations and institutions into functioning innovation networks.

Agricultural P3s integrate science and business by linking R&D expenditures generated by self-organizing producer organizations with the requirements of the market.

P3s appear best suited for operating in orphan crops and other spaces that are not serviced by the public or private sectors for a variety of reasons. As this investigation demonstrates, agricultural P3s emerged to fill gaps in the financing, generation and commercialization of R&D that have been created due to a number of factors including public austerity measures, the growth of intellectual property rights in agriculture and the inability of the public and private sectors to respond to the growing challenge of global food security. Due to the collaborative structure of these emerging business models, there is no single model in operation. Their structure is dependent on the purpose of the P3—technology transfer, financing of R&D, creation of R&D networks or value chains, or the creation of a new agricultural sector. Interestingly, the agricultural P3s analyzed in this investigation are not the result of policies, but rather are the result of well-connected insiders—boundary pushers and social entrepreneurs—responding to challenges related to food security and agricultural R&D by generating hybrid responses in the form of P3s. There is evidence that many agricultural P3s depend on the activities of P3 specialists to provide the initiative, leadership and management capability, and there is a limited number available particularly in the developing world.

Agricultural P3s are expensive, have high transaction costs, require large upfront investments in people and technologies. Therefore, they have long gestation periods as the R&D cycle, particularly in the plant sciences, can be as long as 15 years. This means that these P3s are dependent upon public support until they can commercialize products and services to generate cash flows to sustain their operations. Agricultural P3s can be high-risk ventures due to the long gestation period and their vulnerability to financial disruptions as most public programs and donor organizations work on shorter time horizons. Agricultural P3s are heavily contextualized organizations that are characterized by their partners, objectives and the specific product or service. This means that each model is unique, which limits the ability to draw explicit lessons for other agricultural P3s to emulate.

This investigation introduced two methodologies to advance the analysis of agricultural P3s. Social network analysis (SNA) is a tool that graphically and statistically measures and evaluates P3s in a networked and horizontal process by providing a quantitative and hypothesis-based



methodology that can identify, categorize and measure relationships, organizations and flows of ideas, technologies and resources that previously alluded researchers that govern the R&D process. This is important as agricultural P3s are a critical part of an emerging global complex of organizations that increasingly depend on collaboration to generate R&D solutions to global food security. Additionally, this investigation developed a bibliometric model to identify how collaboration can increase the returns from agricultural R&D.

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## CHAPTER TWO THE ORIGINS OF AGRICULTURAL P3S

### **2.1 Intellectual and Theoretical Origins of P3s**

The origins of P3s can be traced back to the advent of new public management (NPM) and neo-liberalism, two interrelated theories that encompass the state, citizen and economy. Neo-liberalism and NPM are ideologies that seek to privatize the functions of the state and, where possible, dismantle government bureaucracy (Evans and Shields, 2000: 2). A number of factors have influenced the development and acceptance of neo-liberalism as a public philosophy. Ideologically, its intellectual roots are in classical liberalism, with its focus on the individual's utilization of the marketplace to secure all goods necessary for survival. Economically, government fiscal cutbacks and program downloading, which began in the 1970s, have helped legitimize neo-liberalism (Hall and Reed, 1998: 2). Publicly, the image of government bureaucracy has become one of anachronism, arrogance and bloat. Globally, increased trade competition and the post-Cold War drive towards democratization have combined to render the state bureaucracy a less inefficient provider of many services. Neo-liberalism and NPM seek to apply private-sector management techniques and objectives to government. These techniques include the use of technology to reduce labour and increase productivity (Boase, 2000: 76–77).

The NPM philosophy of privatization challenges tenets of the welfare state of Keynesian economics. The welfare state provided public goods and merged the political and economic interests of the individual with a new concept of citizenship that involved explicit guarantee of the social welfare of the individual (Sears, 1999: 92–93). Furthermore, the Keynesian state regulated and managed the private sector and the labour market. Neo-liberalism and NPM changed the citizen into a consumer, responsible for securing his or her own social welfare by procuring goods and services in a competitive marketplace. Government has become a manager and procurer of goods and services in place of being a supplier of goods and services. In place of a direct relationship with the citizen, government increasingly uses financial incentives and collaboration with the private sector to provide goods and services to consumers (Milward and Provan, 2000: 15). This ongoing process is also known as Alternative Service Delivery (ASD).

The UK Conservative government of Margaret Thatcher introduced the NPM-motivated Private Finance Initiative (PFI) legislation in the late 1970s and early 1980s as one centerpiece of its privatization process. PFI introduced competitive bidding to help facilitate the privatization of the delivery of public goods. The ultimate objective of the Conservative government through PFI was the wholesale privatization of public goods delivery, which in its first instance included the transfer of ownership of public facilities such as hospitals, roads and schools (Falconer and McLaughlin, 2000: 1). This process provided the intellectual and policy foundation for growth of the use of P3s. It was emulated in the US with the Reagan administration, in Canada with the Mulroney government and in Australia under the Howard government.

Despite the NPM emphasis on privatization, in the literature P3s do not exclusively focus on the privatization of the provision of public goods such as infrastructure, but rather are considered to be primarily concerned with addressing the need for multi-sectoral collaborative management, financing and governance to provide services that once were the exclusive domain of the public sector. The combined effects of ideology, austerity and globalization have obfuscated the boundaries between the public and private sectors and in many fields have rendered governments dependent upon partnerships with the private sector to provide critical infrastructure and services. Under NPM, P3s increase the productive and management capabilities of governments faced with reduced bureaucracies and budgets by using the private sector to fund projects. In turn, the private sector relies upon user fees to generate cash flows in order to provide a return on its investments (Engels et al., 2007: 2, 37). Therefore, P3s are best understood as public-private collaborative business models that allocate the risk and return between partners in an equitable process. They combine the efficiency of the private sector with the public interest as defined by government. At its core, the NPM P3 represents a collaborative relationship regulated by binding contracts, emulating a principle-agent relationship characterized by the need to support greater efficiency in the provision of infrastructure projects such as roads, schools and hospitals (Velotti et al., 2012: 2).

A true P3 involves the equitable sharing of risk, reward, accountability and authority (Torjman 1998: 3). However, in practice, due to the statutory requirement for governmental accountability over the use of public funds and property, most P3s involve public-private collaboration with

varying degrees of the sharing of risk and reward (Allen, 1999: 7). The private sector can also receive an implicit government revenue guarantee for specific projects. However, regardless of the outcome, the government is responsible for public activities and can be liable for costs in the case of bankruptcy or failure on the part of the P3, including assuming the operational responsibility for an incomplete infrastructure project.

As discussed in the previous chapter, the literature review reveals the absence of a unifying theory that characterizes the growing field of P3 study. This contributes to the absence of a unified working typology of P3s. Instead, there is a wide range of descriptions and characterizations of P3s, making it difficult to categorize them for analysis, as each P3 is application- and context-specific. However, there are a number of methods of categorizing P3s. From a general perspective, P3s can be viewed on a continuum based on the amount of risk transferred from the government to the partner or partnership, ranging from minimal risk transfer executed through a contract to a complete risk-transfer process through a build-buy-operate agreement (Allen, 1999: 17). A second perspective may categorize P3s by their management style, according to three types: designed for network management; process management; or project management (Klijin and Teisman, 2000: 11–13). A third approach would be to categorize the P3 by the amount of authority the government has transferred to the partnership (Kernaghan, 1993: 61–65). Finally, P3s can be categorized by their structure; some are quite formal while others operate more informally.

The measurement of P3s—as with the overall study of P3s—is an underdeveloped field, due to the imprecise nature of these evolving management models and questions’ surrounding what constitutes performance. This leads to ambiguity about how to measure performance (Grossman, 2012: 4). Theory suggests a separate examination for each of the outcome, process and input levels of analysis of the partnership. At the outcome level of analysis, a cost/benefit and/or a value-for-money evaluation, using an NPV or IRR analysis, can provide one measure of performance. This method assumes performance can be effectively computed in terms of return on investments and that all inputs can be monetized. It largely overlooks the differences between private-sector measurements and public-sector standards, such as social outcomes (Grossman, 2012: 4). At the process level of analysis, the “causal chain of evaluation” provides a model that

compares expectations to the performance and outcomes of the partnership through interviews, observations and surveys (Brinkerhoff, 2002: 5–8). P3s can also be evaluated according to the amount of monetary, human and technological assets the P3s acquired (Murray, 2000: 5).

## **2.2 The Theory of Goods and the Institutional Structure of P3s**

The theory of goods employs the concepts of excludability and subtractability to develop a continuum of goods from private to public to common pool goods. Institutional economics uses the notions of exit, voice and hierarchy to develop a range of institutional structures for the delivery of goods to the individual. Positive agency theory is concerned with the measurement costs of managing the principal-agent problem, the asymmetry of information between the principle and agent expressed as nonseparability and task programmability. The theory of goods is constructed from two characteristics of all goods: excludability and subtractability (sometimes called rivalry). Excludability refers to the capability of a seller to prevent the distribution of a product or service unless the buyer meets the terms set forth by the seller (Savas, 2000: 41). Automobiles and clothing are two products that are easily excludable. Excludability is a fundamental requirement for private-sector transactions. Subtractability is whether the consumption of a product or service by one individual precludes its consumption by another individual (Ostrom, 1975: 847). National defense is an example of a nonsubtractable product. The marginal cost of a nonsubtractable product is zero; this is a pure public good, distributed by government where all citizens have equal access or use of the product or service (Ostrom, 1975: 847). Conversely, a pure private good is one where both excludability and subtractability are in evidence; again automobiles and clothing are two such goods. Common-pool goods are those that exhibit varying degrees of excludability and subtractability (discussed further below).

Complementing the theory of goods is the contribution of Albert O. Hirschman, who in 1970 articulated the theory of the “trilogy of institutional economics” consisting of exit, voice and loyalty. Exit is market mechanism that posits when a consumer experiences dissatisfaction with a particular product or service he/she either terminates their use of that particular good or seeks out a competing vendor to satisfy their demand for the good (Hirshman, 1970: 15–16). Hirschman writes that the exit mechanism is a component of Adam Smith’s “hidden hand”. Voice belongs to the political spectrum. Voice is a “recuperative mechanism” where a revision of the

circumstances of dissatisfaction with a product or service is sought in place of the exit strategy (Hirschman, 1970: 30–31). Voice, whether individual or collective, seeks to mobilize opinion to facilitate change. Loyalty, closely related to voice, is an emotional or utilitarian bond to a particular organization ranging from a business to a nation-state (Hirschman, 1970: 76–79). Hirschman writes the significance of loyalty is that it can, under the correct institutional arrangements, neutralize exit and give significance to voice. Therefore, voice is critical to organizational stability by preventing dissatisfaction from removing its constituent members (Hirschman, 1970: 79). Due to its ability to prevent exit behaviour, loyalty induces hierarchy, often associated with vertical organizations in business and government.

Combining Hirschman’s trilogy with excludability and subtractability provides a continuum of goods from private to public to common-pool. Together the institutional parameters of voice, exit and hierarchy (loyalty) and excludability and subtractability define the range of goods and the multiplicity of mixed goods that defy explicit characterization. Private goods can now be defined as those in which excludability, subtractability and limited voice are in evidence. Public goods are those products and services that possess low excludability and low subtractability with the need for hierarchy. Common-pool goods are those which exhibit varying degrees of both excludability and subtractability but require high voice from the participatory sector. Robert Picciotti has developed the following diagram that depicts the combination of goods and the institutional parameters required for their delivery.

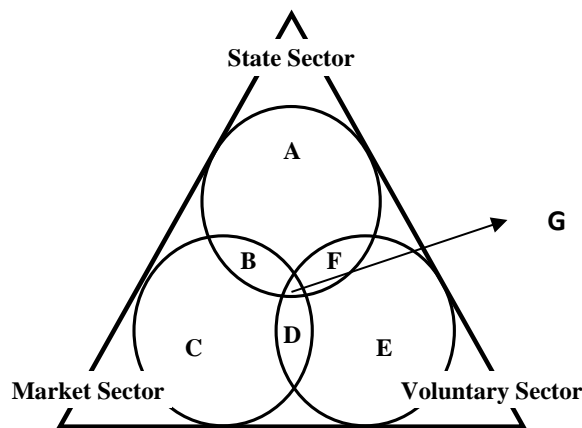


Figure 2.1 Picciotto Model



Using Picciotto’s (1995: 16) diagram as a reference we can now illuminate the institutional structure of goods. (A) represents pure public goods supplied by government in which excludability and subtractability are low and hierarchy is a prerequisite for provision, public goods include law enforcement, national defense and education. (D) highlights market governed private transactions in which excludability, subtractability and exit are present and hierarchy and voice are minimized. (F) indicates common-pool goods where voice is the critical characteristic and where excludability and subtractability vary depending upon the specific product or service. (B), (C), (E) and (G) represent institutions that operate between and within the overlapping dominant parameters of the public, market and voluntary sectors (P3s and hybrid organizations and NGOs respectively), all exhibiting different levels of voice, exit or loyalty characteristics.

The institutional structure can be framed by the theory of “fiscal equivalence” (Olson, 1969: 5), where the fiscal boundaries of the funder of a public good should correspond to the physical boundaries of the consumer of a public good. The institutional structure can be further framed by the “principle of subsidiarity”, where the lowest level of government in contact with a particular public process should be the level of government that governs that process (Paquet, 1994: 190–194).

**Table 2.1.** Typology by Good and Attribute

<b>Institution</b>	<b>Excludability</b>	<b>Subtractability</b>	<b>Voice</b>
Public goods supplied by government	Low	Low	Low
Market goods supplied by the private sector	High	High	Low
Collective goods supplied by voluntary associations (P3s and hybrid organizations and NGOs)	Low	Low to high	High

### **2.3 Intellectual and Policy Origins of Agricultural P3s**

There are five factors influencing the rise of the use of P3s in agricultural R&D systems. First, from an historical perspective, the public sector was once the primary funder of agricultural R&D in the developed world. However, beginning in the 1980s, for a wide variety of reasons,

public R&D spending has been on a steady decline. From 1945 to the mid-1970s in the OECD, the public sector was the primary financier of agricultural R&D and public funding thereof expanded on a yearly basis (Alston et al., 1998: 5–9). But beginning in the late 1970s and continuing to the present day, the public-sector share of agricultural R&D and level of R&D spending has declined precipitously (Beintema et al., 2012: 4–5). This deceleration of public spending is currently occurring on a global basis in both the developed and developing world. To compound matters, with the exception of a small number of large-acreage crops such as corn and soy, private-sector investment has not been expanding to compensate, creating an institutional void. Thus, in a number of sectors, nationally and globally, P3s have developed as a response to the funding and leadership vacuum.

Second, in the OECD, beginning with the policies in the UK under Thatcher, many public-sector institutions have been privatized. The UK Plant Breeding Institute (PBI) was privatized in 1987 as part of a public rescaling process that occurred throughout the UK, leading to a complete divestiture of public assets and personnel in agricultural R&D. This contributed to the large gap—known as the “valley of death” (Phillips et al., 2013: 104)—between the public and private sectors, which inhibits the development of pre-commercial technologies needed to develop market-ready technologies and varieties. This privatization process has been mirrored to varying degrees across the OECD, creating gaps in both the funding and provision of R&D. In Australia, a large number of public plant-breeding programs have been either privatized or turned into P3s (Linder, 2004: 3–4). In Canada, a number of crop (e.g. canola and specialty fruit) and animal R&D programs were privatized or became fee-for-service operations, creating a number of agricultural P3s. Due to reductions in spending, many public programs in the US, Canada and Australia were forced to seek private funding or to create elaborate collaborative research agreements in order to continue operations.

Third, the expanded intellectual property rights (IPR) regime at both the global and national levels of analysis has worked to commercialize many of the formerly ad-hoc relationships between producers and public agencies. The International Union for the Protection of New Varieties of Plants (UPOV) convention was first signed in 1961 and subsequently revised in 1971, 1991 and of particular importance is a 1991 revision to the Act which required all

signatories to implement national plant breeders' rights systems for new plant varieties developed for commercial purposes. Specifically, UPOV 1991 requires members to develop a national plant variety registration system that assigned IPRs to each distinct variety. The objective of UPOV was to commercialize plant breeding in order to help finance continual improvements by creating revenues that might support technological development and innovation. As will be discussed below, UPOV 1991 spawned a number of P3s in Canada and Australia, as users were forced to start paying for the use of newly registered varieties that historically were supplied free of charge by public agencies.

Fourth, a number of developments related to the growth of new technologies have commercialized the development of new agricultural technologies. During the 1980s in the US, in response to perceptions of American economic decline, the federal government passed numerous pieces of legislation to enhance America's competitive position. The Bayh-Dole Act of 1980 permitted universities to patent and license for profit any discoveries that occurred with federal funding (Kloppenborg, 2004: 330). This Act was designed to facilitate the commercialization of technologies from universities and assist in the financing of future research. The Stevenson-Wydler Technology Innovation Act of 1980 and the Federal Technology Transfer Act of 1986 were designed to permit the merging of private interests with research from federal laboratories such as the United States Department of Agriculture. The commercialization of agricultural R&D in the US is particularly relevant, as these policy changes coincided with the development of biotechnology.

Fifth, the growth and expansion of biotechnology in conjunction with the introduction of IPRs and the ongoing privatization of agricultural R&D has resulted in a paradigm shift in the industrial organization of agriculture. The biotechnology revolution, sometimes known as the genomics revolution, has permitted researchers to identify and transfer genes between living organisms such as plants, animals and microbes to increase yields and to withstand abiotic and biotic stresses. Furthermore, the advent of biotechnology occurred simultaneously with the development of IPRs in the United States, which has contributed to the commercialization of the plant breeding process. New breeding tools and processes were developed and commercialized over the intervening period. The patenting of recombinant DNA in 1973 and the patenting of

key biotechnology breeding discoveries in the 1980s began the virtual land-grab. By 2000, most of the genetic sequences identified in the human genome and key commercialized genomes were encoded and claimed in patent filings in the US and elsewhere. This “balkanization” of the breeding tools and genetic materials has precipitated “freedom to operate” (FTO) problems, as no single enterprise or lab had authority to use the appropriate research tools in a way that would facilitate fully licensed commercialization. A review of plant breeding patents issued in the United States from 1981-2001 indicates the significance of this process. Public institutions in this era generated 24% of the key patents, but no single institute possessed more than 2% of the patents (Graff et al., 2003: 2-3). The private sector possessed 75% of the key breeding patents, with the five largest integrated agri-biotech firms holding 41% of the relevant patents (Graff et al., 2003: 2-3), thus limiting the ability of the public sector and producer organizations to conduct R&D without securing access to privately held IPRs, and thereby inhibiting technological innovation (Galushko et al., 2010: 1–2).

#### **2.4 A Lineage of Agricultural P3s**

It is difficult to precisely determine when and where the use of P3s in agriculture began, as collaboration has always been the hallmark of agricultural R&D. However, the use of formal partnerships using the above framework can be traced back to the 1970s and 80s. Internationally, the Consultative Group on International Agricultural Research (CGIAR) began operations in 1971, linking privately held technologies from the developed world with developing-world food security needs. This led to the creation of sixteen individual research centers, each devoted to a specific crop species or research topic. Each center includes a wide and permanent array of partners, ranging from government agencies to private philanthropic donors, private MNCs, international IGOs and NGOs, and developing-world farmer organizations (Binenbaum et al., 2001: 1–2). As will be discussed in chapter three, the CGIAR individual research centers, which usually have different partners from each other, have developed into hubs of international agricultural R&D and the global gatekeepers between the developed and developing worlds for technologies and new germplasm. Specifically, while the developed world possesses the bulk of the advanced agricultural technologies critical to global food security, the developing world is home to the majority of the land-race species that contain the genetic material required to support

technological innovation. Chapter five discusses developing-world agricultural R&D P3s in detail.

In Canada, the first agricultural P3s can be traced to the nascent canola industry of the 1970s, when industry associations began funding R&D in order to transform ordinary rapeseed into canola (Phillips, 2007: 36–37). The introduction of IPRs, beginning in the 1980s, led to the privatization of varietal development in the Canadian canola sector, while simultaneously creating a new space between the public and private sectors occupied by producer organizations and industry associations. These groups provided funding for R&D and new technologies to bridge the funding and R&D gaps that had developed. Since then the P3 model has emerged in most of the commodity areas and a range of international P3s have become important partners or competitors to Canada. This thesis examines a few of them.

In Canada, SaskCanola, a 26,000-strong producer partnership, has developed its own R&D system as a means of compensating for deficiencies in both the public and private supply of R&D. SaskCanola provides stewardship over a \$15 billion sector. It also provides a mechanism for producers to direct R&D to their benefit. This partnership initiated a process that continues to the present day and is discussed in chapter four, in which the role of P3s in facilitating technology transfer is explored.

In the Canadian swine sector, public austerity programs and the development of new technologies laid the groundwork for the creation of a producer-funded P3 between the Fédération des producteurs de porcs du Québec (FPPQ)—the Quebec swine producers' association—and the government of Quebec in 1992. The objective of the Centre de développement du porc du Québec (CDPQ) was to create an organization for recruiting and training highly specialized personnel to capitalize on the genomics revolution by supplying new technologies in order to remain competitive in a globalized industry. The CDPQ began operations with the transfer of public assets and employees and with public funds as the sole source of revenue. Currently, the CDPQ receives 75% of its funding from value-added services and a producer levy. It took fifteen years to develop the internal R&D expertise to generate the

value-added income. The CDPQ employs 50 people and conducts its research internally. The CDPQ is examined in chapter six.

The introduction of the UPOV-mandated plant breeders' rights led to the creation of the Okanagan Plant Improvement Company (PICO) in 1992, a P3 between a specialty fruit growers' association and an existing publicly funded agricultural R&D center. This P3 formalized and commercialized an existing relationship and transferred the financial responsibility for R&D from the public sector to the producers. PICO depends on royalties from PBRs to support its operations. PICO is the sole supplier of new technologies and varieties to its industry and links its producers into global flows of technologies. PICO employs seven people and contracts out all of its R&D needs. In 2009, the Government of Canada awarded PICO the Federal Partners in Technology Transfer (FPTT) award for Excellence in Technology Transfer. PICO is examined in chapter six.

In 1984, the Saskatchewan Pulse Growers (SPG), a producer association, voted to implement a non-refundable crop levy to support R&D. In 1997, due to public cutbacks, the SPG entered into an exclusive R&D P3 with the University of Saskatchewan's Crop Development Centre in order to replace public funding. This P3 ensures that the SPG receives exclusive, royalty-free access to new varieties of pulses. The SPG has 18,000 members who in aggregate contributed an average in 2010-13 of \$11 million annually to R&D to support an export industry worth \$1.8 billion annually. Over the past five years, the SPG has used its levy to leverage an additional \$34 million of R&D. The SPG employs fourteen people and contracts out its R&D. The role of the SPG in the global pulse R&D system is examined in detail in chapter three while the structure and function of the SPG is examined in some detail in chapters three and six.

In Australia, the Grains Research and Development Corporation (GRDC) was formed by the federal government in 1990 as the centerpiece of a national consolidation of various publicly funded state-level and university-based plant breeding programs into a national P3 with a number of national and state producer groups. Austerity measures in combination with the introduction of IPRs created the need for new collaborative funding mechanisms. Additional impetus for the GRDC came from Monsanto, which had commercialized Bt cotton in both the

US and Australia, and through its monopoly position began charging a technology fee to Australian producers that was two times the rate charged to American producers (Lindner, 2004: 6). Australian producers and regulators viewed the monopoly power of international life-sciences competitors such as Monsanto as a threat to the viability of the Australian grains industry. The GRDC is a unique P3 in that it is not a commodity-specific partnership; rather, it is an industry-wide P3, supporting all commodities. Furthermore, the GRDC is arguably the largest P3 when measured by R&D expenditures, as its 2012 R&D expenditure was AU\$121 million. Producer levies and IPR royalties constitute AU\$89 million in revenues, while the government contributes AU\$43 million (Alston et al., 2012: 42). The role of the GRDC in the pulse R&D sector in Australia is examined in chapter three.

Also in Australia, the federal government developed the Cooperative Research Centers (CRCs) to facilitate cooperative research within the country. Formally launched in 1991, the CRC program was a response to declining R&D investment in Australia. A report noted that R&D as a percentage of GDP had been falling in Australia while rising in the rest of the OECD (Buller and Taylor, 1999). The CRC program spawned a large number of agricultural P3s in Australia's sugar, wheat, pulse and plant bio-security sectors. These include the CRC for Sugar Industry Innovation through Biotechnology (CRCSIIB), the Value Added Wheat CRC (VAWCRC) and the CRC for Molecular Plant Breeding (MRBCRC). One CRC creation, the Center for Legumes in a Mediterranean Area (CLIMA), a pulse crop research center funded by partnership between government, producers and the GRDC, is analyzed in chapter three.

In Great Britain, the Pulse Crop Genetic Improvement Network (PCGIN) is a P3 involving the John Innes Center (JIC), the Processors and Growers' Research Organization (PGRO), the National Institute of Agricultural Botany (NIAB) and numerous private breeders. The PGRO is funded by a voluntary levy on pulse production. This levy supports variety and agronomy R&D. The John Innes Center is an independent research and development institute for plant science and microbiology, dedicated to multi-disciplinary research with a focus on cell biology, biochemistry, plant genetics and molecular biology. The JIC is a part of a joint venture of Sainsbury Laboratory with the government, the Gatsby Charitable Foundation and the University of East Anglia.

## 2.5 Conclusion

Agricultural P3s represent a new paradigm in the management and financing of agricultural R&D. There is no single underlying factor behind their ascent in agriculture; rather, there are a number of interrelated factors responsible for the transformation of agricultural R&D into a range of horizontal governance models. The combined effects of globalization, public austerity, new technology paradigms, new ideologies and evolving IPR/PBR regimes have blurred the boundaries between the public and private spheres of operation and created gaps in the financing and generation of R&D. These factors have collectively engendered collaboration in agricultural R&D. One result of these transformations is the growing role of producer associations in the financing and management of agricultural R&D through the use of P3s. P3s signal the end of the vertically integrated, hierarchal R&D system centered on a public-private dichotomy in a specific country or product line and represent a shift to a new system that is horizontally configured, globalized, and consists of heterogeneous organizations using complementary processes to form networks to sustain and accelerate R&D-based innovation.



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CHAPTER 3  
PUBLIC–PRIVATE PARTNERSHIPS FOR THE MANAGEMENT OF  
NATIONAL, REGIONAL AND INTERNATIONAL INNOVATION SYSTEMS:  
A SOCIAL NETWORK ANALYSIS OF KNOWLEDGE TRANSLATION  
SYSTEMS

**3.1 Introduction**

Innovation is increasingly viewed as a key determinant of economic growth. There are a number of divergent perspectives on innovation. One posits that the private sector, at the firm level, is the primary source of innovation (Arrow, 1962: 616–619; Solow, 1956: 28–30). Another firm-centric view suggests innovation is the result of endogenously developed knowledge occurring at the firm level but impacting at the macroeconomic level (Krugman, 1998: 3–4; Romer, 1990: 2–3). The institutional approach examines the effect of economies of scale and scope on developing systems of innovation at the local, regional or national levels (Nelson, 1988: 317–318; Porter, 1990: 15–17). A more recent institutional perspective suggests that innovation is the result of interactions between university, industry and government actors or organizations at either the micro or macro level. This view posits that universities center knowledge generation and diffusion networks by developing collaborative links between the three sectors and with the market (Etzkowitz and Ranga, 2010: 2, 4). A universal perspective suggests that innovation occurs at the global level and the key to economic growth is developing an institutional framework that connects local capabilities to global knowledge flows, such as patents and intellectual property rights (IPRs), to create a value-added process (Bathelt, 2004: 9; Phillips, 2002: 52–53). One common theme that underscores the recent collaborative-oriented institutional and global perspectives is the need for the utilization of public-private partnership (P3) organizations to forge the links, either globally or institutionally, between various organizations and networks to facilitate the knowledge generation and diffusion process (Bathelt, 2004: 12; Etzkowitz and Ranga, 2010: 5). This original empirical study expands the theory, analysis and policy relevance of the P3 as an institution to manage collaborative research and development (R&D) networks and innovation systems in a globalized environment.

## 3.2 Theory

### 3.2.1 P3s Defined and Contextualized

From a definitional approach, a P3 refers to any collaborative engagement between public, private, and/or voluntary actors or organizations. No one standard model exists for P3s; rather, they should be viewed as a process that allocates risk and reward on an equitable basis among key stakeholders. A true public-private partnership (P3) must involve the sharing of authority, risk, responsibility, accountability and benefit. P3s are not a contracting out of government services, nor are they a privatization of government services as the public sector retains an active role in the management of P3s. There are few true legal joint-liability partnerships as this contradicts the requirement for government accountability regarding the use of public funds (Allan, 2000: 7). Therefore, the majority of P3s involve some form of collaboration between the public and/or private and/or voluntary sectors with varying levels of the sharing of risks and benefits.

There are a number of factors influencing the advent of P3. From an ideological perspective, for the proponents of New Public Management (NPM) the P3 represents both a policy option and an organizational structure to reduce the size and scope of government by transferring delivery of a good or service to the most efficient sector. In this viewpoint the state becomes a network manager and procurer of goods and services at the expense of being a supplier of goods and services. In place of a direct relationship with the citizen, government uses financial incentives and collaboration with the private and voluntary sectors to provide goods and services to consumers (Milward and Provan, 2000: 15). From a fiscal perspective, the development of government austerity programs beginning in 1979 in Great Britain with the election of Margaret Thatcher, in 1981 in the US with the election of Ronald Reagan, and with the subsequent elections of the Mulroney and Howard governments in Canada and Australia, all signaled the end of an era of direct government intervention in the economy. And, from a social-economic perspective, the combined effects of globalization and technological development, especially in telecommunications and computers, have facilitated a “compression of time and space”, which has rendered the bureaucratic and hierarchical-structured state as an ineffective and inefficient method of program management and service delivery (Gilpin, 2001: 8).

### **3.2.2 The Network Society and the Challenge of Governance**

British political scientist Rod Rhodes suggests we are in an era characterized by a transformation away from government, with a hierarchal structured bureaucracy with a centralized decision making process, to governance, a distributed decision making process that operates in a network environment defined by collaboration that is horizontally configured (Rhodes, 1995: 1).

