An Economic Evaluation of the Roots and Fruits of Intellectual Property Rights for U.S. Horticultural Plants

A DISSERTATION

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

BY

Jennifer Drew

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Phillip Pardey, Advisor

May 2010

Acknowledgments

Special thanks to my adviser, Professor Philip Pardey, for his support and guidance throughout my graduate program. His kindness, time, patience, and careful editing suggestions are greatly appreciated.

Thanks also to my other committee members, Professors Neil Anderson, Jennifer James, Stephen Polasky, and Terry Roe, for their comments and direction with a particular thanks to Professor Neil Anderson for all his time and help in providing insights and related research experience. I am grateful to other faculty in the Applied Economics Department: Professors Liz Davis and Vernon Eidman, for their insights from the department Ph.D. seminar.

I am particularly grateful to my research colleague Bonwoo Koo for the experience and knowledge gained from working with him.

A special thanks to Professor James Luby in the Department of Horticultural Science for his knowledge on fruit breeding science, and Gordon Bailey, of Bailey Nurseries, and Suzanne Baker, of Rush Creek Growers, for their helpful information about the ornamental industry. I also have a deep gratitude to all those in the ornamental industry that provided data for this study.

To the undergraduate students: Megan Matthai, and David Johnson, your careful and consistent data entry work provided a strong foundation for the price analysis.

Thanks to all the University of Minnesota librarians who facilitated my searches for articles and information with amazing efficiency.

My friends and colleagues in Applied Economics: NaiChia, Meng, Yoshi, Lan, Uttam, and many others, your friendship, companionship, humor, and strong spirit have greatly enhanced my graduate school experience.

I wish to express deep gratitude to my mother and father, Virginia and John for their unconditional love and support and for being strong role models for my life. They instilled a curiosity about the world that has motivated my research. Thanks to my sisters Carolyn, Mary and Kathy and my daughters Jessica and Rachel whose support, strength and creativity have inspired me to persevere with this project.

Abstract

Most prior studies have failed to empirically reveal any significant economic or innovation effects of intellectual property rights for plant products. Perhaps this is because these studies focused on the wrong crops (i.e., wheat, soybeans, and corn) or were unduly circumscribed in the types of intellectual property under consideration (i.e., U.S. plant variety protection and utility patents). This study's focus is on the economic effects of intellectual property rights for horticultural crops in the United States which have garnered the lion's share of the plant protection.

Highlighting differences between the horticultural and agricultural sectors, the first part of this study analyzes the roots of intellectual property rights for plants and associated plant markets and their evolution in the United States. This analysis reveals large structural changes in the pattern of intellectual property protection for plants in the United States which reflects advances in plant related science and technologies, market changes, as well as policies and practices affecting plant-related intellectual property. These structural changes include changes in the form of protection being sought—be it plant patents, utility patents, or plant variety protection certificates; the agent (e.g., individuals, firms, universities, or government agencies) seeking protection; and the plant species being protected. Ornamental plants account for a large and growing share of the U.S. plant economy whether measured as a share of property rights issued or the real value of plant products produced. The notable increase in plant patent applications in the horticultural sector in recent years is paralleled by a rapidly growing effort to brand high-valued crops and garner value by protecting of cultivar innovations with other forms of legal protection such as trademarks.

The second part of this study focuses on the fruits of intellectual property rights for ornamental plants. Ornamental plants account for much of the intellectual property rights for plants, thus providing a potentially more fertile area in which to examine the price consequences of plant-related intellectual property rights. A large, unique, purpose built data set is used to identify the sources of differences in the wholesale price of ornamental plant varieties. A hedonic pricing model was adapted to the particulars of the ornamental plant sector and the data. The hedonic decomposition of plant prices made it possible to identify varietal price premiums associated with plant patent and trademark attributes. After controlling for a host of plant attributes that affect plant prices, an average price premium of 23 percent was identified for plants protected by plant patents compared with those with no such protection. Likewise, the average value of the trademark premium was 2.5 percent, indicating that the branding value of the name trademark is much lower. Surprisingly, when these two plant intellectual properties were used together on one cultivar, premiums were nearly 7 percent lower than if neither were used, a result which raises questions for further research. The premiums for the plant patent and name trademark vary between different firms and between different species particularly between herbaceous perennial and woody species and specializing firms.

Table of Contents

Table of Contents – continued

Table of Contents-continued

List of Tables

List of Figures

List of Figures-continued

Chapter 1

Introduction

1.1. General Research Issues

Humans began domesticating plants about 10,000 years ago. With the first planting of selected wild seed, began the unintended selected breeding of that crop. As farmers began selecting saved seed from plants with favorable characteristics, this began a process of genetic alteration that, for many domesticated plants, rendered the plant unfit to live in the wild. Initially and throughout most of human history, the development of landraces and new varieties was an individual farmer or community achievement. With advances in the science of genetics, breeding became institutionalized with varietal research performed by individuals with specialized scientific knowledge. Although the domestication of plants was a human accomplishment, the life giving nature of domestic crops coupled with perhaps a lack of scientific understanding of the process of domestication meant that many human cultures considered domestic crops a divine gift. (Harlan 1975)

Perceptions of divine provenance, human sustenance and the nature of plants themselves seems to lie at the heart of many recent and historical concerns over the expansion of intellectual property rights to encompass new plant varieties. These controversies include ethical concerns about intellectual property rights for plants in general and for food in particular. More practically, there are unresolved disagreements regarding the feasibility and incentive effects of intellectual property rights for plant innovations. Although R&D investors, in the United States, sought intellectual property rights as a means to appropriate returns from the development or discovery of new plant varieties, controversies delayed and modified the legislative efforts to provide for these rights. Furthermore, these controversies persist, as do legal and legislative efforts to address them.

Those with a fundamental ethical objection to bestowing intellectual property rights on plants believe they are inappropriate subject matter for patent like protection since their design is ultimately of divine and not human origin. Other means have been used to incentivize innovation of new plant cultivars with varying degrees of success, such as prizes or subsidies and investments in public R&D. During the 18th century, the U.S. government supported farmer breeding efforts with programs to collect seed from foreign countries and distribute that seed to domestic farmers. There is a long history of direct government involvement in crop varietal development, dating back, at least, to the Columbian Exchange, a period beginning in 1642, which involved the acquisition and dispersion of crops worldwide. This international movement of plant material involved numerous botanic gardens that disseminated and developed new crops within their respective countries.[1] Today, the United States Department of Agriculture and the land grant colleges and their associated experiment stations conduct varietal research. Prizes have been used as a means to correct for the underinvestment in plant research, ranging

[1] Christopher Columbus introduced maize to Spain (Messer 2000a). This event signifies the beginning of what some refer to as the Columbian Exchange, a period of rapid dissemination of old world and new world crops and the institutionalization and rationalization of science (Fowler 1994).

from monetary awards to prestigious non-monetary awards for innovations.[2] In 1954, David Burpee offered $10,000 to the first breeder who produced a white marigold. After two decades and 80,000 entrees, the prize was awarded, but in the company's own words, "...taking into account the contest costs, the prizes, and the development of the "Snowbird"[the marketed variety], that marigold was the world's costliest flower… (Anonymous 2006)."

Varietal innovations are made with the intent of developing plants with new attributes to meet changing consumption patterns, and most importantly, to assure food security by providing new varieties that increase crop productivity and resist diseases and pests in a changing environment. Food security concerns make the awarding of intellectual property rights to breeders of food varieties highly controversial because of fears that monopoly rights over food varieties will prevent necessary follow-on inventions by restricting access to plant germplasm. Because pests co-evolve with the development of crops, sooner or later a new, resistant variety may will likely become susceptible to new strains of insects, diseases, and weeds. These realities mean that a stream of varietal innovations is required to address the constant threat of crop losses, especially for food crops.

Consequently, most statutory forms of intellectual property over plants are weakened by the inclusion of mechanisms that make allowances for follow-on use by crop breeders. Further concerns involve a perceived narrowing of the genetic diversity in food crops which, according to Harlan (1975), has been the trend since food crops were first

[2] In 1970, Norman Borlaug won the Nobel Peace Prize for his work in breeding high-yielding semi-dwarf wheat varieties.

domesticated.   Some believe that the rationalization and commercialization of crop breeding, spurred by the awarding of intellectual property rights for plants, has contributed to this problem by replacing many and varied landraces with a much-reduced number of genetically more uniform commercial varieties. This problem is believed to have food security and social justice implications when landrace varieties, that can be replanted using saved seed, give way to commercially bred hybrid varieties that require yearly seed purchases.[3] Some of these perceived social costs could just as easily be social benefits if the new varieties involved were significantly higher-yielding pest-resistant varieties and enabled more ecological farming practices.

Interestingly, many of these controversies were quelled when the initial statutory schemes for protecting plants in the United States were debated. This was achieved by giving assurances that the rights being proposed would provide for breeder access to improved germplasm, and lobbying efforts that equated the work of breeders, such as Luther Burbank to the innovations of Thomas Edison. Consequently, the feasibility rather than the ethics of, patent like statutory schemes for plant varieties dominated the congressional debates (Fowler 1994; Janis and Kesan 2002). Fitting plants into patent like intellectual property protection schemes posed significant problems. There were two notable issues: What constituted a new variety? How could the applicant satisfy the written disclosure requirement for a plant innovation?[4]

[3] In 1969 there was a widespread corn crop failure, in the United States, due to the fact that virtually all the corn varieties used the same source of cytoplasmic male sterility to reduce the cost of producing the corn hybrids.

[4] A written disclosure is a requirement for all U.S. patents. The inventor is required to clearly and fully disclose in exact detail how to make and use the invention as to enable any person skilled in the art to make and use the invention. (See 35 U.S.C. § 112)

The absence of intellectual property rights—or some alternative mechanism that enable innovators to earn a return on their investments in R&D to generate new plant innovations—will often result in a market failure, whereby the investments in innovation are less than what is socially optimal. This is because plant innovations have public good properties. The new attributes are non-excludable to the extent that the use of the variety does not preclude others from accessing these attributes. The new attributes embodied in new plant varieties are also non-rivalrous because the use of the variety does not simultaneously preclude others from accessing these attributes. The non-excludable problem is particularly a problem for plant innovations because most plants can be propagated by saved seeds or by vegetative means. In the absence of intellectual property rights, it is possible for multiple producers to freely reproduce and commercialize a new plant cultivar and with it the new attributes it possesses. The comparatively low costs of replication or imitation, by others, undermine the breeder's incentives to innovate.

Absent intellectual property rights, new plant innovation will tend to be underfunded, relative to the socially optimal amount of investment , with innovators resorting to the using of trade secrets and other less desirable methods to exclude competitors from using their innovations.[5] Such research environments may limit the stream of new plant varieties being developed with a consequent loss of social welfare. This problem is compounded because the under provision of R&D for plant improvements always occurs within a dynamic pathogen environment. This implies further welfare losses as well as

[5] Trade secrets prevent follow-on innovations. For plants, trade secrets are most often use to protect the parent lines of hybrid varieties.

potential food insecurity if R&D efforts do not produce new crops with sufficient protection against the evolving pest environment. Furthermore, varietal improvement is both a sequential and a cumulative process. Besides the seven to ten years of breeding that is often required to produce a new variety, to varying extents, new varieties encompass varietal development and discoveries resulting from accumulated knowledge that extends to the beginnings of crop domestication around 10,000 years ago (Feldman 2001; Pardey et al. 2003).

It is then the policy maker's challenge to create a research environment that minimizes social welfare loss such that the innovator captures returns to their R&D investments. If developing intellectual property rights for plants is the choice to meet this challenge, then such appropriability of R&D investments will be leveraged through a grant of exclusivity while extracting disclosure of their plant invention to stimulate follow-on innovations. Part of this task is to balance the monopoly rights (exclusionary rights) with the scope and length of time for these rights so that the plant can be developed and marketed long enough to capture returns to their investment, but not so long that competitive follow-on improved inventions are stifled. Inherent differences in the time required for reproduction, growth and maturation of different plants makes achieving this balance problematic. For example, breeding a new apple variety may require 20 to 30 years with an additional 10 to 18 years for multiplication and distribution, while a new soybean can be developed and brought to market in 7 years (Luby 2006).

Although the United States Constitution provided for exclusionary rights for innovators as a means to promote innovation in 1789, a legislative scheme for plant variety protection was not realized until 1930 with the Townsend-Purcell Plant Patent Act.[6] [7] Even with this delay, the United States was the first country to legislate exclusionary rights for plant innovators. The scope of plant patents was limited to asexually propagated plants which include primarily fruits and ornamental plants. Subsequent statutory schemes and court rulings, over the next 60 years, marked a long evolution in the U.S. intellectual property rights system for plant breeders. Compared with the single system of breeder's rights protection afforded plant varietal innovations in most other countries, the U.S. system is perhaps the most complex in that it now includes utility patents and two forms of plant breeder's rights, the plant patent and plant variety protection certificate (Koo et al. 2004).[8] Utility patents have been applied to plants at least since 1980, plant patents, since 1930, and plant variety protection certificates, since 1971. The plant variety protection certificates and plant patents intellectual property protection together are effectively the same as the plant protection options offered in other countries who are also members of The International Union for the Protection of New Varieties of Plants (UPOV).[9] In addition, trade secrets are a means of protection for

---

[6] "The Congress shall have Power…To promote the Progress of Science and useful Arts, be securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries" (US Constitution 1789).

[7] 46 Stat. 376 (1930) (codified at 35 U.S.C., 161-164).

[8] In other countries, breeder's rights are intellectual property rights for plants that include both sexually and asexually reproduced plants. Like the plant patent and the plant variety protection certificate, these rights are weaker than a utility patent because they can apply to just one new varietal invention, require a relatively small inventive step and allow for farmer and breeder exemptions.

[9] UPOV's stated purpose is "To provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society (UPOV 2010)."

hybrid plant varieties and trademarks are used to protect cultivar names and to associate plant products with quality attributes.

The intent of this research is to assess the relationship between intellectual property rights pertaining to plant varieties in the United States and the changing structure of plant markets and the economic value of marketed plants. Most of the limited prior literature on the varietal innovation consequences of intellectual property protection has revealed little if any economic value attributable to this form of intellectual property rights. Perhaps, this is because most of these studies focused almost exclusively on food and feed crops with comparatively low unit values.[10] Nonetheless, considerable effort and expense goes into seeking and exercising intellectual property rights over plants, and that phenomenon has not only increased but has accelerated over the past few decades. Markedly, the largest portion of plant varietal rights pertains to higher-valued horticultural not agricultural crops. However, the published research on the economic effects of plant variety rights is dominated by studies specific to agricultural crops, and more recently to those crops embodying innovations derived from biotechnology. This study seeks to redress this imbalance by analyzing some of the economic consequences of varietal rights related to horticultural crops, specifically certain ornamental plants.

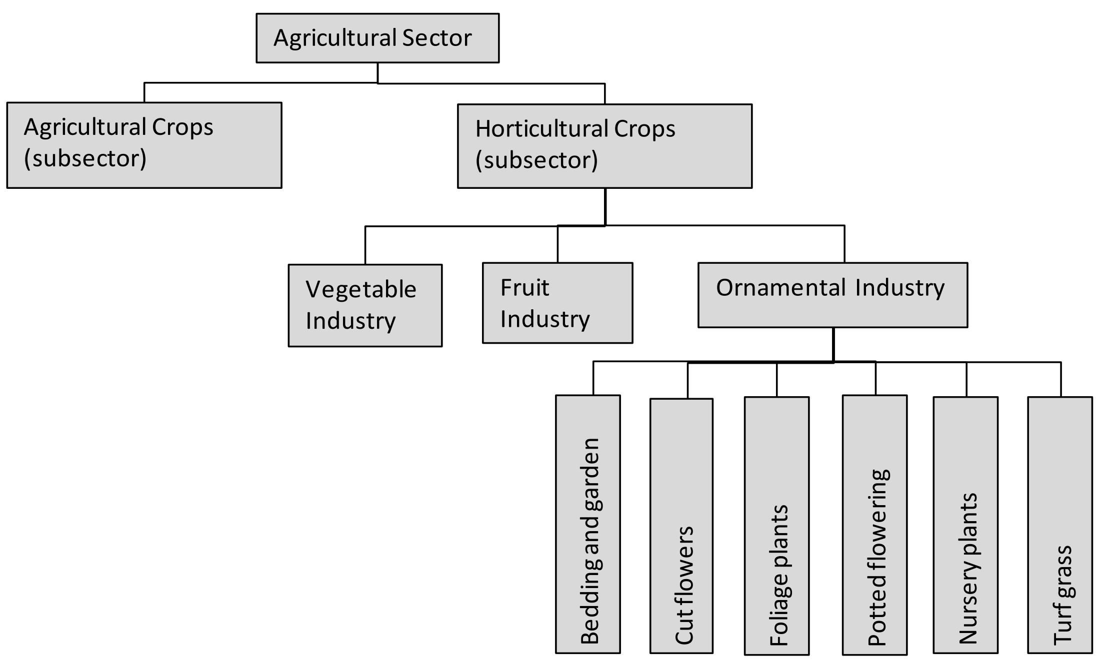
For the purposes of this study, agricultural crops will refer to all crops that are harvested and marketed in a dry or stable state, and horticultural crops will refer to those

---

[10] Studies of the economic effects of plant variety protection certificates in the United States include Perrin, Kunnings, and Ihnen (1983), Butler and Marion (1985), Knudson and Pray (1991), Hansen and Knutson (1996), Lesser (1994), Alston and Venner (2002), and Janis and Kesan (2002). Studies done on similar breeder rights in other countries include Godden (1998) for Australia, CFIA (2002) for Canada, Rangnekar (2002) for the United Kingdom, and Diez (2002) for Spain. Stallman (1986) studied U.S. plant patents for fruit crops, and Penna (1994) investigated breeder’s rights in Great Britain for a few selected fruits and vegetables and the rose.

crops that are usually harvested or sold in a hydrated state and are considered either live or fresh. Horticultural crops include fruits and nuts, vegetables, and ornamentals (nursery and greenhouse) (Figure 1.1). The ornamental industry (also referred to as the nursery and greenhouse industry) is composed of a number of smaller industries that include: bedding and garden plants, cut flowers and cultivated greens, potted flowering plants, potted foliage plants, nursery plants, and turf grass. The horticultural sector is a characterized by a substantial amount of diversity in crops and the methods by which these crops are propagated and cultured and the products marketed (e.g., fresh and preserved fruit and vegetable products, bareroot and potted plant products as well as turf grass products). All of these products have a variety of postharvest care issues, including damage, spoilage and dehydration.

Figure 1.1: Structure of the U.S. Agricultural Sector



Notes: The agricultural sector also includes animal and animal products. Because the focus for this study is on horticulture, the finer subdivisions for the agricultural crop subsector are not shown. The nursery and greenhouse industries (i.e., bedding and garden plants, cut flowers, and foliage plants) are considered part of the ornamental industry group.

1.2. Specific Research Issues

Procuring, maintaining and exercising varietal rights for new varieties is an economic decision made by public-sector breeders and profit-seeking firms with breeding programs. Plant varietal rights in the form of utility patents, plant patents or plant variety protection certificates are obtained and maintained if the expected stream of future rents exceeds the cost of securing and enforcing those rights.[11] Plant intellectual property rights are available for all breeders or firms and apply to all new varieties that meet the criteria for those rights. However, there is much variation in the extent and form of intellectual property protection sought by different plant industries. For example, plant patents are the principal rights sought by breeders of horticultural crops, whereas utility patents and plant variety protection are granted largely for agricultural plants.

This study, with its focus on the horticulture subsector (and a particular emphasis on ornamental plant industries) is motivated by the observation that the preponderance of growth in intellectual property rights for plants are in these areas. There is substantial variability over time in the annual rate of intellectual property applications and significant differences among plant industry subsectors (i.e., agricultural and horticultural), crop industries (e.g., grain fruit, and ornamental), ornamental plant industries (e.g., bedding and garden plants, cut flowers, potted flowering plants, and nursery), crops (e.g., wheat,

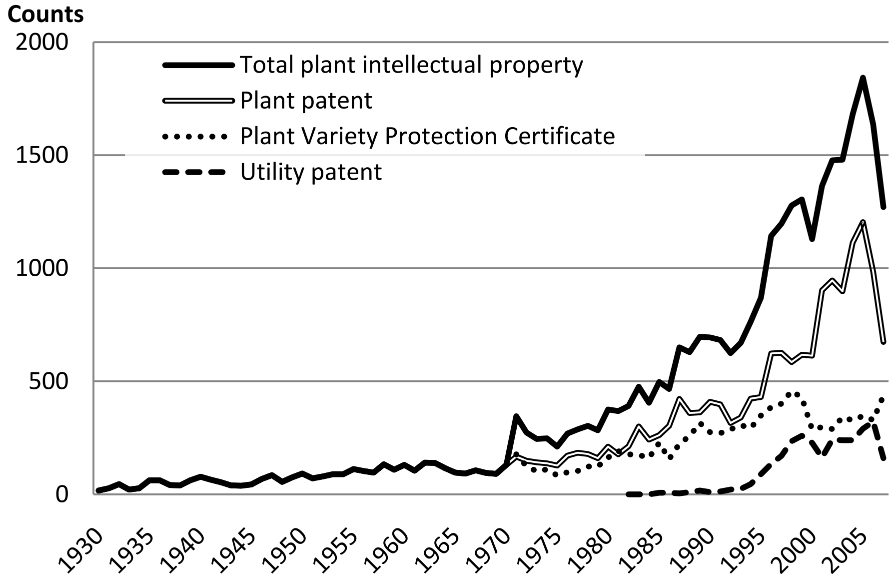
[11] Only utility patents incur maintenance fees, but plant variety protection certificates require the owner to keep a supply of seeds in a genetic storage facility designated by the Plant Variety Protection Office. The seeds must be resupplied if viability declines or the stock falls below 3,000 seeds (USPTO 2006; PVPO 2006).

soybeans, apples, turf grass, roses), applicants (e.g., Monsanto, Driscoll Strawberry Associates Inc., and Ball Horticultural Company), and applicant types (e.g., individual, corporation, government, or university and foreign or domestic). These differences may be caused by underlying factors that affect the appropriability of economic benefits arising from new plant varieties as well as the ability to breed new varieties.

Specifically, the plant sector most active in seeking and securing intellectual property rights is the horticultural sector, not the agricultural sector which was the focus of most of the prior efforts to examine the economic effects of intellectual property rights pertaining to plants. Notably, plant patent applications—of which 99 percent are horticultural—were more numerous and averaged faster growth rate than either utility patents or plant variety protection certificates for the period from 1982 to 2005 (Figure 1.2).[12] Horticultural plants comprise about 83 percent of all intellectual property rights for plants granted in the United States since 1930 (Figure 1.3). Among the three industries that comprise the horticultural subsector, the greenhouse and nursery industry—the industry of focus for this study—has the largest number and fastest growing trend of applications (Figure 1.4). The fast growing bedding and garden industry trend and foreign application trend underlie the greenhouse and nursery industry growth trends (Figure 1.5 and 1.6).

[12] The intellectual property rights application counts for new plant varieties are obtained from a comprehensive database of plant intellectual property rights which has been compiled for this study (for details see Appendix D).

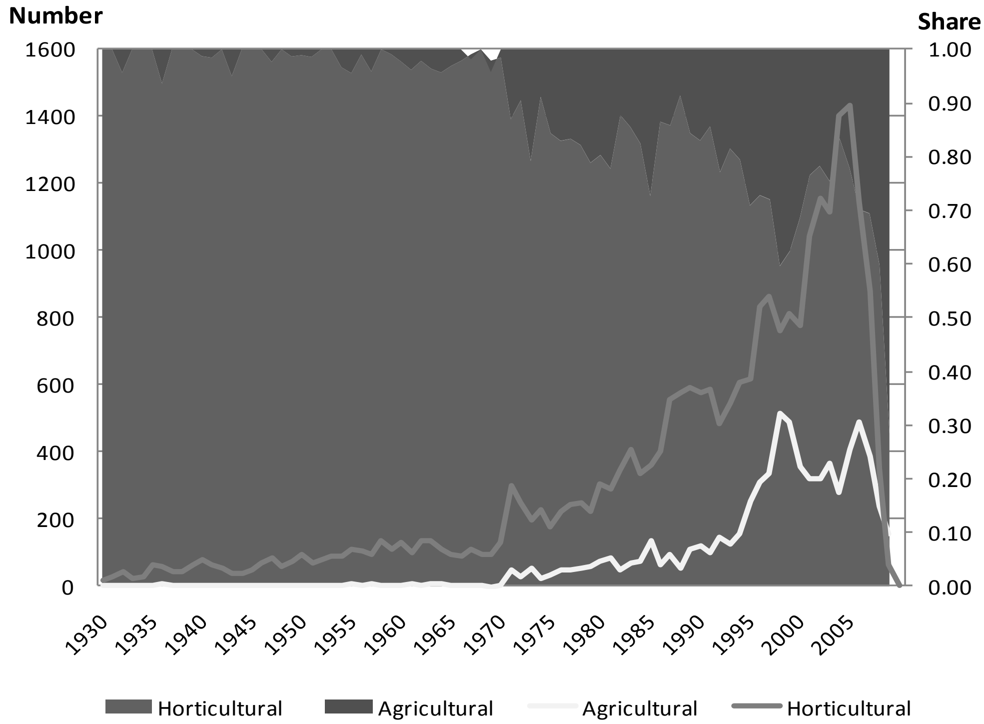
Figure 1.2: Intellectual Property Rights Counts Per Year by Type: Plant Patents, Plant Variety Protection Certificates and Utility Patents (1930-2008)



Source: Compiled by author using the intellectual property rights for plant varieties data base (Koo et al. 2010, Appendix D).

Notes: The plant patent trend and the total plant intellectual property trend are the same prior to 1971. The apparent declines in plant patents and utility patents in recent years reflect data truncation problems, such than recent applications for these two forms of property rights are yet to be published while plant variety protection certificates are published immediately.

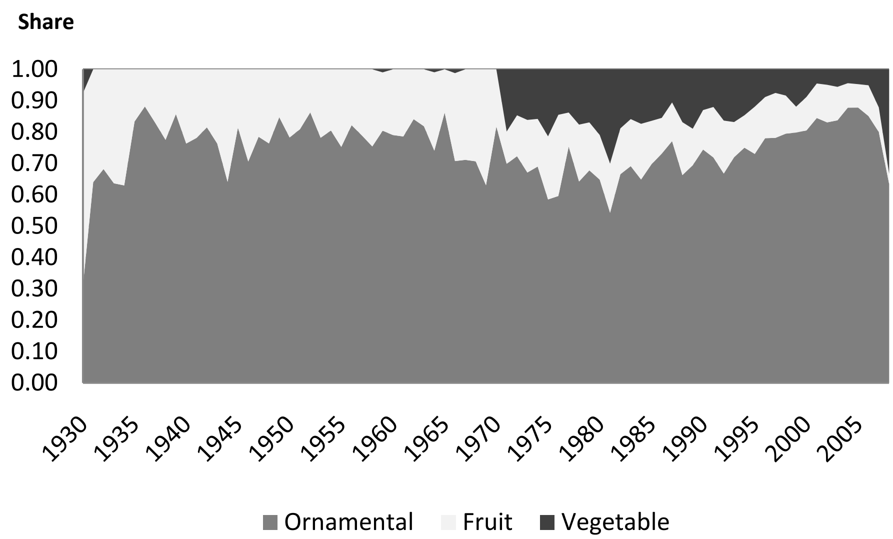
Figure 1.3: Applications for Plant Intellectual Property Rights – Counts and Shares per Year by Agricultural and Horticultural Subsectors (1930-2008)



Source: Compiled by author using the intellectual property rights for plant varieties data base (Koo et al. 2010, Appendix D).

Notes: The apparent declines in plant patents and utility patents in recent years reflect data truncation problems, such than recent applications for these two forms of property rights are yet to be published while plant variety protection certificates are published immediately.

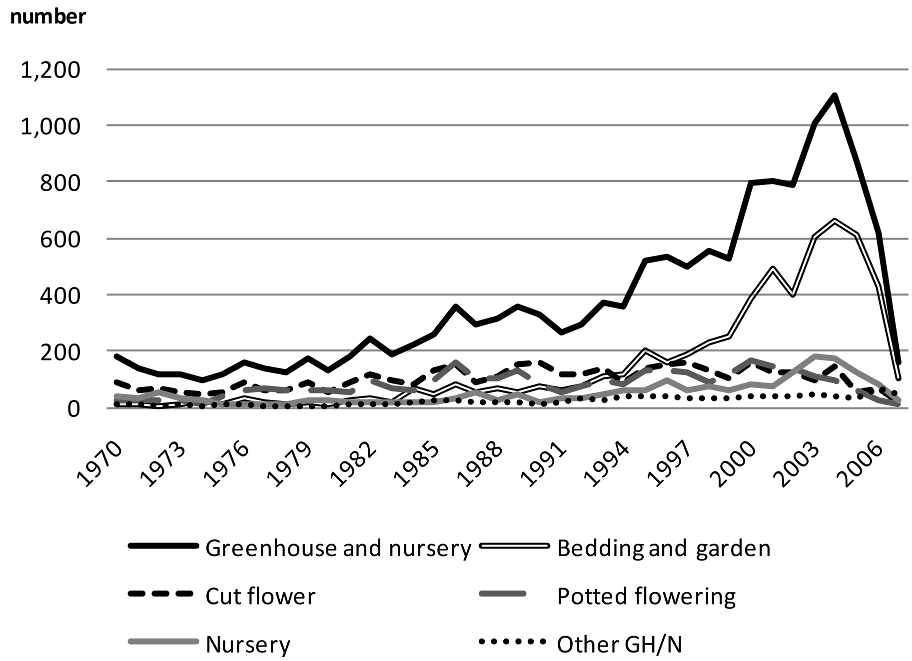
Figure 1.4: Applications for Breeder's Rights (Plant Patents and Plant Variety Protection Certificates) – Shares per Year by Horticultural Crop Groups (1930-2008)



Source: Constructed by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Notes: The apparent declines in plant patents and utility patents in recent years reflect data truncation problems, such than recent applications for these two forms of property rights are yet to be published while plant variety protection certificates are published immediately. Other crops include sugar, fiber, animal fodder and other miscellaneous crops.

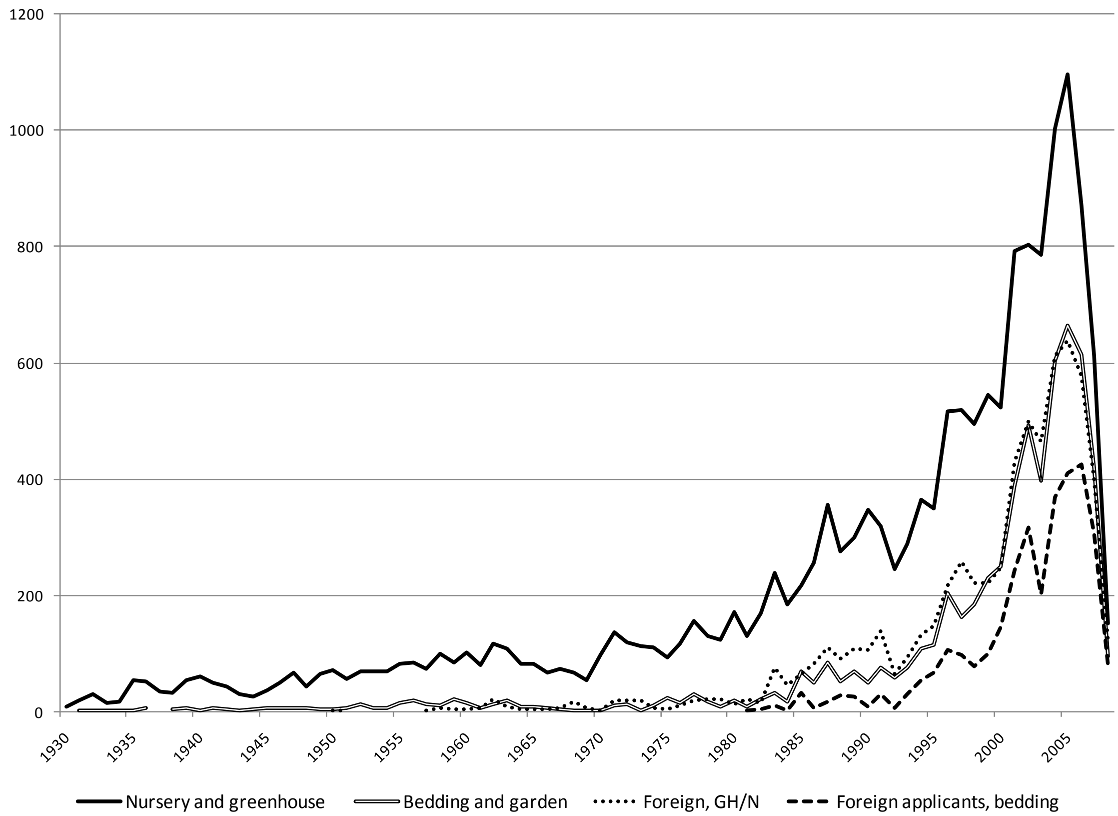
Figure 1.5: Applications for Breeder's Rights (Plant Patents and Plant Variety Protection Certificates)-Counts per Year by Nursery and Greenhouse (Ornamental) Industries with Largest Number of Counts (1930-2008)



Source: Constructed by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Notes: The apparent declines in plant patents and utility patents in recent years reflect data truncation problems, such than recent applications for these two forms of property rights are yet to be published while plant variety protection certificates are published immediately. Other GH/N (Other greenhouse and nursery) includes turf grass, foliage plants

Figure 1.6: Foreign Applications for Breeder's Rights (Plant Patent and Plant Variety Protection Certificate)-Counts per Year for Nursery and Greenhouse Industries and Bedding and Gardening Plant Industry (1930-2008)



Source: Constructed by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Notes: The apparent declines in plant patents and utility patents in recent years reflect data truncation problems, such than recent applications for these two forms of property rights are yet to be published while plant variety protection certificates are published immediately.

Notably, horticulture is the fastest growing crop sector. The estimated wholesale value of production for horticultural crops grew from 19 percent of all crops in 1924 to 42 percent of all crops in 2004.[13] Since 1970, the value of production of ornamental crops has grown faster than the value of output of fruits and vegetables. Presently,

[13] This is calculated using the value of production series (see Appendix C)

greenhouse and nursery crops comprises 33 percent of all horticultural crops compared with 30 percent for fruits and nuts, and 37 percent for vegetables. The primary drivers of growth in the value of production within the nursery and greenhouse industry are the bedding and gardening plant and nursery plant industries (Jerardo 2007). These two industries are strongly influenced by international trends in the supply of new cultivars (Drew et al. 2010).

Interestingly, the high growth rates in intellectual property and crop value for horticultural crops occurred in an environment wherein horticultural crops (in contrast to agricultural crops) have received little government support and comparatively little public expenditures on horticultural related R&D (Singh 1999; Lee and Blank 2004; Alston and Pardey 2008).

1.3. Research Objectives

The overarching objective of this study is to carefully re-examine the role of intellectual property rights pertaining to plant innovations and to assess their economic consequences by focusing on the U.S. horticultural sector within agriculture. Analysis of the horticultural sector may well reveal economically important insights that have eluded the limited number of prior studies of this topic. Not only do horticultural crops account for much of the cultivar-related property rights in the United States, the comparatively high unit values may reflect price premiums attributable to intellectual property rights which are hard to detect in other studies that focused almost exclusively on lower-valued food and feed crops. As a part of this study, the role of trademarks and other marketing factors in relation to plant patents are studied. In addition, this research examines differences among plant industries, specific firms and plant species in the frequencies and values of intellectual property rights.

The first part of this research will provide the economic, scientific, policy and institutional context for this study. It involves a historical analysis that juxtaposes new statistical evidence with event elements to identify the forces and direction of change in the patterns of intellectual property rights and their associated plant markets. This research is enabled by two purpose built data sets: a comprehensive intellectual property rights for plant varieties data base, and a value of production series (for details see Appendices C and D).

In particular, a time series historical analysis will be used to:

- Provide a long-run perspective on the evolution of intellectual property rights in relation to the evolution of the plant sciences, the plant and seed industries, and their markets.
- Identify specific factors that may affect the appropriability of expected revenues over time.
- Analyze time-series data to establish trends and patterns in the intellectual property rights.
- Identify linkages between plant, plant science, plant intellectual property and plant industry events, and examine the patterns revealed in the trend data pertaining to plant related intellectual property rights.

The second part of this study, adapts a hedonic pricing model to the particulars of the ornamental plant sector, wherein plant cultivar prices are econometrically decomposed into the various attributes that give rise to these plant prices. In particular, a hedonic approach is well suited to a study of the price premiums for plants attributable to various forms of intellectual property rights (including trademarks as well as the more obvious forms of plant protection) versus price premiums associated with particular plant and market attributes. To this end, new, detailed, cultivar-specific price data were developed in addition to data on a range plant attributes and alternative forms intellectual property, for a number of economically important ornamental crops.

Thus the more tangible tasks for this research are to determine the sources of economic value for ornamental plants, and in particular to:

- Identify plant and industry differences that affect unit prices and the appropriability of returns from new plant cultivars.
- Identify other, typically unobserved, non-plant attributes that affect price premiums, such as firm reputation, trademarks, branding, and registration of cultivars with plant associations.
- Determine if innovation related forms of intellectual property rights (i.e., plant patents) affects the (wholesale) price of the plant and if their joint use with trademarks significantly affects plant value.
- Determine if other factors such as (or factors proxied by) different firms or species affect the magnitude of plant patent and trademark premiums.

Chapter 2

Literature Review

Both agricultural and horticultural crop innovations have been fundamental to long-term economic growth worldwide. Social leaders supporting and encouraging expeditions to search for useful plants and animals has always been a part of human culture (Juma 1989). In the United States, President Thomas Jefferson declared "The greatest service which can be rendered any country is to add a useful plant to its culture (1821 no. 6677)." This statement reflects the American culture behind the rich history of public support for plant innovations in the United States that includes worldwide searches for plants (Fowler 1994, Juma 1989), distribution of seed packages (Fowler 1994), the formation of publicly funded agricultural research institutions (Ruttan 2001) with high levels of public funded research compared to other countries (Wright et al. 2007).