The new governance paradigm is challenging the structure and process of government in four ways. First, individually, new actors, and collectively, new interest groups are demanding to be a part of the governing process. This desire for participation is most evident in the area of science and technology, particularly in genetically engineered food products. The desire by citizens to be a part of the decision-making process accelerates the transfer of regulatory power away from government and to the voluntary/civil sector and the citizen (Pal and Maxwell, 2003: 9). Second, the policy issues generated by science and technology exceed the technical capability of government to manage, giving rise to the need to procure expertise from non-governmental organizations (NGOs). Third, the rise of independent research organizations, foundations and think tanks, further the transfer of regulatory governance to the civil sector while simultaneously providing the knowledge and skills to both government and citizen alike required by the advent of the governance paradigm (Hird, 2005: 4; Lindquist, 2006: 13–16). Fourth, the diminution of government has led to the development of spatial-oriented policy making conducted through shareholder networks (Hajer, 2003: 5–6).

The state is being transformed into a developer of human capital and social capital, with an emphasis of using this capital to develop links between individuals and organizations to facilitate the formation of networks. The objective of governments in this environment is the transfer of state responsibilities to individuals and NGO's through the innovative use of P3s as learning organizations (OECD, 2000: 3–4). Governance in the new institutional environment is focused on problem solving through the exchange of knowledge and resources between the public, private and volunteer sectors (OECD, 2000: 3–4).

### **3.2.3 Collaboration, the New Production of Knowledge and the P3**

P3s merge the expertise of the public, private and voluntary sectors to help solve intractable social or economic problems. In doing so, collaboration between the divergent sectors facilitates innovative and synergistic responses to policy problems that would not otherwise occur.

Collaboration through P3s empowers actors who lack an institutional or political voice, enabling the marginalized to deal with pressing policy problems. Cooperation creates interdependencies between actors and organizations laying the foundation for collaborative governance (Salamon, 2000: 17–18).

One area in which the advent of collaborative governance is evident is in the production of knowledge. Innovation is dependent on turning the recombining of different types of knowledge into new ideas, markets, products or services that meet with market or societal acceptance. The theory and typology of knowledge is expanded in section 4.1. Two unique and separate processes of knowledge production have been identified (Gibbons et al., 1994: 1–3). Mode I knowledge production is described as a linear and institutional process that is dependent on the individual scientist for impetus in a discipline specific environment. Mode I production is characterized by the autonomy of the both research institution and the researcher and by the experimental and theoretical purpose of the intellectual endeavour. Mode II knowledge production occurs within “heterogeneously organized” networks that are problem and solution organized—transient in nature and horizontal in configuration. Mode II can be characterized by the reflexive nature of the investigation; knowledge production is a dialogic process based upon a high level of interaction between researcher and the research topic. The feedback loops generated by the reflexive process lead to the self-governing nature of Mode II knowledge production (Nowotny et al., 2003: 13).

One method for managing collaborative research is the use of the research and development partnership (R&D P3). There is a large body of research on R&D partnerships, for example, pertaining to this research: in agricultural economics and agricultural innovation systems (Binenbaum et al., 2001; Hall, 2006; Hartwich et al., 2007). Despite this body of work, the theory of the R&D P3 remains underdeveloped, at the minimum; three complimentary but unique theories are needed to explain why public and private actors and institutions collaborate

on R&D (Hagedoorn et al., 2000: 3). The first, transaction cost economics, postulates that firms seek the lowest cost of contract enforcement as they operate in an environment defined by uncertainty over intangible assets such as knowledge and by uncertainty over cost of monitoring the performance of the partners, R&D partnerships are defined as a “hybrid form of organization between the market and the hierarchy to facilitate carrying out an activity specifically related to the production and dissemination of technical knowledge” (Hagedoorn et al., 2000: 3). The second, strategic management suggests that firms use partnerships and networks as a means of achieving economies of scale and scope, which are unobtainable in the absence of collaboration (Hagedoorn et al., 2000: 3). Third, industrial organization theory posits that knowledge development is considered to be a public good, as the returns on investment are insufficient to warrant basic research and development by profit-seeking firms. However, for cost sharing and commercialization reasons public and private collaboration is required for the development of basic knowledge (Hagedoorn et al., 2000: 3).

### **3.2.4 Innovation and Knowledge**

Innovation is defined not only through mere ‘invention’ but, rather, through a broader, more significant process of turning new information into knowledge that can produce new goods, services or organizations that possess long-term staying power within society or the economy (Phillips, 2007: 39–40). The process of innovation begins when new information is transformed into one of six types of knowledge. There are two types of codified knowledge, know-why and know-what, two types of non-codified knowledge, know-how and know-who and two types of relational-spatial knowledge, know-where and know-when.

#### **3.2.4.1 Codified knowledge**

Each type of knowledge can be further delineated by their unique characteristics. Know-why knowledge is the product of a formal and collective process that is primarily concerned with articulating the scientific laws of nature. Much of this work takes place in universities and other publicly funded research institutions. From a plant genetic resource (PGR) perspective, each type of knowledge also possesses specific features (Phillips, 2002: 18–19). The disciplines of applied

and theoretical genetics, molecular biology, biochemistry, plant physiology and genomics are in the domain of know-why knowledge (Phillips, 2001: 16). Know-what knowledge concerns facts and systematic details and procedures of both genetic crossing and the selection of desirable plant traits during the breeding process (Phillips, 2001: 16). Know-what knowledge is created in both public and private institutions and with the advent of PBRs and IPRs has become commoditized and integrated into increasingly sophisticated technology transfer processes.

#### **3.2.4.2 Non-Codified knowledge**

Know-how knowledge integrates the properties of know-what and know-why domains in plant breeding to produce new market ready varieties (Phillips, 2001). This process combines the knowledge developed at universities and technical schools and incorporates it with the skills derived from “learning by doing”. This unique combination of skill and knowledge is contained within private or public institutions, is difficult to codify or transfer to other organizations and may be encompassed in closed community or proprietary processes. Know-who knowledge refers to the ability to identify and locate key knowledge practitioners who possess information critical to a given transformation process (Phillips, 2001). This type of knowledge is not codified and is embedded in individuals, institutions, and in networks or clusters engaged in similar research objectives. Due to the development of information and communications technology, knowledge development is no longer confined to institutions but occurs in widely dispersed networks characterized by multiple sites of knowledge development. In this environment know-who knowledge becomes an important component of the plant breeding process. These particular characteristics of knowledge development and management tend to concentrate innovative activity within local, regional, national, economic and functional clusters that facilitate that transfer of information, knowledge and people between communities and organizations of various institutional configurations. These characteristics are evident in research and development clusters such as Silicon Valley, the Boston Route 128 Corridor, North Carolina’s Research Triangle, Western Europe’s BioValley and Saskatoon’s biotechnology community.



### **3.2.4.3 Relational-Spatial Knowledge**

Know-where knowledge and know-when knowledge are becoming increasingly important in a time of globalization. Both terms originate in the analysis of traditional knowledge. Know-where and know-when traditional knowledge pertains to understanding where and when specific naturally occurring plants and animals would bloom or congregate to provide a harvest of food and sustenance related items to tribal cultures. Taken in a modern, globalized context, know-where and know-when refer to an intimate understanding the location and timing of governance related events that are critical to any R&D process. Know-where knowledge posits that innovation and change often are the result of entrepreneurs who are located at the intersections and borders of dissimilar social networks, differentiated institutional structures and independent research disciplines, acting as a conduit for change by facilitating the transfer of ideas between these separate arenas (Campbell, 2004: 74–76). Know-when knowledge suggests innovation is dependent upon knowing when windows of opportunity for change open simultaneously in multiple arenas (state, market and volunteer sectors) presenting the prospect for change (Teisman, 2000: 18).

## **3.3 Methodology**

Social network analysis (SNA) is a research tool that illuminates previously invisible relations between actors and institutions in a networked and centerless environment (Mead, 2001: 3). SNA enables a researcher to identify the relative position, function and power ranking of the individual actors, nodes and sub-networks in a quantifiable and graphical manner. SNA makes it possible to identify knowledge flows and stocks “as well as under- and over-utilized individuals and organizations within a given network” (Ryan, 2008: 41). As economic growth is highly dependent on linking into and manipulating the global flows of knowledge, SNA can identify the spatial coordinates of the institutions that possess the knowledge stocks and determine the direction of the flows of knowledge. SNA can be utilized to deconstruct the institutional activities that are responsible for knowledge development. There are four measures of analysis that are used in this study. One is related to network density; the other three are measures of centrality applied to individual actors.

Density measures the proportion of bilateral ties between actors against the maximum amount of ties possible. The objective is to identify and measure the ratio of interconnections within a given network. Density—which ranges from zero to one—is determined by dividing the number of actual bilateral connections into the maximum number of bilateral connections possible (Knoke and Kuklinski, 1982: 45–46). Equation 3.1 contains the density formula.

$$Density_{Local} = \frac{2L}{N(N-1)} \dots\dots\dots (3.1)$$

Centrality measures the relative importance of an individual actor based upon their location within a social network. Total degree centrality is a ratio of the amount of actual ties divided by the maximum amount of ties, as it determines the level of intra-network connectedness. An actor with a measure of zero is not connected within a network, whereas an actor with a measure of one indicates an actor is connected to every possible actor in the network. A higher total degree centrality implies a higher level of network activity (Mote, 2005: 12). Equation 3.2 contains the total degree centrality formula.

$$TotalDegreeCentrality = \frac{td(x_i)}{2 * (N - 1)} \dots\dots\dots (3.2)$$

Betweenness centrality measures the level of connectedness to actors that are not well connected in a network. Betweenness implies a role as a “gatekeeper” and “intermediary” within a social network conferring a level of independence unavailable to other actors (Freeman, 1979: 10). Betweenness centrality measures how often an individual actor is located on the shortest path between other actors and sub-networks (Freeman, 1979: 10). In other words, actors with a high degree of betweenness exhibit a level of independence as they experience higher flows of information and may also receive new information sooner than other actors. A higher betweenness centrality measure implies a greater level of control over the flow of information (Freeman, 1979: 10). Equation 3.3 contains the betweenness equation, where  $g_{ij}$  represents the number of ties linking  $i$  and  $j$  and  $g_{ij}(p_k)$  is the number of these ties that contain individual  $k$ .

$$\text{Betweenness Centrality} = 2 \sum_i \sum_j \frac{g_{ij}(p_k)}{\frac{g_{ij}}{n^2 - 3n + 2}} \dots\dots\dots (3.3)$$

The eigenvector measure is an indicator of power within a social network. Eigenvector measures the centrality of the individual actor along with the centrality of that particular actor’s connections (Bonacich, 1972: 2). A high eigenvector rating implies relative power in a network is derived from the relative importance of an actor’s connections, not the quantity of connections. Actors with a high eigenvector measure are regarded as powerful and influential actors within a social network (Borgatti and Evert, 1997: 297). An actor with a higher eigenvector ranking suggests greater diversity in sources of information (Borgatti and Evert, 1997: 297). Equation 3.4 contains the eigenvector formula.  $\lambda$  is the largest eigenvector value of A, n is the number of vertices;  $a_{ij} = 1$  if vertices  $i$  and  $j$  are connected and  $a_{ij} = 0$  if they are not connected (Bonacich, 2007: 2).

$$\text{Eigenvector Centrality} = Ax = \lambda x, \quad \lambda x_i = \sum_{j=1}^n a_{ij} x_j, \quad i = 1, \dots, n \dots\dots\dots (3.4)$$

**Table 3.1.** Typology of Centrality Measures

Measure	Descriptor	Meaning
Total Degree Centrality (TDC)	Intra-network connectivity	An actor or principal with higher TDC is identified as a “hub” or “connector” within the network
Betweenness-Centrality (BC)	Influence	An actor or principal with high BC is identified as a “broker” or “bridge” and can connect or disconnect groups within the network
Centrality Eigenvector (CE)	Power	An actor or principal with higher CE has multiple connections with others with multiple connections

*Adapted from Ryan (2008)*

### **3.4 Research Focus: Global Pulse Breeding System**

#### **3.4.1 Pulse Breeding R&D**

The process of plant breeding in general, and pulse breeding in particular, has been permanently altered by three ongoing and interrelated revolutions. First, plant breeding has evolved from a hands-on and observational supply push process, generally conducted by public agencies, to a globalized and technologically driven demand pull and scientific process taking place in local, national and regional networks. This process is similar to the contrasts between Mode I and Mode II knowledge production. Second, the introduction of national and international IPR regimes governing plant breeding has privatized of most aspects related to plant breeding in the developed world and has facilitated access and benefit conflicts regarding the acquisition and use of technology in the developing world where IPRs are not in use. Third, due to fiscal concerns, the funding of plant breeding has also been privatized, forcing research centers, industry groups and producer organizations into new funding and R&D relationships (Alston and Pardey, 1998: 241; Alston et al., 1998: 19–20; Brennan and Mullen, 2002: 54–55). The ongoing series of revolutions within plant breeding has created the “orphan” crop--neglected by both public and private sectors due to acreage or profitability issues. Orphan crops exist in an institutional vacuum, where neither the public nor private sectors are capable of supplying goods. Pulses are an orphan crop. Despite this, pulse crops are a vibrant and expanding export industry for Canada, the US and Australia, representing a highly competitive multi-billion dollar global sector. The global pulse breeding R&D system provides the scientific foundation for the global production system that exceeds US\$20 billion in exports (Authors’ Calculations, 2012; FAOStat.org).

#### **3.4.2 Composition of Global Pulse R&D System**

The global pulse breeding system of 248 actors is comprised of 45 P3s, 107 government research centers, 83 universities and 13 private sector actors. The global system is constructed on three autonomous regional systems. The Export System, which is Canada, the US and Australia, consists of 17 P3s, 26 government agencies and 22 universities for a total of 65 actors. The Export System is devoted to the production of exportable pulse crops with little internal consumption of pulse crops. The European Union (EU) System has 27 P3s, 40 government agencies, 55 universities and 12 private firms involved in pulse breeding R&D. The EU System

is a producer, consumer and minor exporter of pulses. The Developing World System is constructed of 10 P3s, 41 government research centers, 17 universities and one private firm. The Developing World System is a producer, primary global consumer and an importer/exporter of pulse crops. See Table 3.2, below. Please refer to Appendix A for a complete listing of actor name, institutional configuration, location and network affiliation.

**Table 3.2** Production and exports of pulses, 2003–07, million tonnes

	Production		Exports	
	Volume	% total	Volume	% total
Export System	7,604	12%	4,292	45%
EU System	7,241	12%	1,640	17%
Developing World System	45,046	76%	3,570	38%
World Total	59,892	100%	9,503	100%

*Source: FAOStat.org and Authors' Calculations*

### 3.5 Data and Analysis

The objective of this study is to identify, locate and categorize all P3s related to pulse breeding R&D and assess how they interact with all the other organizations. Two methods were employed in this search. First, an Internet search was conducted starting with known public pulse breeding institutions to search for pulse P3s. All publically available information such as annual reports was analyzed. This was augmented with emails, phone calls and interviews. The relationships identified between actors and institutions are formal, contractual, research or financially based. The second method was a key word search through the ISI Web of Knowledge database to identify research and financial relationships between pulse breeders, funding agencies and P3s. The search was conducted using the following keywords, pulse crops, legumes, dry peas, chickpeas, lentils, faba beans, dry beans and lupins. One caveat is in order: in ambiguous circumstances where it was not possible to determine if the R&D related activities were pulse related or not, the actor or relationship in question was not included in this study. Therefore, some relationships, primarily financial, may have been excluded.

Individual actors are mapped and ranked in the analysis according to how many standard deviations their centrality measures are above the overall population mean in each of the sub-

systems and the global network. Therefore, only institutions with a centrality measure of one standard deviation or more above mean are considered central actors. These actors are ranked in Tables 3.4, 3.6, 3.8 and 3.10 by the number of stars in the context column, with each one representing one standard deviation.

One item warrants review. In the aggregate, there are a total of 269 individual organizations in the three regional networks, but only 248 in the global system, indicating 21 organizations appear in more than one of the three networks. Therefore, a discussion on the parameters utilized to determine the boundaries of the three regional networks is in order. The process of boundary determination in a network analysis is part science—using objective standards to define borders—and part subjective assessment—reliant upon the researcher’s judgment to create borders that can withstand scrutiny by other researchers (Knoke and Kuklinski, 1982: 22–23). At its core, social network analysis depends on “snowballing”, a process that incorporates both objective and subjective determinants to create functional borders (Knoke and Kuklinski, 1982: 24).

Snowballing begins with following all the linkages with known actors to identify all the relevant participants in a network to the point of exhaustion—running out of unknown actors.

This empirical analysis used four logical methods of determining the network boundaries. The first centered on following the linkages on all the known pulse R&D organizations, ranging from universities, to P3s and government research centers. The second, extending from the first, analyzed the specific function of each network. As discussed below, and in Table 3.2 above, the three regional networks can be easily delineated by their function. The Export Network consists of countries that are the primary global exporters of pulses. The EU Network is a geographic entity that generally imports and produces pulse crops for animal feed. The Developing World network is the largest producer, consumer and importer of pulses for both human and animal consumption. The third method, discussed in Table 3.3, below, relies upon the network density measures. The three regional networks each have higher density measures than the global system. This indicates that the activities related to pulse R&D are regional and intra-network and not global. The fourth method relates to the 21 common organizations. There are 248 unique global actors, with 21 appearing in more than one regional network, approximately 9% of the organizations. Out of the 21 organizations, only one is a significant actor in two regional

networks as determined by having a centrality measure of one or more standard deviations above the mean for its particular network. This organization is ICARDA, a P3 that is a central actor in both the Developing World and Export networks. The unique position of ICARDA is discussed in detail in the separate analyses of each network.

**Table 3.3. The Four Pulse Innovation Networks**

			Number of central actors based on centrality measures one standard deviation or more above the mean		
<i>Network</i>	<i>N</i>	<i>Density</i>	<i>Total Degree Centrality</i>	<i>Betweenness Centrality</i>	<i>Eigenvector Centrality</i>
Export System	66	.108	8	6	5
EU System	134	.040	10	2	10
Developing World	69	.055	3	2	2
Global System (aggregate)	248	.022	9	6	10

### 3.6 Comparative analysis

#### 3.6.1 System Structure and the Critical Role of the P3

The following analysis offers insights into the network composition and institutional configuration of four interconnected but unique operational R&D networks. They range in size from 66 to 248 actors, have varying density (.022 to .108) and a variety of individual key actors. All four networks share a single common feature: the critical role P3s provide to the structural integrity of each network as measured by the centrality rankings. Of the 19 actors with measures one standard deviation or more above the mean of the three measures in the Export System, 13 (68%) are P3s, including the top ranked actor in each of the centrality rankings (see Table 3.4). One hundred percent of the central actors in the Developing System are P3s (9 of 9) (Table 3.8). One P3 is ranked number one in all three categories in the EU System (Table 3.6), but overall, P3s occur much less often as central actors in the EU System (18%). In the Global System (Table 3.10), 20 out of 25 (80%) top ranked actors again, are P3s. As characterized by the three SNA measures, P3s are the top ranked actor in each category in each of the four networks.

In each of the four networks, P3s serve as the focal point for a R&D network. The Export System is distinguished by the prevalence of producer-funded and governed P3s that anchor the national

systems of Canada and Australia and link these systems together to create a regional innovation system. The vulnerability assessment (below) demonstrates that by removing two key P3s a 66-actor system fragments into an isolated Canadian network of 21 actors, an isolated and disconnected US system and a much-reduced Export System centered on Australia. The EU System is characterized by a single intergovernmental P3, GLIP, which connects almost 40 different networks, sub-networks and isolates into a single R&D network of 134 actors. The Developing World System is centered on two key P3s, each centering a unique hub and spoke configured R&D network, which develops into a dual hub and spoke network. See Appendix A for a distribution of institutions in the four networks.

### **3.6.2 The Export System**

This system consists of the major export countries of Canada, the USA and Australia along with the International Center for Agriculture Research in the Dry Areas (ICARDA) and some individual research centers in France, India and South Africa. Institutionally, this system is composed of 17 P3s (26%), 22 universities (33%) and 26 government research centers (41%). There is a discernable absence of private firms. As indicated in Table 3.4, the primary actors are the Crop Development Center/Saskatchewan Pulse Growers (CDC/SPG) partnership, the GRDC-Grains Research and Development Center, the Center for Legumes in a Mediterranean Area (CLIMA) and ICARDA—all four are P3s. As earlier noted, 13 of the 19 centrally ranked actors in this network are P3s. The network density is .108 indicating that around 10% of the total potential linkages are realized.

With one notable exception P3s dominate the three measures of centrality. The CDC/SPG is the top ranked actor according to the total degree and betweenness centrality rankings, suggesting this particular P3 is a highly connected gatekeeper controlling the flow of new information into the network and between sub-networks and isolates. Both measures suggest the CDC/SPG P3 possesses a unique status with regards to independence and influence from and over the entire network. See Table 3.4 below for the three centrality rankings, the P3s are denoted by (P3). The GRDC and CLIMA have noteworthy total degree centrality measures indicating a higher than average level of intra-network activity. Five of the six top ranked eigenvector actors are



Australian, implying the Australian pulse R&D network is uniquely positioned as a power broker within the Export System. (See Figure 3.3 below.)

**Table 3.4.** Export System Actors & Centrality

	<b>Intra-Network Connectivity (TDC)</b>	<b>Power (EC)</b>	<b>Influence (BC)</b>
CDC/SPG (P3)	0.3692***	-	0.4754***
GRDC (P3)	0.3231**	1.000**	0.1353*
CLIMA (P3)	0.2923**	0.9049**	0.1305*
ICARDA (P3)	0.2462*	0.7317*	0.1171*
Pullman-ARS	0.2000*	-	0.2265**
PBA (P3)	0.1846*	0.7482*	-
DAFWA	0.1846*	0.7428*	-
CSIRO	0.1846*	-	-
MSU	-	-	0.1245*

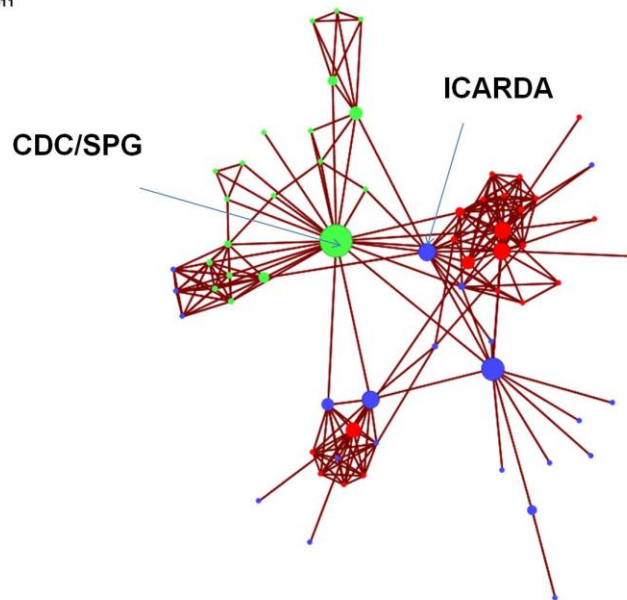
\* number of standard deviations greater than the mean  
Source: Authors' calculations

### 3.6.2.1 Sensitivity analysis

The sensitivity analysis contained in Figures 3.1 and 3.2, below, demonstrates how dependent the Export System is on a small group of actors. The removal of two key actors fragments this regional network into two national systems, one each in Canada and Australia, and a number of isolates. The two critical actors are the CDC/SPG and ICARDA, both P3s. Their removal has an injurious effect on the composition of the network as highlighted in Table 3.5. Despite CDC/SPG and ICARDA representing less than 5% of the individual actors in this network, their deletion causes a reduction in the physical structure of the network ranging from 16% to 97% depending on the function. As discussed earlier, innovation, the driver of economic growth, is derived from linking into the global pipelines and flows of knowledge. If this is the case, then the disintegration of the Export System into two national systems and a number of isolates would inhibit knowledge production. This sensitivity analysis does confirm the results of the social network analysis regarding the key role of the CDC/SPG P3 and of the centralized role of the Australian R&D network. Canada's pulse breeding network becomes isolated from the Export System with the removal of the CDC/SPG P3, while the remainder of the Export System remains centered on the Australian system. The resiliency of the Australian system is noteworthy. As

Figure 3.3 demonstrates, when viewed with the nodes sized based upon the eigenvector measure, the Australian system appears to be so deeply embedded into the Export System that all centrally ranked Australian actors are connected to all the powerful actors in this system. In theory, this confers first mover and first adopter status, or the right of first refusal to do so, to the entire Australian system over ideas and technologies emanating from within or outside of the system. As noted the three top eigenvector actors in this regional system are the three Australian P3s, GRDC, CLIMA and Pulse Breeders Australia (PBA). Interestingly, this phenomenon does not repeat itself in the global system, where none of the three key Australian P3s are in the top five ranked eigenvector actors as indicated in Table 3.4. This suggests that the Australian system depends primarily on relations within the regional system for its R&D and technological needs.

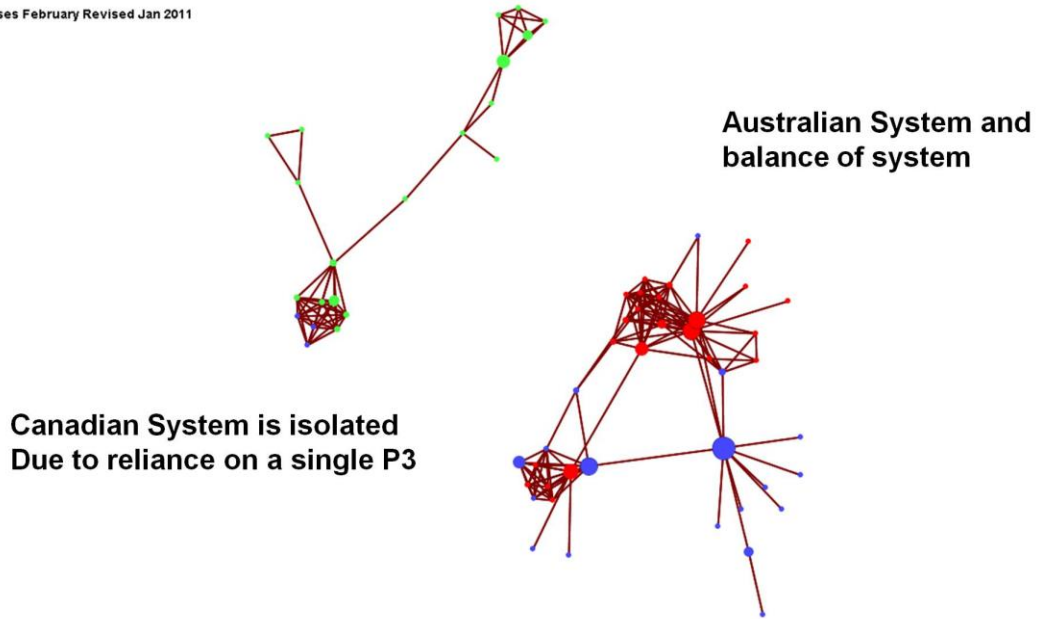
Pulses February Revised Jan 2011



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**Figure 3.1** The Export System

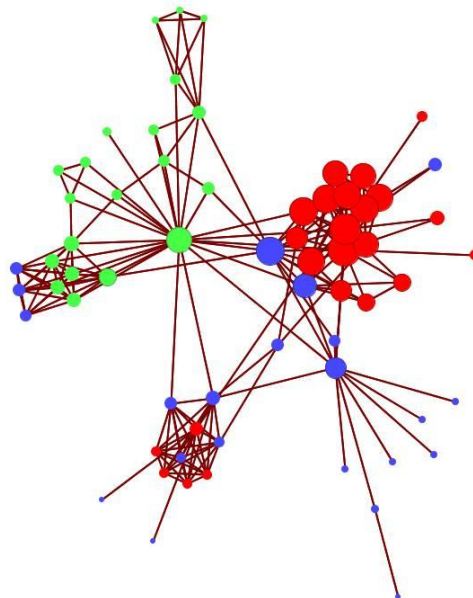
In Figure 3.1, the nodes are sized according to the betweenness measure and the two critical P3s highlighted. The Canadian System is in green, the Australian red and the balance blue.



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**Figure 3.2.** The Export System minus CDC/SPG and ICARDA

In Figure 3.2, the removal of CDC/SPG and ICARDA isolates Canada from Australia and the balance of the system.



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**Figure 3.3** The Export System

In Figure 3.3, the nodes are sized according to the eigenvector measure, visually demonstrating the embedded nature of the Australian system (in red) within the Export System.

**Table 3.5.** An estimate of the vulnerability of the Export System

	<b>With CDC/SPG and ICARDA</b>	<b>Without CDC/SPG and ICARDA</b>	<b>% effect of loss of 2 central actors</b>
# nodes	66	64	-.3.0%
# links	454	370	-17.4%
Density	0.108	0.090	-16.6%
Network centralization	0. 276	0. 202	-26.8%
Betweenness centralization	0. 460	0. 164	-64.4%
Closeness centralization	0. 439	0. 015	-96.5%
Fragmentation (#components)	1	2	+100.0%
Characteristic path length	2.6712	2.6252	-1.72%
Authors' calculations			

### 3.6.2.2. P3s in the export system

With the exception of ICARDA, all centrally ranked P3s are producer formed and governed P3s. ICARDA, from a structural perspective, is critical to the integrity of both the Export System and the Developing World System, but occupies different roles in each of the systems. In the Export System, ICARDA is primarily a supplier of raw, undeveloped technology, in the form of germplasm.<sup>2</sup> All of the centrally ranked actors in this network have germplasm uptake relations with ICARDA, and are also suppliers of advanced breeding technologies and finished varieties to ICARDA, often incorporating the genetic material from ICARDA into the finished technologies.

In Australia, P3s form both the structural foundation for three independent and interconnected pulse R&D systems and link these three systems into a national pulse innovation system. The first national system is formed around the GRDC and PBA, the second is formed around CLIMA and the third around the Center for Innovative Legume Research (CILR), an international R&D consortium headquartered and managed in Australia. Collectively, the result of the innovative use of P3s is a global R&D cluster formed around the Australian national system.

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<sup>2</sup> Germplasm is the living tissue of a plant that contains the plants genetic information.

The GRDC is a partnership between the Government of Australia and the 45,000 producers of Australia represented through the Grains Council of Australia (GCA). The CGA is responsible for about 50% of GRDC's funding through a national levy program. The rationale for the creation of the GRDC came from the international arena. The development of large multinational corporations (MNCs) with their proprietary plant breeding technologies (including enabling and vector technologies) inhibited the ability of Australian plant breeders to compete with international competitors (Lindner, 2004). Australian producers and regulators viewed the monopoly power of international life sciences competitors as a threat to the viability of the Australian grains industry. PBA was formed by the GRDC to perform two specific functions for the Australian pulse sector. First, to prevent intellectual property rights (IPRs) from impeding national technological development and second, to prevent the duplication of R&D efforts related to pulse breeding.