2.1. Plant Breeding and Sources of New Varieties

The sources of new varieties are many and varied, and most of these involve new technologies. New plant varieties or cultivars arise via the introduction of new genetic variation to existing plants. These genetic introductions occur in nature through gene recombination (progeny of a cross between two parent plants), modifications in chromosome number (through hybridization or abnormal division), and mutations (errors in DNA replication).

Since Neolithic times, farmers genetically modified crops by domesticating wild progenitors. The incremental and accumulated consequence of these modifications is that the resulting crops are unable to survive in nature and the complete accounting of their progenitors is difficult if not practically impossible. Farmers achieved these modifications by saving some harvested seeds for replanting in a subsequent year. These saved seeds were often selected on the basis that the plants producing them possessed desirable traits such as seed size, flavor, milling qualities, as well as plant drought or disease resistance, and frost tolerance. Over generations of selecting, saving and planting crops, many locally adapted and farmer bred varieties known as landraces have emerged. Landraces include horticultural plants as well as agricultural plants. Farmers selected seeds from herbaceous perennial plants (e.g., fruits, herbs and ornamentals) that displayed more desirable characteristics found in cultivation or in the wild. Cultivars which can be reproduced asexually needed fewer generations to produce a stable cultivar to become a "landrace" because only one plant with the desired characteristics is sufficient to start a "landrace." In addition, new landraces arose from natural occurring mutations which introduced new desirable characteristics.

A characteristic of landraces is that they move and change with the people that grow them. Plant introductions into a new geographic area are the first step in developing a new variety. Considering the 20 most important food crop origins, all the major regions of the world have some dependency on crops originating outside their region. Interestingly, the two regions that are mostly dependent on outside resources are Australia, the United States and Canada (Pfeiffer 2003).

Purposeful breeding of new plant varieties is a laborious and time-consuming process which can take up to 7 to 10 years to achieve a marketable variety.[14] A breeder first determines the objectives of the breeding program that can involve agronomic attributes (i.e., higher yields, pest or disease-resistance, drought tolerance) or demand related attributes (i.e., taste and texture, milling or color qualities) that are sought by food processors, retailers or consumers. One of the major facts to have emerged during the short history of scientific breeding is that an enormous wealth of genetic variability exists in the plants of the world, and that only a start has been made in tapping that potential.

Some structured approaches to breeding emerged in the 19th century, and scientific approaches to breeding only emerged after the 1900 rediscovery of Mendel’s laws of hereditary. These laws allow breeders to develop more efficient and controlled methods of making genetic improvement. Another valuable innovation during the early part of the 20th century was the development of pure-line breeding of self-pollinating crops. Genetically variable landraces were refined through systematic back-crossing techniques. The resulting pure lines breed true to type and contain consistent and identifiable traits that could be transferred to other plants. Pure-line breeding presents a practical method to improve a plant line's genetic weaknesses.

Conventional crop improvement methods involved the systematic processing of breeding plant material that cumulates in the selection of two or more parent lines or varieties with specific characteristics. Selected plants are crossed and the best progeny of the cross are bred. Again, the best offspring of the cross are selected and bred. After about 12 generations, if the improved varieties are stable then they can be marketed.

[14] Woody plants take much longer—up to twenty to twenty five years.

However, breeding a new variety is often more complex, and may be derive from many parental lines. This may be because a parental line may contain only one desired trait and many undesired ones. In order to transfer the allele without the undesirable ones into the target variety, the breeder must first cross plants of the target variety with plants of the variety with the single desired trait. Then the selected plants are back-crossed with the target variety. This process is repeated until the undesired traits from the introduced variety are negligible in the offspring.

These approaches generally work well with crops like wheat, rice and sorghum that self-pollinate. These tend to be genetically stable and breed true. But inbreeding can develop harmful characteristics for cross pollinators such as maize, millet and pulses. However, this is not such a problem for plants that can be reproduced asexually such as vines, apple trees and potato.

The inbreeding problem was solved for most cereals and pulses with another method developed using Mendelian genetics. In 1910, George Shull introduced the characteristics of hybrid vigor (heterosis) to corn plants resulting from his cross-breeding of inbred pure lines (Shull 1910). The progeny of hybrids do not breed true, so the yield enhancements last only for a single generation. Farmers can benefit from seeds with hybrid vigor only if they buy seeds every planting season.

More recently, modern biotechnology methods have facilitated the movement of genes among different plant species and from different life forms into plants. For example, insect resistance was achieved in corn and cotton by inserting genes from a soil microbe called Bacillus thuringiensis that enables the plant to express a protein that is toxic for the targeted insects that feed on these plants. These techniques include cell fusion, and direct gene transfer into tissue cultures. This direct gene transfer uses bacteria or viruses as carriers of foreign DNA or devices such as high velocity gene guns which literally shoot for in DNA into plants cell nuclei. Genomics, a branch of biotechnology, has been useful in developing techniques that identifying useful genes and the plants that contain them.

Additional techniques for introducing genetic variability into plants include somaclonal variation (i.e., variation due to cellular propagative techniques) and mutations induced by irradiating seeds or treating them with chemicals.[15] Plant breeders manipulate these sources of genetic variation using a variety of tools and methods including biotechnological tools which can also help to assess the genetic make-up of breeding materials. Consequently, modern commercial varieties arise from formal breeding programs, informal selection, discoveries of plants growing in the wild, and discoveries of plants growing in cultivation.

2.2. The Economics of Intellectual Property Rights as Innovation Incentives

During the 20th century, the United States created a legal framework to encouraged private sector innovation through the development of a range intellectual property rights pertaining to plants. Some economists argue that the use of patents do not significantly encourage or may even discourage innovation (Machlup and Penrose 1950, Plant 1934,

[15] To date, worldwide, more than 2,000 commercialized crop varieties have been developed using radiation or chemically- induced mutations (Pfeiffer 2003).

Boldrin and Levine 2002). Although, many economists support the theory that intellectual property rights encourage innovation.

Arrow (1962) developed a theory for innovation and patents which lays the foundation for modern patent theory especially with respect to allocating resources for innovation and the appropriability of inventions. The basis of his theory is that, by definition, innovation is the production of knowledge. Comparing potential profits with the costs of an invention, Arrow showed how the social benefit of an invention always exceeds the realized profits both for competitive firms as well as the monopolist. In this way, he shows that a competitive economic system fails to achieve optimal resource allocation for innovation making it necessary for the government or some other agency to intervene. Arrow showed that technological characteristics of the invention process and nature of the market for knowledge are factors that influence the appropriability of innovation.

While statutory forms of intellectual property rights may dominate public policy, other means exist to provide incentives for R&D as a means to increase innovation such as prizes and contracts. Because of social welfare issues regarding food crops, agricultural research is often encouraged through such means. A body of research compares patents to prizes and contracts to determine the incentive mechanism that has the lowest social welfare costs.

Wright (1983), using methodology developed by Weitzman (1974), found that when researchers and policy makers have asymmetric ex ante information such that policy makers know the value of an invention and researchers know the costs, then prizes are more efficient than patents or contracts. If these information asymmetries are reversed, that is researchers are more knowledgeable, then patents are more efficient. In the first case described by Wright, Scotchmer (1999) found such information could be costlessly extracted and used to create a more efficient contract. Even if prizes and contracts are more efficient in a closed economy, in an open economy where spillovers occur, patents can be more efficient. De Laat (1997), comparing patents and prizes, found patents are more efficient in a non-competitive R&D environment; however, Shavell and Ypersell (2001) found when the policy makers have ex ante information with respect to which projects will fail to break even, then offering optional rewards (especially when based on sales related information) in conjunction with patents, (i.e., innovators choose between the two), will be more efficient.

Intellectual property rights in the form of a patent may be preferred by policy makers because they offer an incentive mechanism that can be applied to all research technologies and products without the need for many centrally administered innovation incentives. This means the information costs for administering the patent could be lower than that for prizes and contracts. In addition, statutory forms of stimulating innovation are less subject to short-term political and economic environments.

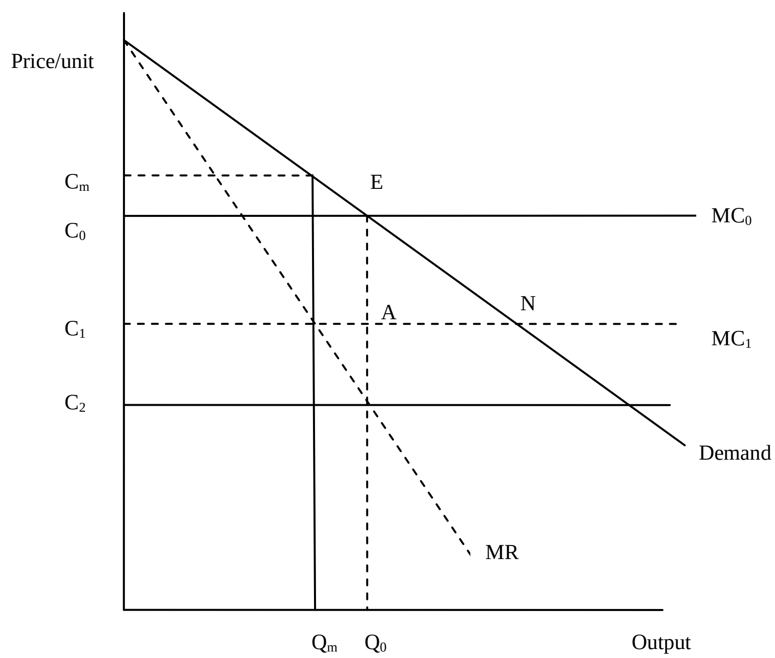
Much of the literature pertains to the value of intellectual property rights from a social welfare perspective and provides insights on why differing patterns in patenting may occur, and on the relation of the length of patent monopoly rights and the size of product space allowed by the patent to the level of appropriability provided by the patent. The underlying theme of this type of research is that the policy maker’s objective is to provide incentives for innovation because the knowledge embodied in innovations has public good qualities of nonrivalry and nonexcludability which can lead to market failure and a less than socially optimal provision of innovations. While these public good qualities facilitate and reduce transaction costs of the diffusion of the innovation, nonexcludability means the innovator marketing their innovation may not recover the full value of their investments because competitors can freely market their innovation. Consequently, the policy maker's objective is to design policy that will provide maximum incentive for innovation while minimizing the social welfare loss.

A widely used theoretical framework for determining an optimal patent design developed by Nordhaus (1969) showed how there is a tradeoff between the social welfare deadweight loss and the efficiency gains in innovation (i.e., the production of information) resulting from the awarding of monopoly rights for an invention. He used a simple monopoly model with a linear marginal demand that assumed that innovation is a "run-of-the-mill" as opposed to a "drastic" innovation, and that it is cost reducing (figure 2.1).[16] Q_0 and C_0 are the competitive equilibrium unit price and quantity produced. The innovator secures exclusive intellectual property rights, and the unit cost becomes C_1. The innovator may produce all the former output at this new price or license the rights to other producers and collect royalties. By either means, the innovator collects a monopoly rent of C_0EAC_1, and the social welfare loss is the triangle *ENA*. Unlike a natural monopoly, the innovator does not have the option of exercising their monopoly power to produce at Q_m in order to raise the price above C_0 to C_m because at that price

[16] Most innovations in ornamental plant varieties are better characterized as quality changes, but such a quality improvement can also be thought of as cost reducing since it lowers the cost of supplying a plant variety with the improved characteristic. In a differentiated product framework market supply and demand curves for a product can be viewed as an aggregation of a set of supply and demand curves for different types of the product each with a different set of characteristics.

they would lose their share of the market to their competitors. Consumer demand is usually inelastic with run-of-the-mill inventions—that is, if prices are too high, consumers will switch from the innovative product to a close-substitute. As a result, the optimal post-invention price and quantity under a patent monopoly is the same as pre-invention. However, if the invention is far-reaching then the patent holder will maximize profits by reducing price below C_0 and producing a quantity greater than Q_0.

Figure 2.1: Pricing for a Production Cost Reducing Innovation



Source: Adapted by author from Scherer (1972).

The key point is that the profit maximizing innovator must balance the costs of their invention with the expected future revenues which result from the patented innovation. The inventor's equilibrium shows that research expenditures increased with inventive output and the length of the patent life, and decreases as the interest rate and the cost of research increases. With this model, social welfare beyond a minimum point is relatively indifferent to the length of the patent life; however, the optimal patent life varies with different technological climates. When invention is “easier” a shorter life is optimal even if the size of the invention may be large. In the case of plant innovation, marketable discoveries of mutations in plant seedlings may be considered "easier" innovation, and the breeding of the new and marketable apple variety may be considered more difficult.

With this study, Nordhaus introduced a class of research that will be referred to as optimal patent design. Generally, these static patent studies imply that the value of the patent varies according to product type and technology field, and the innovating firm’s ability to prevent infringement. The requirements to obtain and secure the intellectual property rights granted by a patent (i.e., the length of monopoly rights, size of product space and renewal fees) are variables that are different between the different forms of intellectual property rights for plants as well as have changed over time through statutory changes or through court rulings.[17]

Cornelli and Shankerman (1999) showed that firm differences in R&D productivity could produce differences in the effect of patents on social welfare. This is relevant to this research because there are a wide variety of firms in plant-related industries. Using a model that included moral hazard, they found that when a firm's R&D productivity is private information, and the government wants to shift R&D production to the more highly productive firms a uniform patent length provides suboptimal incentive for R&D activity. Social welfare was improved by using differentiated patent lives when firms have different R&D productivities.

[17] For more information on the important events in the evolution of intellectual property rights for plants see Appendix A.

Uniform patent life provides too much incentive to firms with low R&D productivity while providing too little incentive for highly productive R&D programs. Renewal fees, which are presently constructed to finance patent offices, can be used to vary the effective life of a patent, so the patent cost structure can be used for an optimal patent design to encourage innovation without discouraging follow on innovation.[18] With such a cost structure, social welfare is greater than from patents with a uniform patent life. For the innovator, value of the renewed patent in terms of the expected future appropriable revenues at any renewal point is greater or equal to the renewal fee. These findings imply that patents with different cost structures are more likely to provide more socially optimal options for appropriating revenues to innovations arising from R&D programs of differing productivity.

In a similar study, using German patent data, Lanjouw (1998) developed a model of optimal patent renewal that included learning the value of a patent, patent depreciation, and enforcement. The value, defined as the additional returns to the innovator from using the patent and calculated as a percentage of R&D investments, was estimated to be an average of 10 percent. Lanjouw found that innovators learned the value of three-fourths of the patents in just two years, and value of most patents within 7 years of the date of application—showing that obsolescence occurred fairly rapidly within the life of the patent.

Patent scope, breadth, or the size of the product space allowed defines which follow-on inventions will be infringing. A narrow patent scope, breadth, or product space is one

[18] For more information about the cost structure of intellectual property rights for plants see Chapter 3, Table 3.1

that allows many close-substitute products without infringing. For differentiated goods, Klemperer (1990) found that the socially optimal patent scope varied across different classes of products. If demand was relatively more elastic in price than in substitution costs, then narrow product space provided less social welfare loss. If the converse was true then a broader product space was more optimal. Long patent life and narrow product space were found desirable when substitution costs between varieties of the product were similar between consumers, but short patent length and wide product space were desirable if consumers share a tendency to switch out of class and not consume at all (i.e., the product became undesirable). On the other hand Gilbert and Shapiro (1990) found for homogenous goods, infinite patent length was optimal, provided the social welfare loss increased with breadth of product space when consumer substitution behavior was out-of-product class rather than to a differentiated good. These studies show that demand price and substitution cost elasticities which can vary across classes of differentiated products affect appropriability of revenues. For the highly differentiated horticultural plant and product markets, consumer demand elasticity is relatively high with low substitution costs elasticity, so accordingly optimal patents should have a narrow scope as does the plant patent and plant variety protection certificates.

Gallini (1992) developed a model for an innovator's decision to patent that endogenized imitation in a homogeneous innovation environment. When imitation costs were positive, Gallini found the longer the patent life the higher the incentive for competitors to imitate. When the width of product space allowed by the patent was also a variable, the optimal patent was found to be broad and the length was adjusted to achieve the desired reward to the innovator. The key aspect of this model is that non-infringing follow-on inventions displaces the grantee's output as the life of a patent is extended. This model is helpful for explaining why plant innovators find the utility patent, which has a broad scope, an attractive alternative to the plant patent and the plant variety protection certificate that have relatively narrow scope.

Generally, these patent studies describe situations most applicable for utility patents, and therefore are most applicable to plant innovation which uses biotechnology. Although these static optimal patent design studies acknowledged the existence of imitators and follow-on innovations, dynamic models incorporated the existence of other innovators and innovations by endogenizing the cumulative nature of innovation which characterizes most plant-related innovation.

A study by Green and Scotchmer (1995) is useful for understanding the issues regarding patenting biotechnologies used in developing new plant varieties with recombinant DNA. They developed a strategic game-theoretic model that modeled the effect of licensing, patent breadth, and length on the division of profit between sequential innovators in a patenting system. The first innovation was basic research and enabled the development of an application, the second innovation was infringing on the first invention. They found that licensing is central to how the incentive system works, and that asymmetric information is the primary obstacle to licensing. The inventor of the application may be unwilling to develop an application without first knowing if they will be able to use the basic invention; therefore, ex ante licensing is socially optimal as opposed to ex post licensing which could put the commercialization of the second generation invention in jeopardy. This study explains the problems that plant-related innovators face using biotechnologies owned by another for their plant-related innovations.

The plant patent and plant variety protection certificate are limited to only one claim, the new variety, but plant-related utility patents can include a wide range of claims that extend beyond the invention. Legal researchers focusing on the post-invention environment, Merges and Nelson (1990), found that the scope of a patent was the most important issue because it is a factor that can be changed.[19] They find that broad scope favored the pioneering firm's incentives while discouraging follow-on innovation. Merges and Nelson advocated that scope should be limited by limiting claims such that they are "trimmed more closely to the inventor's actual results."[20]

Biotechnology is a growing influence in agricultural crops that are increasingly becoming subjects of utility patents. The study by Heller and Eisenberg (1998) suggested that an "anti-commons" was developing in the bio-sciences with the privatization of rights on basic research. They described a situation where a proliferation of rights upstream in the inventive process could stifle important downstream innovations and product development. Broad claims could increase this problem by necessitating reach-through licensing agreements so that upstream patent owners could stack multiple overlapping and inconsistent claims on potential downstream products. The transactions costs, informational asymmetries, outcome uncertainties, and limited resources of

---

[19] The scope of the utility patent is determined by the individual claims granted for each patent on a case-by-case basis. The scope for all types of intellectual property is often tailored by court rulings that result from infringement claims.

[20] Plant patent and Plant Variety Protection Certificate are limited to only one claim, the new variety.

upstream institutions could contribute to an intractable anti-commons problem where antitrust law could limit solutions. This is relevant to explain many developments in the agricultural subsector such as increased licensing, joint ventures and mergers and other inventive solutions to such problems (see Chapter 3).

Perhaps the best model that described most run-of-the-mill plant variety innovations was the one used by O'Donoghue (1998) which was a production-function model that described a quality ladder type of innovation where a sequence of improved products with rapid market turnover discouraged follow-on innovation. The problem was to allow enough flow of future profits to cover costs without discouraging significant superior follow-on innovations. The solution was a patent that requires a large enough inventive step to prevent close follow-on innovations so it was sufficient to give the firm incentives to invest, but small enough so it does not discourage investment in large quality improved follow-on inventions. Another model for this type of innovation showed that the effective patent life was likely to be shorter than the actual patent life and the appropriability of future revenues depended both on the required inventive step and the patent breadth (O'Donoghue and Scotchmer 1998). The inventive step for an invention is the measure of change over existing closely related patented inventions.

2.3. Empirical Assessments of the Value of Intellectual Property

A few studies have been conducted to access the value of utility patents to innovators. Griliches (1990) reviews a number of surveys which investigated the value of utility patents to the innovator. The most extensive survey was in 1957 conducted by Barkev

Sanders and associates at the patent and Trademarks Foundation of two percent of all patents issued. This survey revealed a wide distribution of values with an impressive mean value of all patents $112,000 and a median close to zero. A 1982 survey of 96 NSF Chemistry Program patents conducted by Cutler in 1984 found that 52 patents that were licensed or licensable had an average "economic value" of about $500,000 per patent. Another NSF survey, for Patents of the Engineering Program, estimated $73,000 average royalty potential for each patent with a large distribution of values.

Pakes and Schankerman (1984) used European data on renewal fees and patent survival to derive the parameters of the distribution of the value of the patent to estimate the private value of the benefits derived from patents. They found the majority of patents were either of low value or that their value depreciated rapidly. Only 10 percent of all patents were maintained for the entire life of the patent through payment of renewal fees. The implications of this study were that most patented innovations were of little value, but the ones that did pay-off made up for the R&D investments in ideas that turned out to be of little value. Griliches (1990) noted that this study may have serious identification problems due to the range of patent classes included and the relatively low and stable renewal fee schedules.

Several studies investigated the value of the patents through examining the variation in stock market value, patent counts, and R&D expenditures (Griliches 1981, Griliches 1990, Griliches et al. 1991, Pakes 1985). Difficulties with these studies arose from the "noise" of patent data and Granger type causality between patents and R&D. With some assumptions, technological opportunity which affected a firm's stock market value was identified by abnormal or unexpected bursts or declines in the number of patent applications. Estimates of the values of these bursts ranged between $200,000 (Griliches 1981) and $800,000 (Pakes 1985), and a mean unexpected patent was estimated at $98,000 (Griliches et al. 1991).

Griliches (1998) used extensive and convincing arguments to show that patent statistics are good indicators of inventive activity inputs such as R&D expenditures. In particular, several time series studies gave strong evidence that changes in R&D expenditures contemporaneously parallel changes in patent numbers (Hausman et al. 1984; Pakes and Griliches 1984). Additionally, this relationship was found to differ across industries in absolute terms (Hausman et al. 1984).

2.4. Precedent Economic Analyses of Intellectual Property Rights for Plants

One motivating factor for providing intellectual property rights for plants is to increase social welfare through economic growth by stimulating innovation. The statutory mechanism for stimulating innovation is to grant temporary monopoly rights over the innovation to plant breeders which enable the appropriation of rent from the use of their new variety. However, with a potential to achieve optimal patent design as described in the previous section, many adjustments and additions were made to these statutory acts (Appendix A).

Intellectual property rights are legislated because they are believed to increase appropriability for new innovations which then gives incentives to invest in innovation. Social welfare is then increased by providing cost saving and quality improving innovations. Economic analyses on such effects of intellectual property rights for plants (i.e., increasing R&D, stimulating innovation, increasing social welfare through increased quality or yields, or increasing prices or royalties) has been meager, and for the United States, has been mostly limited to a few agricultural crops. In general, these studies found the effects of intellectual property rights for plants low or nonexistent.

Several studies have investigated the effectiveness of intellectual property rights for agricultural plants by investigating how they have affected R&D. Butler and Marion (1985) used an extensive firm survey to assess the effect of the plant variety protection certificate in terms of R&D investment before and after the Plant Variety Protection Act of 1970. They determined that, due to the breeder's exemption, and the narrow of scope and other factors, only a modest boost to R&D spending was attributable to the plant variety protection certificate. The R&D effect of the act was more pronounced on R&D for self-pollinated crops like wheat and soybeans then on open-pollinated crops such as corn.   Perrin, Hunnings and Inen (1983), in a 1980 survey of seed firms, found the Plant Variety Protection Act's had a significant effect on stimulating R&D investments in soybeans and cereals only.[21] These results held when accounting for corresponding increases in market size (Lesser 1997). Alston and Verner (2002) used three separate survey studies to find that there was no significant increase in R&D spending for wheat varieties attributable to the Plant Variety Protection Act. Diez (2002) analyzed the impact of plant variety rights on public and private research sectors in Spain using a cross-section empirical analysis to explain research activities. He found strong evidence

[21] The fact that seed of soybeans are fragile (they do not hold up under normal handling and storage) implies soybean varieties are more appropriable.

that both the potential market value of the crop and intellectual property rights provide incentives for variety development.

Analyzing a detailed survey of breeders in the fruit industry, Stallmann (1986) inferred that plant patents provided only a small incentive for investment for most fruit variety research due to the narrow breadth of product space required by the plant patent. Stallmann showed the investment effects of the plant patent varied for different species. For example, Stallmann found that the plant patent was less effective for woody plants. This is because woody plants, such as most fruit species have higher R&D spending and plant patent enforcement costs due to the longer juvenile period, greater space requirements, stability of reproduction, and greater uncertainties with respect to research success and market acceptance. Penna's 1994 study of varietal release rates for horticultural crops in the United Kingdom before and after the institution of property rights for plants found positive yet uneven effects on varietal release rates among crops. Plant breeders' rights for plants had a significant impact on roses and strawberries but an insignificant impact on the breeding of snap beans, green peas, and apples. A Canadian survey study found that the Canadian Plant Breeder's Act generally increased R&D spending for all crops and particularly for ornamentals and pulses (CFIA 2002).

The increases in the releases of new varieties following enactment of intellectual property rights gave rise to questions regarding the quality of these innovations both in terms of productivity and technical change. The CFIA study also found that the quality and yields of crops increased in Canada as a result of plant breeders' rights legislation. Econometric techniques were used to show that North Carolina yields for soybeans had a weak increase in the increasing trend after the 1970 introduction of plant variety protection certificates (Perrin et al. 1983). Alston and Verner (2002) using commercial and experimental wheat yield models on U.S. historical data detected no increases in yields due to the Plant Variety Protection Act.

Rangnekar (2002) found the marketable length of time for wheat in the United Kingdom fell from 13 years in the 1960s to 5.5 years in the 1990s. Rangnekar theorized that this was the result of a planned obsolescence appropriation strategy which resulted in a focus on small incremental improvements as opposed to larger more substantive crop improvements. These results imply some of the yearly application increases seen in plant breeders' rights may be due to a wider appropriation strategy over many crops with small improvements.

Janis and Kesan (2002) undertook a detailed legal an empirical assessment of licensing and enforcement of the plant variety protection certificate data from 1971 to 2001. They concluded that the plant variety protection certificate constituted only a marginal role in stimulating plant research because the plant variety protection certificate's "Swiss-cheese like, intellectual property protection does not promote excludability and consequently does not permit appropriability."

Stallmann (1991) suggested that intellectual property rights may cause research to shift towards major high-valued crops and ignore minor crops because high-value crops garnered more immediate returns from the increased appropriability. Knudson and Pray (1991) modeled public sector funding that included social benefits, public use of breeder's rights, and industry support through private investments. Their results supported the notion that the Plant Variety Protection Act had influenced the direction and emphasis of research toward major commercial crops. Also, when industry contributions are considered in conjunction with intellectual property rights, it may be possible too much will be allocated on research for particular crops.

Several studies investigated the effectiveness of intellectual property rights from the perspective of the breeders and owners of the rights and allocation efficiency. Are plant innovators able to appropriate future revenues by charging price premiums for their new varieties? Increases in prices resulting from the institution of plant intellectual property rights can be twofold. First, they may reflect the firm's increased ability to recoup a fair return on their investment in R&D of new plant varieties. Second, since the intent of the legislative property rights is to encourage innovation of new and novel varieties which may embody increased quality, then farmers and consumers would be willing to pay a premium for the higher quality varieties. By looking at farm seed expenditures as a proportion of total expenditures, limited sampling of seed prices and a seed company survey Butler and Marion (1985) determined that there where slight to substantial increases in price premiums for seed of new varieties from 1916 to 1980. The limiting factors for price premiums were farmer seed saving and public variety offerings. The enhancing factor for price premiums was pre-existing firm market power prior to the Plant Variety Protection Act. Lesser (1994) used a hedonic price study that determined that the value of the plant variety protection certificate for soybeans was quite low. Lesser postulated that the narrow scope of protection and the small degree of distinctiveness required of the plant variety protection certificate may be the reason why price premiums were low. He observed that every competitor in the agricultural seed market was producing a virtual copy of a protected cultivar within a few years following the new cultivar's release. Lesser suggested that this phenomena could mean the value for the plant variety protection certificate could be derived from protecting the name of the cultivar rather than the germplasm itself.

Alston and Verner (2002) examined the trends in wheat prices. They found no significant structural changes to support the idea there were any changes in the rates for price premiums for new varieties of wheat due to the Plant Variety Protection Act. The problem of low rents for new varieties due to farmer saved seed was investigated by Hansen and Knudson (1996). They compare yields of soybeans derived from saved seed versus new varieties by using a regional yield model and a likelihood test to contrast the constrained model, were saved seed and grain value are equal, with the unconstrained model. They found seed firms can indirectly appropriate a variety's harvest through price premiums on their seed, but that seed saving reduced the value of these premiums. Using a fruit nursery survey Stallmann (1986) found, for most fruits, nurseries were "…severely constrained in their ability to pass royalty payments on to growers…," and only larger nurseries with lower costs were able to offer plant patented varieties by absorbing the royalty (p. 48). Patent royalties on average were found to be about $.50 which was about the same as the premium a large firm could extract using limit pricing (see section 2.4.1).

Overall, these studies confirm what the optimal patent theoretical literature implied about appropriability of new innovations—when the intellectual property requires a small minimum inventive step and the product space defined is narrow, then appropriability will be lower than optimal. Also, the appropriability of intellectual property rights for different technologies and products will vary. Most of these studies focused on a few agricultural plants. Only the Canadian survey studied covered the whole spectrum of plant types.

In general the research investigated isolated effects of intellectual property for a narrow range of plants and measured only partial aspects of the complex effects providing intellectual property rights for plants. It can be beneficial to put these studies in a broader socio-economic context as was done by Fernandez-Cornejo (2004) for agricultural crops with a focus on the four major crops: corn, cotton, soybeans, and wheat and increasing concentration in the seed industry. This broad USDA study, which made use of multiple studies combined with multiple data sources, analyzed the evolution of the seed industry and R&D for new agricultural varieties in the context of the evolution of intellectual property rights. A similar but less extensive research by Fuglie et al. (1996) focused on incentives for private investment in R&D for agricultural crops. For Australia, Godden (1998) analyzed the recent and future evolution of plant breeding in the context of the evolution of the 1987 intellectual property rights for plants legislation in Australia. His analysis involved comparing the evolution of the intellectual property rights with the property rights statistics. He concluded that, because of the weaknesses of the plant variety protection, breeders will increasingly turn to patents which offer greater appropriability. There have been no studies like these broad based historical evolutionary studies for intellectual property rights that have focused on horticultural crops.

2.5. Factors Affecting the Price of Plant Varieties

The factors that influence the appropriability of current and future revenue streams, attributable to intellectual property rights for plants, and the extent to which these and other factors influence the price of plants may vary between horticultural and agricultural crops, among plant types, and between species. Differences may affect breeders and breeding firms in their choices to secure and practice intellectual property rights for new plant varieties and their pricing and marketing strategies for maximizing their rents from protected verses unprotected cultivars.

2.5.1. Limit pricing

Expected revenue streams for plants with intellectual property rights depend on the innovator's ability to charge a premium price for the product of the innovation. Stallmann (1986) developed a useful pricing theory for new plant innovations with intellectual property protection. She provided a framework for analyzing prices of competitive plant producers of different sizes to show that only large firms offer new patented varieties.[22] The basis of her theory is a limit pricing theory that explains competitive pricing among oligopolistic firms (Scherer 1988). In essence, this theory maintains that in a market with differentiated products, larger firms opt for a long-run pricing strategy over a short-run profit maximizing strategy because the former reduces price to a level that discourages new entrants and the expansion of smaller firm competitors with closely related products.

Stallmann extended this theory to show how a large firm's pricing of protected new varieties is limited in a competitive market with close substitutes and where there is a

[22] She assumes the larger the firm the larger their economies of scale cost savings.

threat of infringement from both competitive production firms and growers which purchase the plants. The grower is willing to pay the lowest price of competing nurseries if it is still lower than their own propagation infringement costs. A smaller competing firm is motivated to infringe if it can expand production and sell at a lower price. A large producer, *L*, (or a producer with sufficient cost saving efficiencies) secures its market share by setting their plant cultivar's price, P_L, is just low enough:

$$P_L \leq C_G + I_G \ and$$

$$P_L \leq C_S + I_{S,}$$

so that P_L is below the grower's, *G*, average cost to propagate that cultivar, C_G, and their potential cost of infringement, I_G , as well as lower than the difference between its own and every competing firm, *S*, total costs, C_S, to produce and market that plant and their potential cost of infringement, I_S. Therefore, any royalty, R_L, passed on to the grower must satisfy:

$$R_L \leq C_L - C_S.$$

In a related study, using a fully dynamic pricing model Gaskins (1971) showed that if the competing firm's costs were high enough so they exceeded a monopolist's short-run price, where marginal revenue equals marginal costs, the dominant firm would always enhance its long-run profits by holding its price below the short-run profit maximizing level. The price path chosen over time of the dominant firm varied depending on its cost advantages over the competing firms, the discount rate and an entry response coefficient.

2.5.2. R&D and Reproduction Costs

There are some important plant attributes that can influence the costs of varietal innovation. The size of a plant affects the space requirements for breeding and developing a new plant variety. Smaller plants require less space and so are less costly to breed. The length of a plant's juvenile period, the time to develop seed and fruit, also affects the cost of breeding and testing new varieties. Stallmann (1986) noted that because tree fruits have large space requirements and long juvenile periods they were generally more costly to breed and test. R&D costs associated with size and space are significantly higher for fruits and nursery plants which mostly consist of woody vines, canes, shrubs, and trees (Stallmann 1986, Luby 2006).[23] Thus, not surprisingly, intellectual property rights had strong positive effects on the rate of innovation (Penna 1994) and investments in R&D (Stallmann 1986) for strawberries, which are small and have short juvenile periods relative to other fruits, whereas, intellectual property had little or no positive effects for apple trees which are large and have long juvenile periods. These factors, size and juvenile period, also influence production costs and the time it takes to bring a new cultivar to market, and thus also affect the appropriability of a new cultivar.

Breeding and development costs are influenced by the likelihood that a trait will be passed to its progeny. Heritability is a measure of the degree (0 -100 percent) to which offspring resemble their parents for a specific trait. Heritability determines the number of progeny required to achieve trait improvement at a particular level of probability. The larger the number of progeny required, the less heritable the trait and the costlier it will

[23] Strawberries which are herbaceous and not woody are an exception.

be to test for the existence of a desired and stable trait. Blue flower color for a rose would be considered a trait that has a low heritability. Stallmann (1986) observed that for many fruit and nut crops, even when traits are highly heritable, the costs of testing may limit the number that can be tested due to the costs of land and the length of time required for testing the progeny. While differences in heritability exist among different traits and, most of these differences are unknown for the large numbers of horticultural species (Stallmann 1986). If the target traits for breeding a species are highly heritable, then the breeder has greater ability to invent around a plant of that species protected by intellectual property rights.

Additional costs may arise from reproductive barriers. Liedel and Anderson (1993) pointed out that while sexual reproduction is the simplest approach to introducing genetic heterogeneity into a plant using classical plant breeding techniques, horticultural plants often present a variety of reproductive barriers that prevent using outcrossing. Many of today's commercialized horticultural crops are the result of strong selection pressures for crops that are self-fertilizing (thus making outcrossing difficult). In addition, horticultural plants that have been excessively inbred or have developed asexual means of self-replication become increasingly homozygous with undesirable traits that can easily be exposed. Furthermore, many horticultural crops, where yield is composed of vegetative or reproductive parts (e.g., cabbage, onion and potato), pollination mechanisms are of no importance, and in some instances even reduce crop yield (e.g., sweet potato). Finally, the seedless characteristic is often desirable for fruits and vegetables and flowers.

2.5.3. Market Factors and Expected Revenues

Market factors also affect the expected revenues new plant products. The price premium that can be charged for a new plant variety will be circumscribed by the number of closely differentiated plant products on the market. When there are a large number of marketed differentiated plants, there are higher costs to the consumer associated with obtaining the necessary information to make a product choice than for markets with just a few close substitutes. High costs for product information decreases the willingness to pay (Nelson 1970, 1974, 1978). For example, for some ornamental species such as the rose, there are hundreds (if not thousands) of cultivars on the market with many close substitutes. Information costs would be lower if a new cultivar embodied a large inventive step (i.e., a truly blue rose) and so could command a high price premium due to an increased willingness of consumers to pay for this attribute. Informative advertising can lower costs as well as increase the demand for a particular new cultivar and thus expected revenues.

Because demand for horticultural products have higher income elasticities (Singh 1999), new plant products with a particular appeal to wealthier cross sections of consumers are likely to have higher expected premiums. If consumer wealth is expected to decline, then breeders may limit their breeding focus on fewer species with higher demand.

Horticultural plant markets are relatively small compared with many agricultural crop markets, so the length of a plant's commercial life may negatively impact expected revenues (Penna 1994, Stallmann 1986). If a plant's commercial life is comparably short and market preferences shift rapidly, then owners of protected plants may have insufficient time to exploit the rights provided. On the other hand, nursery crops or woody crops tend to be long-lived, so potential buyers may not be willing to replace them often enough or only under specific conditions and thus limit the potential earnings within the life of their intellectual property rights. In the case of fruit, nurseries may find that fruit growers are unwilling to replace trees of optimal bearing age with a competing new variety that will take time to bear substantial fruit (Stallmann 1986, Penna 1994).

Other market factors that influence the expected returns from protected plant innovations include market concentration and size, and economies of scale in R&D and marketing. Several studies suggest that the larger the perceived size of the potential markets the greater the incentive for innovation of new varieties (Griliches 1957, Heisey et al. 2001, Diez 2002). The firm size can lower fixed costs and produce economies of scale and scope for R&D departments and advertising (Heisey et al. 2001, Tait et al. 2001). The more concentrated the market the more favorable pricing conditions will be (Tait et al. 2001).