A late 1980s report noted that R&D spending in Australia, as a percentage of GDP, had been falling, while rising in the rest of OECD countries (Buller and Taylor, 1999). The report indicated that R&D spending was 50% higher in other OECD countries as compared to Australia. As a result of this report, the government of Australia created the Collective Research Centers (CRC) program for the purpose of increasing collaborative research between the public and private sectors in Australia. CLIMA was originally established as a pulse breeding CRC in 1992 and has expanded into a producer managed national pulse-breeding center. The Council of Grain Growing Organizations (COGGO) represents producers. CLIMA is an integrated multi-disciplinary research facility built upon four once-separate small breeding programs.

The CILR was created by and is partially funded by the Australian Research Council and consists of CILR, a P3, and seven other partners.<sup>3</sup> The objective is to create cutting edge pre-competitive breeding technology using legumes as a base species for research.<sup>4</sup> Although centered on Australia, CILR is a global R&D enterprise consisting of pulse research centers on four continents, permitting the Australian system to access to global stocks and flows of pulse related technologies.

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<sup>3</sup> The seven partners of CILR are The John Innes Center, KDNARI in Japan, North Carolina State and four Australian universities.

<sup>4</sup> Pulse crops are a part of the legume species.

The origins of the CDC/SPG P3 come from the opening of the Crop Development Centre in the early 1970s to develop a new crop for Saskatchewan producers who were suffering from low prices on wheat and barley. The Saskatchewan Pulse Growers was created in the late 1970s, and in 1983 became permanently involved in the direct financing of R&D with the implementation of legislation and a positive producer vote supporting a non-refundable production levy. Pulse production has increased by 36 fold since 1985 and has made Saskatchewan and Canada the dominant global exporter of pulse crops (SPG and FAO, 2011). Spending reductions by government led to the partnership being formalized in the early 1990s through a number of exclusive R&D agreements. As a part of the R&D agreement, the SPG is the exclusive and royalty free distributor of CDC pulse varieties, providing the SPG with a price and technology advantage (SPG, 2011). The SPG R&D portfolio is approximately CDN \$25 million, with around 80% focused on genetic improvements. The CDC/SPG P3 uses R&D to link producer funded and managed research with consumer focused market outcomes in a globalized economy, as over 90% of Canadian pulse production is exported. The CDC/SPG P3 consists of approximately 18,000 producers.

### **3.6.3 The EU System**

The EU System is the largest of the three sub-systems with 134 actors. There are 27 P3s (20%), 40 government research centers (30%), 55 universities (41%) and 12 private sector actors (9%). This system is characterized by the critical role of a single P3, the Grain Legumes Integrated Project (GLIP), an intergovernmental P3 designed to boost EU pulse crop production. With the exception of GLIP, the EU system is characterized by the near absence of P3s as centrally ranked actors. In this system the predominant institutional type is the government agency. The EU System has the lowest density of the three regional networks with a measure of .040 as noted in Table 3.3.

**Table 3.6.** EU System Actors & Centrality

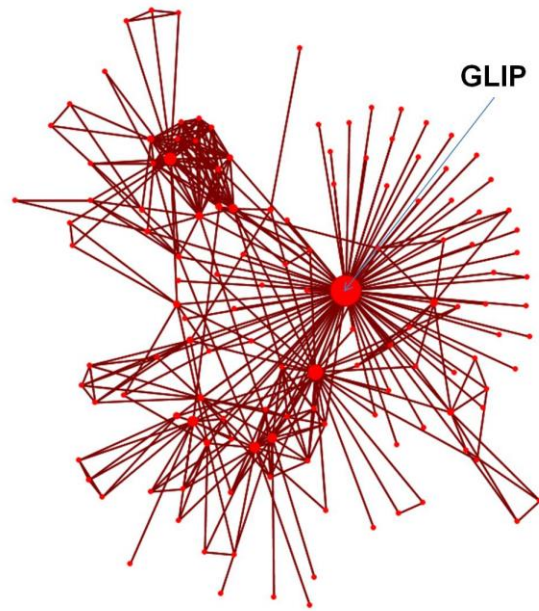
	<b>Intra-Network Connectivity (TDC)</b>	<b>Power (EC)</b>	<b>Influence (BC)</b>
GLIP/FP6 (P3)	0.5789*****	1.000****	0.7112*****
INRA-HQ	0.2331***	-	0.1656**
CSIC	0.1654**	0.8243***	-
John Innes (P3)	0.1579*	-	-
IFAPA	0.1278*	0.7367**	-
GenXPro	0.1203*	0.7669**	-
Rennes INRA	0.1203*	0.8016***	-
CNRS	0.1128*	-	-
Frankfurt U	0.1128*	0.6821**	-
* number of standard deviations greater than the mean Source: Authors' calculations			

As indicated in Table 3.6, based upon the three centrality rankings, there is a single critical actor—GLIP. Interestingly, GLIP and the John Innes Center are the only two P3s that are centrally ranked. Overlooking GenXPro, a private firm, government agencies dominate the three centrality measures. INRA-HQ, INRA-Rennes, CSIC, IFAPA and CNRS are all public sector agencies. The EU System is further delineated by the dearth of influential actors according to the betweenness (BC) measurements. The only two organizations in this network with significant BC rankings are GLIP, and INRA-HQ, implying the existence of numerous relatively isolated and unconnected sub-networks and clusters within this regional system.

### 3.6.3.1 Sensitivity analysis

Figure 3.4 below, depicts the EU System. The sensitivity analysis confirms the central position of GLIP and of the existence of a number of relatively unconnected sub-systems and isolates. Removing GLIP, one out of 134 actors causes this system to fragment into a network of 94 actors and 38 isolates (Figure 3.5).

New Meta-Network

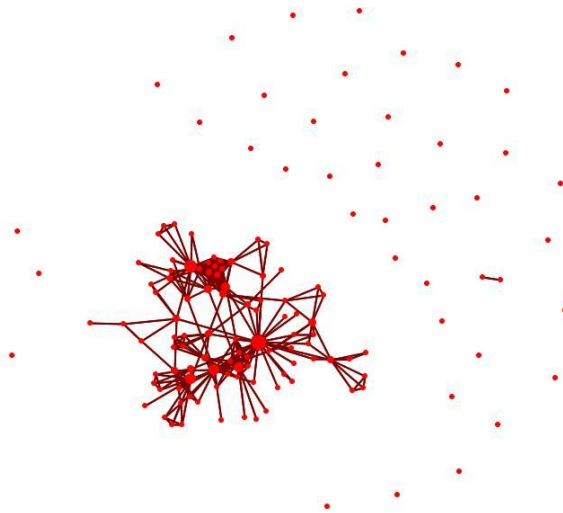


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**Figure 3.4** EU System

In Figure 3.4, the nodes are sized according to the betweenness measure.

New Meta-Network



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**Figure 3.5** EU System less GLIP

In Figure 3.5, the removal of one P3, GLIP, reduces the size of the network by 30%.



The removal of GLIP causes network density and number of links to drop by more than 20%, while the structural coherence of the network, as determined by the three network measures, is reduced by 60% to over 90%. See Table 3.7 below. The placement of a large number of government research agencies in the centrality rankings along with the presence of GLIP, an intergovernmental P3, indicates a large number of relatively unconnected national pulse R&D systems in Europe and the Mediterranean basin. In this particular case, the sensitivity analysis is not an abstract exercise, as the funding for GLIP does not appear to have been renewed after 2008.

**Table 3.7.** An Estimate of the Vulnerability of the EU System

	<b>With GLIP</b>	<b>Without GLIP</b>	<b>% effect of loss of GLIP</b>
# nodes	134	133	-.01%
# links	708	554	-21.8%
Density	0.040	0.031	-22.5%
Network centralization	0.547	0.199	-63.6%
Betweenness centralization	0.705	0.226	-68.0%
Closeness centralization	0.601	0.011	-98.2%
Fragmentation (#components)	1	78	+7700.0%
Characteristic path length	2.576	2.927	+13.6%
Authors' calculations			

### 3.6.3.2 P3s in the EU system

The single P3, GLIP, is an intergovernmental P3 as its primary relations are with and between governmental institutions of various levels and countries in Europe. GLIP was created to pursue a Europe-wide pulse sector development strategy by linking the disparate national R&D programs into a single continental effort. The primary objectives of GLIP were the development of breeding strategies to eliminate regional and national variances in production and yields, to advance the knowledge of using legumes as animal feed, to develop new genetic and post genetic breeding technologies to sustain long-term growth and to transfer the new technologies to the private sector. GLIP was not refunded in 2008 and has ceased operations.

### 3.6.4 The Developing World System

There are a total of 69 actors in the Developing World System consisting of 10 P3s (14%), 41 government agencies (59%), 17 universities (25%) and one private actor (2%). This system is distinguishable by its unique dual hub and spoke configured system, as the Developing World System is created by existence of two developmental-oriented P3s, ICARDA and International Crops Research Institute for the Semi-Arad Tropics (ICRISAT). As noted in Table 3.3 the density of this network is .055, ranking in between the Export and EU Systems.

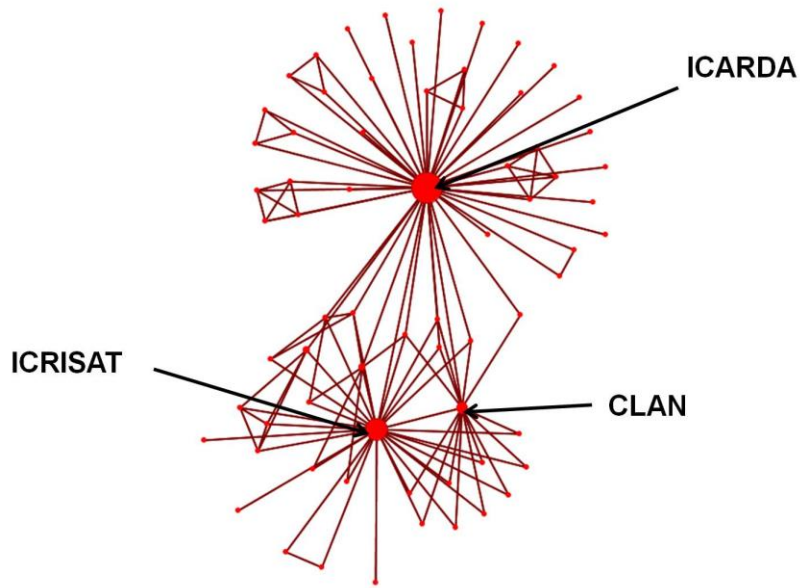
As demonstrated in Table 3.8 and earlier noted P3s are the only institutional type that is a centrally placed actor in this network. ICARDA, ICRISAT and to a lesser degree CLAN, all P3s, are the only centrally ranked actors in this network. Based on all three measures, ICARDA is the most influential actor, being the most intra-connected and most powerful entity. See Figure 3.6 below. Essentially, these two P3s connect the national agriculture research systems of various developing world counties into a regional sub-system.

**Table 3.8.** Developing World System Actors & Centrality

	<b>Intra-Network Connectivity (TDC)</b>	<b>Power (EC)</b>	<b>Influence (BC)</b>
ICARDA (P3)	0.6912*****	1.0000*****	0.7844*****
ICRISAT (P3)	0.4559***	0.7493****	0.3627****
CLAN (P3)	0.2353*	0.4979**	--
* number of standard deviations greater than the mean Source: Authors' calculations			

#### 3.6.4.1 Sensitivity analysis

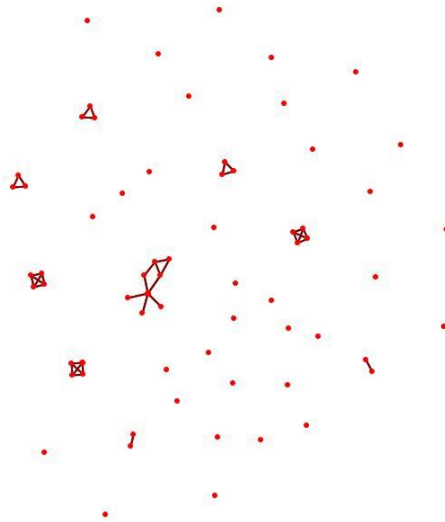
As visually demonstrated in Figure 3.7, the sensitivity analysis substantiates the centrality measurements as the removal of ICARDA, ICRISAT and CLAN causes the network to disintegrate into 33 isolates and nine mini-networks of at least two actors each and a total of 75 components, in place of the one network. Table 3.9 confirms the visual analysis, as network composition is reduced by 67% to 99%, depending on the measurement.



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**Figure 3.6** Developing World System

In Figure 3.6, the nodes are sized according to betweenness measure.



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**Figure 3.7** Developing World System less ICARDA, ICRISAT and CLAN

In Figure 3.7, eliminating the three central ranked actors, all P3s, results in the destruction of the regional network.

**Table 3.9.** An Estimate of the Vulnerability of the Developing World System

	<b>With ICARDA, ICRISAT and CLAN</b>	<b>Without ICARDA, ICRISAT and CLAN</b>	<b>% effect of loss of 3 central actors</b>
# nodes	69	66	-4.3%
# links	258	76	-71.5%
Density	0.055	0.018	-67.3%
Network centralization	0.655	0.061	-90.7%
Betweenness centralization	0.776	0.074	-90.5%
Closeness centralization	0.650	0.003	-99.5%
Fragmentation components)	1	75	+7400.0%
Characteristic path length	2.272	1.439	-54.3%
Authors' calculations			

### 3.6.4.2 P3s in the developing world system

ICARDA and ICRISAT are both a part of the Consultative Group on International Agriculture Research (CGIAR), a non-profit network of governments, charitable foundations, various international organizations and a number of private actors, formed in the early 1970s to use agricultural technology to reduce poverty. CGIAR has matured into large scale technology transfer system constructed upon P3s providing undeveloped germplasm and raw local knowledge to actors in the Export System in return for access to developed IPR assets such as breeding technologies through a multitude of project and process oriented partnerships. Research by the Australian Center for International Agricultural Research determined that raw germplasm acquired from ICARDA contributes to about \$13,000,000 in productivity gains by Australian producers annually (ICARDA, 2004). One specific task for the CGIAR crop oriented centers is the accumulation and preservation of scarce plant genetic resources of the world. In all, CGIAR is responsible for the maintenance of over 650,000 unique germplasm samples of plants and flora. This is critical as none of the major export crops of the world, wheat, maize and soybeans for example, are native to the major exporters of the world. Using pulse crops as an example, lentils are from Turkey, peas and chickpeas are originally from western Asia and dry beans are from Central and South America. The Export System countries of Canada, the US and Australia depend on access to the germplasm stocks of ICARDA and ICRISAT for sources of new, but raw and unprocessed technologies. These dual qualities, the application of collaboratively developed technology to promote economic development in conjunction with the vast repository

of native plant and flora species uniquely position CGIAR centers such as ICARDA as key global actors. An expanded view would suggest that ICARDA and ICRISAT in particular and CGIAR in general, with their stocks of germplasm, repository of codified knowledge and global access to local non-codified knowledge, their capacity-building capabilities along with their policy-development experience, qualifies both as suppliers of international public goods (IPGs) (ICARDA 2009).

Despite the global prominence of ICARDA and ICRISAT, both remain highly dependent on the flow of funds and other resources from donor organizations and countries for their survival. The two depend on five types of supporters. First, national governments, such as the United States, Australia, China, Germany and Canada, among others, or through agencies such as USAID that represent national governments are the primary supporters of both. A second type of donor is International Governmental Organizations (IGOs), such as the UN/FAO and the World Bank. A third mode of support is from philanthropic organizations such as the Gates and Rockefeller Foundations. A fourth means of support is contract research paid for by outside entities ranging from national governments to private sector actors. The fifth type of donor provision is through the exchange of scientists and researchers from donor countries and organizations that contribute hard to quantify hands-on skills, representing a form of non-codified technology transfer. In addition to the use of contributor scientists and researchers, many donors supply board members to both ICARDA and ICRISAT. One area of concern is the level of uncertainty associated with the financing of ICARDA and ICRISAT. Based upon a website review, there is a high degree of variability in the amount provided by each funding agency, and in the total number of funding partners, both on an annual basis. This is compounded by the current large deficits and the accumulation of unsustainable debt levels in the major donor countries of the United States and Great Britain, calling into question the long-term viability of their support.

### **3.6.5 The Global System**

As previously discussed, there are 248 actors in the Global System. This includes 45 P3s (17%), 107 government research agencies (43%), 83 universities (34%) and 13 private entities (6%). The Global System is depicted in Figure 3.8 below. Four critical P3s are labelled on the Global System. These are CDC/SPG, ICARDA, ICRISAT and GLIP. The network density of .022 (see

Table 3.3) is the lowest of the four networks, suggesting that the primary research activity takes place within the three regional networks, with exchanges of technology and information between key actors operating as gatekeepers between the networks. The P3s are highlighted in red for ease of reference.

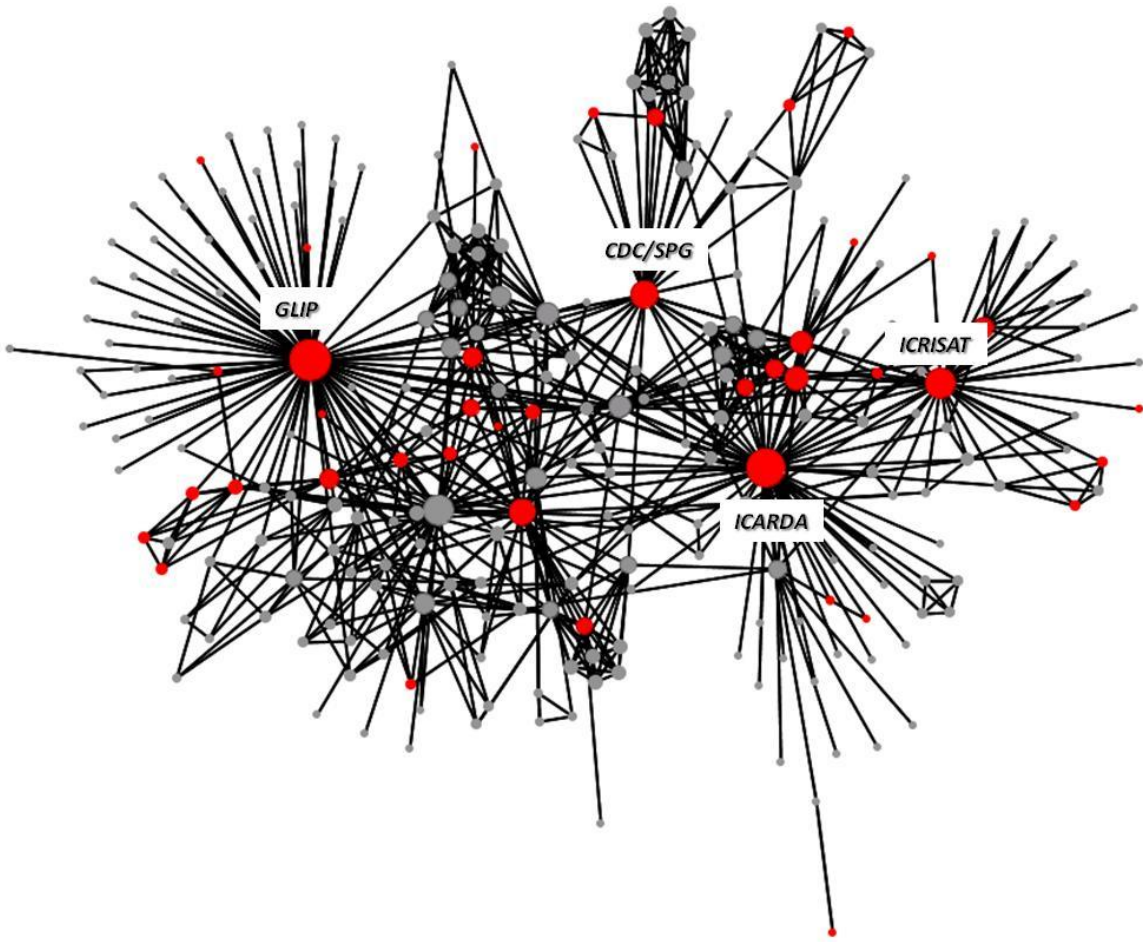
GLIP, ICARDA, CDC/SPG and ICRISAT, all P3s and INRA, a government agency, are the top actors in each of the three categories of centrality. In the entire Global System, 20 out of the 25 top centrally ranked actors are P3s, suggesting their critical role in providing linkages between dissimilar institutions and networks.

### 3.6.5.1 Global sensitivity analysis

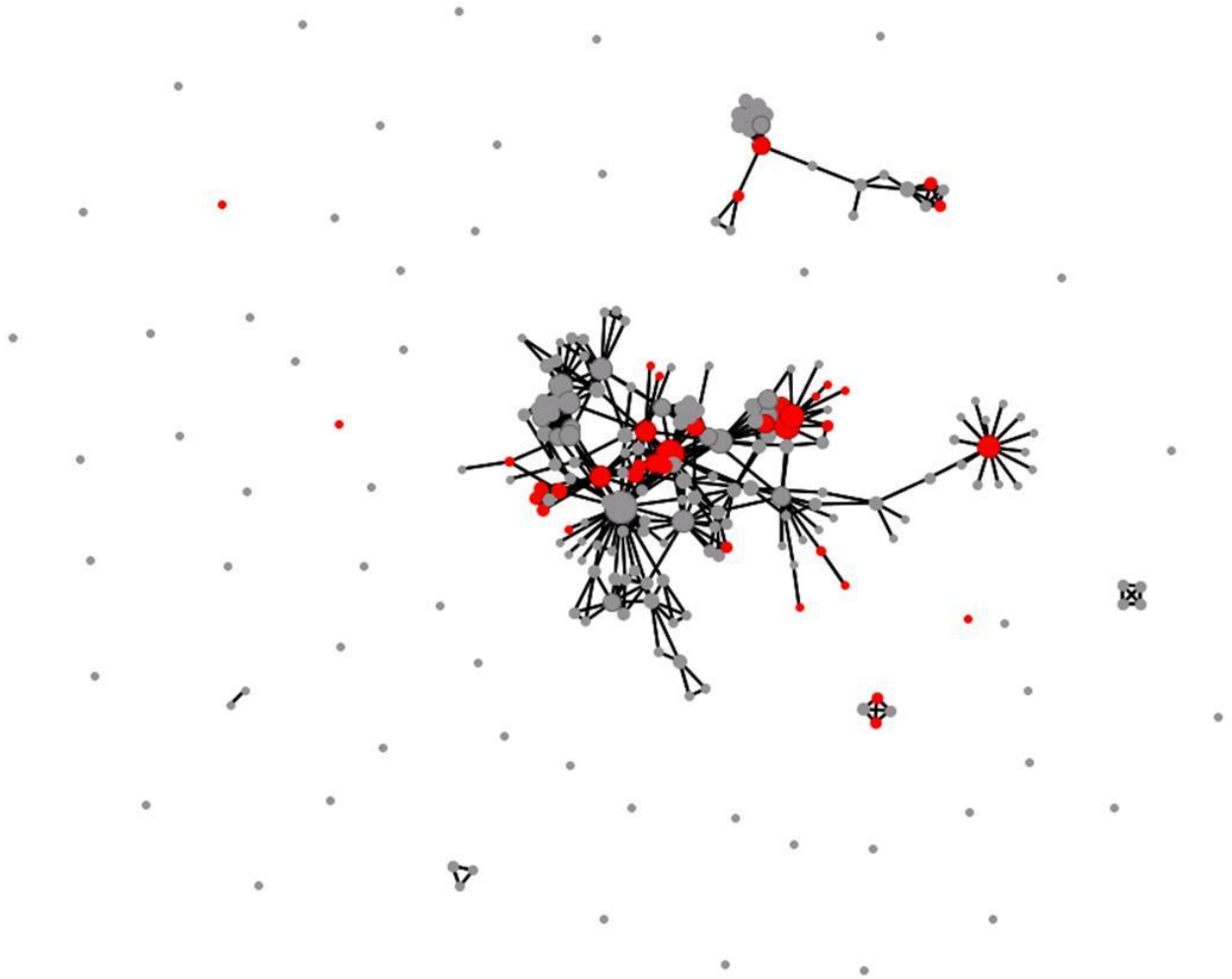
As before, we undertook a sensitivity analysis to confirm the role key P3s occupy. As demonstrated below, in Figures 3.8 and 3.9, removing four P3s—ICARDA, ICRISAT, CDC/SPG and GLIP—causes a disproportionate loss of network coherence. As noted in Table 3.11 removing these four P3s (about 2% of all actors) cause network impairment ranging from 25% to 98% depending on the measurement. Without these four key players, the system fragments into 60 components reducing the size of the Global System to 159 linked actors, 21 actors in the isolated Canadian system, four mini-networks of two or more actors and over 50 isolates.

**Table 3.10.** Global System Actors & Centrality

	<b>Intra-Network Connectivity (TDC)</b>	<b>Power (EC)</b>	<b>Influence (BC)</b>
GLIP (P3)	0.2996*****	0.9387*****	0.3853*****
ICARDA (P3)	0.2591*****	1.0000*****	0.3247*****
ICRISAT (P3)	0.1579****	0.5496**	0.1396***
INRA HQ	0.1579****	0.8033*****	0.1547***
CDC/SPG (P3)	0.1336***	0.8641****	0.2249*****
John Innes (P3)	0.1174**	0.6726***	-
GRDC (P3)	0.0850*	0.6230***	-
CLIMA (P3)	0.0810*	0.5791**	-
CSIRO	0.0810*	0.7747*****	-
* number of standard deviations greater than the mean Source: Authors' calculations			



**Figure 3.8** The Global System



**Figure 3.9** The Global System less GLIP, CDC/SPG, ICARDA and ICRISAT



**Table 3.11.** An Estimate of the Vulnerability of the Developing World System

	<b>With ICARDA, ICRISAT, CDC/SPG and GLIP</b>	<b>Without ICARDA, ICRISAT, CDC/SPG and GLIP</b>	<b>% effect of loss of 4 central actors</b>
# nodes	248	244	-1.6%
# links	1392	980	-29.6%
Density	0.022	0.016	-26.1%
Network centralization	0.279	0.133	-52.3%
Betweenness centralization	0.387	0.162	-58.1%
Closeness centralization	0.350	0.005	-98.5%
Fragmentation (#components)	1	54	+5400.0%
Characteristic path length	3.006	4.198	+40.1%
Authors' calculations			

### 3.7 Conclusion

Four primary themes stand out from this research. First, as demonstrated, P3s anchor and connect disparate systems of innovation into coherently organized national, regional and global innovation systems. In Australia and Canada, the P3 anchors the individual national systems and link these two systems into the Export System. In the EU, a P3 connects a plethora of individual national actors and national systems into a single, supra-national innovation system. In the Developing World System, two P3s connect a large number of isolated national research systems into a regional R&D network. These three, relatively autonomous regional networks are connected together through four key P3s, each a central actor in their respective networks, into the global system of pulse R&D. The regional and global structure of the global pulse R&D systems closely matches the Mode II form of knowledge production, which is characterized by problem and solution focused heterogeneously organized networks.

Second, the innovative use of P3s has led to the development of a research cluster in Australia as demonstrated graphically and statistically by the eigenvector centrality measure in Figure 3.3. Three relatively autonomous networks, each with different objectives, each centered on at least one P3, together form a national system of innovation that is deeply embedded into the regional system. From a theoretical perspective, this implies that as a national system, and through well

connected individual actors, primarily P3s, Australia has a competitive advantage over its the rest of the world regarding awareness of and access to new flows of knowledge, of all forms, and new forms of technology. This suggests that Australia possesses first mover and first adopter status regarding technological innovation within the global pulse R&D system.

The third theme identified is the role of the P3 as an organizational structure to manage an R&D intensive technology transfer process. In the Export System, the three primary P3s, CDC/SPG, the GRDC and CLIMA, are producer-managed and financed P3s, which came into existence in the institutional void created by the retrenchment of public financing of R&D activities. The producer P3 is an organic, bottoms-up response to a changing economic and political environment. This P3 closely resembles a demand-pull R&D organization, linking the research to market needs. In the EU System, GLIP is an intra-governmental P3, designed to coordinate the research activities of the national systems of the European Union into an organized system with specific continental objectives. ICARDA occupies central positions in two of the networks, demonstrating its unique status in the global pulse R&D system. Along with ICRISAT, ICARDA sustains the germplasm needs of the pulse world, without which the majority of the global pulse system could not exist, highlighting the global dependency on ICARDA in particular and ICRISAT in general. In the Developing World System, ICARDA and ICRISAT have two roles: the supply of new cultivars and technologies to expand production, and capacity building from both a network/regional perspective by creating connections between countries and from within the individual national agriculture research systems. This research suggests more than one model of P3 may be necessary to achieve efficient operations.

The fourth theme concerns the vulnerability of P3s on the vagaries of their partners. The P3s examined all are dependent on financial and in-kind contributions from a plethora of partners, ranging from individuals, entrepreneurs, venture capital corporations and angel investors, national governments, NGOs, IGOs and philanthropic organizations. Furthermore, P3s are also dependent on the legislative decisions of governments or their agencies. The termination of GLIP demonstrates the vulnerability of P3s to a change in public policy. If theory is correct regarding the dependence of economic innovation on capitalizing on the global flows of knowledge, the EU is in jeopardy of isolating itself from the global R&D community and becoming dependent

on narrow, uncompetitive national research programs for growth. ICARDA and ICRISAT are both highly dependent on financial and in-kind resources from a large donor base, adding a level of uncertainty to their operations. This financial uncertainty is magnified by the recent budgetary problems of the US and the UK, two of the largest financial donors to ICARDA.

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## CHAPTER FOUR

# COLLABORATION AND THE GENERATION OF NEW KNOWLEDGE IN NETWORKED INNOVATION SYSTEMS: A BIBLIOMETRIC ANALYSIS

### 4.1 Introduction

This article expands on previous research on the political economy of innovation in canola research and development (R&D). Canola is a high-value export-oriented agricultural product that was developed by Canadian public institutions over a period of 40 years by importing the original plant species and using imported technologies and imported researchers. This long-term process culminated in the creation of a global market for this branded and highly differentiated product. In 2000, a longitudinal citation analysis, using five-year intervals, was performed on Canadian public institutions involved in the transformation of canola, comparing their relative citation rates to a global average of 1.0 (Phillips and Khatchatourians, 2001). This research demonstrated that changes in the relative citation rates reflected changes in the industrial organization of canola R&D. Specifically, the privatization of a process once dominated by public institutions led to lower relative citation rates, due to the need for confidentiality by the private sector. A follow-on study, conducted 10 years later, again in five-year intervals, confirmed the bias towards lower citation rates from the privatization of canola innovation. Interestingly, in the second five-year interval, the relative citation rates of public sector research grew by 60%. This article focuses on the factors that caused this increase. The descriptive statistics indicate three variables behind the increase in relative citation rates: collaborative funding of public R&D, the use of hybrid organizations to fund and manage the innovation process, and the use of innovative public funding tools that facilitate collaboration in funding public R&D. To isolate the variables responsible for the 60% increase in relative citation rates, a regression model was developed to work with the unique nature of citation data.