2.5.4. Exclusion Costs

Exclusion costs are particularly important for plant intellectual property rights because both the plant patent and the plant variety protection certificate have a relatively narrow scope of coverage that allows many close substitute varieties to be marketed without infringing.[24] The strength of exclusionary power of a plant right depends on the

[24] In addition, Plant patents and plant variety protection certificates do not have a non-obvious requirement or equivalence clause like the utility patent has that requires the innovation to have a larger inventive step. As a result, plant patents and plant variety protection certificates are granted for new varieties with only

availability of close substitutes. If the rights holder prices their new variety too high in relation to the size of the innovative step embodied in that variety, then competitors have incentives to enter the market by inventing around the invention or to infringe on the right. Scherer (1988) observed that under these conditions, with a monopoly and consumers with high price elasticities and low substitution costs, prices will be kept lower and the monopoly's future earnings are discounted less. Because of these conditions, if exclusion costs and investment costs are less than or equal to the returns to oligopolistic pricing, then intellectual property rights may encourage sufficient R&D investments. This means inventions may realize profits even when the full value of the productivity or quality increases cannot be recovered. For some species, R&D costs are high, so low cost spontaneous mutations and discovered seedlings in cultivation (natural variations that may be covered by a plant patent) may be the primary source of new cultivars. However, even if the full value of productivity or quality increases can be obtained, the inventor may not recoup R&D costs if all costs exceed the stream of quasi rents resulting from the new variety. This is the case with fruit tree breeding.

The rights holder is responsible for enforcing their property rights, which involves detecting infringement, which until recently could be quite difficult, as well as prosecution.[25] The cost of infringing is triple royalties. If the exclusion costs are higher than the awarded triple royalty then competitors have an incentive to copy. The costs associated with these efforts depend on the value of the cultivar. A way to reduce these

small differences from existing protected varieties. These differences are not necessarily quality improvements.

[25] DNA testing and typing technology allows for a genetic "fingerprinting" that can give strong verification of infringement.

costs is for the innovator to selectively prosecute in a way to acquire a perceived reputation of aggressive policing and prosecution. An inability to enforce their property rights reduces their value. For a given species, the value of the cultivar depends on the level of novelty, quality or productivity embodied in the new cultivar, and the number of close substitutes on the market. In addition, product value ranges across species, plant types (woody or herbaceous) and subsectors (horticultural and agricultural).

Stallmann (1986) observed that the relationship between exclusion costs and intellectual property rights for plant varieties depends on an interaction between the stability and accessibility of reproductive materials which could vary depending on the plant and the industry. Stallman defined accessibility as the degree of technical expertise and capacity required for reproduction of a variety. The higher the stability and accessibility of the plant, the higher the exclusion costs will be for the plant patent holder. For example, wheat seeds are considered both stable and accessible. Hybrid corn seed is considered unstable because the performance of their progeny varies greatly from one another and their parents. Hybrids would have low accessibility because farmers would be unlikely to have either the expertise or capacity to reproduce the seed. Asexually reproduced materials are generally considered very stable because they are identical to their parent stock. Propagator nurseries have the ability and the capacity to reproduce asexually reproductive materials, but grower nurseries may or may not depending on the technical knowledge needed.[26] Stallmann (1986) observed exclusion costs would vary depending on the plant and the degree of stability and accessibility of the reproductive

[26] In the ornamental plant industry producer nurseries or propagator nurseries specialize in producing small plantlets (propagules) to sell wholesale to other grower nurseries to grow on or finish for landscapers or retail outlets (See Figure 2.2).

materials. The costs of excluding farmers from replicating a stable protected variety may be high, due to the investment required to police and prosecute all the potential infringers, but as reproductive technologies become more sophisticated, the ease with which these varieties can be reproduced may be reduced. On the other hand for horticultural crops, there are fewer nurseries, so and policing, enforcement and prosecution costs may be lower.

In addition, exclusion costs can vary among seed or plant industries according to the level of self-regulation. The ornamental plant industry has developed an environment that encourages self-regulation. In the ornamental plant industries, most large propagation nurseries publish catalogs and have online databases of their cultivar offerings, thus, making their plant offerings a matter of public record. These publications combined with peer pressure within industry associations and trade publications discourage infringing behavior (Stallmann 1986). However, because this industry has grown considerably in size and in the international dimension in the last 20 years, self-regulation has a greater moral hazard due to the larger number and more widely dispersed economic agents (Drew et al, 2010).

2.6. Advertising, Branding and Trademarks

There is a plethora of differentiated products in plant and seed markets, and each product embodies an array of attributes important to the wholesale buyer and consumer. This creates a market situation where the search for all the information necessary for plant choice could easily overwhelm the average buyer. Advertising and its associated tools (i.e, brands and trademarks) is commonly employed in such markets.

A vast amount of literature has accumulated on advertising that show that advertising is a subtle and nuanced art with varied effects dependent on many factors that remain poorly understood. In general, the primary role of advertising is to generate awareness of products and also to make consumers aware of how alternative products are different. Advertising can be *informative*, *persuasive* and *complimentary* (Bagwell 2007).

When advertising is *informative* it affects demand by conveying information. By supplying information, advertising can increase the price elasticity of consumer demand with an effect of lowering prices. This effect is reinforced when production scale economies are present. In the simplest case, advertising may provide the indirect information of high quality. Informative advertising tends to be used by new firms with low cost, high quality products. Stigler (1961) noted that, in markets where the search for information is required to make informed product choices, the “law of one price” (i.e., where a single equilibrium price prevails in a perfectly competitive market) does not hold. Stigler explains the dispersion of prices often observed is the result of consumer ignorance which arises because obtaining information, regarding the existence, location and prices of products can vary in costs to different consumers. Thus, by conveying such information, advertising can effectively reduce search costs and reduce price dispersion. So while the price of an advertised product will include additional costs for advertising, the presence of such advertising increases consumer welfare by reducing search costs.

Often, when obtaining product information is difficult and search costs are high, advertising can serve as a quality signal (Nelson 1970, 1974, 1978, Kihlstrom and Riordan 1984). With advertising, a high-quality firm can realize a larger price premium from sales in the high-quality market, and so is willing to incur the additional costs. Nelson (1970) developed a model for advertising which predicted that firms selling goods with high search costs (as opposed to firms selling goods with lower search costs) would have more monopoly power, tend to not cluster geographically as much, and create a need for expert information (advertising will be used more for durable goods than nondurable goods).[27]

For plant propagation firms, not all plant offerings have promotional advertising associated with the cultivar. The product and advertising and branding associated with the cultivar can originate from the breeder or the innovating firm. Bloch and Maceau (1999) developed an advertising model that described *persuasive* advertising. *Persuasive* advertising is a means by which a firm can shift the distribution of consumer tastes towards one product. They showed, when both products are sold by the same firm, advertising led to an increase in the price of the advertised product and a decrease in the price of the other product, and as long as the bias is not too great, profit was higher when the distribution was concentrated around one of the products.

Grossman and Shapiro (1984) developed an advertising model that included horizontal market differentiation which we see in the ornamental plant market. They provide a unified framework that could explain a broad range of pricing issues observed

[27] Nelson draws a distinction between two types of goods, experience goods where obtaining information requires the maximum cost (i.e., the product must be purchased and experienced to obtain information) and search goods where information can be discovered through as search and therefore is less costly.

in complex product markets (Bagwell 2007). Their model showed that in market equilibrium, *persuasive* advertising induces less price elasticity in consumers and a higher equilibrium price. Advertising, profits and costs of advertising increases if product differentiation is greater.

Complementary advertising primarily affects demand by exerting a complementary influence in the consumer's utility function with the consumption of the advertised product. For example, if advertising served as an input that enabled the consumer's social prestige to be enhanced with the consumption of the product then such advertising would be considered *complementary* (Bagwell 2007). This may explain why some current ornamental plant advertising has more to do with associating life styles with plants than promoting the plant's intrinsic attributes.

Virtually all of these economic studies in advertising focus on retail markets. While these advertising theories provide insight to the purchasing behavior of wholesale growers—as well as retail consumers—it is important to recognize there is another dimension to the economics of advertising from a wholesale market behavior perspective. From this perspective, growers may be interested in advertised plants in addition to the information provided—that is, for the way they help to secure a larger market share at the retail sales level by informing and persuading consumers to purchase the advertised plant product.

Advertising typically goes hand-in-hand with the use of brands or trademarks. A brand or a trademark is used to identify a set of attributes and consumer experiences with a product (service, group of products or services) and its supplier. Thus, the use of a trademark is a kind of advertising "shorthand" which enables consumers to distinguish between different goods and suppliers. In a market environment with information asymmetry and uncertainty of product quality, firms have incentive to mislead consumers, and as a result both product quality and market size will decline (Akerlof 1970). The use of a trademark or brand can counteract the asymmetry of information problem by indirectly but efficiently conveying product information particularly regarding quality (Akerlof 1970). The trademark simultaneously influences firm reputation while conveying product information (Akerlof 1970, Landes and Posner 1987). This is because it also provides the means (through product identity) for a consumer to connect their experience with their subsequent purchase decisions, so the firm has incentive to maintain or improve product quality (Akerlof 1970)

The word trademark is often used when describing the intellectual property rights associated with brands. According to the Lanham Act: "The term Trademark includes any word, name, symbol, or device, or any combination thereof: used by a person, or which a person has a bonifide intention to use in commerce and applies to register on the principal register establishes by this Act, to identify and distinguish his or her goods, including a unique product, from those manufactured or sold by others and to indicate the source of the goods, even if that source is unknown." Under common law, the use of "™" indicates that a trademark is intended. Registration of a trademark with the USPTO is beneficial as it notifies others that the mark is being used and increases the strength of the trademark should a dispute arise (Aguirre 2006).[28] The symbol "®" is used in connection with a registered trademark.

The mark must be properly used and in continuous use to retain the rights to use it. The application requires the submission of proof of its use in commerce, and subsequent renewals require an affidavit of use (Aguirre 2006). Since the Lenham Act, Lemley (1999) argues that court rulings have expanded the rights of trademarks by extending the rights over the marks beyond their value for commercial advertising connected with a particular product. The language of the courts increasingly treats trademarked brands as things owned in their own right.

When used in conjunction with horticultural products, a trademark can be used in several different ways: to identify plants of a particular breeder, breeding program, or plant selection program; to identify a series of plants; to indicate a grower or nursery; to identify the product of a group of growers; to indicate a level of testing or approval (certification); to identify a particular service (e.g. marketing support); and to use as the selling name for a single cultivar (Aguirre 2006).

In the United States, the use of trademarks with commercial cultivar names is the most prevalent use of the trademark in the ornamental plant industries. The reasoning for using a name trademark is multifaceted. First, a name trademark used to link the name with the plant attributes is believed to be a lower cost way to protect a cultivar, and can be used when a plant is unpatentable (Aguirre 2006). Second, it is believed that the name trademark can be used to obtain price premiums originally obtained using the plant patent beyond the life of the plant patent (Stallmann 1986, Aguirre 2006). Last, it is believed

[28] The USPTO maintains a searchable database of registered trademarks (USPTO 2009).

that the intellectual property rights of a plant patent can be enhanced with the use of a trademark (Aguirre 2006). If adoption of a plant patented cultivar by wholesale growers, retailers and consumers is speeded up by using an advertised trademark name, the longer the breeder, or plant innovation firm can collect royalties within the life of the plant patent or before competitive follow on cultivars can be produced.

2.7. Hedonic Pricing Framework

Currently, there is a plethora of ornamental plants marketed with each cultivar differentiated by a host of different combinations of attributes. Of a survey of 15 popular ornamental species, sold from 2005-2007, 24 percent of the plant cultivars were protected using plant patents, and about 23 percent of these cultivar's names were protected using a name trademark.[29] Plant patents and trademarks can be viewed as a product attribute in the sense that they are tangible signals of innovative quality, novelty, and added value. The hedonic price framework is a useful means by which to assess the value of these intellectual property rights and other plant attributes in that it links observed prices to specific attributes.

To date, Lesser (1994) is apparently the only published study that utilized this approach in this context. He examined the price premium implications of plant variety protection certificates on 43 varieties of soybean seed marketed in New York in 1992. Waugh (1928) developed and employed this approach with a study of price behavior in the Boston wholesale vegetable market. By deriving implicit prices for product characteristics, he found attributes such color, size, and uniformity of size had marketable

[29] For details see Chapter 4, section 4.4.2.

value, while characteristics such as existing grading and packaging schemes had no measurable implications for the wholesale price of vegetables. Later, Court (1939) and, in particular, Griliches (1961) revived and popularized the hedonic framework in applications to the automobile industry that sought to develop automobile price indices which took into account changes in the quality of cars.

Lancaster (1961) developed a theory of consumption that encompassed "consumer activity analysis." Drawing on Samuelson's production theory (1953), Lancaster developed a concept of consumer demand: consumption consists of an activity much like production wherein goods are viewed as bundles of characteristics. These bundles of characteristics are the inputs into consumption activities where utility is then the output. From this perspective, utility is derived from the quantities, rankings and combinations of characteristics embodied in consumed products. With this framework, goods viewed as bundles of characteristic can be intrinsically related, or not, because the characteristics can have complimentary or substitute relationships when consumed.

The approach was extended by Rosen (1974) in his seminal work deriving the set of prices pertaining to product characteristics from a market equilibrium for differentiated products. According to Rosen, "A theory of hedonic prices is formulated as a problem in the economics of *spatial* equilibrium in which the entire set of implicit prices guides both consumer and producer *locational* decisions in characteristic *space* (Rosen 1974 p. 34)." Hedonic prices are then the implicit prices of a product's characteristics. These implicit prices determined by market clearing conditions are revealed to economic agents from observed product prices and the amounts of those characteristics that are associated with them. Accordingly, in Rosen's model, the implicit characteristic price estimates are a description of a competitive equilibrium in the market for that characteristic, which is the locus of intersections of the demand curves of different consumers with varying tastes and the supply functions of different producers with possibly varying technologies of production. Central to his theory is that both consumers and producers recognize a product's characteristics in the same way. Thus, the derived implicit price for each characteristic is the customer's marginal willingness-to-pay for an additional unit of that characteristic. The value of Rosen's framework to this study is that it indicates that prices can be decomposed into value contributions that are attributable to specific characteristics. When differentiated products or different brands of products can be viewed as bundles of different groups of characteristics, then their observed market prices can be compared on the same basis.

With theoretical roots in production theory (Samuelson 1953, Lancaster 1961) and practical roots in a wholesale market analysis (Waugh 1928), the development of a hedonic price theory for production inputs in a wholesale market was accomplished by Ladd and Martin (1976). They developed a hedonic model for equilibrium prices in a wholesale market for agricultural production inputs.   Instead of modeling consumer consumption activities, they model firm production activities where a profit maximizing firm chooses an input based on the sum of the values derived from the input's characteristics. Ladd and Martin showed that the value of a characteristic supplied by an input good is the quantity of the characteristic supplied by that input times the marginal value of that characteristic.

Hedonic prices are revealed by regressing the market price of a good upon its characteristics. Thus, the individual contribution for each characteristic to price is revealed by the market observations. To study the welfare impact of a change in a characteristic, the underlying structural demand of hedonic price equation needs to be estimated (Estes and Smith 1996).

Rosen (1974) not only produced the standard theoretical model for these studies, he also recognized an identification problem for estimating supply and demand equations for each characteristic when assessing the welfare impacts of a change in a characteristic's supply. This is because the price function, which can have any form that does not violate the underlying supply and demand curves, may be non-linear and discontinuous. So, Rosen offers an efficient solution for estimating the hedonic price market described by three equations: two structural equations of supply and demand and a hedonic price equation. Rosen's solution to the problem was to develop a multi-step procedure, wherein he first estimated the price, *P*, as a function its characteristics, *Z*, using the best fitting functional form, and then used this estimated function and the amounts of the characteristics to estimate marginal implicit prices $\partial P(Z)/\partial Z$. Supply and demand functions were then "recovered" using the estimated marginal implicit prices and supply-shift or demand-shift variables.

The main focus of many studies is to describe existing market conditions and to test the short-run effects of various attributes on price. Therefore, Rosen's hedonic price estimations for attribute and product relationships are of primary interest. With this approach, the analysis is limited in that it only obtains equilibrium conditions for one specific market rather than the preferred general equilibrium that includes demand or supply schedules obtained by the multi-stage approach. Thus, generalizations about attributes and their marginal values may be limited. However, single market estimations of implicit prices are useful for comparison with estimations of other markets (Estes and Smith 1996).

A problem with many hedonic studies of differentiated products arises from the incongruities between theory and the real world. Rosen (1974) assumes symmetric information between consumers and producers when in fact asymmetric information is common in markets with many differentiated products. This is particularly a problem when products have one or more important attributes that can only be known through experience. Such models that omit many attributes can lead to estimation biases or result in under-specification of the estimated model (Ruder and To 2004, Requena-Silvente and Walker 2005). Inclusion of difficult to ascertain attributes or the variables that best represent them should be considered necessary for specification of a hedonic model. In markets with many products with many attributes, some of the variables that may be used in a hedonic price model that represent these difficult to ascertain attributes may, in fact, be the variables consumer's use when making their purchasing decisions. Examples of such variables would be product brands, labels for organic and fair-trade, and firm attributes, and in the case of ornamental plants, plant patents and trademarks. Several studies actually include these variables as the characteristics of interest (e.g., Estes and Smith 1996, Maietta 2003, and Huang 2006). This is an interesting and important feature of the hedonic model. It can be used to find an implicit value for characteristics which cannot be directly observed by buyers of the product in which these characteristics are embodied.

In general, the results from hedonic price models depend on the choice of appropriate attribute variables as well as the correct specification of the form of the estimation function. Traditionally, hedonic price models included products which have been defined in terms of a few 'baseline' models, even though for many industries that produce consumer goods, products cover a wide range of differentiated versions. For many consumer durables such as cars and computers, it is relatively easy to obtain set of appropriate attribute variables, but this is much less true for products such as foods, beverages and plants. Developing an appropriate hedonic model for products with little precise and rigorous information available to the consumer is more difficult. Because of this difficulty, the characteristic space for many models has been limited to a few observable, or readily measurable product attributes and omits variables that represent or control for unobservable or unmeasurable attributes.

Although Rosen's model (1974) associates differences in the estimated parameters of his model to differences in factor prices, technology and firm-specific R&D expenditures, Pakes developed a hedonic model for differentiated goods that explicitly includes market power in an effort to explain the higher value of newly introduced goods. He reasons that new products are largely a result of prior investments in R&D and marketing. The resulting hedonic price equation can then be decomposed into a marginal costs and a markup component. Such a model has the flexibility to explain market price behavior when some of the differentiated products garner markups and others may not. Although

Pakes used a Bertrand price equilibrium to develop the model, his model can be used for any price equilibrium that is not just marginal cost pricing. Pakes points out that his model is based on the same three primitives of previous studies: utility functions defined directly on the characteristics of the products, cost functions which are defined by characteristics of the product, factor prices, scale of production, and productivity, and an equilibrium assumption that determines prices given demand and costs.

2.8. Empirical Applications

While this research will use the hedonic framework as a means to learn about the value of intellectual property rights for new plant cultivars, the hedonic price framework also provides a basis of analysis which can be applied in a variety of ways for a multitude of purposes.

Griliches (1961) and Court (1939) estimated consumer price indices in the automobile market based on implicit prices for car characteristics such as length, weight, and horsepower. Many studies examined various welfare implications, including the environmental impacts on the housing market, by estimating implicit values of housing qualities (i.e., number of bedrooms, garage space, and gardens), neighborhood qualities (i.e., schools, availability of jobs, and parks), and environmental qualities (air or water quality, natural habitat such as woods and ponds).[30] Kitchen and Hendon (1967), Correll et al. (1978), and Netusil and Bolitzer (2000) respectively estimated implicit prices for parks in Lubbock, Texas, for properties adjacent to greenbelts in Boulder, Colorado, open

[30] See, for example, Kitchen and Hendon (1967), Correll, Lillydahl et al. (1978), Palmquist (1984) and Netusil and Bolitzer (2000).

space on property values in Portland, Oregon.[31] Hedonic studies have been also used to measure welfare impacts in labor markets (Heckman et al. 2003 & 2005, Eckeland et al. 2004).

A number of studies have used hedonic analysis on agricultural products, both as inputs of food and beverage products and as value-added food products. Observable vegetable characteristics were studied in wholesale markets by Waugh (1928), Estes (1986) and Bierlen (1995). Estes found that cooler vegetable temperatures and larger sizes were premium attributes for green peppers for three temporally different markets. Bierlen found that vine-ripened tomatoes garnered price premiums in the summer, while mature green tomatoes received price premiums in the winter. However, his conclusion that these attributes were favored by consumers due to the price premiums is questionable because wholesale buyers consider two sets of attributes when making purchase decisions: their own choice attributes, as handlers and retailers of produce, and their customer's choice attributes as consumers. Bierlen did not consider the attributes important to the wholesale buyer such as ease of handling, shelf life, and availability of substitutes (garden tomatoes and farmers' market tomatoes are available in the summer and not in the winter). This example points out the importance of carefully interpreting wholesale market results. Ladd and Martin (1976) estimated implicit prices for nutritional content in corn inputs in a wholesale market, and Wilson (1984) estimated implicit prices for plumpness and protein in barley on the Minneapolis Grain Exchange for four separate years.

---

[31] Note that the high valuation of "green" amenities on the housing market has some strong implications for prices of ornamental products.

Antonivitz and Liu (1996), Estes and Smith (1996), and Huang and Biing-Hwan (2006) estimated implicit prices for product attributes which consumers cannot ascertain when purchasing but are measurable. Antonivitz and Liu tested consumer's willingness to pay for reduced pesticides in fifteen fruits and vegetables over ten years using FDA's Total Diet Study data and estimated a small but significant implicit price for items known to have low amounts of pesticide residue. Estes and Smith estimate implicit prices for an array of appearance and health risk attributes (organically grown) to determine if consumers will pay a premium for organic produce—specifically for celery, oranges, apples and grapefruit. Huang and Biing-Hwan use multiple regional retail market purchase data and consumer characteristics to determine that consumers are willing to pay a premium for organic tomatoes.

The hedonic work in the wine markets closely relates to this research for the ornamental plant market in that most wine attributes are difficult to evaluate as are many of the characteristics of plants purchased in wholesale markets. Moreover, many of the attributes in wine, like plants, entail (subjective) sensory evaluations that must be directly experienced and are not easily or precisely observed or measured. Sensory wine characteristics can only be known through experience and as a result are more costly to ascertain, or partially ascertained through proxy information on labels or in reports by tasters or tasting panels. Similarly, many of the attributes with potential value in ornamental plants can only be known through experience, experts, and published and online catalogs.

Hedonic studies of wines address these problems by including a variety of proxy or representative variables for wine sensory attributes. Most hedonic wine studies have used sensory wine evaluations that ostensibly represent measures or perceptions of quality in their estimated price functions. Wine studies have focused on attributes such as regional and weather influences (Byron and Ashenfelter 1995, Schamel 2003, Schamel and Anderson 2003, Haeger et al. 2006), taster's and tasting panels (jury grading) (Combris et al. 1997, Schamel 2003, Schamel and Anderson 2003, Haeger et al 2006), label information (Steiner 2004), and winemaker's reputation (Schamel 2003, Schamel and Anderson 2003, Steiner 2004, Heager et al. 2006).

Oczkowski (2001) noted that in hedonic wine studies, the inclusion of all types of attributes leads to higher significance levels for all variables and better specification of the hedonic model. But a problem arises when two or more variables are used as proxies for sensory quality. Because of the nature of proxy variables, they are imprecise measures of the information they are intended to represent, and so are likely to be correlated with other proxy variables that represent sensory information. The greater the measurement error, the higher the correlation is likely to be.

Choosing the correct functional form for the estimation of the hedonic price function has been an ongoing issue for hedonic empirical studies (as it is for almost all empirical applications), because there is no a priori theory that reveals the appropriate functional form (Rosen 1974, Blackley et al. 1984, Estes and Smith 1996). Therefore, many hedonic studies used empirical methods to determine the best functional form to estimate the price equation. The Box-Cox power transformation advocated by Blackley, Follain and Ondrich (1984), Palmquist (1984), and Cropper, Deck and McConnel (1998), is widely used to determine the best functional form for the price data (Palmquist 1984, Estes 1986, Estes et al. 1996, Huang et al. 2006). The Box-Cox regression model also provides framework for a specification test for linearity or log linearity which can be employed to determine the appropriate model (Green 2003). Anglin and Gencay (1996), and Cropper, Dech and McConnel (1988) found that simple linear functions for unobserved characteristic variables (or proxy variables) outperform non-linear functions and the linear Box-Cox transformation. Requena-Silvente and Walker (2006) emphasized the inclusion of unobserved characteristics to minimize bias in estimating the hedonic price function. Steiner (2004) gave support for the use of the logarithmic (log linear) functional form for hedonic price equations with dummy variables because these are most easily interpreted as the percentage contribution to price from the presence of a binary or dummy variable.

More recent econometric research into the estimation and identification of the hedonic price equation advocated that parametric and or semi-parametric functional forms are less biased than other models (Anglin et al. 1996, Heckman et al. 2003 & 2005, Ekeland et al. 2004, Kondo and Lee 2003). Using several common model comparison tests, Anglin and Gencay showed that linear estimations with the appropriate interaction terms outperformed their benchmark log-linear estimations with appropriate interaction terms of a hedonic equation that included both continuous and dummy variables. They found that a semi-parametric model that estimated the dummy variables with linear parametric estimates and the continuous variables with nonparametric estimates generated the most accurate in- and out-of-sample predictions. While these methods may be superior for estimating the welfare effects of marginal attribute changes on prices, by their nature they are of little value for relating the marginal affects of changes in attributes on price itself where estimated coefficients are needed.

Several methods are used in the hedonic literature for model selection and to determine which variables may be excluded. This is an issue often discussed in hedonic research due to problems arising from misspecification. A test constructed by Ramsey (1969) called the RESET test, which employs both t statistics and F statistics to test nested models, was used in each of Anglin and Gencay's functional forms to determine which variables can be excluded. Combris, Lecocq, and Visser (1997) used the more commonly deployed stepwise selection approach and found the same results for both forward and backward selection processes. Other hedonic studies address variable selection in terms of minimizing collinearity problems (Antonovitz and Lui 1994, Oczkowski 2001, Unwin 1999, Estes and Smith 1996). Oczkowski (2001) used factor analysis to empirically assess the ability of observed indicator variables to adequately reflect their latent attributes, and then used two stage least squares to address this problem.

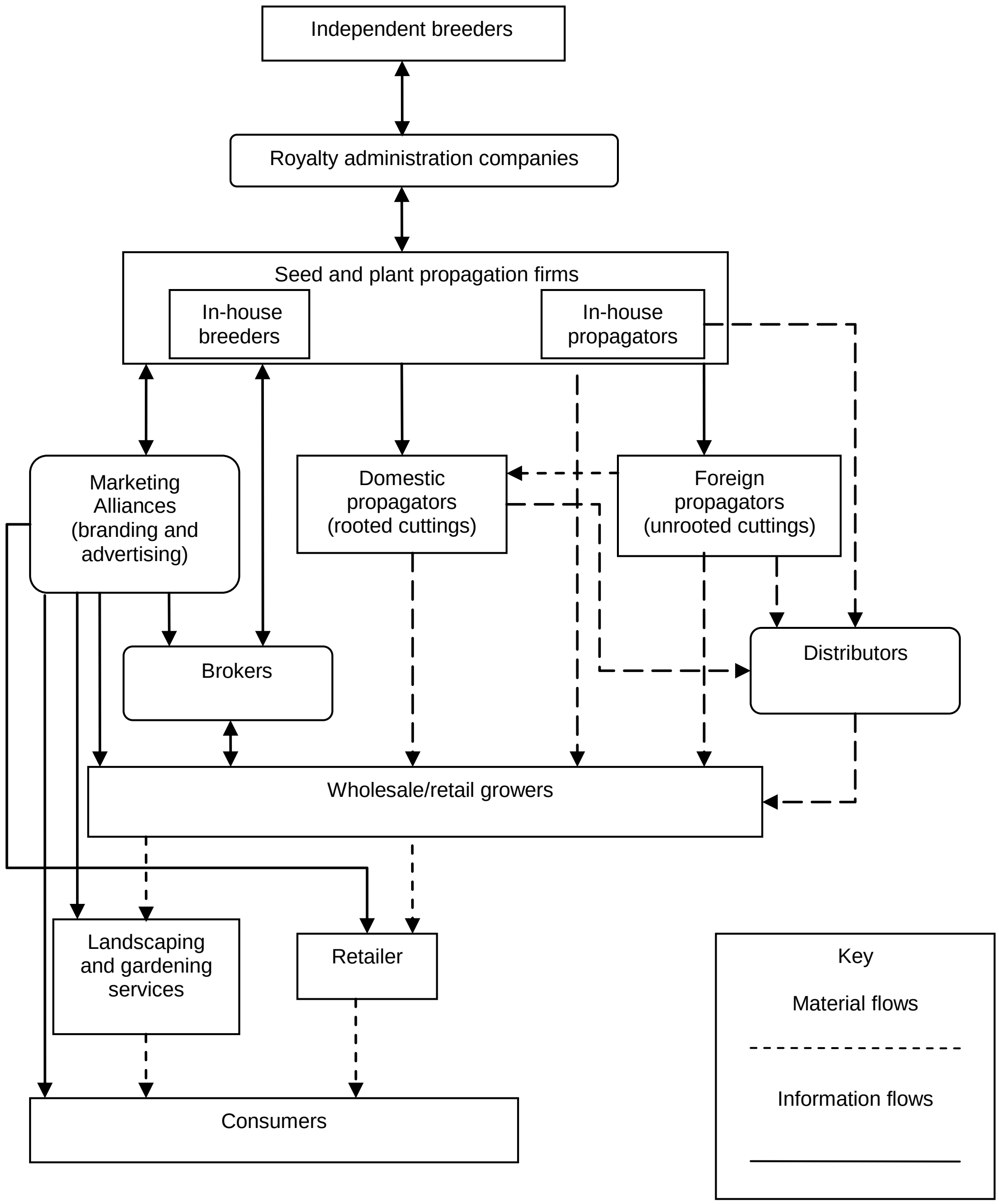
2.9. The Ornamental Plant Industry

The ornamental plant production and distribution system has evolved into a complex system involving a variety of firms with different sets of propagation, marketing and distribution functions (Drew et al. 2010). Propagation firms can be specialized or integrated to varying degrees both horizontally or vertically. It is also common for them to specialize in either herbaceous perennial, annual, or woody plants, particular crops (e.g., chrysanthemums, roses, and geraniums), innovative plants, geographic regions, size and form of plant offerings, and plants for particular gardening styles. However, larger firms specialize less and market to larger areas, with a broad range of plant offerings to satisfy a wide range of wholesale plant buyers. Propagation firms are competitive and flexible in their abilities to adapt production to demand. For example, distinctions between herbaceous perennial producers and woody plant producers are not as clear as they once were as perennial producers have added flowering shrubs to their offerings, and woody plant producers have extended their offerings to include more herbaceous perennial offerings.

A simplified portrayal of the horticultural plant distribution chain which describes the flow of new cultivars and plant products and information through the market channels (Figure 2.2, Anderson et al. 2006). One key aspect of this figure is that it describes the vertical production stages for plant products which begins at the top of the figure with the production of new cultivars via independent plant breeders and ends at the bottom with consumer purchases of plant products. Propagation firms (third box from top) propagate the new cultivars along with other cultivars to sell on the wholesale market. These firms may also supply new cultivars either as a byproduct of their activities or through an "in house" breeding facility. On the other side of the wholesale market are the growers (third level box from bottom). Brokers and distributors (fourth level boxes from the bottom) serve as mediators in the wholesale market. In addition, marketing firms (e.g., Proven

Winners® and Flowering Fields®) are separate specialized firms that develop brands and provide and coordinate information associated with the plant product (Figure 2.2, left center).

Figure 2.2: The Ornamental Plant Industry Distribution Chain



Source: Adapted by author from Anderson et al. (2006).

As the numbers of introductions of new cultivars have increased, ornamental plant sector has increasingly become more complex (Figure 2.2. Anderson et al. 2006). Some of these developments may be a structural response to deal with the comparatively weak intellectual property rights inherent in a plant patent. For example, royalty administration companies, with an international reach, act as agents for breeders matching markets to new cultivars, policing cultivar intellectual property rights, and administering the collection and distribution of royalties. In addition, marketing alliances have emerged to aggressively promote a nursery's or a group of nursery's newer plant cultivars. These marketing efforts often include branding schemes which may use cultivar or series name trademarks. These firms orchestrate a consistent marketing approach throughout the distribution chain, which often requires licensing agreements that assure plants are produced to prescribed quality standards, sold with required tags, and plants subject to a plant patent are not propagated without authorization. Overall these efforts reduce the time it takes for a new cultivar to be adopted in both wholesale and retail markets. These arrangements may also increase the incentives for smaller firms and individual breeders to innovate.

2.10. Ornamental Plant Attributes

Every cultivar offered on the wholesale market is associated with a host of attributes which distinguish it from all other cultivar offerings. Because growers make their plant choices based on these attributes, the market for ornamental plants can be defined by classifying product attributes along a continuum of attributes ranging from those that are very difficult or costly to ascertain to those that are very easy or costless to determine. Attributes that are readily ascertained at little or no cost include the mature size and shape of the plant, as well as, its flower form and color, and leaf size and color. The grower purchasing wholesale plants can obtain this information, prior to purchase, from trade show exhibitions, arboretums, and local plantings. Partial sets of these types of attributes can be acquired through catalogs, plant manuals and other sources provided the grower trusts that these sources give an accurate representation. Other attributes that are experiential in nature are revealed to the grower after purchase and use of the plant, and so are more difficult and costly to ascertain. Knowledge about these attributes may come either from a grower's prior experience or from the experience trusted experts. Such attributes include those that affect overall greenhouse or nursery performance such as temperature and light responsiveness and tolerances.[32] In the case of newly introduced plants, most attributes would be experiential in nature because few sources would exist that could be trusted to have the experience necessary to accurately describe the new cultivar's attributes.[33] Finally, an attribute may have a credence nature which means the buyer may not readily judge this attribute even after purchase. Such attributes that include plant origin and invasive tendencies are difficult and costly to ascertain. Disease resistance (and other environmental tolerance attributes) would also be considered a credence quality attribute(s) because, in the case of disease resistance a buyer may not be inclined to test their plants by introducing pests or pathogens. Thus, choices regarding

[32] Firm product offering attributes such as type, size, and form fall into this category.

[33] This is particularly true for some attributes that require years to discover.

such an attribute are mostly based on the grower's belief or information provided regarding that attribute.

Plant innovators may make claims about these attributes which range from being easy and relatively costless through to difficult and costly to verify. Intellectual property associated with the plant germplasm or its name, that is a plant patent or a trademarked, may signal the presence or absence of a particular set of attributes. As such, intellectual property is a product attribute which is a signal for information about the plant or the plant product. More directly, intellectual property distinctively enables exclusionary commercialization of plant products.

In general, due to the large numbers of different cultivars offered on the ornamental market, and the sketchy provision of information, it may be very costly to the wholesale grower to uncover information regarding a product's attributes. Thus, growers may be inclined to look for low cost signals or cues to determine the quality of cultivar attributes and the firm cultivar product offering. In addition, inexperienced buyers may find most attributes costly to ascertain and rely on signals or cues for cultivar product attribute information.

Caswell and Mojduszka (1996) point out that markets for products with many attributes that are costly to verify can operate successfully if sellers use effective quality signaling (searchable cues). Many ornamental propagation firms have catalogs that provide detailed descriptions of their plant offerings that include information and cues regarding many plant attributes. Growers use these catalogs, and increasingly internet sources, as sources of plant attribute information.[34] Costly to ascertain attributes can present a moral hazard for a propagation firm providing signals for costly attributes because the propagation firm can signal high-valued quality and then supply low-valued quality, perhaps, without the consumer detecting the difference (at least at the time of purchase). For example, a plant's health can be affected by many factors along the supply chain, and the effects may be hard to tie to a single event or supply firm. However, if a propagation firm consistently supplied plants with compromised health, an association between the signaling and the effect would eventually become apparent and they would lose market share. In this way the true attribute can become known through costly experience.

As a plant attribute, the plant patent used for ornamental plant cultivars has a multidimensional impact on the wholesale value of a plant cultivar.[35] For ornamentals, a grower may value the plant patent in several different ways. Growers must consider the purchase from a cost of production perspective, including the added finishing and marketing costs that may be required to retail the plant, as well as a marketability perspective that includes an anticipation of consumer tastes among other things.[36] From a cost of production perspective, a patented cultivar cannot be legally cloned without a license. This means a higher cost of purchasing starter plants for growers who might

[34] Many wholesale and retail plant producing firms have internet plant libraries.

[35] Most propagator firms include the plant patent number in their cultivar descriptions in their annual online or print catalogs.

[36] For example, future weather may affect the marketability of a plant be it a late or early planting season, or abnormally variable season in other dimensions that affect potential plant sales.

otherwise propagate these plants “in house” to realize some cost efficiencies.[37] From a marketability perspective, the grower must anticipate and interpret consumer preferences when making cultivar choices. Plant patents may add value as a cue that signals particular innovative attributes or combinations of attributes. Since plant breeders often seek plant patents for new cultivars with attributes they consider to have market value, the presence of a plant patent may have value as a signal for attributes in addition to its affect on plant prices due solely to the patent’s exclusionary feature, wherein identical (but not necessarily close) substitutes may be legally excluded from sale if the plant patent is effectively enforced.

The age of a patent might affect the price premium of a protected cultivar for a range of reasons.[38] A newly acquired patent may elicit a higher price premium that an older (but still valid) patent simply because competitors have had insufficient time to bring a close substitute to the market. On the other hand, the intellectual property signal may not be easily evaluated for untested plant cultivars that have recently granted plant patents or cultivars that have a plant pending because attribute claims are relatively untested in terms of experience and trials.[39] In such cases, the price premium may be discounted. For patented cultivars that remain in the market longer, age may signal increase lack of

---

[37] If the additional costs for a plant patented plant are sufficiently high the buyer may have incentive to cheat and propagate the plant patented variety; however, many of these varieties are associated with international royalty administration firms that “police” the use of their varieties. The threat of punishment decreases this incentive. It is possible that this strong enforcement of plant patented cultivars can spillover to plant patented cultivars that may not be under the protection of these specialty firms.

[38] Buyers can detect newer patented varieties by the magnitude of the patent number given in product listings or easily by an online patent search which will provide the grant date.