The changes in the industrial organization of canola R&D closely mirror the Triple Helix Models of innovation. The Triple Helix Models of innovation have evolved over time from Triple Helix I, where the state dominates the innovation process, to the Triple Helix II, where the market reigns supreme, to the Triple Helix III, where innovation is dependent on the development of

hybrid organizations and interactions between the public, private and academic spheres to create new knowledge to drive the innovation process. The Triple Helix Models of innovation provide the analytic framework for this case study. Building from Triple Helix theories, this empirical analysis seeks to determine if innovation is a path-dependent process, one dependent on the historic presence of the state and market, or if innovation can occur in the absence of evolution.

There are seven sections to this article. The next section examines the Triple Helix Models of innovation to develop a framework for understanding the evolution of canola R&D. The methodology is explored in section 4.3, which links the theory and process of citation analysis with a regression model specific to this analysis. Section 4.4 contains the findings and interpretations of the results of this paper. Section 4.5 discusses the conclusions of this paper. Section 4.6 focuses on the policy implications of the findings of this research. Finally, section 4.7 reviews the directions for further research.

## **4.2 Theory**

### **4.2.1 Triple Helix of Innovation**

Joseph Schumpeter is generally credited for being the first person to define and quantify innovation as a process of economic growth, as driven by the recombination of existing ideas and factors that leads to increasing incomes (Schumpeter, 1939: 3). The increases in income are a result of new technologies, new markets, or sources of supply, from improvements to production systems and from the creation of new organizational structures (Schumpeter, 1939: 59). According to Schumpeter, innovation drives an evolutionary process of technologically oriented economic growth and change that is both disruptive and discontinuous, by simultaneously creating new opportunities for growth while spelling economic death for older methods of production. One method of understanding and contextualizing innovation is the Triple Helix Model, which posits that innovation is the result of interactions between three independent institutional spheres: government, university, and industry. The Triple Helix is a model for developing and applying knowledge to engender innovation (Viale and Etzkowitz, 2010: 3).

Three unique configurations of the Triple Helix Model are possible, depending on the hierarchy and structure of relations between the three institutional spheres.

In Triple Helix I, also referred to as the Statist Regime, the state is the dominant sphere occupying a “commanding heights” position over the institutional domains of both university and industry. In the Statist Regime, there are clearly defined boundaries among the public, private and academic domains, with interactions between the spheres controlled and mediated by the state in a linear and institutional process through formal organizations, such as technology transfer offices and contracts (Leydesdorff and Etzkowitz, 1998: 3–4). From a historical perspective, the Statist Regime was the system best characterized by the former Soviet Union, where innovation and relations between the spheres was entirely dependent on the state. This model also characterized the military-dominated system of innovation in Cold War USA, where large-scale national security-oriented projects dominated the highly structured and regimented R&D relations between the three spheres in a hierarchal system with the state determining the rules of the game (Etzkowitz and Leydesdorff, 2000: 2–3).

The advent of communications technology coupled with growing globalization represents the force driving the evolution from Triple Helix I to Triple Helix II, where industry, enabled by technological innovation, is the dominant sphere that indirectly drives growth. This is also known as the laissez-faire regime, where the spheres are driven by market forces, operate independently of each other, and where each sphere has specific and unique functions in the R&D process. This regime is characterized by the relative absence of overlap between the three institutions; relations are institutionalized and formal, occurring in a synchronized and linear process. Interactions between the spheres are limited to R&D activities that did not challenge the boundaries or move beyond one-to-one activities between the different institutions, with these relationships taking place through intermediaries such as specific technology transfer organizations, or through arms-length market-oriented transactions (Etzkowitz, 2008: 16–18). Knowledge generally flowed in a direct, linear process from source to use (Leydesdorff and Etzkowitz, 1998: 3–4).

Unlike the first two models, the Triple Helix III Model is characterized by interdependent relations between the spheres. In this model, the three institutional domains overlap, creating new spaces and methods of collaboration for developing new knowledge (Etzkowitz and Leydesdorff, 2000: 4–5). In this model, the formal delineation between the spheres disappears and each of the institutional domains takes on the attributes and functions of the other domains, thus creating networks and new organizational structures to manage the non-linear and spiral flows of new knowledge that transcend the boundaries of the Triple Helix I and II Models. This model is also known as the balanced model, reflecting the interdependencies generated through the spherical overlaps of the knowledge-based system. Knowledge and communication continually shape and re-shape the physical configuration of the innovation networks and spawn the novel organizational structures required for collaborative R&D efforts (Etzkowitz and Ranga, 2010: 5). Relations in this model are reciprocal, based on a culture of institutional entrepreneurship driven by the social nature of knowledge development (Etzkowitz, 2008: 18–23). The complexities of developing science-based knowledge in this model result in the development and use of specialized, organically configured hybrid organizations that incorporate the activities of each sphere, including financing, technology transfer, and commercialization. The hybrid organization can be conceptualized as a structure that transcends the boundaries between the three spheres and allows the transfer of ideas to support the capitalization of knowledge “through collaboration” to enable innovation (Viale, 2010: 32, 41–42). In agricultural biotechnology, the creation of new knowledge is a complex process that depends on face-to-face endeavors grounded in trust among actors drawn from the three spheres; hybrid organizations provide the institutional and organizational proximity required for personal interactions (Viale, 2010: 66–68).

The production of new knowledge, the prerequisite for innovation, has undergone a similar transformation from a linear, vertical, and mono-institutionalized process to a spiraled, horizontal, and collaborative process. Mode I knowledge production is analogous to Triple Helix Models I and II, as this process is characterized by the hegemonic nature of knowledge being developed by individuals working within autonomous institutions focused on theoretical pursuits (Gibbons et al., 1994). The Mode II system of knowledge production shares the attributes of the Triple Helix III configuration, as the development of new knowledge is a collaborative venture

occurring in heterogeneously configured networks. Mode II knowledge production is trans-disciplinary and occurs within the context of an application directed to developing creative and technological solutions to intractable problems (Nowontny et al., 2003: 8–9).

The evolutionary nature of the three Triple Helix Models and the transformation of the production of knowledge closely mirror the ongoing revolution in governance, where organically developed and self-governing networks appear to be replacing the vertically organized and hierarchical state as a means of social and economic organization. One perspective suggests that the advent of globalization, pluralism, and technological innovation are creating a new space—an institutional void—that is beyond the reach of the state (Hajer, 2003: 1–4). This has rendered the centralized state an archaic structure incapable of managing horizontally configured governance network (Weiss, 2000: 6–12). This new model of networked governance, as opposed to the vertical governing model dominated by the state, represents a transformation away from centralized government to distributed governance, which is characterized by interdependence, the multiplicity of new, hard-to-categorize actors and indistinct boundaries between the public, private, and academic spheres (Rhodes, 1995: 1).

The arrival of self-organizing networks has facilitated the growth in the use of public-private partnerships (P3s) to provide a flexible and developing organizational structure capable of facilitating collaboration. One area where P3s have emerged is in the management of national and international agricultural R&D innovation networks. Agricultural P3s function as innovation brokers and intermediaries as they link the heterogeneously configured actors into coherent systems to develop and commercialize transformative agricultural technologies (Hall et al., 2010: 25–27; Klerkx et al., 2009: 2–4). One perspective suggests that agricultural P3s provide a structural means of linking top-down, technology-push innovation systems with bottom-up demand-pull innovation systems by creating feedback loops and horizontal linkages that drive the evolving and self-organizing innovation process (Viale and Etzkowitz, 2010: 13–14). P3s have become the focal point for agricultural innovation systems by linking national, regional, and international sub-networks into larger systems designed to create efficiencies through economies of scale and scope (Boland et al., 2010: 9–14). By linking different systems and actors, P3s can control the innovation process by coordinating the flow of funds, knowledge, and

technology. Agricultural P3s accelerate the innovation process by exploiting the comparative advantage of each partner through pluralistic funding measures, collaborative problem solving, and institutional synergies (Hall et al, 200: 3–4).

#### **4.2.2 Research Focus: The Political Economy of Canola R&D**

The Triple Helix Model of innovation provides a framework of analysis for a case study on the development of canola, which, from an historical perspective, closely mirrors the evolutionary nature of the structure of the three Triple Helix Models, the transformation in knowledge production, and the transition to self-organizing networks.

Canola is a Canadian innovation that transformed rapeseed into a globally recognized product that provides the world's third largest source of edible oil. Historically, rapeseed has been used as cooking oil, industrial lubricant, and animal feed. However, due to high levels of erucic acid (linked to heart problems) and glucosinolates, which lowers the animal feed value, rapeseed faced market limitations that prevented large-scale cultivation. After importing the raw plant species from Poland, numerous technical innovations performed at public Canadian agencies transformed rapeseed into a low erucic acid and low glucosinolates product, trademarked as canola by Canadian trade associations, thus creating a global market for this transformed rapeseed product (Phillips, 2007: 36–37). As a part of the transformative process, new breeding technologies and agronomic traits were developed using imported biotechnology tools, creating the world's first transgenic crop (Smyth and Phillips, 2001: 2–3). From a Canadian perspective, canola is often referred to as a “Cinderella” crop, as it created new export markets for producers facing declining prices and profits in existing crops. Due to first mover advantages derived from public investments that created a regional innovation cluster providing R&D economies of scale and scope, Canada is the world's leading exporter of canola and is a world leading entrepôt for agricultural R&D and innovation as measured by the number of scientists employed, by the number of technical innovations, and by the flows of codified and non-codified knowledge (Phillips and Ryan, 2007: 8–12).

From the 1940s to the mid-1980s, innovation in canola was primarily a public venture occurring across public research agencies and universities in Canada. During this formative period, the

primary actor in the funding and management of R&D activities was Agriculture and Agri-food Canada (AAFC), the dominant public agricultural agency in Canada. The era was characterized by an unsophisticated, linear and sequential system of innovation dominated by the public sector, and AAFC in particular (Phillips and Khachatourians, 2001: 65–72). The introduction of intellectual property rights regimes, such as plant breeders' rights, led to the beginning of the privatization of canola innovation, particularly down-stream varietal development, in a linear but non-sequential process with the nascent use of feedback loops. Due to the complexities and the financial risks and costs associated with developing a transformative transgenic crop, P3s were created to provide producers with control over the innovation process. This engendered the creation of horizontal linkages between the public, private, and producer spheres, replacing the linear innovation system with a networked system characterized by collaboration and feedback loops that incorporated the attributes of both the technology-push and demand-pull systems (Phillips and Khachatourians, 2001: 21). The changes in the structure and process of canola innovation were a part of a larger trend in agricultural R&D in Canada where the public sector, due to the advent of the knowledge economy, austerity and globalization, began developing partnerships with industry and producer organizations in a long-term process of transferring the responsibility for managing and financing innovation (Carew, 2001: 3, 11).

As a part of a study on the political economy of canola, a longitudinal citation analysis was performed on the Canadian public institutions involved with canola innovation, comparing their relative citation rates on peer-reviewed and published canola articles to a global average of 1.0 from 1981–1996 in five-year intervals. In this 15-year period, based upon quantity, Canada was the leading publisher of peer-reviewed canola papers, with the AAFC being the largest source of papers in Canada and globally. In this 15-year segment, AAFC was the primary funder and provider of canola R&D and innovation as measured by the number of scientists in canola research and the percentage of acreage using AAFC canola varieties. During this era, as explored in more detail in section 4.4, the relative AAFC citation rates, compared to the global average of 1.0, ranged from .84 during the 1981–85 interval, 1.22 in the 1986–90 interval, and .93 during the 1991–96 interval. Interestingly, during this 15-year period, AAFC collaborated with other public and private organizations on 21% of its papers, resulting in a slightly lower citation rate, challenging the notion that collaborative R&D should improve the quality of the output (Phillips

and Khachatourians, 2001: 87). As noted above, this era was punctuated by the transition of canola R&D from a public-dominated venture to the large expansion of private activity in response to the implementation of intellectual property rights beginning in the late 1980s. By 1995, more than 75% of the new canola varieties were developed and commercialized by private corporations. As a part of the privatization of canola R&D and due to public austerity measures, AAFC began fee-for-service R&D activities with the private sector. At that time, it was predicted that due to the private sector requirement for confidentiality and non-disclosure, AAFC relative citation rates would decline precipitously (Phillips and Khachatourians, 2001: 86–87).

A follow-on analysis was recently conducted on AAFC citation rates over two intervals, spanning 1997–2002 and 2003–2007. As noted in Table 4.1 below, in the first interval, AAFC citation rates declined to .66, confirming the earlier hypothesis. However, AAFC relative citation rates increased over 60% in the 2003–2007 interval to 1.11. The descriptive statistics suggest that changes to the structure and process of the funding of AAFC canola papers could be the cause of the improvement in the relative citation rates. Specifically, three items appear to have influenced this increase: the role of collaborative funding, the use of producer-funded P3s, and the use of innovative public financing mechanisms that engendered public–private R&D collaborations.

**Table 4.1.** AAFC Peer-Reviewed Canola Paper Citation Rates

Period of Analysis	Relative Citation Rate Based on Global Average of 1.0
1981-1985	0.84
1986-1990	1.22
1991-1996	0.93
1997-2002	0.66
2003-2007	1.11

### 4.2.3 Research Question

The remainder of this article, using the methodology described in section 4.3 below, examines how these three factors influenced the 60% increase in relative AAFC citation rates. In doing so, this study uses the Triple Helix framework to determine if innovation systems are evolutionary, meaning whether a system depends on developing a state-dominated Triple Helix I Model and



progress into the market-dominated Triple Helix II Model as a means of creating a knowledge-based economic system. This case study explicitly questions whether innovation is path-dependent (Leydesdorff, 2012: 12). The ultimate objective of this paper is to explore how technology-oriented agricultural innovation systems that exhibit attributes associated with the evolutionary perspective of the three Triple Helix Models can be exported to the developing world.

### **4.3 Methodology**

Citation analysis is the scientific and quantifiable measurement of citation data from peer-reviewed publications. Citation analysis introduces objectivity to the evaluation of research by comparing relative rates against absolute counts, such as global averages, to determine emerging trends in the development and dissemination of new knowledge (Nederhof, 2006: 85). The use of relative counts allows for comparing individuals, institutions, and countries to global averages to document and measure the flow of knowledge. A highly cited paper indicates that a relatively large number of other papers have found utility in that particular research (Garfield, 1979: 5). In addition to comparing like to like and identifying emerging trends in the flow of knowledge, citation analysis permits a deeper understanding of the processes that govern the generation of knowledge, providing the basis for generating better informed decisions over the allocation of scarce resource (Pendlebury, 2008: 7). In sum, citation analysis provides benchmarking capability, and the mapping of knowledge facilitates the identification of trends that otherwise would not be observable.

This paper utilizes the same data collection method as the original research; a keyword search through the ISI Web of Science uses canola, rapeseed, brassica rapa, brassica napus, and brassica campestris as the keywords. In the 1997–2002 interval, there were 4,692 peer-reviewed canola articles published worldwide with an average citation rate of 14.02 per paper. In this period, AAFC papers had an average citation rate of 9.27, representing a 0.66 relative rate. In the 2003–2007 timeframe, there were 4,712 papers published with a global citation rate of 3.75. The AAFC papers published in the period were cited an average of 4.16 times per paper for a relative citation rate of 1.11, representing a 60% increase.

The highly skewed distribution of the citation data presents challenges to research that need to be addressed. There are two factors influencing the distribution of citation data. First, the high prevalence of papers without citations skews the data in one direction. Second, there are a small number of papers with extreme measurements, also known as outliers, skewed in the opposite direction in a process referred to as “over-dispersion,” creating a situation where the conditional data variance exceeds the conditional mean (Allison and Waterman, 2002: 6). The skewed distribution phenomenon is common to citation data analysis (Pendlebury, 2008: 6).

A fixed-effects negative binomial regression model was utilized to predict the likelihood of the occurrence of a specific variable against an estimated base-line value. This model creates a dummy variable to standardize the effects of the over-dispersion of the data permitting the estimation of the conditional probability of a specific event against a reference value or group (Allison and Waterman, 2002: 2, 17). A logarithmic likelihood count model determines the probability of occurrence (UCLA, 2007: 5). The analysis was conducted using Stata Statistical Software version 11.2 (Stata, 2012). The output is measured in incident-rate ratios (IRR) against the estimated base-line value (Stata, 2009). In this analysis, the base-line value is an AAFC peer-reviewed canola paper published in the absence of collaboration, in the absence of funding from a producer P3, and in the absence of public funding mechanisms. Therefore, each explanatory variable in question is compared to this non-collaborative paper by estimating the likelihood that each variable, in the absence of the other variables, will increase the incidence of a canola paper being cited by another peer-reviewed canola paper.<sup>5</sup>

#### **4.4 Analysis**

As discussed, there are three variables that appear to have influenced the 60% increase in citation rates between the two intervals in question. The descriptive statistics indicate that collaborative funding, meaning more than one funder per AAFC canola paper, the use of producer P3s in funding AAFC canola research, and the use of the Matching Investment Initiative (MII), a public

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<sup>5</sup> Please see Appendix “B” for complete formula.

funding mechanism designed to engender collaboration, appear to have contributed to the increase in AAFC relative citation rates.

First, as noted in Table 4.2, below, in the 1997–2002 interval the use of collaborative funding did not lead to a marked increase in relative citation rates. However, in 2003–2007, there is a marked increase in citation rates associated with an increase in funding partners. The increase in citation rates is most evident with three funders, in which case the AAFC citation rate is 78% higher than the global average and almost twice the citation rate of three funders in the 1997–2002 period. The use of two funders generates a 1.26 relative citation rate, about a 60% increase from the previous era. The use of four or more funders leads to a 1.42 relative rate, which is consistent with the 1997–2002 data. However, this was based upon 10 papers, suggesting the small sample size calls into question the validity of the 1997–2002 citation rate.

**Table 4.2.** Collaborative Funding Descriptive Statistical Comparison

Number of Funders	1997–2002		2003–2007	
	Relative Citation Rate	N	Relative Citation Rate	N
One Funder	0.65	72	0.70	65
Two Funders	0.74	47	1.26	59
Three Funders	0.94	26	1.78	44
Four or More Funders	1.42	10	1.48	37

Second, as noted in Table 4.3, below, in the 1997–2002 interval producer P3s were not an important factor in the financing of AAFC canola papers as signified by the small number of papers and a relative citation rate below the global average of 1.0. This changed in the 2003–2007 era as the number of papers financed by producer P3s expanded from 15 to 62, with a relative citation rate of 1.61, almost doubling the citation rate from the previous interval. A number of factors have influenced the rise in the use of producer P3s for financing AAFC canola papers. Producer P3s first appeared in the 1970s and they were instrumental in the financing and managing of the R&D innovation process that transformed rapeseed into low erucic acid and low glucosinolate canola, creating the product that opened new international markets for this branded, trademarked, and differentiated product. This process marked the beginning of P3s venturing into the management of the canola innovation process through the financing and

coordinating of R&D activities taking place in AAFC and Canadian university laboratories. During this period, a multitude of producer associations began using crop levies to finance canola R&D and to help shape government agriculture policy to accelerate the development of this sector. Government austerity programs created a requirement for new sources for the financing of canola R&D, a process that began in the early 1990s and gave rise to a number of producer P3s devoted to the management of the R&D process. The introduction of intellectual property rights, beginning in the early 1990s, opened an institutional space for the private sector to dominate the downstream R&D process, primarily in the development of breeding technologies and varieties. The privatization of the downstream R&D process resulted in a number of technology needs of producers going unfulfilled, something the levy-financed producer P3s have addressed. This process, beginning in the 1990s and reaching fruition in the 2003–2007 interval, marked the end of AAFC as the dominant actor in canola innovation and the beginning of the AAFC as support organization to both the private sector and producer P3s. Last, as a part of the funding of AAFC canola papers, many producer P3s require the publication of a peer-reviewed research article, creating a process conducive to knowledge development and dissemination.

**Table 4.3.** Producer P3s and MII Descriptive Statistical Comparison

	1997–2002		2003–2007	
	Papers	Relative Citation Rate	Papers	Relative Citation Rate
Producer P3s	15	0.84	62	1.61
MII	11	0.92	52	1.66
Both	2	1.6	36	1.78

Third, in the context of Table 4.3, above, one can see that the use of the MII, similar to the use of producer P3s expanded in both quantity of papers and relative citation rates. Specifically, in 1997–2002, the MII was utilized on 11 papers, which resulted in an average slightly below the global average of 1.0. In 2003–2007 the MII was used to finance 52 AAFC papers, resulting in a 1.66 relative citation rate and representing about an 80% increase over the previous period. The MII was an AAFC funding mechanism designed to link AAFC research capabilities with industry needs in a process that was intended to keep AAFC scientific capabilities relevant and to compensate for the reduction in public spending (BearingPoint, 2004: 4–5). The MII is a tool

that permits the AAFC to exert influence over agri-food R&D activities in an operating environment characterized by austerity and privatization. AAFC began using the MII in the mid-1990s.

One last explanatory variable of interest is the simultaneous use of producer-financed P3s and the MII in the financing of AAFC canola papers. As noted in Table 4.3, above, only two AAFC papers were financed by both producer P3s and the MII in the first interval. This changed dramatically in the 2003–2007 period as 36 papers were financed by both, resulting in a 1.78 relative citation rate.

Therefore, there are six variables of interest to this analysis: two funders, three funders, four or more funders, producer P3s, the MII, and the use of both the producer P3 and MII in financing AAFC canola papers. As discussed in section 4.3, each variable is being compared directly to AAFC papers that did not use collaborative funding, producer P3s, or the MII. Put simply, this investigation seeks to determine, through a regression analysis, the impact of each variable on the increase in citation rates by determining the likelihood of a canola paper being cited through the use of each variable, compared to a canola paper without the variable in question.

In Table 4.4, below, the regression analysis indicates two statistically significant variables, both related to the number of funders. In 2003–2007, using three funders on an AAFC canola paper resulted in 2.3x increased chance of being cited as opposed to a non-collaborative paper at a 95% confidence level. Using four or more funders resulted in a 2.0x increased chance of being cited, although it should be noted both the Z and P values indicate that the results are ambiguous as each value is on the margins of the significance interval. This suggests that the benefit from collaboration, in this analysis, is maximized at three partners with declining returns in evidence at four or more funders, implying limitations on the returns from collaboration.

**Table 4.4.** Regression Results

Variable	IRR <sup>6</sup>	STD Error	Z	P> z	[95% Conf. Interval]	
2 Funders	1.76	0.665	1.49	0.136	0.837	3.693
3 Funders	2.36	0.812	2.50	0.012*	1.203	4.634
4 or more Funders	2.00	0.700	1.98	0.048*	1.006	3.975
MII	1.10	0.536	0.19	0.847	0.422	2.860
Producer P3	1.03	0.346	0.08	0.933	0.531	1.990
Both MII and P3	1.14	0.327	0.47	0.637	0.653	2.005
/lnalpha	0.63	0.143			0.349	0.913
Alpha	1.88	0.270			1.418	2.493

\* Denotes Statistically Significant Result

Building from theory and from this analysis, there are two areas that warrant further research: the role of enablers, plus the role of P3s and other hard-to-define organizational structures that facilitate collaboration. While neither the MII, as an enabler, nor the producer P3s, as collaborative structures, were statistically significant factors in the increasing citation rates, it is important not to underestimate their role in creating a process conducive to collaboration. Innovation in the canola sector has migrated to a new space and process defined by collaboration and the presence of novel organizational structures such as P3s.

One important issue is whether agricultural science and technology systems from the developed world, such as Canada's canola innovation system, can be exported to the developing world. The answer is a qualified yes. The Canadian canola story presents a model for emulation. Canada's agricultural sector is small compared to its competitors in the United States and the European Union, as Canada lacks many of the economies of scale to compete effectively. Therefore, Canada must pursue innovative strategies in identifying and developing novel crops such as canola to remain a factor in global markets. The development of canola provides an institutional model for the developing world, as interconnectedness with global knowledge flows and global markets provides the means for agriculturally based economic growth in a process known as techno-leapfrogging (Gilpin, 2001: 139–140). This process enables lesser-developed economies

<sup>6</sup> IRR=Incident rate ratios, this number represents the likelihood of an AAFC paper being cited compared to the non-collaborative, baseline AAFC canola paper.

to leverage the technological assets of developed economies to accelerate economic growth and development.

Expanding from this research, collaboration in P3s appears to be an emerging organizational structure and process for identifying, developing, and transferring relevant technologies from the developed world to the developing world for agricultural economic growth. An online database compiled by the Syngenta Foundation for Sustainable Agriculture has identified 203 agricultural P3s in the developing world. A total of 122 of these P3s have been in operation less than five years, and another 62 have been in operation for less than 10 years, suggesting that agricultural P3s in the developing world are a recent and growing phenomenon.

Recent research into the growing use of agricultural P3s in the developing world suggests that P3s are a revolutionary structure capable of operating in environments that are beyond the capabilities of either the state or the market. Specifically, it has been demonstrated that agricultural P3s in the developing world provide a structure and process that facilitate the development of local governance capabilities and social capital that can compensate for the absence of a state or a rule-based, transparent economy with functioning markets (Poulton and MaCartney, 2012: 2–3). Because P3s facilitate both trust and transparency, they can work to generate higher levels of technology transfer between the developed and developing worlds, resulting in yield gains, lower costs for small farmers, and increasing farm incomes (Hartwich et al., 2007: 55–61). Developing world P3s specialize in “orphan crops”—so named because they are neglected by both the public and private sectors—in an effort to create an institutional space dedicated to sustenance crops such as millet, cassava, and sorghum by merging public and private technologies and capabilities to develop new crops for the “bottom billion” of the world (CropLife International, 2009).

#### **4.5 Conclusion**

This empirical analysis extends the knowledge about the role of collaboration in generating higher rates of knowledge development and transfer. Four items warrant comment. First, the evolution of canola closely emulates the evolutionary nature of the three Triple Helix Models as measured by the citation data. The changes in the structure of the financing and management of

the canola R&D process progressing from state to market to collaboration mirrors theory. This suggests that collaboration and communication are the primary drivers of innovation in a knowledge economy, which in turn supports the view that collaboration has replaced the linear systems characterized by institutional hegemony as the primary driver of innovation. Second, the critical role of collaboration in this study suggests that innovation is not path-dependent, but rather is based on emerging qualities derived from interdependencies that create economies of scale that are difficult to measure and evaluate. This analysis suggests that pluralistic funding measures, collaborative problem solving, and institutional synergies can lead to a process of techno-leapfrogging that can accelerate technological-driven agricultural development. Third, the recent growth in the use of agricultural P3s in the developing world indicates that collaboration is an emerging process. Fourth, this model suggests that there may be certain physical limits to collaboration, as the returns were maximized at three partners as the addition of a fourth partner led to a lower return from collaboration indicating diminishing returns.

#### **4.6 Policy Implications**

Theory and this empirical analysis indicate that innovation is driven by economies of scale developed from interdependencies created by collaboration. This suggests a recasting of the analysis, moving away from vertical processes characterized by the dominant position of a particular institutional sphere, to a horizontal process characterized by the absence of hierarchy. Policy needs to reflect this transformation, as governments can influence but not directly control the processes that govern the generation of new knowledge. Therefore, policy needs to be directed to creating tools, processes, and organizations that enable collaboration. The public sector needs to develop tools that permit the leveraging of public research assets with the needs and capabilities of other sectors to create interdependencies and generate economies of scale. Additionally, policies must be developed to permit the lessons of multi-sectoral collaboration to be absorbed, analyzed, and transferred; there is a need for learning communities and learning organizations to develop the economies of scale that underscore innovation. Government policies should reflect the need for trust and transparency in both the development and implementation of policies but also the need for tools and organizations that engender trust and transparency to provide a framework that is conducive to collaborative ventures.



## 4.7 Directions for Further Research

The transformation from linear and sequential innovation systems to non-linear, non-sequential and spiral-configured innovation networks that are shaped and re-shaped by interactions challenges research policy. The Triple Helix Models of innovation offer one perspective on this process and provide a framework for analysis. Citation analysis provides an established scientific method of examining the flows of knowledge as measured by the number of times an individual or institution has referenced the work of another entity, indicating the transmission of knowledge. The methodology developed in this analysis links theory to practice by creating a model that uses count-data to identify and isolate the variables that underscore this transformative process. By doing so, it is possible to identify novel processes and trends in the production of new knowledge. In this particular case study, collaboration appears to be the new institutional environment that drives innovation in canola research. This leads to two directions for further research. First, from a methodological perspective, this model adds another tool to help visualize the flows of knowledge, illuminating previously invisible processes and relationships. This fixed-effects negative binomial model needs to be tested on more cases to validate whether it can provide a new method for evaluating the impact of research. Second, from a theoretical perspective, if collaboration is the driver of innovation, what facilitates collaboration? Does the impetus for collaboration occur in individuals or in organizations, or does the institutional environment provide the catalyst for collaboration?

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## CHAPTER FIVE

# A TYPOLOGY OF RESEARCH AND DEVELOPMENT AGRICULTURAL PUBLIC-PRIVATE PARTNERSHIPS COMMON TO THE DEVELOPING WORLD BIO-ECONOMY

### 5.1. Introduction

Public–private partnerships (P3s) in agriculture are frequently designed and used to alleviate hunger and poverty in the developing world. But there has been little investigation of how they emerge, function and perform. This paper seeks to remedy that.

The term public–private partnership (P3) refers to any collaborative engagements between public, private, and not-for-profit actors or institutions (Kernaghan, 1993: 57–60). P3s allow for the division of labour and authority and a sharing of human and financial resources under a single organizational structure in the pursuit of common goals and outcomes (Vieira and Hartwich, 2002: 30–31). The pooling of public and private resources in a P3 structure adds value to any given process by exploiting the comparative advantage of each partner (Van de Meer, 2002: 123–137). Specifically, P3s facilitate collaboration between heterogeneous partners by developing trust, which engenders the creation of interdependencies and the formation of networks of shared interests, which together lower the transaction costs of collaboration (McQuaid, 2000: 9–11).

For the purposes of this analysis, we distinguish two main categories of P3s: R&D P3 and the value-chain P3. The R&D P3 is focused on developing upstream breeding technologies to develop higher-yielding varieties through enhanced abiotic and biotic stress resistance (Boettiger, 2011). The objective of R&D P3s is to facilitate the transfer of private sector technology to developing world countries in order to compensate for their lack of scientific capacity (Pray, 2001: 2–7). This P3 exists as a technology transfer mechanism, linking private sector assets with developing world technology needs. The R&D P3 is a structure that protects the private sector’s IP investments by creating and implementing a regulatory regime that uses IP tools such as plant variety protection and patents to facilitate R&D-based technological innovation. This P3 provides both an incentive for innovation and a means to attract investment

by offering a structure and process that captures the benefits of the value-added R&D process (Kock, 2011).