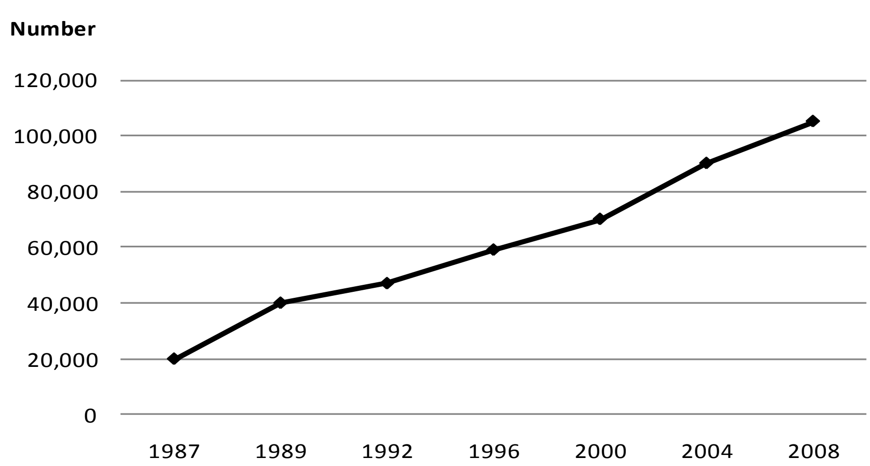
[39] The intellectual property rights for cultivars for which a patent pending status are perceived nearly the same those of the plant patent, due to the fact that upon issuance of the plant patent those that may have propagated the variety during the application process period may be prosecuted for infringement.

close substitutes, a continuing (and even potentially increasing) demand for the attributes being protected by the patent, or both. If this were the case, the price premium for an aging patent could well be sustained or even increase over time. The magnitude of patent age on the price premium of a plant cannot be denied a priori. Some wholesale propagation firms include expired plant patent numbers in their annual catalog plant descriptions. For example, Monrovia, one of the largest wholesale propagators in the United States includes expired plant patents numbers in both their online and print catalogs.

Branding, which has been pervasive in our culture for decades, is now increasingly used in the ornamental plant business. For the ornamental plant trade, a brand is used to tie a set of distinguishing attributes and perceptions about these attributes to a cultivar, group of cultivars, style concept, innovating firm, marketing agency, or wholesale or retail firm. Historically branding efforts were limited in the ornamental trade due to the difficulties in tying a brand to a living plant and having that following the plant through the production and distribution channels (Figure 2.2). However, the success of the branding and promotional program developed for the Purple Wave® petunia in 1983 set a workable model for associating brands with plants (Craig 2003, Anderson 2008). Trademarks are used to protect the intellectual property rights of these brands which are most often in the form of a name or slogan.

In recent years, the range of plant attributes and the associated intellectual property practices for ornamental plant cultivars have increased as the number of cultivars has mushroomed (Figure 2.3, Drew et al. 2010). This development has increased the demand for reliable cultivar information. Meta data that details the attributes of each cultivar are often relied upon by wholesale buyers when placing their orders. A number of firms and organizations have formed to service the information market. Particularly in the past 10-20 years, marketing firms and marketing alliances have formed to promote new cultivars for breeders and plant propagation firms. These firms use branding, informational tagging and retail promotion schemes to promote their cultivars in wholesale and retail markets.   Regional and national plant associations have also formed and grown in importance over last twenty to thirty years to ensure a reliable source of information about each newly released cultivar and to administer cultivar name registration databases that are used internationally. Many of these organizations annually recognize and award high performing cultivars. A leading promotional firm's brand, such as Proven Winner's® or a highly recognized award such as the American Rose Society Award, can signal value for a plant cultivar.

Figure 2.3: Number of Horticultural Cultivars Offered in the United States and Canada (in Thousands), 1987-2008



Source: Adapted from Drew, Anderson and Andow (2010)

Chapter 3

Plant Science, Markets and Evolving Intellectual Property Rights

3.1. Introduction

At the end of the 19th century, U.S. agriculture had reached the limits of westward expansion, and so further increases in crop production relied largely on improving cultivars and farming practices (Duvick 1996, Fernandez-Cornejo 2004). In the horticultural subsector, nurseries shifted their emphasis on supplying fruit stock to supplying ornamental plants for which consumer demand depends on diversity and novelty of cultivars to sustain market interest (Mendel 1992).[40] The plant sciences increasingly influenced plant breeding as scientific breeding methods evolved hand in hand with the establishment of land grant universities, research stations and extension services (Fowler 1994 and 2000). As the American population became increasingly urbanized and communication and transportation infrastructure improved and became more pervasive, agriculture became increasingly commercialized. Despite these generally positive developments, bad business practices dampened the demand for seed and new plant propagules, as well as discouraged investments in breeding and the development of new cultivars (Fowler 1994, 2000, Lyon-Jenness 2004). Such practices included: firms seeking to pass off cultivars developed by other firms as their own, and selling substandard seed or plants, often under the established names of other firm's cultivars. In addition the government continued distributing free seed to farmers who

[40] Fruit and vegetable industries where still mostly farms located near large cities, while rural areas were supplied by family gardens.

also continued saving seed for replanting. Thus at the beginning of the 20th century, nursery and seed industry leaders and organizations sought to coordinate their efforts and find ways to protect the intellectual property rights of their plant innovations, both to protect their investments in plant innovations and to secure and increase their market shares (Fowler 1994, 2000).

In the absence of intellectual property rights or some other additional incentive for investment in new plant innovations, plant industries would likely be undersupplied with new cultivars. Although the U.S. Constitution, ratified in 1789, provided for exclusionary intellectual property rights as a means to promote innovation, due to various controversies, these rights could not encompass plant innovations.[41] The knowledge embodied in most new plant cultivars has public goods characteristics in that it is non-rivalrous and non-excludable—that is its use does not preclude another from using it and others cannot be prevented from using it without payment. The non-excludability problem is exacerbated in plants because most plants reproduce independently through seeds or by vegetative means. These public good properties mean that in a competitive market, where other firms can quickly gain access to new plant cultivars, the incentives for investment in R&D are suppressed.

There are reasons why this underinvestment problem may be attenuated for horticultural crops (Alston and Pardey 2008). There is a diverse array of horticultural crops, and generally compared to most agricultural crops, horticultural crops have lower total acreage devoted to production and smaller wholesale value market shares.

[41] "The Congress shall have Power…To promote the Progress of Science and useful Arts, be securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." (US Constitution 1789)

Moreover, some horticultural plants have a comparatively high price elasticity of demand which means that benefits will accrue largely to consumers rather than producers. Many horticultural crops have higher cost associated with R&D and production. In addition, market distortions can cause spillover benefits from improved cultivars such as increased land values, improved environmental quality and human health which cannot be appropriated to private R&D.

In this chapter, the evolution of intellectual property rights for plants and the associated plant markets will be examined with a focus on identifying and explaining the differences between the horticultural and agricultural subsectors.[42] There is a paucity of economic research on the U.S. horticultural subsector generally, and in relation to intellectual property rights in particular, in part, because there is a lack of suitable data. This research is enabled by two newly data sets: an "intellectual property rights for plant varieties" data base and a "value of production" series (Appendix C and D).

What follows is primarily a descriptive analysis juxtaposing statistical and event elements to determine the forces and direction of change in the patterns of intellectual property rights and their associated plant markets. These elements include the following: a) the evolution of intellectual property rights for plants, b) the evolution of plant science and plant industries, c) a statistical description of the changing domestic markets for plants and plant products, and d) an analysis of the statistical structure of the relevant intellectual property patterns. The time covered spans from the early 1900s to the present. There is a particular focus on the ornamental plant industries of the horticultural

---

[42] Agricultural crops are crops that are harvested and marketed in a dry or stable state. Horticultural crops are generally harvested or sold in a hydrated state which can be considered either live or fresh.

subsector which have accrued most of the intellectual property rights for plants in that subsector. Attention is given to the influences of advances in biotechnology, improved plant propagation techniques, legislation that brought the United States intellectual property rights system for plants into accord with international agreements and U.S. legal rulings that enabled the use of utility patents for plants.

This study will summarize and describe aspects of these elements and with each add a layer of understanding to the context of and the affects from the evolution of intellectual property rights for plants in the United States. First, there is a description of the evolution of the intellectual property rights for plants including the acts that instituted and strengthened the intellectual property rights for plants and the court and administrative rulings that affected their use. Then, there is a description of the changing science of plant breeding which includes the industrial structures and trends in the plant industries that have coevolved with the plant sciences. Next, there is an assessment of the trends in the "farm gate" crop values by industry, crop category and by plant types. Finally, there is a description and analysis of time series of plant varietal intellectual property rights stratified by crop category, plant type, and applicant.

3.2. Legislative and Tort Law Developments

The United States has the oldest and most complex system of plant related intellectual property rights in the world. This system evolved over the twentieth century through a series of legislative acts, court and administrative rulings.[43]

---

[43] For a detailed account of these events see Appendix A.

The U. S. government intervened well before the twentieth century to encourage the development of new plant cultivars, by funding ambitious efforts to collect new cultivars worldwide and distribute them to farmers and eventually assigning these efforts to the agency which became the U.S. Patent Office (Fowler 1994).[44] In 1855, one million free seed packages were distributed to farmers (Fowler 1994). In 1862, Congress established the U.S. Department of Agriculture (USDA) which increased government seed innovation and distribution activities. This act mandated the USDA to "collect new and valuable seeds and plants; to propagate such as may be worthy of propagation; and to distribute them among agriculturalists."[45] With a series of acts, from 1862 to 1887, plant research was further institutionalized through the establishment of the U.S. land grant colleges and universities and the agricultural experiment (research) stations. The USDA in conjunction with these state land grant colleges and the experiment stations were established in part to developed and test new cultivars of domestic crop species. (Thomas 2002)

Following an industry boom period in the mid to late 1800s, U.S. nursery industry sales were declining as a consequence of increasing consumer wariness caused by unethical activities of hucksters and charlatans (Fowler 2000, Lyon-Jenness 2004). Nurserymen seeking a fast fortune employed unethical practices: the propagation and sale of new successful plants made and introduced by other nurseries, and propagation of

---

[44] In 1849 the congress made the U.S. Patent Office part of the Department of Interior with the primary agricultural function of distributing free seeds and collecting agricultural statistics with the objective to encourage agricultural innovation. This distribution was terminated in 1924 when private seed companies that had emerged in the 19th century became established. (Fowler 1994)

[45] Act of May 15, 1862, ch. 72, 12 Stat. 387.

inferior plants which they sold under the guise of established and hitherto respectable crop names. In the absence of enforceable property rights for plants, a firm's new variety would be quickly reproduced and sold by competing firms, or a similar variety would be labeled and sold as the new variety. In these emerging plant markets which competed partly on the basis of who offered the best new cultivars, a firm needed to innovate to stay competitive, but returns to any innovation investments were short lived. (Fowler 1994)

Likewise, in the seed industry, there was an environment that discouraged investment in developing new cultivars. Bad business practices with regard to the labeling and grading of seed dampened demand for commercial seed (Leibenluft 1981). In addition, the government distributed free seed—particularly vegetable seed—and for many seed crops, farmers saved seed harvests for future planting (Fowler 1994).

Trademarks were used for horticultural products in the later part of the 19th century and the beginning of the 20th century as a means for nurserymen to distinguish their offerings from other products and to protect their product names and reputations (Stallman 1986). In 1881, the Trademark Law was passed to encourage investment in product quality and prevent consumer deception (Brown 1948). This law allowed firms to register any word, name, symbol or device or any combination of these which are used by the manufacturer or merchant to identify his goods or distinguish them from other goods. A trademark can be renewed and used indefinitely, and after five years the legal grounds for challenging a trademark are narrowed, thus validating the trademark. Only the "likelihood of confusion" needs to be shown to establish infringement with penalties of injunction from further use and up to triple damages plus offending firm's profits acquired during the period of infringement. However, trademarks were not sufficient to avoid the confusion produced by the hucksterism of the early 20th century.

At this time, trade secrets were (and still are) effectively used in the seed and plant industries. In particular, they were used to protect the inbred lines used in breeding hybrid varieties. Competitors were unable to copy successful lines without the parent stock. And since the hybrid's progeny does not exhibit the same traits as the hybrid seed, firms prevent infringement by keeping the parent lines of the hybrid a secret.

Trade secrets are proprietary information that have commercial value, and can be protected if the holder conceals the information from competitors to prevent others from duplicating or using it. Information protected under trade secrecy can include any material, notes, or knowledge regarding proprietary processes, procedures, and inventions. The secret is not fundamentally a property right, but is recognized as a common law personal right. The legitimacy and life of a trade secret is unlimited as long as the holder of a trade secret maintains reasonable efforts of secrecy. In the case of infringement, the rights holder can seek restitution through the courts in the form of an injunction or damages. A product or process made using the trade secret is infringing only if the secret was obtained illegally. Trade secrets are governed by state laws with 42 states conforming to the Uniform Trade Secret Act (Carpenter 2005). While exact definitions vary, the fundamental concepts that govern what qualifies as a trade secret are: the secret must be of qualifying information, it must be secret with reasonable efforts to maintain its secrecy, and it must give the holder a competitive advantage (Carpenter 2005).

So prior to legally enforceable plant varietal rights, competitive firms sought to appropriate revenue streams by resorting to trade secrets when applicable, trademarks, and first-mover advantage.[46] However, absent trade secrets, trademarks were insufficient to avoid rapid copying of plant reproductive material by competing firms.

Prior to the Townsend-Purcell Plant Patent Act of 1930, industry leaders and representative organizations (including the American Seed Trade Association and American Nursery and Landscape Association) helped write and back several legislative attempts to give patent-like protection to their cultivars (Fowler 2000, Janis and Kesan 2002).[47] These groups were seeking to reinstitute ethical business practices and revive product credence which had waned and undermined consumer confidence as well as breeding efforts in the plant and seed industries. The first legislative attempt was a trademark proposal in 1906 which sought to assign patent like coverage to plant cultivars through use of the trademarks. According to Janis Kesan (2002), this effort was somewhat misguided. They observed that while trademarks may be effective for product differentiation, they were not an entirely suitable means of appropriating the returns to plant R&D because the property rights of a trademark pertains to the branding of a plant variety and not for a plant innovation per se. Within weeks, another attempt was to

[46] First mover advantage is the advantage gained by being the first to enter a market. In the case of plant markets this advantage is from capturing sales for a new cultivar with a unique set of characteristics before competitors can enter with similar or improved cultivars.

[47] For additional details regarding the evolution of the U.S. and the international legislative framework for intellectual property rights for plants see Appendix A.

amend the utility patent law to incorporate utility patents for plants. This attempt failed for several reasons: the belief that patents should not be applied to living things, a concern that the use of utility patents would impede free access to important genetic materials for food crops, and the problem of describing plant innovations in writing, as required by the patent law. Although these initial attempts failed, through persistent efforts, the Townsend-Purcell Plant Patent Act was passed in 1930.[48] [49]

The plant patent extended to breeders "the same opportunity to participate in the benefits of the patent system as has been given to industry, and thus assist in placing agriculture on a basis of economic equality with industry."[50] However because of its restriction to asexually reproduced plants, plant patent protection excluded all plants that were sexually reproduced as well as tuber reproduced plants.[51] The conditions necessary for obtaining a plant patent are that the cultivar is new, exhibits stability and distinctness, and that it has been asexually propagated. The plant patent initially provided exclusionary rights to the owner for 17 years. Like all forms of intellectual property, the owner is responsible for enforcing these rights. The penalty for established infringement is triple damages. The distinctness criteria means a plant patent can be granted for a new cultivar even if it is very similar to another plant patented cultivar as long a distinctive difference can be established between the new cultivar and any other existing cultivar.

[48] For details about the plant patent and comparisons to other intellectual property rights for plants see Appendix B.

[49] 46 Stat. 376 (1930) (codified at 35 U.S.C. § 161-164)

[50] Ibid

[51] These exclusions were due to food security and/or cultivar stability concerns, so tuberous ornamental plants were acceptable.

Thus, the plant patent requires only a small inventive step. This also makes it easy for competitors to invent competing differentiated new cultivars that qualify for a plant patent. In addition, the exclusionary rights do not clearly prohibit the breeding of new cultivars from a patented plant cultivar.

The Plant Patent Act amendment of 1954 broadened coverage to include mutants, sports, hybrids, and plants found in a cultivated state (the later was accomplished by precluding patent protection for plants found in an uncultivated state).[52] Whether or not the inclusionary aspect of this amendment had much of a practical impact is a moot point since most found commercialized plants are adapted to cultivation by a selection process that would likely render it an acceptable subject for a plant patent. The significant point is that this broadened coverage by extended patent rights to cultivars derived from important, pre-existing industry sources, (i.e., mutants, sports, hybrids, and plants found in cultivation).

In 1948 a Trademark Act was passed that strengthened the Trademark Law and more explicitly defined the use of trademarks (Lemley 1999). However, the horticultural subsector did not begin to use trademarks in conjunction with plant patents until the late fifties. Prior to this, there was confusion, both in the courts and the industry, as to whether the two forms of intellectual property could be used for the same cultivar. Since then, trademark use has become commonplace for plant names. The trademark may have several advantages over the plant patent: the trademark can be renewed indefinitely; neither customer confusion nor the intent to confuse needs to be proven; and the penalties for infringement are greater for the trademark than for the plant patent. Common law

[52] Act of Sept. 3, 1954, P.L. 83-775, 68 Stat. 1190

trademarks, trademarks which are used but not registered, are also used for plants particularly in the plant introductory stages while waiting the enactment of a trademark registration. (Stallmann 1986)

Intellectual property protection for sexually reproduced plants was ushered in with the passage of the 1970 Plant Variety Protection Act.[53] [54] One impetus to pass this act was the argument that the science for crop breeding had evolved to the point where the identification and stability of crops was sufficient to qualify for standards similar to those of the plant patent (Janis and Kesan 2002). In addition, the American Seed Trade Association (ASTA), which represented breeders and had supported the earlier efforts to pass the Plant Patent Act, were executing significant political pressure to expand the scope of U.S. patent law to include sexually reproduced crops (Janis and Kesan 2002). At the same time, there were efforts elsewhere in the world (notably Europe) to establish *sui generis* intellectual property protection for plant varieties, and similar practices were codified in the International Union for the Protection of New Varieties of Plants (UPOV) that were initiated in 1961 (Janis and Kesan 2002). As a country heavily reliant on the importation of genetic material, harmonizing plant related intellectual property laws with the rest of world developments was important for the United States (Fernandez-Cornejo 2004).

The necessary conditions for awarding a plant variety protection certificate are similar to those for obtaining a plant patent—uniformity, stability and distinctness must

---

[53] For details about the plant variety protection certificate and comparisons to other intellectual property rights for plants see Appendix B.

[54] 7 U.S.C. § 2321-2583

be established for a new crop variety. The 17 year exclusionary protection of the plant variety protection certificate could be granted to qualifying open-pollinated cultivars and tuber propagated plants. Also like the plant patent, plant variety protection certificates require a small inventive step and provide protection to a narrow product space; thus it grants protection for new cultivars with very small differences from previously protected cultivars. However, in contrast with a plant patent, a plant variety protection certificate has more explicit exclusionary rights, which allow certificates holders to "exclude others from selling the variety, offering it for sale, reproducing, importing, or exporting it, or using it in producing (as distinct from developing) a hybrid or different variety therefrom."[55] Two important exemptions, in the original version of this intellectual property legislation, weakened these rights for the breeder. The first allowed farmers to save seed to be used to produce future crops, and to sell with few restrictions. The second, a research exemption, allows researchers to use the variety for breeding in "bona fide" research (Chen 2005).