Conversely, the purpose of the value-chain P3 is to link local developing world farmers into global distribution systems for both inputs and outputs (Boettiger, 2011). Linking into the global agricultural systems enhances food security in the developing world by accelerating the rate of knowledge absorption and accumulation, which increases local innovation capabilities allowing for agricultural-based economic growth as a means to eliminate poverty (Pardey and Beintema, 2001: 23). The value-chain P3 seeks to create local networks as a means of developing the capacity to export commodities to developed world markets. Essentially, the value-chain P3 organizes the “bottom billion” into local and regional value and supply chains in a process of integration into the global economy. Due to the lack of efficient markets and stable political systems, the value-chain P3 develops local capabilities to provide end-users with assurances of product quality and safety, compensating for the lack of economic and political transparency (Poulton and MaCartney, 2012: 2–3). Additionally, value-chain P3s develop local governance capacities to facilitate the creation of rules-based and transparent supply-and-demand markets.

There are four objectives to this chapter. First, the paper provides information on the characteristics of P3s not otherwise available in the public domain in order to provide a practical perspective on what is required to create and operationalize these organizational structures. Second, it illuminates the incentives, constraints, enablers, and hidden costs associated with creating and managing agricultural P3s in the developing world. Third, it seeks to determine the characteristics that separate upstream research and development (R&D) P3s from downstream value-chain P3s. Finally, this chapter compares and contrasts the findings of this work to previous research on this subject, offering an array of insights for policy makers.

## **5.2 Methodology**

The evidence presented was gathered through interviews with people directly involved in various P3s. A total of 90 individuals working with 67 P3s were contacted for interviews. Based on the responses, 20 individuals affiliated with 9 P3s—involving 10 private sector and 8 public sector organizations—were interviewed for this research paper, representing a small sample size.

Therefore, the content of this paper reflects a small subset of opinions and viewpoints of experts and practitioners actively involved with agricultural P3s in the developing world. While this provides an insider's perspectives on the challenges and opportunities associated with agricultural P3s, one cannot use them to infer broader opinions or applications.

To facilitate open and free discussion, the interviewees and their organizations were promised confidentiality, such that their statements could not be traced back to them or their respective organization. This contributed to determining the format of this paper; in place of a number of discrete case studies, this paper focuses on the big picture in order to recognize patterns that occur in multiple P3s.

The survey results were analyzed in the context of a number of key issues. Each P3 was assessed and grounded in the theory of knowledge development and innovation and of collaborative governance. Second, the incentives, constraints, and enablers of P3s (based on a literature review) were analyzed to illuminate the hidden characteristics of P3s. A summary analysis section is then structured around six interview questions that probe the nature of the incentives, constraints, and enablers of agricultural P3s: (1) What are the incentives to join a P3? (2) What are the constraints to joining a P3? (3) How have P3s overcome these constraints? (4) What are the key enablers of P3s? (5) What are the hidden costs associated with working with P3s? (6) What is the most important lesson you can offer on P3s?

### **5.3 Theory**

One method of contextualizing the advent of the P3 is to examine the differences between the vertical concept of governing through the state and the horizontal concept of governance through heterogeneous networks. Specifically, it has been hypothesized that the culmination of neo-liberalism, austerity, the advent of the internet, and globalization has rendered the state-dominated mode of governing through laws and hierarchy impotent and has replaced it with a new model of governance (Weiss, 2000: 6–12). This new model of governance should not be viewed as a revision of the existing system of governing, but as a new system of “self-organizing networks,” or governing in the absence of a central authority (Rhodes, 1995: 1). Therefore,

governance is not synonymous with governing, but rather represents a radical departure from historic processes associated with centralized government. We are in an era defined by the emergence of distributed governance involving interdependence, new non-state actors, and obfuscated boundaries between previously clearly delineated sectors (Rhodes, 1995: 1). Collaborative governance depends on the use of problem-focused P3s that facilitate the exchange of knowledge between the public, private, and voluntary sectors (OECD, 2000: p. 3–4).

One area where collaborative governance has become an emergent process is in the production of new knowledge. It has been hypothesized that there are two forms of knowledge development, one vertical, known as Mode I, and one horizontal, Mode II (Gibbons et al., 1994). Mode I knowledge development is a vertically oriented process dependent upon the development of theoretical knowledge in autonomous and isolated institutions (Gibbons et al., 1994). Mode I knowledge development is synonymous with Rhodes's definition of hierarchal governing. Mode II knowledge is horizontal and problem focused, occurring in "heterogeneously organized" networks characterized by the dialogic nature of the process, one that is dependent on a high level of interaction between the members of the problem- and solution-focused network (Gibbons et al., 1994). The feedback loops created by the perpetual network interactions facilitates the governance-oriented nature of Mode II knowledge development (Nowotny et al., 2003: 8–12).

Economic growth is dependent on innovation—a process of recombining existing knowledge into new forms of knowledge to generate new wealth-creating economic processes. Joseph Schumpeter is credited with defining innovation as the introduction of a new good or the enhancement of an existing good, a new method of production, the creation of a new market, the discovery and exploitation of a new supply of input materials, or the creation of a new organizational structure (Schumpeter, 1939: 59–61). Schumpeter's definition of innovation reflects a process where something new is created or adopted from an existing stock of knowledge. This provides a foundation for an analysis of the competing paradigms that attempt to explain the processes that govern innovation. This perspective looks at the three Ps of innovation: "special people" performing "special processes" located in "special places" (Leadbeater, 2005; Phillips et al., 2012: 215).



The “special people” innovation paradigm suggests that economic growth is dependent upon creative people seeking to be on the leading edge of technological, social, and organizational change (Florida, 2002: 1–3). This perspective suggests human and social capital underscore economic growth. Florida’s three Ts—technology, trust, and tolerance—facilitate innovative re-combinations of existing knowledge into new ideas. Related to this concept is the role of social and policy entrepreneurs, who, through their efforts and locations within private and public organizations, identify and implement new ideas that drive the innovation process (Campbell, 2004: 74–76; Faminow et al., 2009: 3). These individuals use their ability to negotiate and transcend the boundaries between state, business, and society to become agents of change and influence by positioning themselves to recognize new opportunities and having both the will and the capacity to mobilize change within institutions and networks. In international development organizations, social entrepreneurs are characterized by their ability to identify and/or create technological solutions to poverty; they possess the requisite ability to create networks to influence positive change (Faminow et al., 2009: 3–5).

The second perspective on innovation, the special processes, is also referred to as the innovation systems paradigm. The special processes approach posits that interdependencies between networks of firms, governments, and learning institutions generate economies of scope that engender innovation. This view hypothesizes that universities center knowledge development networks by forging links with and between government and industry (Etzkowitz and Ranga, 2009). The innovation systems theory proposes that collaboration creates the interdependencies between institutions that foster innovation. A related perspective suggests that innovation is now global and that the key to innovation-driven economic growth is developing an institutional capacity to connect local and regional capabilities to global flows of knowledge, which occur in the form of advanced technology protected by intellectual property rights (Bathelt, 2004: 31–33; Phillips, 2002). The innovation and global innovation systems viewpoints acknowledge the need for a new hybrid form of organization to link the heterogeneous partners into functioning innovation systems (Bathelt, 2004: 33; Etzkowitz and Ranga, 2009: 4).

The special places theory of innovation is based on development of clusters of firms and industries that lead to the development of national and regional economies of scale (Porter, 1990: 17). Clusters depend on four interrelated factors in order to develop a comparative advantage that generates economies of scale. The first factor is the competitive structure of a cluster that forces industries to innovate or perish. The second factor is a strong consumer market that provides the conditions necessary for creating competition. The third factor is the existence of supporting industries to create upstream and downstream value chains to drive the innovation process. The fourth factor is the recognition that special places are dependent on thick labour markets, highly developed infrastructure, and deep and established capital markets for sustained investments. Special places develop economies of scale by continued competition and by developing interdependencies between markets, and supporting industries and labour markets.

The above analysis provides a framework for contextualizing the role of P3s in creating and managing effective agricultural research and development (R&D) innovation systems that attempt to organize researchers, organizations, and farmers into networks that create and transfer new forms of knowledge-based technology to facilitate agriculturally driven economic growth. P3s have become central actors in managing R&D agricultural innovation systems. P3s use voice, trust, and reciprocity as methods of engendering collaboration. They take on the role of an intermediary by coordinating the financial, R&D, and governance activities between the public, private, and voluntary sectors (Hall, 2006: 3–7). This improves the efficacy of R&D by facilitating a more efficient rate of technology transfer, which leads to higher yields and lower input costs for producers (Hartwich et al., 2007: 55–61). The trust, transparency, and accountability developed by the horizontally configured P3 generate the higher knowledge and technology absorption rates (Spielman & von Grebmer, 2004: 16–38). As P3s center agricultural R&D innovation systems, they provide an institutional structure for managing the introduction of transformative agricultural technologies (Hall et al., 2010: 25–27). This suggests that P3s are “innovation brokers” because they create linkages between developers and users of technology and provide the physical nucleus of heterogeneous configured networks (Klerkx et al., 2009: 2–4). Essentially, P3s have become the focal point for coordinating the financing, development, and diffusion of new knowledge required for agricultural technological innovation. As

innovation brokers in agricultural R&D systems, P3s facilitate technological innovation by synchronizing the activities of the public, private, and voluntary sectors.

For their formation and for the achievement of successful and enduring operations, agricultural P3s depend on a number of interrelated factors. One method of contextualizing the formation of P3s is analyzing the incentives that motivate organizations, public and private, to form P3s. Private sector organizations join P3s to collaborate with the public sector to gain access to raw and undeveloped germplasm stocks and to local and regional knowledge systems developed by the public sector (Byerlee and Fischer, 2002: 8). This suggests that the private sector joins P3s as a means of developing new markets in the developing world by accessing networks (and their resources) created by public sector institutions (Byerlee and Fischer, 2002: 8–10). Additionally, the private sector lacks detailed knowledge of “orphan crops,” such as millet, cassava, and sorghum, so engaging in P3s provides private sector firms with access to public experience and technology to help broaden their technical and scientific knowledge of those crops that provide sustenance for over one billion people (CropLife International, 2009).

Similarly, the public sector’s motives for joining P3s mirror those of the private sector: the public sector seeks access to the seed development and distribution systems of the private sector in order to access cutting-edge breeding technologies and private funds (Spielman and von Grebmer, 2004: 17–18). Essentially, the public and private sectors require the technological and knowledge assets of their counterparts, a reflection of the incapacity of either sector to work alone in developing innovative technological solutions to poverty in the developing world.

Despite the many incentives to facilitate the creation of P3s, there are a number of constraints that impede collaboration. One main concern is the potential for the misuse and abuse of proprietary technologies by both the public and private sector in a P3. Specifically, the private sector may attempt to use public-domain technologies for private gain; additionally, privately held intellectual property rights (IPRs) in the form of breeding technologies and finished varieties can be transferred, accidentally or intentionally, to competitors or farmer groups, both of which can inflict harm to a firm’s bottom line by threatening its market position (Spielman et al., 2007: 49–54). A second concerns the inability of the global IPR regimes to prevent the

unintended and illicit transfer of proprietary technologies and knowledge between organizations and countries; this inability inhibits collaborative ventures (von Braun, 2007: 11). A third constraint inhibiting the development of P3s is a dearth of experience among potential partners in developing and implementing P3s, suggesting P3s require a specific skill set that can only be derived through experience (Hartwich et al., 2007: 46–47). A fourth constraint is the hidden costs of collaboration related to the time and resources required to establish trust and eliminate competition for the limited resources within the P3 (Hall, 2006: 14–15). Finally, developing and implementing successful P3s can be impeded by the focus on short-term and medium-term results, which are generally measured by return on investment (Ferroni, 2010). The constraints identified are compounded by the lack of examples of successful P3s in agricultural development.

A number of enablers have been identified in the literature that work to counterbalance the incentives and constraints of developing P3s. First, a stable macro-political economic environment has been identified as a prerequisite for multi-sector collaboration in agricultural R&D in the developing world (World Bank, 2008). The second and probably most prominent enabler is access to sustained financing to provide the time and resources necessary to develop the relationships and the structure necessary for the long-term viability of a P3 (Warner and Kahan, 2008). A third related key enabler is effective design of the P3; ultimately P3s need to be capable of attracting private sector financing, suggesting that P3s need to be able to be profitable at some point (Warner and Kahn, 2008). A fourth enabler is to employ third-party entities to act as brokers between the partners to help them develop a set of goals and a plan to attain those goals in order to prevent conflict between the partners from interfering with the objectives of the P3 (Hall, 2006: 14). Fifth, many P3s employ specialized non-profit international organizations, such as the International Organization for the Acquisition of Agri-Biotechnology Applications (ISAAA), to link the technology needs of developing countries with the technology and germplasm stocks of public and private organizations in the developed world (ISAAA, 2012). In addition to ISAAA, the Public Sector Intellectual Property Resource for Agriculture (PIPRA) and Cambia perform a similar function by providing access to agricultural technology and organizational assistance to developing-world entities seeking to build up the capacity to use the technology. These organizations can provide an array of facilitating services, including

workshops on IP management, commercialization strategies, and forming public–private partnerships.

## **5.4 Summary and Analysis of the Responses to the Questions**

This section summarizes the specific evidence and impressions drawn from the interviews with P3 actors.

### **5.4.1 The Incentives to Join or Form a P3**

A number of themes emerged in response to questions about why private or public actors would engage in a partnership. First, many developed world private corporations have policies and/or cultures of “goodwill” towards development projects in the developing world. Sometimes this can be the result of a specific board directive, or a corporate policy that mandates or encourages employees and divisions to engage in charitable activity. It was suggested in the interviews that adopting a culture of goodwill means that corporations receive many benefits from these activities, including, but not limited to, happy employees, enhanced public image, and new relationships in the developing world, indicating that there are multiple factors driving what otherwise looks like simple corporate charity. In many cases, P3s have been created due to the personal initiative of individual employees who recognized opportunities where commercially developed technologies could be transferred to subsistence crops without compromising the market positions of their employers. It was suggested by a number of respondents that Corporate Social Responsibility (CSR) has also become a motivating factor for corporations to engage in developing world agricultural P3s, as many of the large agri-food companies are publicly traded and depend on the investment community for their financial well-being. There are now systems in place, such as the Dow Jones Sustainability Index, that track the CSR activities of companies, and this type of monitoring provides an incentive for action, as their investors, in response to public pressure, now require a positive public image as a condition of continued investing.

Similarly, philanthropic activities in developing world P3s garner positive press and social media releases. It was noted by more than one individual that by donating technology and money, and by lending employees to developing world P3s, corporations create an image of supporting sustainable agriculture, something that is becoming a long-term consumer trend regarding food

product choices. More than one interviewee suggested that the market position of corporations depends on supporting sustainable agriculture just as much as on price and quality, which indicates a response to long-term consumer trends favouring sustainability and equitable development. Additionally, there is a powerful “feel good” logic governing the incentives that drive private sector companies to engage in developing world P3s. Again, a number of respondents, all drawn from the private sector, commented that this makes employees feel good about their jobs and themselves, and therefore enhances employee morale.

A second theme was that corporate actors perceived commercial incentives to join P3s. The developing world represents the new frontier as both a consumer market and a commodity supplier. Multiple private-sector interviewees indicated that engaging in P3s permits companies to develop local capabilities in the developing world by organizing farmers into coherent value chains, essentially incorporating the developing world into the global agricultural economy. This also allows corporations to access local knowledge and resources for their long-term strategic needs. Respondents from R&D P3s indicated that learning about and acquiring local plant species was a powerful incentive for collaborating in P3s, as the genetic material contained in plants can be a scientific asset and may hold commercial potential for expanding developing world markets. Interviewees from value-chain P3s indicated that they require local knowledge as a means of learning how to work with the “bottom billion,” as the developing world represents the new markets for both customers and suppliers, and, therefore, the major global source of growth. Furthermore, given the insights these partnerships offer on local and regional operating conditions, both political and knowledge-oriented, engaging in P3s also reduces the risk of investing into new countries and products.

One common underlying theme is that the developing world has become strategically important to the long-term aspirations of corporations involved in the agri-food sector, and P3s are the best means of opening up this new economic space by providing a structure to learn how to work with the developing world. It was suggested by more than one informant that P3s, due to their collaborative structure, provided a means of creating coherent networks where there was a discernible absence of economic and political stability. It was noted that forming developing-world P3s gives companies access to the networks that have been established by national and

international aid agencies such as The Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation (GIZ)), International Development Centre (IDRC), and USAID, in this way speeding up the learning process by leveraging public knowledge with private sector assets.

Third, multiple informants from the public sector indicated that the public sector joins P3s to gain access to private technologies, especially new technologies such as Bt and herbicide tolerant varieties. By collaborating with the private sector, the public sector can gain a deep understanding of what knowledge and technologies the private sector has. This, in turn, permits both public and private entities to create a scientific division of labour to tackle various disease-related crop problems in the developing world. This leads to an acceleration of research programs, getting new technologies into the hands of developing world farmers more quickly and efficiently. It was noted by numerous public-sector respondents that most P3s exist because neither the private nor the public sector possesses the requisite capabilities to respond to the technological needs of developing world farmers. In the developing world, the public sector needs the expertise of the private sector to set up regulatory systems, as corporations have a plethora of experience in establishing standards for the introduction of new technologies, especially biotechnology. Their expertise and experience covers the spectrum of dealing with new technologies, including regulatory and biosafety technologies, all critical to the successful introduction of the new plant varieties.

Although the public sector is adept at developing new technologies, especially for subsistence crops, it lacks the experience of the private sector in bringing new technologies to the market, or, in the case of the developing world, to the local farmer. One respondent noted that the process of successfully launching a new product, both GM and non-GM, takes years, usually more than a decade. This person noted that the greatest indicator of success of P3s in the developing world was having experience with previous failures in product development and launches, something the private sector has experience with.

#### **5.4.2 Constraints in Joining or Forming a P3**

From the private sector perspective, there are three major constraints to joining or forming a P3 in the developing world. The first major impediment concerns intellectual property rights (IPRs). From the perspective of an R&D P3, corporations are heavily invested in IPRs, the right to specific genetic traits as an example, and P3s can threaten these investments by permitting the intellectual property (IP), in the form of food, to be exported from the host country or region in the P3 to the developed world markets, threatening their market position and profits. The second major impediment blocking private sector partners from joining P3s pertains to control issues: who is in charge of the P3? P3s depend on multiple steering committees, which obfuscate the chain of command and leadership functions. Many P3s answer to not-for-profit donors or development agencies, not to the private sector. Put simply, it was suggested by a number of informants that the private sector does not always understand how P3s operate. The private sector engages in many contracts and bi-lateral agreements with P3s, but these are often accomplished on a project-by-project basis, meaning the experience usually is not transferred to the operating standards of an organization. This point was addressed by multiple respondents who suggested that a lot of the private sector experience in dealing with P3s is embedded within individuals, not the corporation. The third constraint identified from the interviews relates to cultural differences between organizations. These cultural differences can be related to public vs. private operating standards. The public sector is often oriented towards activities defined in a contract, and the private sector is usually focused on results, with the activities dependent upon acceptable outcomes that are generally measured in commercial terms. It was suggested by a number of informants that the process and activities change repeatedly in order to achieve the desired outcomes. Cultural differences, including language and norms, can also be understood as differences between developing and developed worlds.

Respondents from the public sector identified four major constraints to joining a P3. First, according to many interviewees, there are a limited number of researchers and scientists trained and focused on crop-based R&D P3s in the developing world. This limited research capacity limits the number of projects in which the scientists can engage at any given time. One issue that came up repeatedly was that each project requires an inordinate amount of administrative attention, which further dilutes the limited amount of qualified people to work with R&D P3s.



Second, it was noted in multiple interviews that it is difficult for public sector institutions and not-for-profit research centers to identify relevant technologies and identify genuine and honest private sector partners. This difficulty is compounded by public scrutiny of private sector motives for engaging in P3s, suggesting that negative perceptions of the large agro-biotech firms by the public sector may prevent the development of effective P3s. Third, public and not-for-profit institutions are constrained by a lack of funding. Fourth, multiple respondents indicated that many public institutions lack experience in dealing with private sector partners, similar to the issues raised with the private sector in the above paragraph.

### **5.4.3 How Have P3s Overcome the Constraints?**

Interviewees identified five methods for overcoming the constraints to building effective P3s in the developing world. First, start simple by focusing on building relationships with the partners. A number of individuals stated that the P3 is best constructed by building friendships through face-to-face interactions; this builds trust and develops the basis for long-term relationships. The objective of developing relationships is to prove the process works. It was advised to start simple and leave the formal agreements and lawyers to the last stage of developing a P3, after the objectives, process, division of labour, and financing arrangements have been agreed upon.

Second, the most important aspect to build successful P3s is to employ P3 experts from developmental agencies and/or donor agencies who have experience with establishing developing world P3s; this is to say, experience matters. P3 experts act as translators to bridge the differences between public and private sector standards, and they help overcome cultural differences between the developing world and the developed world partners. One item of significance did stand out. None of the informants from R&D P3s suggested a requirement for P3 experts. This was an item of significance only from interviews with respondents who work with value-chain P3s, again suggesting there are large differences between the two types of P3s related to the experience and expertise required to start operations.

Third, remain focused on the ultimate objective: increasing the incomes and health of developing world farmers through agriculture. This objective is best accomplished by focusing on mission-critical items starting at the highest level of the structure of the P3. Fourth, due diligence matters;

it is prudent to research the technologies involved, as well as the potential partners and their means and motives. Fifth, a majority of the people interviewed suggested that personal commitment matters, as this can overcome problems associated with complexity and culture.

#### **5.4.4 The Hidden Costs Associated with Working with P3s**

Respondents identified six hidden costs associated with P3s. First is the hidden cost of time. P3s depend on a many meetings as part of the consensus-building process. It takes an enormous amount of time to connect the various partners and systems into a single organizational format. This entails merging public- and private-sector personnel and possibly divisions into a P3, which includes members from a varying number of developing world countries, each with their unique cultures, languages, and organizational idiosyncrasies. The majority of the P3s analyzed contained a minimum of three partners, with many having up to fifteen partners drawn from the public and private sectors and a multitude of countries. It was noted by many interviewees that this complexity engendered an unpredictable, difficult-to-forecast, and time-consuming process of getting to understand the dynamics of the partners in the P3. It was noted by multiple respondents that prior to joining a P3, it was impossible to predict with any accuracy the amount of time an organization would need to devote to the partnership.

Compounding this problem is the issue of accounting for the opportunity cost of the time devoted to building a P3, as this does not show up on a balance sheet. This is a critical hidden cost for both the public and private sectors, something that was repeatedly discussed by the majority of the interviewees. This matter is intensified by the fact that the major donor agencies, both public and not for profit, do not permit the recovery of in-kind contributions, an issue that expands on one of the major constraints discussed in question number two.

The second hidden cost, related to the hidden cost of time, is the amount of intercontinental travel required for building an effective P3. As noted, P3s depend on committee meetings for their survival and success; therefore, travel becomes a hidden and unpredictable cost. Not only is travel required to build a successful P3, the amount of travel increases when it comes to field trials of new crop varieties in the developing world. The larger the geographic footprint of the P3, meaning the greater the number of country partners, the larger and more unpredictable the

travel costs are for field trials, a necessary component of any successful crop-based R&D P3. It was noted in the interviews that there is little financial room for trial and error in the process leading up to and including field trials.

The third hidden cost, which is related to the uncertainties associated with time and travel, is the poorly understood problem of complexity with P3s. As P3s develop, their structures and processes change, frequently through the addition of new partners, and these changes lead to new objectives and missions as new partners bring in new ideas and new opportunities. These elements of change both add to the complexity of the P3 and can cause mission drift, making it easy to lose focus on the strategic objectives of the original partnership. This in turn adds to the cost of the P3.

The fourth hidden costs are related to financial reporting, writing grant proposals, and the never-ending process of acquiring funding. The reporting and documentation requirements vary depending on the structure of the P3. However, it was noted by a number of informants that each type of partner has unique reporting requirements, creating documentation challenges for the constituent partners. Public sector donor agencies, such as GIZ, USAID, and IDRC, and not-for-profit centers, such as The Gates Foundation and the Rockefeller Foundation, have unique reporting requirements that necessitate the need for complex and expensive documentation systems and in turn present expensive challenges for the P3 and its partners. It was noted by more than one private sector partner that the level of specificity created expensive burdens that added unforeseen costs that are hard to justify. Again, the donors do not permit the billing for such indirect costs.

It was noted that larger private sector partners have R&D budgets measured in the nine- or ten-figure range, absolutely dwarfing the size of grants from the donors. Despite this, their financial accounting systems need to be revised to accommodate the donor and P3 requirements, something noted in the constraints section. Many interviewees also commented on the high transaction costs associated with P3s. This was related to both the reporting needs and to the time and energy spent looking for funding. Additionally, most private sector partners lack experience with writing grant proposals. There were also hidden costs associated with the verification of

results from developing world accounting systems as donors and private sector partners noted that most developing world partners are not up to accepted accounting practices in the developed world.

The fifth hidden costs are the vagaries associated with managing IPRs. The majority of crop-based R&D P3s depend on technologies from private corporations, public agencies, universities, and even individuals. As there is no global IPR regime, freedom-to-operate (FTO) issues are a hidden cost that is difficult to predict in advance. Generally, FTO searches involve the use of private attorneys and require IPR searches in multiple jurisdictions. In one P3, a total of 43 IPRs were required, taking years of effort and expense. It was identified that the “golden rice” project is a great example of how FTO issues can dictate the pace and outcome of P3s. This remains an impediment to developing R&D P3s for the developing world, as it takes time and money to hunt down legal access to required technologies. This is a hidden cost that is unique to the R&D P3.

The sixth and final hidden cost is the lack of infrastructure in the developing world. In many cases with R&D P3s, it was necessary to construct roads, build laboratories, buy scientific equipment, and train scientists and technicians to fulfill the objectives of the R&D P3. The individuals interviewed from value-chain P3s noted that accurately forecasting infrastructure needs was even more complicated and therefore harder to predict. It was suggested that with value-chain P3s, the profit margins of the export commodity are low to begin with, so scale is important. However, to be successful, it is best to start small and develop a working model before trying to achieve scale operations.

In value-chain P3s, both traceability and transparency are required by consumers in developed world markets. So value-chain P3s must engage with and/or build civil society capacity to achieve transparency and traceability. This requires people on the ground developing educational outreach programs to reach as many farmers as possible, as soon as possible. The interviewees stated that this is a large expense that is difficult to predict accurately. In one way, the value-chain P3 faces a financial and organizational hurdle at the beginning of operations that a R&D P3 faces only after the successful development of a plant variety. The value-chain P3 must develop a network at the beginning of operations in order to reach as many farmers as possible.

This problem is compounded for value-chain P3s that are focused on tree-based commodities, such as coffee and nuts. These trees can take years to mature before they are ready for production. These issues were brought up by a number of informants. Furthermore, they noted that it is difficult to justify large-scale expenditures because most expenses are related to education, capacity development, and creating farmer organizations, none of which leads to quick returns on investment. This was a problem area mentioned by several people involved with value-chain P3s: to achieve scale, the value-chain P3s require large scale investments, but donor agencies require tangible results in order to continue funding. This creates a measurement problem.

One respondent stated that one way to receive future funding is to bring funders on location to demonstrate what their funds had created. It was further noted that many value-chain P3s operate in more than one country. This requires developing governance systems with multiple governments, which adds both cost and complexity to the process. One informant indicated that operating in multiple countries aided transparency because it forced other governments and organizations to conform to outside standards of operation. However, this added to both the cost and complexity of developing the value-chain P3. It is difficult to predict and forecast what infrastructure and capacity needs will be required until the P3 has developed. As noted above, most P3s have a significant gestation period where the objectives mature as the P3 grows and develops, adding to both the uncertainty and complexity of developing world P3s.

#### **5.4.5 The Key Enablers of P3s**

The first and most prominent enabler identified by respondents was the role of specific people in the creation and success of P3s. In one case study, an R&D P3 was the result of a single individual's efforts spanning almost three decades, from their university years through their professional career. This individual, while working for a not-for-profit, developed the initial technology, recognized the need for further technological development, and initiated a long-term relationship with a private sector partner. Furthermore, over the span of three decades, this person arranged for funding from almost every possible large-scale donor, including national

governments, the private sector, and, most recently, The Bill and Melinda Gates Foundation. This project is in process.

Each P3 analyzed for this paper was the result of the personal initiative of an individual, without whom these P3s would not currently exist. In two cases, individuals in the private sector recognized that a technology owned by their employers had the capability to resolve a crop-based disease or nutritional problem in the developing world. They launched what can be best described as a crusade to transfer the identified technology to solve a crop-related problem; the P3 in these cases is a direct result of acquiring partners to develop the technology and finance the process of building the capacity in the developing country to get the technology in the hands of farmers. Another P3—a value-chain P3 in multiple countries—was the result of a P3 expert from a national development organization recognizing a non-obvious commercial opportunity for farmers. This P3 was entirely dependent on the product, process, and industry knowledge of this person who understood industrial profit margins and had a deep knowledge of how to create a value-chain P3. Again, without the personal zeal of one person, this large-scale P3 would not exist.

In other case studies, public researchers recognized the limitations of their programs and began building relationships with the private sector and with donor agencies to bring their technology to the farmers. In each case, the actions of the key individuals formed the basis for a compelling story of initiative, effort, and belief to solve the hunger and poverty problems. It also exposes how dependent these P3s are on these particular individuals; without their efforts, it is questionable whether these particular P3s would have ever formed. It must be emphasized that these efforts took place over a period of decades, essentially over the professional careers of these individuals. In two cases, the P3 was a result of one individual handing the “file” to a new employee who then took the project over. In one case, the developer of a technology-based P3 has remained in their position to continue working and nurturing the P3. Therefore, based upon the case studies and interviews for this paper, the key enablers are people who see possibilities that are not always obvious.

A second enabler identified by respondents is funding and expertise from donor and national development agencies. Without funding or P3 expertise, most P3s will not get off the ground. They are simply too expensive and too complex to be organic or driven by demand from farmers or farmer cooperatives in the developing world. They require outside assistance in the form of money, technology, P3 expertise, product knowledge, and, most importantly, the ability to develop networks around the P3. P3s should be best understood as linking organizations that connect special people, special places, and special processes to develop technologically and market-based solutions to hunger and poverty in the developing world. In each case study, the P3 was the nucleus for developing world-based national or regional value chain, or the focal point for a global network of individuals and institutions dedicated to working with agriculture development in the developing world.

In this analysis, all the global institutions dedicated to agricultural development in the developing world were identified as key enablers. These include Syngenta Foundation for Sustainable Agriculture (SFSA), IDRC, GIZ, USAID, MonsantoFund, The Rockefeller Foundation, and the Howard G. Buffett Foundation, among others. Each organization brought funding and expertise, ranging from scientific to institutional knowledge of crop-based development in the developing world. Based on the interviews, one organization did stand out: The Bill and Melinda Gates Foundation, a recent addition as of 2007. The Bill and Melinda Gates Foundation (BMGF) was identified in a number of case studies as being the difference between failure and continuance of operations. The BMGF added billions in funding in the aggregate to agricultural development. Additionally, the Foundation has hired a staff of development experts that brought a wealth of knowledge to crop-based R&D and value-chain P3s, including, but not limited to, eliminating or reducing FTO issues around plant and process-based technologies. Essentially, the BMGF, due to the scale of its operations, has clarified global rules or norms on freedom to operate issues, making it easier for P3s to effectively engage the public sector, including universities, and the private sector on technology matters.

A third key enabler identified in the interviews was an institutional willingness to experiment by operating outside of their comfort zones. This is related to the first enabler, people. Organizations, both public and private, must be willing to allow employees both to devote time

to personal projects on institutional time and to use institutional resources. P3s are an evolving concept built around collaboration. The focus on the role of individuals in the creation of both R&D and value-chain P3s challenges the literature, as it is not an item that has received much attention; essentially, the literature is silent in this regard. This suggests that P3s are not an institutional response to the challenges of alleviating developing world poverty through agriculture, but rather the result of people recognizing the limitations of the current industrial organization of the global agricultural and developmental structure. In one aspect, the combination of people, places, and processes closely matches the theory of innovation outlined in the introduction. This suggests that individual entrepreneurs in both the public and private spheres are the driving force behind the development of P3s in agricultural development in the developing world. This warrants further research.

#### **5.4.6 The Most Important Lessons Learned by Practitioners of P3s**

It was suggested by the majority of respondents that the problems with food insecurity and poverty are beyond the capabilities of the public and private sectors acting alone; therefore, P3s are the only viable means of creating sustainable technological solutions using agriculture to eliminate poverty. P3s are a growing phenomenon and represent a new organizational model of collaboration built upon personal relationships. P3s depend on commitment and leadership from their partners. Many respondents indicated that, where feasible, P3s are most efficiently constructed by people with experience in developing P3s; these people understand local conditions, the methods of acquiring funding, and how to effectively engage the private sector. It was noted by more than one interviewee that successful P3s are driven by commercially viable goals. Under optimal conditions, P3s create value chains that connect developing world farmers or farmer cooperatives with global agricultural markets.



## 5.5 Analysis

This section summarizes the specific evidence and impressions drawn from the interviews with P3 actors.

The first lesson is that P3s result from building relationships and networks between individuals and organizations. As noted in the theory section, P3s depend on people and personal relationships. Trust, communication, and face-to-face relationships have been identified as the key drivers of P3 creation. All of the P3s analyzed for this paper were formed based upon the zeal and initiative of specific individuals, not as a result of policy or institutional parameters. Relationships that form the bonds of a P3 also permit the P3 to develop the capability to become the nuclei or node that constitutes the center or origins, depending on type of P3—R&D or value-chain—of heterogeneously configured networks.

All the P3s studied are, in one form or another, the glue that holds together networks of dissimilar organizations. This suggests P3s engender the development of horizontally configured networks of organizations with shared interests in delivering technological solutions to small-scale farmers. The technological solutions are a result of the exchange of ideas and creation of new knowledge through the networks of individuals and organizations linked together by the P3. To deliver the innovative technological solutions to developing world farmers, both R&D and value-chain P3s must develop the capacity to effect change. This includes developing the physical, scientific, and governance capacity to permit small-scale farmers to absorb the technology and link to global networks, but it also refers to developing the internal capacity to perform these quite varied and complex tasks.

The second lesson relates to complexity. As P3s are an evolving phenomenon, there are no hard and fast rules governing their development, and there is a discernible dearth of models to emulate. The P3s discussed by the respondents interviewed for this paper were created to address serious global problems of hunger and poverty in the developing world that, to date, are beyond the ability of either the public or private sectors' ability to solve. Complex problems require

complex responses. As P3s are new structures that are not modelled on either public or private organizations, they present unique challenges.

It is difficult to overstate the complexities associated with the dynamics of building relationships with multiple dissimilar partners. One informant stated P3s are like being in a marriage involving at least three unique partners; put another way, this is uncharted territory. The informant noted that the key to a successful marriage is a long courtship. This means that building P3s is expensive and time-consuming, yet holds great promise. Borrowing a phrase from Donald Rumsfeld, P3 developers should beware of the “unknown unknowns,” which are plentiful within P3s. Despite the best efforts of planners and forecasters, respondents noted the difficulty in determining with any accuracy the hidden variables that will add to the complexity of establishing and maintaining a successful P3. These hidden variables include, costs, reporting issues, how the structure and process of the P3 may evolve with additional partners and new missions, and the trial and error process of developing new technologies, including the expenses of managing issues surrounding IPRs.

Despite the above-described challenges, practical solutions to developing and implementing successful P3s have been developed. First, there are experts embedded in a multitude of national, donor, and international organizations and agencies that are familiar with the vagaries of P3s. Organizations such as the Bill and Melinda Gates Foundation, GIZ, USAID, to name a few, possess a vast amount of knowledge and experience with creating and managing P3s. As discussed, many P3s would not exist if not for the activities of P3 experts who bridge the differences between the public and private sectors, and understand the dynamics of acquiring funding from the multitude of funding agencies. Secondly, a clear understanding of the incentives may also present a clear picture of potential constraints to successful operations. Understanding the motivations of all parties that seek involvement with P3 is critical: what does the P3 offer that is unobtainable in the absence of collaboration? Third, structure matters. Developing a plan with clear timelines and specific responsibilities, all directed to targeted outcomes, is highly encouraged. Those working on plans and timelines must do so with the understanding that achieving sustainable operations will take years of effort and funding and will require the support of P3 experts and organizational commitment.

The analysis relates to the current literature in four ways. First, the emphasis by the interviewees on the hidden costs associated with implementing P3s warrants deeper analysis. The literature generally refers to hidden costs as a constraint preventing the formation of P3s. However, most respondents referred to hidden costs from an operational perspective, after the P3 has been formed. The overriding theme from the interviews is that hidden costs are a difficulty that can be managed. However, hidden costs add to both the expense and complexity associated with developing world R&D and value-chain P3s.

As noted, none of the P3s from which the respondents were drawn have achieved successful operations, according to the opinions of those interviewed. This raises the question: are hidden costs of P3s a factor in the slow fruition of achieving positive results? Based on the discussions for this paper, the answer is yes—the hidden costs identified here are a factor in the longer-than-anticipated gestation periods. This is a subject that merits further research and discussion, as there is little mention of this issue in the literature. It bears repeating that agricultural P3s are a new and growing phenomenon in the developing world, which also contributes to the paucity of working models or successful examples.

The second item that warrants further analysis is the role of enablers in creating P3s. Specifically, an analysis of the critical role of individuals with the formation of R&D P3s and the role of specialists in creating value-chain P3s is not found in the literature. As this current paper demonstrates, people matter; without the initiative and insight of key individuals, the P3s that are part of this analysis would not exist. The ramifications of this are profound, as this suggests that policies and institutions are secondary to the role of individuals in identifying innovative, organizational and technological solutions to poverty and hunger. The literature does acknowledge a role for social entrepreneurs in driving organizations in new directions, as earlier discussed. However, this requires more attention; it may also confirm that the public and private sectors, for various reasons, are not capable of developing and implementing solutions to hunger and poverty.

The third item of interest is the role of technology and knowledge in value-chain P3s. Value chain partnerships are dependent on process technologies and non-codified forms of knowledge that influence the ability to generate profits in low-margin commodity exports. Based on the observations brought up in the interviews, value-chain P3s may face limitations in both scale and scope due to the inability of competitors to work together as a number of respondents noted the difficulty in preventing the transfer of proprietary process and product knowledge to competitors. Value-chain P3s may be more complex than the literature suggests, and possibly more difficult to start up than R&D P3s; they require a different non-scientific knowledge to achieve operations. In place of scientific knowledge, value-chain P3s require a technically oriented facilitator who understands local conditions, the operating characteristics of large food distributors, processes of acquiring start-up funding, and global trading patterns. The facilitator requires the requisite ability to identify export opportunities in multiple countries.

Last, while both R&D and value-chain P3s anchor heterogeneous networks critical to delivering technology and capacity to poor farmers, each P3 may need a different style of functioning network at opposite stages of their development. Based upon the responses for this paper, the R&D P3 begins operations on a linear basis by forming relationships depending on its technology needs, generally starting with one partner, and then expanding operations as the process matures and the technology is ready for field trials and distribution to farmers. Conversely, the value-chain P3, by design, immediately begins by developing heterogeneous networks to develop the capacity to educate farmers and to provide farmers and farmer cooperatives with the ability to link to distant and technically sophisticated developed world marketplaces. This suggests that the start-up costs of a value-chain P3 will greatly exceed those of an R&D P3.

Additionally, this paper amplifies previous research on the incentives and constraints influencing the formation of both types of P3s. Most of the issues brought up in the interviews are consistent at some level with existing literature. This suggests that the existing body of research on P3s has identified many of the issues that practitioners of P3s specified as critical to the understanding of P3s. There are a number of factors limiting this paper that provide future research trajectories. First, this is a qualitative analysis conducted with a “silo” perspective, limiting the ability to

draw explicit inferences; thus the contextualized lessons cannot be extrapolated. Second, as discussed, there are a number of biases, including geography, sample size, and the absence of successful and operational P3s, that may influence the interpretations of this study. These limitations provide opportunities for new research methods. This paper, and the study of P3s, can be greatly extended by the use of social network analysis to statistically and graphically illuminate the relationships between the different institutions as well as the different processes that govern and shape the relations between organizations. P3s are part of a large, complex global system of institutions, actors, and relationships that have emergent properties based on feedback loops. This means it is not possible to sub-divide the system into its component parts for analysis without eliminating critical elements that are necessary to the understanding of how the system functions; as such, alternative research methods are required. In the absence of new methods such as social network analysis, it will be extremely difficult address the strengths and limitations of R&D and value-chain P3s in alleviating poverty and enhancing food security in the developing world.

### **5.6 Strategic Implications**

The interview results for this paper lend credence to the descriptions of the multiple functions of an agricultural P3. There can be no doubt that P3s perform the role of an intermediary by linking heterogeneously configured organizations into functioning R&D innovation systems. This conforms closely to the Mode II form of knowledge development, where networks have replaced the vertically organized public and private sector R&D structures as the primary developers of new knowledge. The partnerships in this analysis are also the innovation brokers described earlier, as they provide a structure for the development and implementation of technologically driven innovative responses to poverty and hunger that appear to be beyond the ability of either the public or private sectors to address. In this approach and based on the interviews, the P3 is the structure that connects special people with special processes in special places. This suggests that innovation depends on collaboration, something the P3 is suited for. It further suggests that innovation is dependent upon social entrepreneurs and creative institutions that permit organizational boundaries to be challenged. Therefore, this analysis indicates that P3s are good strategic choices because they provide a structure that mobilizes ideas, individuals, and institutions for the development and implementation of agriculturally oriented and

technologically driven solutions to poverty and hunger at the farm level in the developing world. P3s connect farmers to global markets and global technologies in a manner that public- and private-sector organizations appear to be incapable of accomplishing in the absence of collaboration; this pattern acknowledges limitations to these individual sectors in combating global hunger.

This paper adds to the knowledge of agricultural P3s in six ways. First, this research illuminates how time, complexity, financial reporting, and acquiring financial support are hidden costs of implementing and sustaining P3s. Second, this paper expands the knowledge of the relationships between both R&D and value-chain P3s and network configuration. Third, the requirement for different types of networks at different stages of the development of the P3s suggests that the value-chain P3 requires higher start-up costs. Fourth, we now know more about the critical role individuals occupy in creating R&D P3s and the role of P3 specialists in the formation of value-chain P3s. Fifth, value-chain P3s face unique challenges managing non-codified knowledge and trade secrets, limiting the number of private sector partners per partnership. Sixth, based upon interview data, there appears to be a short-term capacity shortage of scientists, researchers, and P3 specialists involved with developing world agricultural P3s that may inhibit the growth of new partnerships.

There is no off-the-shelf approach or process for developing and implementing P3s. There is a lack of standard practices and an absence of a global institutional method of absorbing and transferring lessons from previous P3 experiences. Without this type of institutionalized support, P3s remain a boot-strap process operating in an institutional vacuum. In the continued absence of institutionalized global learning networks, each P3 will be a standalone process, meaning it will be difficult to develop economies of scale on a global level with agricultural P3s; this significantly limits their potential for alleviating poverty. Developing and implementing P3s, based on this analysis, constitute more of a dark art rather than a science. However, it is clear that both public and private sectors see huge potential in improving incomes and livelihoods, for smallholder producers while simultaneously improving food and nutrition security for the world's poor as the number and variety of partnerships continues to grow. Creating the

institutional capacity to achieve the development objectives of P3s in agriculture remains a global challenge.

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## CHAPTER SIX

### PUBLIC-PRIVATE-PRODUCER PARTNERSHIPS (P4S) IN CANADA

#### 6.1 Introduction

The concept of public–private–producer partnership (P4) is relatively new in the agricultural sector. Some use the commonly applied P3 (public–private partnership) terminology, which is used widely in governments around the world, while others propose it be modified to P4, to more fully incorporate the role of agricultural producers and producer organizations in the partnership. This chapter performs a case-study analysis on four P4s currently in operation in Canada that are representative of this rapidly evolving subset of agricultural P3s that are characterized by the critical role of producer organizations in the structure of the partnership.

P3s are generally defined in the literature and in practice as institutions that involve cooperation between public, private and collective organizations and people (which in other sectors frequently, but not always include primary producers). These collaborative organizations involve sharing risks, cost and resources as well as long-term commitment (e.g., 10 to 30 years). Such partnerships are initiated to pursue shared objectives, and depend on complementarities between partners. The term public-private-producer partnership covers a wide variety of interactions including university-industry-producer association research projects, multi-party and multi-sectoral research consortia and local development programs between small businesses, producers and government. Producer organizations refer to any agricultural-based, product-specific organization that is formed by independent farmers and producers to collectively manage any part of their industry. Typically, producer organizations develop to collect production levies to support R&D and market development activities. P4s spur innovation and may, in general, have advantages over other institutional arrangements at fostering R&D and new product and market development as they link the R&D requirements of producers and their financial resources to market outcomes by involving producers in each stage of the innovation process.

The first case study is the Saskatchewan Pulse Growers, which expands the analysis of this organization as it is discussed in Chapter 3. The second case study is the Centre de

développement du porc du Québec (CDPQ), swine-producer partnership located in Quebec. The third case study is the Okanagan Plant Improvement Corporation (PICO), a specialty fruits partnership located in the Okanagan Valley in British Columbia. The final case study is the Vineland Research and Innovation Centre (VRIC), a recently developed P4 located in Ontario.

## **6.2 Methodology**

Two distinct methodologies were utilized to conduct the case studies. The first was confidential interviews with key personnel in the selected P4s, and the second was a record analysis of all publically available information on each P4. As P4s are dependent on the activities of key people, the interviews were designed to illuminate the constraints and opportunities associated with these partnerships. The interview questionnaire was developed from a detailed literature analysis on previous research on agricultural P3s. Please see Annex C for the questionnaire. The questionnaire was designed to examine three facets of P4s: (1) inputs (background, structures, relationships, resources); (2) processes (business models, funding sources, function and sustainability); and (3) outputs (measures of success, reporting structures, information exchange, dissemination and changes in business practices). These questions provide insights into the challenges and opportunities associated with P4s and link the current research with previous case studies. The objective of conducting one-on-one confidential interviews was to develop a deeper understanding of the challenges and opportunities associated with forming and managing P4s in Canada that could not be derived from other methods. Confidentiality was offered as a number of interviewees indicated they could not permit their statements to be public as the P4s analyzed depend on multiple sources of revenue and on relationships with a wide variety of partners that could be compromised if statements contained in the case studies were directly attributable to the interviewees as current members of the P4s. A total of 17 individuals were interviewed for the four case studies. The record analysis was designed to provide factual information to support and expand upon the findings of the interviews. The organization of the case studies follows the structure of the questionnaire as explained above.

## 6.3 Case Study 1: Saskatchewan Pulse Growers

### 6.3.1 P4 Inputs

The Saskatchewan Pulse Growers (SPG) is a pulse-crop producer association consisting of over 18,000 members who pay a non-refundable production levy to support R&D. A number of factors facilitated the creation of the SPG. The first was the hiring of a pulse breeder from Washington State in the 1960s. The second was the desires by a small number of producers to begin to grow pulse crops in Saskatchewan. In the 1970s, due to rotation schedules surrounding wheat and barley, there was a large amount of acreage devoted to summer fallow; pulse crops, due to their ability to increase soil nitrogen levels, could turn fallow land into productive land. Saskatchewan's soil composition, cool summers and cold winters are conducive to the production of pulse crops. The third was the creation of the Crop Development Centre (CDC) at the University of Saskatchewan in 1971 with a mandate to develop new crops for producers as price pressures on traditional crops such as wheat and barley created an opportunity for Saskatchewan producers to diversify. In 1976 a small group of producers formed the SPG to educate Saskatchewan producers on the benefits of growing pulse crops (SPG, 2012). In 1983 the growing SPG, again led by a small cadre of producers, partially in response to the success of the Washington and Idaho pea and lentil check-off program, worked with the Provincial Government to implement legislation to support the creation of a popular-vote-dependent, non-refundable production levy to support R&D at the CDC (Government of Saskatchewan, 1984). The levy was approved by a vote from the producers and put into effect through provincial regulation (Government of Saskatchewan, 1984). From 1983 until 1997 the levy supported SPG R&D on a contract basis with the CDC.

Government fiscal austerity programs in the 1990s left the CDC without secure funding for its breeding programs. Concurrent to this development was strong growth in Saskatchewan's pulse sector, leading to enlarged check-off funds. The growth in revenues permitted the SPG to enter into negotiations with the CDC for a long-term and exclusive variety development program. From 1984-89, levy revenues averaged \$230,000 per year; from 1990-94, \$435,000 annually; and from 1995-99, \$1.3 million yearly (Gray and Scott, 2003: 9). The producer-run SPG sought access to new varieties without paying royalties or technology user fees (Gray and Scott, 2003:

10). The result of these developments was the Variety Release Agreement (VRA) between the SPG and the CDC in 1997, which formalized the P4 between the SPG and the CDC. The SPG, under the VRA, would receive, in a timely manner and on a cost-effective basis, new and improved pulse varieties without royalty payments. Conversely, the CDC received from the SPG a long-term agreement to support pulse breeding and 320 acres of land to support its breeding program. The VRA, currently in effect, was renewed in 2000 and again in 2005, with the program being extended for fifteen years with \$21,000,000 to be supplied by the SPG to support the CDC program (SPG, 2012). The SPG, through the VRA with the CDC, collaborates with the provincial government, the federal government, other provincial producer associations and international breeders and consumers of pulse crops to provide Saskatchewan producers timely technologies and strategies needed to underpin growth and profitability.

### **6.3.2 P4 Processes**

The SPG is governed by a seven-member board of directors and managed by a staff of 14 specialists. Directors are elected to serve a three-year term with a limit of serving two consecutive terms. Board members must be registered growers of pulses, by having paid a levy in the past two years before seeking election. Companies and organizations that pay levies are permitted to designate a representative for nomination. The board is responsible for policy and strategic direction. It has an advisory group consisting of key members from industry, the provincial government, CDC breeders, Pulse Canada and a number of technology and market specialists to provide research-driven advice. The SPG advisory group creates a two-level partnership with the Saskatchewan Ministry of Agriculture, one at the policy level, the other at the operations level. The board sets the long-term R&D trajectory of the SPG by the allocation of funds between breeding/genetic, agronomy and process and utilization programs. The board of directors is also advised by an R&D committee that reviews all research proposals put forward for board's approval. The SPG receives feedback from producers, brokers, processors and consumers through a number of venues including the Annual General Meeting, the annual Pulse Days—an industry convention—and through its multitude of media outlets.

Through joint committees with the provincial government and the CDC the SPG aligns provincial policy and funding and CDC R&D capabilities with producer levies by anchoring an

innovation system that encompasses the entire value chain from producers to processors and international export markets. Over 90% of Saskatchewan pulses are exported. There are three key organizations: the SPG, the provincial government and the CDC. The provincial government is a key supporter of the CDC by funding a large number of positions and supporting infrastructure. Furthermore, through various programs such as the Agricultural Development Fund (ADF) and grants, the government supports R&D by providing additional and leveraged funding. In 2010-11, the ADF provided \$1.5 million for pulse R&D and \$675,000 for operations at the CDC (SPG, 2012: 11).

In 2010–11 the SPG received \$11 million from the producer levy (SPG, 2012: 21). The SPG spent \$8.6 million on R&D and varietal development, and \$3.5 million on market development and communications (SPG, 2012: 21). In 2010–11, the SPG funded \$17.5 million in 68 new projects. They also committed to providing \$9.1 million to the CDC under the VRA over the next five years (SPG, 2012: 4). The SPG provides about \$900,000 yearly to Pulse Canada for national and international market development and regulatory management. Over the previous five years, the SPG has leveraged its \$32.9 million in R&D spending to acquire an additional \$34.3 million in cash and in-kind contributions to support pulse crop research. In 2010–11, the SPG supported 43 programs and projects related to genetics, 27 in agronomy and 19 in processing and utilizations. The SPG funds R&D at six other Canadian institutions, including the NRC-PBI and is supporting an international genomics sequencing consortium.

The VRA, as noted, was originally signed in 1997 to provide royalty-free access to new varieties. It has been renewed multiple occasions and is now in effect until 2021. Under the VRA, the SPG has become the largest funder of pulse R&D in Canada supplanting the provincial and federal governments as the dominant source of funds (Gray et al., 2008: 11). Since 1997, 95 varieties have been released under the VRA. These varieties included 38 types of lentils, 29 types of pea, 20 types of chickpea, 7 types of bean, and 1 type of faba bean. Two studies on returns to producer R&D, conducted in 2003 and 2008, demonstrated that producers were creating increasing economies of scale from R&D, particularly in genetics, suggesting a need for greater increases in R&D spending to maximize these benefits (Gray et al., 2008: 18). It was suggested that the absence of an IPR regime, in conjunction with the trust generated by the lack of IPRs,



increased the speed and rate of adoption of new varieties by SPG producers, which creates a more efficient and timely process of responding to consumer changes (Gray et al., 2008: 18, 31). Put simply, the SPG/CDC partnership increases the speed of technology transfer by eliminating transactions costs related to IPRs and royalty payments, creating a competitive advantage for SPG producers. This process eliminates the incentive for producers to “brown-bag” seeds, by providing access to certified seeds without royalties or paperwork, which increases the rate of adoption of new varieties and technologies, engendering a more efficient innovation system.

### **6.3.3 P4 Outputs**

There are a number of methods of measuring the output, and success of the SPG. The first are the two studies on producer returns to levy supported R&D. A 2003 analysis demonstrated the SPG received a 13.5-1 (Gray and Scott, 2003: iii) return on levy supported R&D. A 2008 follow-on analysis demonstrated a 15.8-1 (Gray, et al., 2008: 3) return to R&D investments including a 27.2-1 return on genetics R&D. A second measure is the amount of acreage devoted to pulse crops in Saskatchewan. Land seeded in pulse crops grew from less than 200,000 acres in 1984 to 4.73 million acres in 2013. A third measure is the dominance of the SPG in global export markets. In 2011, Canada was responsible for 56% of global lentil exports and 54% of pea exports (Food and Agriculture Organization, 2013). In 2010, Saskatchewan produced 97% of Canada’s lentils and 72% of its peas (SPG, 2012). In 2010, Canada exported \$2.1 billion in pulses, with \$1.8 billion coming from Saskatchewan (SPG, 2010: 7). A final measure of the efficacy of the P4 is the endurance of the non-refundable levy. It has been the subject of a number of votes via plebiscite since its inception in 1983 and has always been sustained. This stands as a long-term measure of producer satisfaction with the levy. Additionally, Alliance Grain Traders, the world’s largest pulse trader has established pulse processing facilities in Saskatchewan and is in the process of establishing an R&D facility in Saskatoon, Saskatchewan. This suggests that the investments in R&D by producers through the SPG have created a feedback loop resulting in downstream investments in processing and R&D facilities.

## 6.4 Case Study 2: Centre de Développement du Porc du Québec

### 6.4.1 P4 Inputs

A number of inter-related factors led to the formation of Centre de développement du porc du Québec (CDPQ). The first was related to long-term reduction in public sector resources allocated to pork R&D that began in the 1970s, and continued until the early 1990s and the creation of CDPQ. One result of the austerity measures was a growing shortage of industry specialists as the provincial government was replacing only one position for every two lost to retirements or departures. The second was a growing demand from provincial producers for R&D leadership due to growing foreign competition. The third was a desire by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) to both centralize all aspects of pork R&D and to transfer the responsibility of managing this to the private sector. The fourth was a need to incorporate the growing field of genetics into R&D for the benefit of Quebec producers. At the time of the formation of CDPQ, the austerity measures had led to a real risk that the swine expertise that had been developed over a period of decades might be lost. This risk was magnified by the potential of missing the benefits of the growing genetics revolution. An industry survey conducted among producers, processors and public servants led to the idea of CDPQ—a non-profit focused on supplying needed R&D expertise to the Quebec swine industry.

In 1992, the CDPQ began operations as MAPAQ transferred responsibility for managing the genetic, health, herd analysis and evaluation tests programs to CDPQ. To help operationalize CDPQ, MAPAQ provided five years of funding at \$1.6 million per year (CDPQ, 2012a). MAPAQ also provided facilities and the general manager to CDPQ. After the first year of operation, based upon negotiations with industry and CDPQ, the MAPAQ began transferring civil servants and public assets related to swine R&D and program management to the CDPQ. The CDPQ was tasked with filling the R&D void; ultimately, the goal was to produce and to develop technological and process innovations for the Quebec swine industry to lower input costs and increase yields for producers.

## 6.4.2 P4 Processes

Currently, CDPQ employs over 50 people with an annual budget of nearly \$5 million (CDPQ, 2012a: 7). The MAPAQ has supplied funding ranging from \$1.175 to \$1.6 million yearly, from 1992 to the present (CDPQ, 2012a). The Fédération des producteurs de porcs du Québec (FPPQ) provides an average \$1.3 million in funding based upon a \$0.10 per head levy on slaughtered hogs. The FPPQ implemented this levy in 2001 as a means of supporting swine R&D (CDPQ, 2012a). CDPQ also receive \$1.12 million per year from selling R&D and technical services to the private sector. This has increased from \$50,000 in the last five years alone. Lastly, the CDPQ manages \$1.0 million in public projects. The CDPQ's funding has evolved considerably in its lifetime, moving from being dependent entirely on public funding, to becoming a value-added swine R&D specialist with multiple sources of funding. There are three primary sources of funds: the MAPAQ, the FPPQ, and from contract research projects for industry and government. It took 15 years to develop the technical and scientific staff and expertise necessary to facilitate this transformation. Last year, CDPQ received funds from 41 different organizations. Out of these 41 organizations, 22 are private, three are academic, 10 are industry or producer associations, and six are public agencies or publicly funded research centres.

Research projects conducted by the CDPQ cover a broad range of areas using a mix of expertise. The search engine that has been developed for the organization's website identifies 11 areas: buildings and equipment; animal welfare and behaviour; economics; use of data; genetics; nutrition, diet and breeding governance; animal health; public health; live animal measuring technologies; meat products and governance of agrifood organizations. In 2011–2012, the board of directors authorized the CDPQ to participate in 12 new R&D projects valued at \$4.6 million (CDPQ, 2012b: 6). From 2007–08 to 2010–11, the board authorized over \$23.5 million in new R&D projects, while the total value of the new and pending projects is \$5.9 million. Besides R&D, the CDPQ produces decision-making tools that aim to help producers and other actors from the swine industry (CDPQ, 2012b: 15–21). For example, the CDPQ offers information related to production costs, price projections and market value. Additionally, competitiveness indicators are developed in order to facilitate benchmarking and comparative studies (CDPQ, 2012b: 20–22). Every year, the CDPQ participates in a study about production costs that is conducted by the FPPQ. Moreover, results from tests in station and herd analyses are used to

develop the indicators. The results allow actors from the swine industry to gain knowledge related to their own performance. The CDPQ works closely with the Canadian Center for Swine Improvement, Ontario Swine Improvement, the Western Swine Testing Association, and the Atlantic Swine Center. The CDPQ is using its expertise in swine genetics to become useful to the beef and sheep industries as the technologies are transferable between the sectors with minimal revision.

For the 2011–2012 year, the active voting members of the CDPQ's board of directors are drawn from various producer associations and other organizations. The president, Normand Martineau, is from the FPPQ. The vice-president is from the Canadian Meat Council. Other board members are drawn from the Quebec Association of Animal Industry and Cereal Producers (Association Québécoise des Industries Animales et Céréalières), the Society of Quebec Hog Producers (Société des Eleveurs de Porcs du Québec) (2 members), the Coop (La Coop Fédérée), The MAPAQ, and the FPPQ (2 members) (CDPQ, 2012b: 4). In addition, the board of directors includes four active non-voting members, one each from Laval University, McGill University, the University of Montreal and AAFC. There six advisors, one each from the Quebec Association of Animal Industry and Cereal Producers, the Society of Quebec Hog Producers, the Coop, the Canadian Meat Council and the FPPQ. There are two permanent board members, both key employees of the CDPQ.

At its core, the CDPQ is a partnership between the MAPAQ and the FPPQ, as together they provide approximately 50% of its budget. From there the CDPQ collaborative model is contract-based determined by the needs of producers, both levels of government and industry. CDPQ uses its expertise to link its various stakeholders into an evolving and iterative innovation value-chain designed to lower input costs and increase yields for its partner organizations. Although primarily focused on the needs of Quebec producers, the CDPQ serves the national swine industry as evident by the wide and national array of partner organizations and funders. The key to the evolution of the CDPQ was the need to develop independent streams of revenue to lessen its dependence on public funding. Interviews indicated that the CDPQ early on experienced difficulties between the short-term focus of public funds versus the longer timeframes associated with developing technologies with market applications. This, along with the introduction of

genetics and structural changes to the swine industry from global competition, provided the impetus for the CDPQ to develop new sources of funding based upon its swine R&D specialization. The CDPQ has developed its own genetics program and its own pure breed herd. As noted above, it took 15 years to develop the internal capacity to create independent R&D and royalty revenues that have only in the past five years become substantial cash flows, increasing from \$50,000 five years ago to the current \$1.12 million, which is about 22% of current 2011-12 revenues (CDPQ, 2012b: 6).

From a financial perspective, the CDPQ remains challenged. The MAPAQ, due to austerity concerns, is generally expected to reduce its level of funding in the near future. Furthermore, the swine industry, in Quebec and nationally, faces pressures from the rising costs of animal feed, namely corn, due to demands from ethanol production, and from the high value of the Canadian dollar, which inhibits exports. Therefore, it is anticipated that both MAPAQ and the FPPQ will both lower their levels of funding. The interviewees acknowledged that in the short-term, year-to-year, this may impact the operations of CDPQ, but noted that the evolution of the CDPQ has always been driven by changes to the structure and process of its funding sources. Therefore, the CDPQ will continue to evolve and develop additional sources of funding related to the needs of its stakeholders. It was suggested the CDPQ will adapt by becoming more efficient from an operations perspective and by becoming more relevant to the needs of industry.

### **6.4.3 P4 Outputs**

The CDPQ has become the center of Quebec's swine industry, replacing a moribund public agency with an industry-centric collaborative business model that through the infusion of producer money and private technologies has created new operating standards for industry by making all aspects of R&D more accountable to stakeholders. The CDPQ connects Quebec producers to the rest of the world in a manner that was unimaginable at its inception 20 years ago. It coordinates the R&D activities for the swine at the direction of producers, consumers and processors while managing and conducting R&D with universities, public laboratories and industry associations. There are a number of measures of success including the continued development of non-public sources of funding, all at some-level dependent upon producing tangible results for stakeholders. The growth in the scale of operations, including the

development of a genetics program and a pure breed herd and the expansion of services offered ranging from public program management to providing scientific, technical and economic services to the swine industry, illustrate how the CDPQ adds value for its stakeholders. The CDPQ turned its challenges (industry recognition and overreliance on public funding) into assets. The key legacy of the CDPQ is its brand name for excellence in swine R&D. The CDPQ must add value through its R&D to remain in operations; in the absence of relevant outputs, its stakeholders would cease funding the CDPQ. As the majority of R&D is conducted on a contract basis, the CDPQ must continually respond to changing market and industry conditions to remain both relevant and solvent.

### **6.5 Case Study 3: Okanagan Plant Improvement Corporation**

#### **6.5.1 P4 Inputs**

The introduction of plant breeders' rights (PBRs) in Canada in the early 1990s provided the impetus to create the Okanagan Plant Improvement Corporation (PICO). PICO was created as a partnership between the British Columbia Fruit Growers' Association (BCFGA) and the Pacific Agri-Food Research Centre (PARC) at Summerland and Agassiz, B.C. AAFC provided start-up capital and provided PICO with office space at PARC. Further funding came from Western Economic Diversification Canada programs and the BCFGAs. The original board of directors included AAFC officials and members of the BCFGAs. PARC also provided land for PICO to develop and operate a rosebud orchard at Summerland, presently the only virus-free rosebud orchard in Canada (PICO, n.d.). The introduction of PBRs led the century-old relationship between the B.C. producers and PARC to become formalized and more financial in nature.

PICO's original mandate was to be the exclusive marketing agent for PARC by licensing new apple, cherry, berry, and soft fruit varieties domestically and internationally. Prior to PICO, PARC supplied varieties primarily for the B.C. soft fruit sector without licensing or PBR protection. The B.C. soft fruit sector lacked the economies of scale to support a domestically funded and managed breeding program. To help offset R&D costs, PICO was tasked with creating an international demand for PARC varieties (Warner, 2012). The B.C. soft fruit sector also faced competitive pressures from Washington State, Minnesota, and upstate New York, all

substantially larger and capable of challenging the market position of B.C. fruit growers, domestically and internationally. B.C. producers found them competing against the lower-priced fruits of Washington State producers, who benefitted not only from economies of scale in R&D and production, but also from direct and indirect subsidies (Sardinha and Steele, 2011: 12). To help protect domestic producers while establishing an international footprint with PBR protected varieties, Canadian producers, under a “Canada First” process, receive varieties for a period of around five to six years before international competitors do; they also pay lower royalties and are not under acreage restrictions as is the case with non-Canadian licensees. Furthermore, if the customers are in the Northern Hemisphere, they may face restrictions on their ability to compete in markets where Canadian producers have an established presence, including but not limited to Canada. Ownership of PARC varieties remain with the Crown and the public share of the royalties are transferred to the treasury by PICO.

#### **6.5.2 P4 Processes**

The original business model and funding structure of PICO changed after five years of operation. Financial problems with the B.C. soft fruit industry forced the BCFGGA to withdraw its yearly operational funding. PICO was re-structured to become a wholly owned subsidiary of the BCFGGA, operating independently of both the BCFGGA and PARC. PICO began applying for and receiving funding from AAFC under the Matching Investment Initiative (MII) program to replace the lost producer funding. As a result, PICO was forced to move its operations away from PARC, as it could not receive federal funding while sharing public facilities. Additionally, the board was re-structured, leaving AAFC without direct input over PICO. The royalty agreement with the Crown was revised to provide PICO with a larger share of the revenues; this allowed PICO to compensate for lost funding, and to support the transition from a marketing agent towards a market-based and consumer-oriented developer of new knowledge and technology. PICO changed its operating mandate to become the exclusive commercialization agent for PARC in Western Canada for tree and soft fruits, and to be an authorized international licensee and distributor of the same products. Additionally, PICO has become the conduit for translating R&D for the benefit of the B.C. soft fruit industry. This transformation occurred because the process of establishing technical proof of new varieties became complex and highly specialized, forcing PICO to adapt by developing and leveraging expertise in PBR management to add value

to the B.C. soft fruit sector. PICO is now a highly specialized R&D and commercialization organization employing seven people; it focuses on the identification, evaluation, propagation, and commercialization activities for both PARC and the BCFGGA. Through relations built with other breeding programs and nurseries, PICO is, on a global scale, positioned to identify varieties and technologies that may be beneficial to the BCFGGA. PICO has identified and commercialized a number of high-value and differentiated products developed outside of PARC, such as the Ambrosia apple. PICO has also commercialized products from New Zealand, Japan, and the United States that have market value for Canadian producers (Ambrosia Growers, 2001: 7). Research has demonstrated consistently that the new varieties bring higher returns to B.C. soft fruit producers (ON Strategy Case Studies, n.d.).

PICO has developed its own R&D program. Presently, PICO receives funding from royalties and from the Growing Forward Program under the Developing Innovative Agricultural Products (DIAP). It is estimated that PICO receives around \$1 million per year from royalties to help fund R&D (Authors estimate from online data and interviews). To manage DIAP and to work with producers and the BCFGGA, PICO has hired a product development specialist who prioritizes the R&D needs of the BCFGGA and links PICO and PARC with other growers associations in Canada to develop economies of scale and create a national growers testing program. PICO also conducts market research, develops marketing strategies, and operates sensory panels to gauge consumer preferences and create products that will meet marketplace acceptance (AAFC, 2012). PICO has been instrumental in working with producers and multiple levels of government in a long-running program designed to replace older trees with higher density trees that produce new varieties with higher margins for producers (Farmwest, 2007: 5–6). In some cases, apple orchard densities have increased by more than 1000% (Farmwest, 2007: 5–6).

Despite the long running relationship among PICO, the BCFGGA, and PARC, there are a number of ongoing concerns about the long-term sustainability of the partnership. First, a number of interviewees expressed concern about the long-term reduction in the number of scientists employed at PARC. It was noted that a recently retired cherry breeder has not been replaced. Cherries are the primary source of royalty income for both PARC and PICO (PICO, 2009). It is estimated that 80% of the cherries grown worldwide come from PARC-developed varieties



(Boparai et al., 2012: 2). This has created producer insecurity—AAFC/PARC have developed a global brand for world-class cherries and some producers are concerned that this could be jeopardized by a lack of public research. Furthermore, it was noted that there are a number of other vacancies at PARC that negatively impact the BCFGAs and PICO. The B.C. industry is entirely dependent upon PARC for new varieties and technologies. The industry asserts that it cannot afford to support its own breeder, and non-Canadian public breeders are unable or unlikely to breed varieties appropriate to the unique Canadian environment.

A second area that feeds insecurity is the mixed and muddled messages AAFC sends to the B.C. soft fruits sector. In a recent Parliamentary Committee meeting on the Agriculture for the Growing Forward 2 program, the past president of the BCFGAs noted that producer associations were concerned by the lack of transparency on the part of AAFC, as a number of time-intensive research proposals were recently rejected based upon unclear ‘11th-hour’ criteria (Sardinha, 2011). This costs producers time and money and it forces producer associations to be wary of any commitment from AAFC as the rules can change and create financial injury through the misallocation of scarce resources. The lack of transparency and the last-minute program and funding changes from AAFC create uncertainty for producers and inhibit producer organizations such as the BCFGAs from making long-term funding and personnel commitments to collaborative projects with AAFC. One item that was repeatedly brought up was the assumption by many producers that the expansion of producer-funded and managed P4s represents a long-term strategy on the part of AAFC to download fiscal responsibility for R&D to producer associations.

The third area of concern relates to the nature of the relationship between PICO and PARC. On its website and documents, and in the confidential interviews with PICO employees, PICO claims to be the exclusive commercialization agent for PARC for the apple, cherry, berry, and soft fruits varieties (PICO, 2012). However, in confidential interviews with AAFC/PARC employees, it became clear that PICO has exclusive rights to apple and cherry varieties for Western Canada only, and has to bid for the right to commercialize PARC varieties in the rest of Canada and internationally in competition with other potential licensees. Therefore, the nature of the relationship is ambiguous as each party has a divergent perspective.

### 6.5.3 P4 Outputs

Despite the above challenges, changes to the structure and funding of PICO, and questions concerning the specific nature of the partnership between PICO and PARC, the relationship has been extremely successful for all parties including the BCFGa. In 2009, PICO was awarded the Federal Partners in Technology Transfer (FPTT) award for Excellence in Technology Transfer from the Government of Canada in recognition of PICO's success in commercializing and distribution of PARC developed cherry varieties. PICO has commercialized over 100 PARC cherry varieties and generated over \$2 million in royalties to AAFC through the development and implementation of over 250 license agreements in Canada and internationally (PICO, 2009). PICO has developed into an international R&D and commercialization hub that links the BCFGa with global markets and varieties. Although PICO works primarily with PARC, it has licensing agreements with a wide variety of private firms and international nurseries. PICO allows the BCFGa to be early adopters of new varieties and technologies providing a competitive advantage in a highly competitive environment. Apple and cherry trees take seven years mature before the first harvest and cost approximately \$20,000 per acre to plant—any breeding error could impose a huge financial loss for producers. Through its R&D, PICO manages this risk for producers. PICO has encouraged the BCFGa to think strategically by offering a long-term approach to innovation: linking upstream R&D with downstream applications and by eliminating the ad hoc approach to technology development and transfer.

PICO represents a new business model for funding and carrying out collaborative R&D. Interestingly, it receives no funding from producers through the BCFGa, and it operates independently of AAFC/PARC. The BCFGa receives no returns from PICO; all revenues from royalties are applied to operations and R&D at PICO in consultation with producers through the BCFGa. As PICO is engaged with AAFC on a number of collaborative funding projects that are guided by a board of directors drawn from the BCFGa, it qualifies as a producer P4. The interviews indicated that PICO has changed how its partner organizations, both formal and informal, conduct R&D; the collaborative and networked approach created by PICO has made all partners more accountable to stakeholders by the constant dialogue over R&D and technology transfer. The BCFGa suggested the industry is dependent on both PICO and PARC for the continual stream of new high value and high margin varieties for its survival.

Measuring the impact and success of PICO is not a direct or simple process. As it enters its third decade of operations, PICO must be considered successful on this measure alone. Additionally, PICO has developed a specialized value-added process that generates relatively independent revenue streams. It was suggested that PICO represents an industry good (or more formally a common-pool good) as cost-effective and risk-free technology transfer is critical to the survival of the industry and the financial performance of individual producers.

## **6.6 Case Study 4: Vineland Research and Innovation Centre**

### **6.6.1 P4 Inputs**

Created in 1906 by an endowment from M.F. Rittenhouse, the Vineland Research Station was mandated to create a soft fruit industry in Southern Ontario through R&D driven by input from growers. Although in 1911, the federal government established a presence at Vineland through The Dominion Entomological Lab, from 1906 to 2007 the Vineland Research Station was the property of the Government of Ontario and in 1945 was renamed the Horticulture Research Institute of Ontario (HRIO) (VRIC, 2010). In 1996, management of Vineland was transferred to the University of Guelph as part of a program of fiscal downloading. Historically, Vineland existed to serve the R&D needs of the soft fruit industry through the directives of its many partners.

By 2006, Vineland (HRIO), due to cutbacks and a lack of strategic direction, had fallen into a state of disrepair, both physically and institutionally. Additionally, the soft fruit industry of Ontario faced challenges related to declining yields, declining profitability, and declining quality of some crops (Vineland Renaissance Project, 2006: 13). These challenges were directly attributed to reductions in R&D investments in the industry, a reduction in the number of scientists employed by HRIO, and the inability to effectively transfer the results of R&D endeavors from Vineland to producers (Vineland Renaissance Project, 2006: 13). The innovation system was too fragmented, as it was based on old bureaucratic silo-based structures, with each sector operating in a system of confederated isolates the overall system, from a holistic perspective, was no longer relevant to the changing needs of government, industry, or

consumers. Essentially, the innovation system that supported the soft fruit industry was in a state of disrepair and was not producing tangible results. A 2008 independent industry analysis, funded by Vineland, confirmed that competitor soft fruit producing regions were more efficient and profitable and thus constituted a threat to the survival of Ontario's fruit sector (Deloitte, 2010: 2). Ontario's system was deemed too fragmented, which inhibited collaboration and led to uncompetitive products and declining market positions from an industry-level perspective (Deloitte, 2010: 3).

As a result, a commission was formed to determine the best method of re-energizing the horticulture industry of Ontario. The primary objective of this study was to find a way to best utilize the existing resources at HRIO to provide a process that would link R&D activities and expenditures to marketplace opportunities while integrating science with sound business practices. To do so, the panel recommended the creation of a not-for-profit and independent innovation centre at Vineland that would become a regional, national, and global hub of horticulture R&D and commercialization (Vineland Renaissance Project, 2006: 26). In contrast to its historic function of serving the needs of its partners and parent organizations, Vineland would become the focal point for creating a horizontally configured innovation system that would systematically identify and rectify the problems contributing to the under-performance of the horticulture sector. The objective was to energize the existing relationships from the multiple levels of government, the various producer and processor associations, and the agriculture schools of Ontario to the consumer with a new model of operation built upon collaboration with a consumer-centric focus. Because the horticultural and soft fruit industry was under financial stress, the costs of creating and operating the not-for-profit would not be transferred onto industry (Vineland Renaissance Project, 2006: 13).

The commission recommended that the Government of Ontario provide \$25 million and transfer the assets of the HRIO to the non-profit. The panel also recommended the creation of an independent board of directors selected with the understanding that the newly minted Vineland Research and Innovation Centre (VRIC) was, in and of itself, an innovation, representing a departure from past business models in agricultural R&D and governance. The funding from the province, along with the ability to leverage the assets at Vineland, would sustain 10 years of

operations and facilities development required to develop revenue streams from commercializing the results of their R&D endeavours.

### **6.6.2 P4 Processes**

Presently, VRIC employs over 70 people working on three core scientific research disciplines: Consumer Insights and Product Innovation; Applied Genomics; and Horticultural Production Systems. These three disciplines support the four strategic research goals: creating new and differentiated horticultural products; driving down production costs; delivering the health and environmental benefits of horticulture; and safeguarding horticultural crops against environmental stress. VRIC is governed by a board of 12 directors drawn from a wide range of critical stakeholder groups. The board is supported by scientific advisory and stakeholder advisory boards. Although the federal and provincial governments are key stakeholders, they are not on the board of directors; this reflects the independence of VRIC.

VRIC has an annual budget of about \$9 million drawn from a wide range of sources. The current accounting system cannot accurately disaggregate expenses from funding sources; therefore, all figures are approximations derived from interviews and the analysis of public data. The core costs of \$3 million come from AAFC and OMARFRA. VRIC receives funding from a multitude of sources. In 2010, VRIC was awarded funding under the Growing Forward Horticulture Clusters program. As part of this agreement, VRIC has assumed the responsibility for administering the national Horticulture Clusters program for AAFC. The Federal- Canadian Agricultural Adaptation Program (CAAP), OMAFRA, and the Federal Development Agency for Southern Ontario (FeDev) constitute the balance of the key sources of program funding for VRIC. VRIC has organized webs of grants and granting as the program manager of an emerging large-scale innovation chain. Last year, VRIC invested over \$4 million in applied R&D (VRIC, 2011: 12–13) and received \$780,000 in industry contributions for research. Revenues from royalty payments were \$150,000 last year; developing this revenue stream is a long-term process requiring time to develop and commercialize agricultural technologies. It is estimated that VRIC has acquired over \$30 million in additional funding since its founding (Authors' estimates from public and private sources).

VRIC is replacing government grants by becoming the program manager and conduit of resources of all types to support the development of the horticulture innovation chain. VRIC has multiple contracts with both AAFC and OMAFRA to administer and manage key programs. Interestingly, VRIC has not changed its core partners, but rather has created a new, open system of innovation that is dependent upon collaboration. VRIC has two levels of partners. The first level consists of a semi-permanent group of government and key institutional stakeholders such as universities and producer groups; the second level is a transient set of partnerships created through contracts and programs. In the new science model being developed at VRIC, technology transfer occurs at the project level. VRIC occupies the gatekeeper role in a growing innovation system consisting of over 30 partner organizations. It uses interlocking projects to leverage national R&D assets to revitalize the horticulture industry and create new markets. VRIC utilizes its unique structure of public program management and private sector investment and engagement, and its consumer-centric focus to engender innovation.

Among the many programs and projects under the umbrella of VRIC, three illustrate the scale and scope of its operations and objectives. The first, the World Crops Program, is developing new crops to meet the demand from the rapidly growing Chinese, South Asian, and Caribbean communities in the Greater Toronto Area. It has been estimated that these communities import over \$700 million worth of vegetables yearly (VRIC, 2012a: 14). VRIC is the center of a large-scale project to develop new locally grown varieties to link the prosperity the Southern Ontario horticulture industry to the changing demographics of Toronto and area. This endeavour is centered upon a network that includes VRIC and producer, processor, and grocers' associations. The second program leverages the robotic and automation technological assets of Ontario, derived from the automotive sector, to increase productivity and cost competitiveness in the horticulture sector. VRIC has created a number of projects, with funding from both public and industry sources, to automate the entire value chain to reduce industry-wide labour and fuel costs (VRIC, 2012b: 8). The third program involves developing a new system of innovation based upon collaboration that can respond to the competitive, technological, environmental, and demographic challenges facing horticulture.

In the interviews, the board of directors stood out above all as the most important structure of VRIC. The board spearheads the governance, expertise, and ideas that provide the foundation for the networks of interdependent relations between science, industry, and consumers. The work of the board provides a means of achieving a new model in agricultural R&D that is neither private nor public, but represents a radical departure from previous top-down models associated with governments and producer associations. The independence derived from the board of agricultural experts has been credited with providing the governance that drives the open and accountable structure of VRIC—a structure that accelerates innovation.

VRIC represents a new business model, but as a part of a new and poorly understood system of innovation with a long-term outlook, it faces some challenges. The first challenge is funding. As the original plan acknowledged, VRIC supplies a public or industry good to a sector that lacks the means of conducting R&D, and therefore it remains dependent on government funding. The timeline for developing plant varieties is sometimes measured in decades, while government programs are much more limited in duration. The second challenge involves conflicts or clashes related to cultures. The evolving horizontally configured and collaboratively based system of innovation that VRIC is tasked with creating and managing runs counter to the silo and bureaucratic system it is replacing. As VRIC is neither public nor private, its methods of operations challenge existing orders, as the old system is not collaborative but rather is vertically integrated; the new scientific model is collaborative, existing in a transient web of inter-linked contracts, projects, and programs. It was noted in the interviews that VRIC and the innovation system it is creating represent the end of the paradigm created in the 1886 Experimental Farms Stations Act and the end of contextualizing agricultural R&D on the public–private dichotomy.

### **6.6.3 P4 Outputs**

VRIC is entering its sixth year of operations. It has met the first objective of revitalizing the Vineland facilities and creating an organization capable of engendering large-scale change. It has created a research staff and has developed multiple programs and processes for creating new markets and improving the efficiency and productivity of the horticulture sector through the application of science. VRIC has changed both the process and structure of R&D. It has centralized the management of R&D management that provides focus; it increased the level of

funding; and it has created a more balanced and focused approach to R&D by linking marketplace needs with research capabilities by making the process of funding more accountable and transparent. The openness generated by the linkages created between stakeholders reinforces the transparent nature of the nascent innovation system.

As VRIC is a work in progress, it is difficult to develop a set of metrics to measure success. In the medium run, success will be determined by the amount of acres and store shelf space devoted to new varieties from the World Crops Program. Other metrics may include the rate of growth, productivity, and profitability of the horticulture sectors of both Canada and Southern Ontario from the endeavours of VRIC R&D. The scientific advisory board has identified the need to develop a quantifiable set of indicators to measure the efficacy of VRIC. This requires developing an internal job-costing and reporting system that segregates operational and overhead costs from project costs. It also requires the creation of measures of the impact of R&D funding to assist governments to assess their role. Personnel, including a Chief Operating Officer, have been hired to create a reporting system capable of measuring the activities of VRIC.

## **6.7 Analysis**

Agricultural P4s in Canada represent a new paradigm in the management and financing of agricultural R&D. There is no one underlying factor behind their ascent in Canadian agriculture; rather, there are a number of inter-related factors responsible for the transformation of agricultural R&D into a range of horizontal governance models. The combined effects of globalization, federal and provincial austerity programs, and new technology and shifting IPR regimes have broken down the boundaries between the public and private spheres of operations. These factors have collectively engendered collaboration in agricultural R&D. One result of these transformations is the growing role of producer associations in the financing and management of agricultural R&D in Canada through the use of P4s. P4s reflect the end of the vertically integrated and hierarchical R&D system centered on a public-private dichotomy and a shift to a new system that is horizontally configured, globalized, and consisting of heterogeneous organizations using dissimilar processes to form innovation networks.



The P4s studied in this chapter depend on some public support, either in the form of money or through the use of public assets and personnel. One item of significance is the length of time it takes to develop alternative sources of revenue either from royalties or from supplying specialized R&D services. In the cases of the P4s in this study, both types of processes took about 15 years to bring to fruition as measured by the changes in cash flows. Government, and in particular AAFC, is critical to the successful formation of the Canadian P4s studied in this report. Although there is a strong organic element to the P4s studied here—at some level each developed due to the actions of a small group of people—governments have the assets and financial tools that are essential for P4 ventures to be successful. In each case, the P4s needed help from governments in the form of grants, annual payments, or the outright transfer of the title of public R&D assets to the partnership, including, in a couple of cases, the transfer of key personnel.

P4s fill a niche that the public and private sectors cannot. The objective of P4s is to commercialize science; therefore, technology transfer is key to their success and survival. P4s in this study integrate science and business by providing new means of collaborating and communicating with stakeholders. This, in turn, helps accelerate the R&D process by linking expenditures with marketplace opportunities. It also makes partners and stakeholders more accountable to each other. P4s provide a strong voice for partners, especially producers who benefit by their early and constant involvement in the R&D process, which is evident in the pulse, and B.C. soft fruit sectors. As a matter of survival, agricultural P4s must develop unique product and process expertise that can be translated into a recognizable brand. Excellence in commercializing R&D is one obvious focus—the CDPQ exemplifies that approach. Additionally, through the R&D process, P4s link disparate partners into coherent innovation systems that stop key actors from being isolated from new ideas and products. Creating high-value products, which create high returns for producers and industry, is a key characteristic shared by the P4s. Collaboration, communication and commercialization all underscore effective technology transfer. In the end, P4s must lower input costs, or increase yields and productivity or create new markets.

## **6.8 Conclusion**

P4s represent a new and unexamined subset of agricultural P3s by shifting the focus from public-private collaboration between governments and/or academia and the private sector to public-private collaboration centered on producer organizations. This study indicates that producer organizations represent a paradigm shift in the financing and management of agricultural R&D and innovation. By utilizing production levies and the governance capabilities of the producer organizations, P4s have developed into a new business model to collectively manage product-specific industries in Canada to fill the void created by public austerity and by the failure of the private sector to respond to the needs of producers.

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## CHAPTER SEVEN CONCLUSION

### 7.1 What Was Known

The origins of P3s can be traced back to a number of inter-related factors beginning with combined effects of public austerity programs and the growth in the acceptance of the neo-liberal and new public management theories that changed the relationship between government and society. Beginning in the late 1970s and continuing to the present, P3s have emerged as organizations to augment and replace government in the financing, construction and management of public infrastructure-goods such as roads, schools and hospitals. Faced with declining revenues and reduced bureaucracies, governments have been forced to partner with the private sector and to adopt private sector management practices in the provision of public-goods. As a result, P3s have merged as both a practice and policy for governments in performing some of their traditional functions.

As the literature analysis in chapter one demonstrated, the study of P3s is also an emerging field of analysis as the majority of the scholarly articles has been published within the last five-years. The primary source of research on P3s is in the public administration/new public management area where the focus has been on the use of P3s as collaborative ventures between governments and the private sector to finance and manage the construction and operation of new infrastructure projects. P3s are characterized as organizations that merge the expertise of both the public and private sectors by the equitable sharing of risk and reward through the establishment of principle-agent relationships. P3s increase the management capabilities of governments by relying on the private sector to finance and management projects, which, in turn, generate profits for the private sector.

In agriculture, P3s developed due to a number of factors, including but not limited to public austerity measures. Again, beginning in the late 1970s and continuing to the present, the public sector, due to ideology and declining revenues, has reduced its involvement in the financing and generation of agricultural R&D. Additionally, the development and implementation of formal IPR and PBR regimes has led to the privatization of formerly public-funded agricultural R&D

programs. In combination, these factors—ideology, austerity, privatization and the new IPR regimes—have created conditions conducive for the use of P3s for the generation of agricultural R&D.

As discussed in chapters one and two, the use of P3s is an established practice in multiple sectors, at the local, national and international levels. This has created a condition where practice exceeds research as the limited number of peer-reviewed articles demonstrates. Specifically, there is a paucity of case studies, limited application of theory to agricultural P3s and a lack of models for analysis. In place of theory there are a number of concepts that provide descriptions and narratives to often only help to characterize agricultural P3s.

Agricultural P3s have been characterized as “innovation brokers” as they link a wide-array of disparate organizations into functional innovation networks that finance and govern the development and introduction of new agricultural technologies. P3s have emerged to address the complexity in agricultural R&D; neither the public nor private sectors are able to succeed without collaboration. Furthermore, P3 growth also has responded to the emergence of self-governing producer organizations that do not conform to the public-private dichotomy that once characterized agricultural R&D.

## **7.2 What We Have Learned**

This research offers eight advancements to the theory of agricultural P3s.

First, agricultural R&D is being transformed from a vertically structured process based upon a public-private dichotomy to a horizontally configured process operating on a global basis with a wide range of hard-to-categorize actors that challenge the public-private perspective.

Agricultural P3s, based upon the results of this study, appear to be best suited to meeting the challenges of this transformation. Specifically, the collaborative structure of P3s permits these organizations to act as gatekeepers controlling the flow of money, ideas, technologies and key personnel in R&D oriented innovation networks. It has been demonstrated that P3s frequently perform the role of innovation brokers by providing the structural nuclei of a number of dissimilar innovation networks operating at national, regional and global levels of operations.

Due to their collaborative structure and process, agricultural P3s also provide an evolving business model to link users of R&D, primarily self-organized and self-governed producer organizations in the developed world and a wide range of hard-to-define organizations operating in the developing world, to the capabilities of public and private agricultural research centers. P3s perform a variety of functions that control the generation of R&D for food security. While many agricultural P3s emerged as a means of replacing lost public funding of R&D, they have evolved into collaborative models that accelerate the R&D process by capitalizing on the core competencies of their partners, creating economies of scale and scope from collaboration that appear to be unobtainable in traditional management systems.

Second, as P3s link dissimilar institutions and networks into coherent and functioning innovation networks, the evidence suggests that the use of agricultural P3s can confer a competitive advantage on users at the national and international levels of operations. As agricultural R&D is being transformed from a linear supply-push model to a spiral and networked demand-pull model, P3s in this study integrate science and business by providing new means of collaborating and communicating with stakeholders. This, in turn, helps accelerate the R&D process by linking expenditures with marketplace opportunities and requirements. It also makes partners and stakeholders more accountable to each other. P3s provide a strong voice for partners, especially users who benefit by their early and constant involvement in the R&D process. This, in turn, leads to higher returns from investments into R&D and a more efficient and transparent method of technology transfer.

Third, agricultural P3s appear to be best suited for operating in orphan crops and largely ‘empty’ spaces that for a variety of reasons are ignored or overlooked by both the public and private sectors. As this study suggests, agricultural P3s have emerged to fill gaps in the financing, management and generation of R&D that have been created due to evolving IPR/PBR regimes, privatization and downloading programs and the inability of public or private actors to respond adequately to the challenge of food security in the developing world. Specifically, P3s fill niches that are beyond the ability of traditional organizational models and existing policy responses.

Fourth, due to the diversity of partners and functions there is no standard agricultural P3; rather their structure is entirely dependent upon the attributes of the partners, and the purpose of the partnership—technology transfer, capacity development, financing of R&D, development of R&D networks or the creation of global value-chains, or the creation of a new agricultural sector. As demonstrated, and to be explored below, P3s develop as a result of the work of individuals responding to intractable problems by mobilizing networks of insiders. Therefore, the structure of P3s is dependent upon the type of partners—producer associations, public sector agencies, philanthropic organizations, NGOs, IGOs, and private sector partners. Furthermore, the objective of the P3 also determines the structure and the type of network surrounding P3s. This study identified and categorized a number of application-specific P3s. The producer P3, common to the developed world in a number of sectors including pulses and canola, which specializes in the financing and commercialization of R&D are organic partnerships created by users responding to market failures. The development P3, common to the developing world, where capacity development often precedes technology transfer are the result of a wide-array of organizations dedicated to the challenge of food security and the task of market-making. The inter-governmental P3, where the primary partners are national R&D bodies collaborating with a wide range of public and private partners are more about non-market coordination. P3s may be further delineated by their purpose, be it for the development of R&D, to develop technical and political management capacity or to construct global food supply-chains or commodity suppliers.

Fifth, agricultural P3s, more often than not, are created due to the efforts of a small group of individuals who through experience and insider knowledge recognize opportunities for collaborative R&D ventures. While theories of institutional design and incentives provide some insight into this, there are undoubtedly some quite idiosyncratic aspects to most venture. P3s are not only the result of policies and programs; chance and circumstance are almost always part of the story. As demonstrated, there is evidence to support the claim that the creation of P3s is dependent upon organizational boundary pushers—also known as social entrepreneurs—people using insider connections and knowledge to develop hybrid responses to problems related to food security and agricultural R&D that are beyond the capability of existing policies, programs and actors. Additionally, there is a growing body of evidence that indicates that the use of P3s specialists may be an area that warrants further analysis, particularly for the use of P3s in the



developing world where the lack of organizational and technical capacity may hinder collaboration. Given the critical role of leadership in these ventures, public and international agencies are advised to focus on creating incentives and processes to help identify individuals with the vital leadership qualities that increasingly personify exceptional partnerships by leadership.

Sixth, P3s are expensive, have high transaction costs and require large upfront capital investments in people, processes and facilities. They are rarely the products of privatization of formerly publicly funded R&D operations; instead, generally they are new and emerging collaborative business models that transcend the public-private dichotomy. They are vulnerable to the vagaries of their partners—particularly funding agencies—for their survival. Agricultural P3s are particularly vulnerable to disruptions in cash flows as these organizations operate on R&D timelines that can be measured in the decades while most governments, granting agencies and foundations operate on much shorter periods, sometimes year-to-year.

Seventh, agricultural P3s have long gestation periods as the development and commercialization of agricultural R&D, especially in the plant-sciences, is a process that can take years from concept to field testing, regulatory approval and commercialization. Many P3s need to build rather than buy the core capabilities that support the R&D and commercialization process, adding to the time it can take to generate market-ready products that deliver cash flow. Therefore, agricultural P3s are high-risk ventures characterized by uncertainty. In place of providing specific infrastructure projects such as roads or hospital—common to the literature of generic P3s—agricultural P3s are created to generate R&D based technological innovation as part of a value-added process where the returns on investments are difficult to calculate and it is uncertain if or when they may be realized.

Last, the complexities associated with creating and managing agricultural P3s may hinder their development. As discussed above, P3s are heavily contextualized organizations defined by their partners and objectives, so that each model is somewhat novel, which limits the ability to copy or emulate. Each P3 faces multiple challenges in building and sustaining relationships with partners with dissimilar institutional characteristics, especially facing the constant challenge of

securing funding and meeting the unique and varied reporting requirements of a multiplicity of granting agencies, and often the dissimilar conditions from operating on multiple continents. The literature is deficient in regards to these challenges.

This thesis also contributes to our methodological tool-kit for analyzing P3s.

The methodologies used in this research advance the knowledge of the analysis of agricultural P3s. Social network analysis (SNA) provides an analytical tool to graphically and statistically measure the function of P3s in a networked environment. As agricultural P3s are a part of an emerging complex of organizations and institutions that increasingly depend upon collaboration in all phases of the generation of R&D, SNA is a tool that can illuminate relationships, networks and sub-networks and processes that govern technological innovation. Specifically, SNA provides a quantitative and hypothesis-based tool for evaluation that can identify, categorize and ordinally rank organizations, networks and processes to provide a deeper understanding of the complexities associated with the use of agricultural P3s in the R&D process that previously eluded researchers. SNA can also be employed to identify, operationalize and measure variables such as ideas, terms and theoretical concepts that impact or influence relational-based and collaborative agricultural R&D.

For example, the use of a bibliometric model to evaluate and measure the impact of collaboration on the generation of R&D in a fast-evolving system characterized by new organizations and processes is novel. It allows the isolation and evaluation of key variables such as the number of collaborative partners and the institutional configuration to determine their impact on knowledge dissemination and technology transfer. This makes it possible to identify emerging trends that influence the generation of R&D. It also permits the use of comparative measures as evidence to assist in resource allocation decisions.

### **7.3 Policy Implications**

This research leads to at least five policy insights.

1. P3s should not be viewed as a tool for downloading or the privatization public agricultural R&D programs. Although their origins can be traced back to a number of

factors related to privatization, they represent a new paradigm in the generation of R&D for food security. P3s represent a new paradigm in agricultural R&D and innovation based upon collaboration and interconnectedness. The public–private dichotomy that ruled agriculture no longer applies in a globalized environment characterized by public austerity. They are expensive and high risk institutions that operate in spaces where neither the public nor the private sectors operating alone appear to be well suited. As such, they should only be considered for high risk ventures related to R&D, market and product development, and technology transfer when market failures are in evidence.

2. New tools and policies for developing incentives to create and operate P3s are needed. Agricultural P3s are not primarily the result of overt policy and programs, but rather the result of the initiatives of well-placed and motivated individuals. P3s appear to be personified by leadership from industry experts who can recognize and respond to opportunities. This suggests that incentives, not programming, may be a more important variable for triggering new P3s for agricultural innovation. The caveat is that there appears to be shortage of P3 experts, particularly in the developing world. Many of these social entrepreneurs emerged from public and private agricultural research systems—now that many of them have folded into these often scarcely resourced P3s, the supply of motivated, skilled and networked individuals may dry up.
3. Public policy in the agricultural R&D space, in both the developed and developing world, may need to be revised to reflect the growing importance of collaboration between the mix of sectors, including public, private, producer and philanthropic. The evidence in this study suggests that trust and transparency are becoming critical determinants that govern the generation and dissemination of technological solutions to food security. Governments have yet to respond to the changed culture and norms.
4. Long-term financial and technical support is vital for the successful development of P3s. As discussed, agricultural P3s have long gestation periods due to the uncertainties of research and the related processes for commercialization of science. It appears from this work that the duration and security of funding is of greater importance than the short-term scale of contributions.
5. In the developed world, agricultural P3s provide both the incentive and structure for producer organizations to fund and manage the R&D process. These institutions link

producer investments with public and private assets and research capabilities and in turn coordinate industry and government priorities. P3s have forced producer associations to think strategically, considering both upstream investments and downstream commercial applications, thereby facilitating a long-term and systematic approach to innovation. In the end, P3s have proven to be critical to the successful commercialization of many publicly funded technologies and to represent an attractive policy instrument for the creation of new markets. The Canadian experience in both the pulse and canola sectors highlights the potential.

#### **7.4 Limitations**

1. The study of agricultural P3s is limited by the confidentiality of the operations of P3s. As discussed in chapters 5 and 6, a number of factors regarding the protection of operational secrets and the desire for anonymity during interviews of key employees and stakeholders illuminate this challenge to researchers. As each P3 is engaged in competitive market operations, there is a strong tendency to limit access to any R&D or operational process that may provide competitors with information and insights that could harm the P3 being investigated. The additional desire for anonymity on the part of employees and stakeholders also highlights this limitation. One key reason for confidential interviews is to prevent statements from being attributed to the interviewees, as each P3 is dependent upon material and financial support from a wide range of organizations that could use any perceived slights as a reason for changing their support; the possibility of misunderstandings is an ever-present threat in this digital era.
2. Despite the use of quantitative tools in this dissertation, to a degree, all case studies on agricultural P3s do have a narrative-based element to them. This means we know their story—how they formed and what opportunities and constraints affect their operations—but we are unable to directly observe processes such as decision making and dealing with problems unique to P3s (such as those that were discussed in chapters 5 and 6). Therefore, there may be institutional and cognitive gaps in their operations that is beyond the view of researchers.

## 7.5 Directions for Future Research

1. There is a need for the development of econometric models to empirically measure the return on investment on agricultural P3s. Greater knowledge on the economic returns from P3s would enable policy-makers and researchers to determine when P3s are a better model for generating agricultural R&D than traditional public or private organizations. The work on this dissertation suggests that such an analysis would need to take into account that P3s don't just replicate the roles of government or industry but do tasks that neither can do. However, in the absence of a large-scale analysis comparing the returns from P3s to other public investments in agricultural R&D it will be difficult to assess when the use of P3s is warranted.
2. As discussed, there is a plethora of hard to-categorize P3s in operation delineated by the composition of partners, by the R&D objectives, and by sector. As noted in this research, there are hundreds of agricultural P3s in operation on a global scale. Therefore, there is a need for a sharper typology that categorizes P3s from more of an analytic perspective. This would be a significant undertaking that would require the identification of all funding, research, philanthropic, public and private partners involved in each P3. This will allow the development a typology of P3s that include the function, size, number of partners, types of different partners, and by geographic location and type of network. Interestingly, SNA would provide the analytic tool to both advance this much needed task and then to analyze the network effects of such systems.

## APPENDICES

### Appendix A: List of and coding for organizations in Chapter Three

<b>Actor</b>	<b>Location</b>	<b>Institution Type</b>	<b>Network</b>
GRDC	Australia	P3	Export
PBA	Australia	P3	Export
SARDI	Australia	Government	Export
VDPI	Australia	Government	Export
NSWDPI	Australia	Government	Export
QDPIF	Australia	Government	Export
DAFWA	Australia	Government	Export
ICARDA	CGIAR	P3	Global
ICRISAT	CGIAR	P3	Global
CLIMA	Australia	P3	Global
ACIAR	Australia	Government	Export
COGGO	Australia	P3	Export
CDC/SPG	Canada	P3	Global
Pullman-ARS	USA	Government	Export
CSIRO	Australia	Government	Global
U of Adelaide	Australia	University	Export
NPBP	Australia	P3	Export
Muresk Inst.	Australia	University	Export
NDSU	USA	University	Export
GCI-S Africa	S Africa	Government	Export
MSU	USA	University	Export
Prosser-ARS	USA	Government	Export
U of Wis	USA	University	Global
CIAT	CGIAR	P3	Global
CSU	USA	University	Export
U of Idaho	USA	University	Export
U of Guelph	Canada	University	Export
NRC	Canada	Government	Export
AAFC-Saskatoon	Canada	Government	Export
AAFC-Morden	Canada	Government	Export
AAFC-Lacombe	Canada	Government	Export
IH AAFC	Canada	Government	Export
IOA	Australia	Government	Export
WAHRI	Australia	P3	Export
FFICRC	Australia	P3	Export
Tasmanian Inst Agr Res	Australia	Government	Export
Punjab Agr Univ	India	University	Export
UWA	Australia	University	Export
U of NFLD	Canada	University	Export

Guelph AAFC	Canada	Government	Export
MII AAFC	Canada	P3	Export
SC AAFC	Canada	Government	Export
Purdue	USA	University	Export
New Mexico	USA	University	Export
Montana State Univ	USA	University	Export
Scott AAFC	Canada	Government	Export
Univ Manitoba	Canada	University	Export
Univ Alberta	Canada	University	Export
AAFRD	Canada	Government	Export
ACIDF	Canada	P3	Export
APGC	Canada	P3	Export
WGRF	Canada	P3	Export
Northern Pulse Growers	USA	P3	Export
CILR	Australia	P3	Export
John Innes	UK	P3	Global
NC State	USA	University	Export
Queensland U	Australia	University	Export
ANU	Australia	University	Export
U of Newcastle	Australia	University	Export
U of Melbourne	Australia	University	Export
KDNARI	Japan	Government	Export
USDA-STPaul	USA	Government	Global
CLAN	Asia	P3	Developing
FIA	Austria	Government	Developing
AGERI	Egypt	Government	Developing
MTT	Finland	Government	Developing
DSMZ	Germany	Private	Developing
University of Frankfurt	Germany	University	Global
University of Hannover	Germany	University	Global
CRA	Italy	Government	Developing
UC Davis	USA	University	Global
TIGR	USA	Private	Global
IFPRI	Spain	P3	Developing
Egypt NARS	Egypt	Government	Developing
Tunisia NARS	Tunisia	Government	Developing
Ethiopia NARS	Ethiopia	Government	Developing
BARC	Bangladesh	Government	Developing
ICAR	India	Government	Developing
PARC	Pakistan	Government	Developing
Morocco NARS	Morocco	Government	Developing
AREEO	Iran	Government	Developing
Turkey NARS	Turkey	Government	Developing
Aleppo University, Syria	Syria	University	Developing
BAU	Bangladesh	University	Developing

Rajshahi University, Bangladesh	Bangladesh	University	Developing
Alemaya University, Ethiopia	Ethiopia	University	Developing
GAU	Georgia	University	Developing
LARI	Lebanon	Government	Developing
CRIDA	India	Government	Developing
NCPGR	India	Government	Developing
CAAS	China	Government	Developing
CRIFC	Indonesia	Government	Developing
DAR	Myanmar	Government	Developing
NARC	Nepal	Government	Developing
PCARRD	Philippines	Government	Developing
SLDOA	Sri Lanka	Government	Developing
DOAT	Thailand	Government	Developing
MARDV	Vietnam	Government	Developing
MARY	Yemen	Government	Developing
NCPGR India	India	Government	Developing
NRCPB	India	Government	Developing
IARI	India	Government	Developing
SVPUAT	India	University	Developing
TLP	CGIAR	P3	Developing
EIAR	Ethiopia	Government	Developing
LZARDI	CGIAR	P3	Developing
Gates Foundation	USA	P3	Developing
IIPR	India	Government	Developing
PBI-CA Univ Germany	Germany	University	Developing
BMZ	Germany	Government	Developing
KVL	Denmark	University	Developing
PRC	Bangladesh	Government	Developing
BARI	Bangladesh	Government	Developing
U of Helsinki	Finland	University	Developing
BAZ	Germany	Government	Developing
U of Wolverhampton	UK	University	Developing
U of Gottingen	Germany	University	Developing
CSIC	Spain	Government	Global
IFAPA	Spain	Government	Global
NYRC	Israel	Government	Developing
U of Greenwich	UK	University	Developing
Wageningen University	Netherlands	University	Global
IAMZ	Spain	Government	Developing
ISA	Spain	Government	Developing
UC-Riverside	USA	University	Developing
WARDA	CGIAR	P3	Developing
IRRI	CGIAR	P3	Developing



INRA HQ	France	Government	Global
GLIB/FP6/FP7	EU	P3	EU
INIFAP	Mexico	Government	EU
GenXPro	Germany	Private	EU
Svetošimunska 25	Croatia	Government	EU
Universita di Pisa	Italy	University	EU
U.P.M.	Spain	University	EU
C.B.G.P	Spain	Government	EU
CNRS	France	Government	EU
Bielefeld University	Germany	University	EU
AEP	France	P3	EU
MPI	Germany	University	EU
GCNRG	France	Government	EU
TWTSInT	UK	P3	EU
JWGU	Germany	University	EU
University of Dundee at SCRI	UK	University	EU
BRC	Hungary	University	EU
Animal Sciences Group	Netherlands	University	EU
University of Córdoba	Spain	University	EU
MIPS	Germany	University	EU
Schothorst Feed Research	Netherlands	Private	EU
UAAR	Denmark	University	EU
SWRSAA	Switzerland	Government	EU
FIB	Belgium	Government	EU
IPK	Germany	Government	EU
RISØ	Denmark	Government	EU
IVV, Fraunhofer Institute	Germany	P3	EU
NARCN	Norway	Private	EU
ESA	France	University	EU
PRI-NETH	Netherlands	P3	EU
ILB	Sweden	P3	EU
PAS	Poland	Government	EU
University of Leon	Spain	University	EU
CLS	UK	Government	EU
University of Sevilla	Spain	University	EU
IBMC	Portugal	University	EU
CEREOPA	France	University	EU
NIAB	UK	P3	EU
UPN-SP	Spain	University	EU
CESFAC	Spain	University	EU
CZU	Czech Republic	University	EU
University of Reading	UK	University	EU
IGER	UK	University	EU
UNIP	France	P3	EU

PBAI	Poland	University	EU
ARO	Israel	Government	EU
ABIO	Bulgaria	Government	EU
AEL	Spain	Government	EU
University of York	UK	University	EU
Murdoch University	Australia	University	EU
IG-ABC	Hungary	Government	EU
IRM	Italy	Government	EU
University of Ghent	Belgium	University	EU
GL-TTP	France	P3	EU
ADAS	UK	Private	EU
ARRIAM	Russia	Government	EU
FAKS	Egypt	University	EU
FAN	Gaza/West Bank	University	EU
IAV	Morocco	University	EU
INRAT	Tunisia	University	EU
EMBRAPA	Brazil	Government	EU
UCB	Brazil	University	EU
SIPPE	China	Government	EU
University of the Witwatersrand	S. Africa	University	EU
ITQB	Portugal	Government	EU
PCGIN	UK	P3	EU
PGRO	UK	P3	EU
CIMMYT	CGIAR	P3	EU
APPO	Belgium	P3	EU
UFOP	Germany	P3	EU
EC	EU	Government	EU
IITA	CGIAR	P3	EU
DEFRA	UK	Government	EU
LESP	France	University	EU
UFPE	Spain	University	EU
IBRC	Japan	Government	EU
FST U of Tunis	Tunisia	Government	EU
Université de Nantes	Italy	University	EU
LM Univ Munchen	Germany	University	EU
U of MN	USA	University	EU
LSPPPBV	France	Government	EU
U of Oxford	UK	University	EU
PPRI	S. Africa	Government	EU
USD	Algeria	University	EU
Université d'Abobo-Adjamé	Ivory Coast	University	EU
Université de Picardie	France	University	EU
INP-ENSAT	France	Government	EU
Limagrain	France	Private	EU

Wherry & Sons Ltd	UK	Private	EU
SR Noble	USA	P3	EU
IPG-BZFAR	Hungary	P3	EU
Stanford University	USA	University	EU
Nancy University	France	University	EU
NKMU	Taiwan	University	EU
University of Georgia	USA	University	EU
CBBC	Tunisia	Government	EU
NPZ	Germany	Private	EU
BioPlante	France	P3	EU
Serasem	France	P3	EU
Agrovegetal SA	Spain	Private	EU
Array-On GmbH	Germany	Private	EU
ITACyL	Spain	Government	EU
Saatzucht Steinach GmbH	Germany	Private	EU
U of Valladolid	Spain	University	EU
Angers INRA	France	Government	EU
Dijon INRA	France	Government	EU
Montpellier INRA	France	Government	EU
Nantes INRA	France	Government	EU
Poitou Charentes INRA	France	Government	EU
Rennes INRA	France	Government	EU
Toulouse INRA	France	Government	EU
Versailles-Grignon INRA	France	Government	Global
UMR-LEG Bretenieres INRA	France	Government	EU
Lusignan INRA	France	Government	EU
Mauguio INRA	France	Government	EU
Castanet-Tolosan INRA	France	Government	EU
ILM	France	Government	EU
Agrovegetal SA	Spain	Private	EU
Array-On GmbH	Germany	Private	EU

## Appendix B: Formulation of the Negative Binomial Distribution<sup>7</sup>

$$(1) PR(Y = \gamma | \lambda, \alpha) = \frac{\Gamma(\gamma + \alpha^{-1})}{\gamma! \Gamma(\alpha^{-1})} \left( \frac{\alpha^{-1}}{\alpha^{-1} + \lambda} \right)^{\alpha^{-1}} \left( \frac{\lambda}{\alpha^{-1} + \lambda} \right)^\gamma$$

$\Gamma$  = gamma function;  $\lambda$  = mean or expected value of negative binomial distribution;  $\alpha$  = over dispersion parameter.

Likelihood function for the negative binomial model:

$$(2) L(\beta | y, X) = \prod_{i=1}^N \Pr(y_i | x_i) = \prod_{i=1}^N \frac{\Gamma(y_i + \alpha^{-1})}{y_i! \Gamma(\alpha^{-1})} \left( \frac{\alpha^{-1}}{\alpha^{-1} + \mu_i} \right)^{\alpha^{-1}} \left( \frac{\mu_i}{\alpha^{-1} + \mu_i} \right)^{y_i}$$

where  $\mu_i = E(y_i | x_i) = \exp(x_i \beta)$

---

<sup>7</sup> See Cameron and Trivedi, 2008 pages 100-102; and UCLA, 2007 pages 4-7.

```

. poisson TimesCited Fund_2 Fund_3 Fund_4 MII_2 Prod_2 Comb
Iteration 0: log likelihood = -1027.9866
Iteration 1: log likelihood = -1027.9854
Iteration 2: log likelihood = -1027.9854

Poisson regression              Number of obs =      205
                               LR chi2(6)         =     113.31
                               Prob > chi2         =     0.0000
Log likelihood = -1027.9854    Pseudo R2          =     0.0522

```

TimesCited	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
Fund_2	.5442039	.1003992	5.42	0.000	.347425 .7409827
Fund_3	.8418488	.1085454	7.76	0.000	.6291038 1.054594
Fund_4	.6671167	.1158973	5.76	0.000	.4399623 .8942712
MII_2	.1183992	.12468	0.95	0.342	-.1259691 .3627675
Prod_2	.0658009	.10335	0.64	0.524	-.1367614 .2683632
Comb	.1869656	.0894654	2.09	0.037	.0116166 .3623145
_cons	.958277	.0768645	12.47	0.000	.8076254 1.108929

```

. nbreg TimesCited Fund_2 Fund_3 Fund_4 MII_2 Prod_2 Comb, robust

```

```

Fitting Poisson model:

```

```

Iteration 0: log pseudolikelihood = -1027.9866
Iteration 1: log pseudolikelihood = -1027.9854
Iteration 2: log pseudolikelihood = -1027.9854

```

```

Fitting constant-only model:

```

```

Iteration 0: log pseudolikelihood = -539.45029
Iteration 1: log pseudolikelihood = -521.05894
Iteration 2: log pseudolikelihood = -521.04516
Iteration 3: log pseudolikelihood = -521.04516

```

```

Fitting full model:

```

```

Iteration 0: log pseudolikelihood = -515.51588
Iteration 1: log pseudolikelihood = -515.12609
Iteration 2: log pseudolikelihood = -515.12316
Iteration 3: log pseudolikelihood = -515.12316

```

```

Negative binomial regression      Number of obs =      205
Dispersion = mean                 Wald chi2(6)      =     13.06
Log pseudolikelihood = -515.12316 Prob > chi2       =     0.0421

```

TimesCited	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]
Fund_2	.5646162	.3786179	1.49	0.136	-.1774612 1.306694
Fund_3	.8593384	.3439631	2.50	0.012	.1851831 1.533494
Fund_4	.6934953	.3503017	1.98	0.048	-.0069165 1.380074
MII_2	.0942558	.488082	0.19	0.847	-.8623674 1.050879
Prod_2	.0284211	.3367385	0.08	0.933	-.6315744 .6884165
Comb	.1350114	.2860519	0.47	0.637	-.42564 .6956628
_cons	.9605032	.2118731	4.53	0.000	.5452395 1.375767
/lnalpha	.6314984	.1439743			.3493139 .9136829
alpha	1.880426	.2707331			1.418094 2.493489

```

. fitstat

```

```

Measures of Fit for nbreg of TimesCited

```

```

Log-Lik Intercept Only:      -521.045      Log-Lik Full Model:      -515.123
D(197):                      1030.246      LR(6):                  11.844
                               Prob > LR:          0.066
McFadden's R2:              0.011      McFadden's Adj R2:      -0.004
Maximum Likelihood R2:      0.056      Cragg & Uhler's R2:     0.056
AIC:                         5.104      AIC*n:                  1046.246
BIC:                         -18.387      BIC':                   20.094

```

```

. nbreg TimesCited Fund_2 Fund_3 Fund_4 MII_2 Prod_2 Comb, robust irr

```

```

Fitting Poisson model:

```

```

Iteration 0: log pseudolikelihood = -1027.9866
Iteration 1: log pseudolikelihood = -1027.9854
Iteration 2: log pseudolikelihood = -1027.9854

```

```

Fitting constant-only model:

```

```

Iteration 0: log pseudolikelihood = -539.45029
Iteration 1: log pseudolikelihood = -521.05894
Iteration 2: log pseudolikelihood = -521.04516
Iteration 3: log pseudolikelihood = -521.04516

```

```

Fitting full model:

```

```

Iteration 0: log pseudolikelihood = -515.51588
Iteration 1: log pseudolikelihood = -515.12609
Iteration 2: log pseudolikelihood = -515.12316
Iteration 3: log pseudolikelihood = -515.12316

```

```

Negative binomial regression      Number of obs =      205
Dispersion = mean                 Wald chi2(6)      =     13.06
Log pseudolikelihood = -515.12316 Prob > chi2       =     0.0421

```

## Appendix C: Questionnaire for Chapter Six

### I. Background Information (P4 Inputs)

1. Please tell us a bit about your public private partnership.
  - *[PROMPT: date est, expected duration, size, # partners / names of players, #employees, location(s), scope of operations]*
2. What were your goals/priorities in selecting your P4 partners?
3. What is the overarching mandate of your P4? *[PROMPT: functional priority]*
4. How did your P4 evolve? *[PROMPT: out of previous/historical relationships, did one of the partners lead the process? Was it incited through external incentives – if so, which?]*
5. Does your P4 conduct and/or support research in any form? If applicable, please tell us about your current research program. *[PROMPT: how funded (grant, industry, other, in kind contributions)? Scale, scope]*
6. Do you collaborate with other organizations/firms that are NOT formally part of your P4? If so, describe.
7. What is the nature of your collaborative model(s)? Are they forced or based upon a history of relationships? Who is your most important (NON P4) collaborator?  
*[PROMPT: terms]*
8. How did you find / select / negotiate with your current list of stakeholders/partners?
  - Seeking (informal, historical relationships, etc or ‘tender’)
  - Formalizing strategies
9. Who do you view as your P4’s primary stakeholders?
10. Please describe a typical day/week/cycle in your organization.

### II. P4 Processes

11. What are the main incentives for your partners to be involved in this P4? *[PROMPT: access to new knowledge, new product offerings, funding, new markets, etc]*
12. In your opinion, what are the best practices to employ when establishing a public private partnership?

13. What do you view as the main obstacles to the long-term sustainability of a P4? Does long term sustainability matter?
14. How is your P4 funded? Has the funding mechanism changed or will it change over its life?
15. What is the role of government in these types of arrangements? *[PROMPT: observer, funder, supporter, steerer, full-on partner]* Will government remain a major component or operator in your organization or will that change over time?
16. How important is a balance of both public and private investment in your P4? *[PROMPT: are there strategic 'optics' that go with including both sectors?]*
17. In your opinion, do public private partnerships (P4s) enhance or detract from the overall functioning of markets? Necessary evil or a value-add?
18. Have you been involved in a P4 that failed? Details. Has your P4 had failures with respect to any major partner or project? Why do you think that failed?

### **III. P4 Outputs**

19. How do you define and measure success within the scope of your P4? How does this compare with how your primary organization (as a partner) operates? *[PROMPT: ROI, #patents/products, etc]*
20. How does the P4 business model compare to your member organizations' business models? Are P4 business operations vastly different from previous approaches by partners? If so, in what way?
21. Please explain. Has the operation of the P4 changed the business practices of the member organizations? How?
22. How do you exchange information with P4 partners and/or collaborators?
23. As a P4, have you ever been blocked in any of your endeavors/goals/strategies to push P4-related products/services downstream... either in terms of the product or in terms of reaching new markets? Please explain.
24. How and what do you report in terms of your output of the P4? *[PROMPT: are these reports publicly available?]*
25. Have there been any unintended outcomes/outputs of the P4? Good or bad?

26. If you were to craft this P4 arrangement all over again, what elements would you change?

*[PROMPT: terms, partners, collaborators, business model, practice]*

27. What do you view as the primary legacy of this P4?



**Appendix D: A Discussion on the Provenance of Each Article/Chapter**

Due to presentations and the nature of research, there was some collaboration involved on each of the investigations. The level of collaboration is explained in Table D.1 below.

**Table D.1** Provenance of Each Article/Chapter

	Chapter 3	Chapter 4	Chapter 5	Chapter 6
Idea	90% Boland; 10% Phillips	80% Boland; 20% Phillips	100% Boland	100% Boland
Theory	80% Boland; 20% Phillips	100% Boland	90% Boland; 10% Phillips	100% Boland
Model	95% Boland; 5% Ryan	100% Boland	100% Boland	100% Ryan
Data	100% Boland	100% Boland	100% Boland	100% Boland
Analysis	100% Boland	100% Boland	100% Boland	100% Boland
Conclusions	90% Boland; 10% Phillips	100% Boland	90% Boland; 10% Phillips	90% Boland; 10% Phillips
Writing/editing/publication efforts	90% Boland; 10% Phillips	80% Boland; 10% Phillips; 10% McPhee-Knowles	90% Boland; 10% Phillips	90% Boland; 10% Ryan
Conference Presentation	50% Phillips; 50% Ryan	100% McPhee-Knowles	100% McPhee-Knowles	60% Boland; 20% Phillips; 20% Ryan

**Table D.2** Dissemination of Thesis Chapters

Chapter	Title and Form of Distribution	Known Usage and Uptake
3	“Public–Private Partnerships for the Management of National, Regional and International Innovation Systems: A Social Network Analysis of Knowledge Translation Systems” contains two articles that were merged for this thesis. They were individually presented at the Triple Helix VIII and IX peer-reviewed conferences on innovation systems. Each article has also been presented at two other peer-reviewed conferences (VALGEN and CAIRN)	The first presentation was purchased and published by the Canadian Agricultural Innovation and Research Network (CAIRN). The first presentation/draft of this article was also published by online by the Open SUIC Digital Commons Network and has been downloaded 331 times.
4	“Collaboration and the Generation of New Knowledge in Networked Innovation Systems: a Bibliometric Analysis” was presented at the Triple Helix X Conference	This presentation was one of 35 out of over 450 papers from this conference selected by a peer-review process to be published in <i>Procedia - Social and Behavioral Sciences</i> . It has been cited once since publication.
5	“A Typology of Research and Development Agricultural Public-Private Partnerships Common to the Developing World Bio-economy” began as an independent investigation for the International Development Research Centre (IDRC) of the Government of Canada and the Syngenta Foundation for Sustainable Agriculture (SFSA)	This investigation went through a peer-review process at IDRC prior to being presented to IDRC and industry. It has also been presented at the peer-reviewed International Consortium on Applied Bio-Economy Research (ICABR).
6	“Public–Private–Producer Partnerships (P4s) in Canada” began as an independent investigation for the Innovation and Growth Policy Division of Agrifood and Agriculture Canada (AAFC), which commissioned a study on P4s in Canada to help develop specific AAFC policies for creating and supporting P4s in Canada	This investigation has been presented to senior members of the Innovation and Growth Policy Division of Strategic Policy Branch of AAFC. It was then presented to the AAFC Agri-Innovators’ Committee, consisting of the Deputy Minister of AAFC and select industry leaders. Recently, it was presented to the Federal, Provincial and Territorial (FTP) Working Group on Collaboration in Agricultural R&D to address specific policy questions.
7	Conclusion	The findings of the multiple investigations have been presented and evaluated by multiple

		peer-review processes as discussed above.
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