In 1980, an amendment to the Plant Variety Protection Act added the previously excluded "soup vegetables" of okra, carrots, celery, tomatoes, peppers, and cucumbers to the list of cultivars covered by the Plant Variety Protection Act, as well as extended the exclusionary term from 17 to 18 years (Chisum 2002).[56] The passage of the Bayh-Dole Act, in that same year, allowed U.S. universities, small businesses and non-profits to own intellectual property rights for inventions that resulted from federal government-funded

---

[55] 7 U.S.C. § 2483(a)

[56] U.S.C. § 2321

research (Mowery 2001).[57] Perhaps most importantly, the landmark United States Supreme Court decision in *Diamond v. Chakrabarty* extended patent rights to genetically engineered microorganisms; thus, allowing utility patent coverage for living matter.[58] [59]

In 1985, the ruling *Ex parte Hibberd* upheld the 1980 court ruling as well as established plants as acceptable subject matter for utility patent coverage.[60] Subsequent rulings by the U.S. Patent and Trademark Office from 1985-1988 widened the scope of utility patents from whole plants to include things such as seeds, plant parts, genes, traits, biotechnological processes, tools, and chemical extracts (Fernandez-Cornejo 2004). Although the U.S. Patent and Trademark Office did not consider plants as patentable material prior to these rulings, utility patents were issued for methods of breeding new varieties some of which included claims for the plants themselves (Seay 1989). Patent rights in general were strengthened with the establishment of the Court of Appeals for the Federal Circuit in 1982 (Hall and Ziedonis 2001).

A plant invention is considered eligible for a utility patent if it can be shown to be novel, non-obvious and useful. The utility patent requires a larger inventive step than is required for either of plant patent or a plant variety protection certificate. Multiple related claims for a single utility patent may be made, and claims for cultivars require a germplasm deposit (Lesser 1987). The utility patent's exclusionary rights are for 20 years and require payment of renewal fees (Table 3.1). In the case of a new plant

[57] U.S.C. § 200-212

[58] 447 U.S. 303, 1980

[59] For details about the utility patent for plants and comparisons to other intellectual property rights for plants see Appendix B.

[60] 227 U.S.P.Q. 443 (P.T.O. Bd. App. & Inter. 1985)

cultivar, the patentee has the right to exclude others from making, using or selling the patented cultivar or any part thereof within the United States, (thus excluding imports of the patented material without the owner's consent). The utility patent also excludes farmers from saving and replanting seed and breeders from using the new cultivar in breeding programs without a license issued by the owner.

Table 3.1: Plant Intellectual Property Rights Fee Structure

	Type of IPR							
	Trademark		Utility patent		Plant patent		Plant variety protection	
Fee	2003	After Dec.8, 2004	2003	After Dec.8, 2004	2003	After Dec.8, 2004	As of Feb. 10, 2003	As of Sept. 16 2005
	dollars							
Filing	335	375	750	300	520	200	432	518
Filing (small entity*)			375	150	260	100		
Search				500		300		
Search (small entity*)				250		150		
Exam				200		160		
Exam (small entity*)				100		80		
Search and exam				700			3,220	3,864
Search and exam (small entity*)				350				
Issuance	100	100	1,300	1,400	630	1,100	432	768
Issuance (small entity*)			650	700	315	550		
Maintenance due at 3.5 years			890	900				
Maintenance due at 3.5 years (small entity*)			445	450				
Maintenance due at 7.5 years			2,050	2,300				
Maintenance due at 7.5 years (small entity*)			1,050	1,150				
Maintenance due at 11.5 years			3,150	3,800				
Maintenance due at 11.5 years (small entity*)			1,575	1,900				
Renewal fee-every 10 years indefinitely	400	400						
Total	NA	NA	8,140	9,400	1,150	1,760	4,084	5,150
Total (small entity*)			4,095	4,700	575	880		

Sources: The United States Patent and Trademark Office (USPTO 2003, 2005), and the United States Plant Variety Protection Office (PVPO 2003, 2005).
Note: A small entity is an establishment with less than 500 employees, a non-profit organization, or any university.

The evolution of U.S. intellectual property rights occurred in an international context where other national and international developments for intellectual property rights for plants influenced the U.S. laws and where the United States has often led and thereby influenced the evolution of intellectual property protection for plants internationally. The combined protection provided by a plant patent and a plant variety protection certificate arguably can be regarded as breeders' rights like those afforded by the *sui generis* systems of UPOV, which in most other countries in the world who are signatories to the UPOV, extends protection to both sexually and asexually reproduced plants. Plant breeders' rights conform to the UPOV agreement if they require new varieties to be new, uniform, distinct and stable. In addition since 1995, trade-related aspects of intellectual property rights (TRIPS), for members of the World Trade Organization (WTO), requires member states to offered intellectual property protection for plant cultivars either by breeders' rights prescribed by UPOV or by an effective *sui generis* (of its own kind) system, or a combination of the two (Fernandez-Cornejo 2004).[61] In 1994, both the Plant Variety Protection Act and the Townsend-Purcell Plant Patent Act were amended (effective April 1995) to conform to the international standards.[62] The exclusionary rights provided by a plant patent were extended from 17 to 20 years (Gioia 1996) and those rights provided by a plant variety protection certificate were extended from 18 to 20 years (25 years for woody cultivars).[63] In addition, farmers are precluded from selling

[61] In 1986, the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) established TRIPS.

[62] P.L. 103-465, 108 Stat. 4809 and P.L. 103-349 amended section generally, subsections (a)-(j) for the plant patent and Plant Variety Protection respectively.

[63] The life of the utility patent was also extended from 17 to 20 years.

seed of cultivars with plant variety protection certificates, and potatoes and F1 hybrids also became eligible for protection via a plant variety protection certificate (Chisum 2002).[64]

Additional tort and legislative acts during the 1990s affected the strength of intellectual property rights for plants. In 1995, a court ruling, *Pioneer Hi-Bred International v. Holden*, determined that inbred lines could be protected by trade secret law, but ironically, the challenge presented by Holden reinforced the usefulness of the stronger intellectual property rights for plants provided by the utility patent for firms wishing to avoid possible litigation.[65] While the fundamental concept behind trade secrets and patent law is to encourage innovation, trade secrecy is in fundamental conflict with one of the requirements for a patent namely disclosure as a means to foster further rewards of innovation.

Also that year, the landmark case of *Imazio Nursery Inc. v. Dania Greenhouse* determined that in the case of the plant patent infringement was limited to clonal reproduced material, and in addition, required that the owner prove the genetic basis for infringement claims.[66] This ruling established the most narrow product space for any form of plant related intellectual property. The Plant Patent Amendments Act of 1998 broadened the plant patent's exclusionary rights to cover plant parts along with imported fruit and cut flowers of protected cultivars (Butcher 2003). In 2001, the United States Federal Court of Appeals ruling in *J.E.M. Ag Supply, Inc v. Pioneer Hi-Bred* determined

---

[64] In 1995, the Supreme Court ruling, *Asgrow v. Winterboer*, determined that the farmer's practice of saving and selling seed for profit (brown bagging) was unlawful without a license.

[65] 31 USPQ2d 1385 (8th Cir. 1994)

[66] 36 USPQ2d 1673 (Fed.Cir. 1995)

that plant breeders may have multiple and concurrent IP rights, including a utility patent (Quick 2002, Carpenter 2005).

In the latter part of the 20^{th} century, many other forms of intellectual property protection were used in conjunction with these conventional forms of intellectual property for plants to govern transactions in plant markets. Seed companies often deploy purchase agreements in conjunction with plant variety protection certificates to exclude researchers from using protected varieties and farmers from selling seed derived from these varieties (Seay 1989). Companies that supply vegetatively propagated plants often use license agreements in conjunction with plant patents and aggressively police the use of their products (Anderson 2004). Such agreements restrict the purchasers of the plant material from propagating these plants and from claiming rights to any mutations. Furthermore, firms entering into such licensing agreements with the licensing firm are required to report mutations when they are discovered. Additional requirements may specify that each plant is sold with the supplied plant tag which displays certain trademarks. Such agreements are now commonplace in the floriculture and nursery industries. For example, Proven Winners®, an innovative plant marketing firm, which provides bedding plants to greenhouse growers, uses a license agreement with propagation and use restrictions on all the cultivars it sells whether or not the plant is subject to a plant patent (Anonymous 2007/2008).[67] Lease agreements are also used in the fruit and cut flower industries where the company supplying the productive plants charges a yearly fee per productive plant and stipulates contractual terms that restrict

[67] The purchaser of any Proven Winners® or a Proven Selections® plant enters into this contractual agreement upon receiving or opening a shipment of their variety.

propagation of the plants and claims property rights over any mutations (Anderson 2004, Luby 2006).

3.3. Science and Technology of the Plant and Seed Industries

The evolution of U.S. intellectual property rights for plants is inextricably intertwined with the expanding capacity to reveal, manipulate and commercially exploit plant genetic material and the resulting phenotypic variation therein.

At the beginning of the 20th century plant science was beginning to bloom. With the advent of the land grant colleges and the state experiment stations in the later part of the 19th century, the improvement of crop cultivars that had hitherto largely been in the province of seed saving farmers was increasingly taking place in publicly funded research agencies. Although the nursery industries experienced a boom in the previous century, in the 20th century they were in a diminished state (Lyon-Jenness 2004). Nursery plant production was still focused on horticultural food crops—ornamentals were primarily for public spaces and the wealthy (Mendel 1993). The basic plant propagation methods (i.e., seeding, tubers and rhizomes, layering, cuttings and graftings) in use at that time and to remain of primary importance throughout the 20th century had been in use since about 9000 B.C. (Hartman et al. 2002). Primitive by today's standards, controlled environment technologies for nurseries were limited mostly to lath houses, hotbeds warmed by manure and glass houses that had hand operated venting and were warmed by hot water heated by oil (Mendel 1993). Over the next century, the increasing individual and aggregate wealth of the population spurred shifts in the structure of demand for horticultural crops so that ornamentals gain a bigger market share and fruit and vegetable markets increasingly shifted from local to national sources of supply (Mendel 1993, Singh 1999, Frazao 1999). However, the horticultural subsector generally lagged in the extent to which it was mechanized relative to the agricultural subsector (Fossom 1953).

Basic genetic science discoveries at the beginning of the 20th century set the stage for a continuum of advances throughout the century and the revolutionary recombinant DNA plant transformations that became available in the later part of the century. In 1900, Mendel's laws of inheritance were rediscovered, and between 1901 and 1903, Dutch botanist, Hugo De Vries, published a series of papers detailing his theory of mutation which was based on his work with *Oenothera* (evening primrose) (Garland 1969). The basic discoveries of inheritance informed classical breeding methods and enabled hybrid breeding technologies.

Between 1915 and 1930, state seed certification programs with their quality assurances resulted in many farmers switching from saving to purchasing commercial open pollinated seed cultivars developed in the public sector and increasingly marketed by nascent private seed companies (Fernandez-Cornejo 2004, Ruttan 2001). After much petitioning on behalf of agents for seed companies who felt that the public distribution of seeds discouraged private enterprise, the congressional distribution of seeds was discontinued in 1923 (Fowler 1994, USDA 2008).

The first known hybrid produced by breeders, reported in 1717, was between two horticultural species, *Dianthus caryophylus and Dianthus barbatus,* and the first commercial F_1 hybrid was *Begonia gracilis* "Prima Dona" introduced in 1909 by Ernst

Benary (Craig 2003). The first practical methods for commercial hybrid crop breeding of a large field crop, corn, were developed Donald. F. Jones in 1918 (Smith 1979).

From 1930-1970, hybrid corn became the backbone of the private seed industry in which 150 companies were formed to produce hybrid corn and 40 existing firms added corn seed to their market lines (Fernandez-Cornejo 2004, Duvick 1996). Some of these firms also established in-house breeding and research programs (Fernandez-Cornejo 2004). As long as the inbred lines were unknown to a firm's competitors, the firm had natural intellectual property rights over their hybrids produced from these lines. Farmers would not save seed for future planting because the seed of hybrid corn does not reproduce corn with hybrid vigor like the parent. In addition to agronomic crops, hybrid technology has also contributed significantly to the development of many ornamental and vegetable cultivars (Janick and Goldman 2003).

The rapid adaption, throughout the world, of high yielding hybrid corn and rice and the subsequent differences in yields in the United States and Japan contributed to the development of a high-payoff input model of research and development that was applied to developing country agriculture (Ruttan 2001). Hybrid technology combined with other new scientific approaches to breeding high yielding cultivars soon became the basis of international efforts that raised crop yields worldwide mostly in the latter half of the 20th century. This "Green Revolution" began in Mexico (from 1943-1949) with the coupling of new wheat cultivars bred by Norman Borlaug with his improved production technologies (Dill 1997). This approach, which concentrated on the applications of dwarfism and high nitrogen usage in its new varieties, brought to the forefront the importance of international genetic resources for public and private crop research.

The increased productivity that was generated from applying scientific knowledge to breeding and cultivation practices generated many studies to estimate the average rate of return to crop research. Alston, Chan-Kang, Marra, et al. (2000), found in a meta analysis of 292 studies reporting a total of 1,886 rate of return estimates the average rate of return was 100 percent per year for research, 85 percent for extension, 48 percent for studies that estimated the returns to research and extension jointly, and 81 percent for all the studies combined.

Mid 20th century scientific advancements solved many long-standing breeding problems and contributed to more efficient asexual propagation techniques. These technical developments helped spur the growth in supply of ornamental plants particularly bedding and gardening plants. This suite of advancements also laid the basis for the gene transfer techniques developed later in the century. The first growth regulator compound, auxin, was isolated in 1934, and in a few years was widely used to accelerate the development of plants propagated by rooting cuttings (Mendel 1993). For asexually reproduced plants, growth regulators enable more efficient and rapid clonal reproduction of a new cultivar to marketable quantities. This in turn increases the likelihood that the innovators will capture returns to their breeding efforts before follow-on competing cultivars appear on the market. Throughout the second half of the 20th century, many compounds, including growth enhancers and inhibitors, were isolated that advanced asexual plant propagation methods as well as enabled cellular propagation techniques (micropropagation). In addition, discoveries with respect to the effects of pathogens on plants were used to develop protocols for aseptic propagation.

After World War II, a variety of in-vitro biological techniques were developed in association with growth enhancers to generate new sources of genetic variation for breeders (Pfeiffer 2003). These techniques include somatic hybridization, embryo rescue and mutagenesis. Somatic hybridization fuses protoplast cells of different, otherwise incompatible, plants, and then regenerates this in culture as one plant. Embryo rescue methods were developed that solved the problem of embryo abortion which often occurs between hybridizing between two distinct species or genera. A technique called mutagenesis uses chemicals, radiation and transposons on seeds, meristems, somatic sells, or pollen to generate mutants with desirable traits or for using breeding with other cultivars.[68] While these techniques pose additional costs for breeders, they offer solutions for problems such as low heritability of traits and reproductive barriers (e.g., male sterility and self incompatibility) which occur in some species. Reproductive barriers are particularly problematic for many horticultural species (Liedl and Anderson 1993). While these now "commercial" plant transformation techniques give breeders the capability to radically alter and recombine genetic material, the resulting plant innovations do not require the extensive evaluation and field testing that are required for plants that are transformed using modern genetic modification methods.[69]

---

[68] Transposition mutagenesis is a process that allows genes to be transferred to a host organism's chromosome, interrupting or modifying the function of an extant gene on the chromosome and causing mutation.

[69] In the U.S. as many as three federal agencies can be involved with the evaluation of a crop developed using biotechnology transfer methods. The Food and Drug Administration evaluates food and feed safety

Modern recombinant DNA methods were enabled by the developments of tissue culture protocols where horticulturalists played an important role in their development (McCown 2003). In 1958, the first whole plant was regenerated from a single cell of *Daucus* (carrot) (Craig 2003). The first application of clonal propagation using tissue culture techniques was for orchids (Craig 2003). Early demonstrations of disease removal procedures using meristem culture involved virus removal from a *Dahlia* (McCown 2003).

Tissue culture techniques enabled a proliferation of commercial labs in the 1970s and 1980s resulting in the emergence of a previously non-existent micropropagation industry (Zimmerman and Jones 1991, Zimmerman and Griesbach 2001). An important by-product of using micropropagation technologies is an increased likelihood of genetic variants (somaclonal variation) which can result in profitable new cultivars (McCown 2003).[70] Like other asexual propagation techniques, micropropagation technologies also reduce the time it takes to produce marketable quantities of new cultivars so they can be brought to market sooner; thus, effectively extending the commercial life of any prevailing intellectual property protection.[71] Micropropagation technologies also enable

---

aspects, the USDA ensures agricultural and environmental safety, and the Environmental Protection Agency evaluates food safety and environmental issues associated with insect resistance.

[70] On the other hand, this attribute contributes to plant non-uniformity which is considered a problem.

[71] For the Dutch iris it is possible to get only 5 daughter bulbs annually through conventional bulb multiplication. At that rate it would take 10 years for commercial quantities of new cultivars to be built-up. With micropropagation techniques you can get 100-1,000 bulbs per stem, cutting the build-up time to just a few years. (Sutter 2006) Also, this technology enabled orchids to become the most important pot grown plant when it was once just a plant for specialists. (Craig 2003)

plants to be brought to market year-round, and by limiting the amount of parent material, the technology can significantly reduce disease problems (Altman and Loberant 1998).[72]

The advanced labor intensive propagation techniques have facilitated offshore production where there are more favorable growth environments and lower labor costs and still meet phytosanitatary import standards (Altman and Loberant 1998).[73] For example, almost all the U.S. production of unrooted cuttings of asexually reproduced crops occurs in Latin America, and Israel (Schoellhorn 2009).

Two major developments were adapted by the ornamental industry that radically increased the volume and speed with which new plants could be supplied. In 1983, the promotion and branding scheme for ‘Purple Wave®’ petunia which coordinated promotional information throughout all levels of the horticultural marketing chain spurred a wave of consumer demand unlike the industry had known before (Craig 2003, Drew et al. 2010).[74] This wave was a rising tide that lifted the possibilities for all new cultivars, and was soon to become a common phenomenon in the ornamental industry. Later that decade, an efficient and space saving system for propagating and growing seeds and cuttings was quickly adapted by firms producing ornamental plants (Beytes 1997). This so-called “plug revolution,” which enabled the industry to meet the increasing demand for floriculture products, was facilitated by other technological

[72] The carnation (*Dianthus caryophyllus)* industry, a segment of the cut flower industry, was suffering in the 1960s and 1970s due to disease, low yields and lack of product uniformity. A scheme developed in the 1970s and used today that uses testing for diseases combined with micropropagation techniques solved the disease problems, and produce larger crop yields and more uniformity. (Altman and Loberant 1998)
[73] Micropropagation is labor intensive with labor about 50 percent of production costs.
[74] ‘Purple Wave®’ petunia is also an F_1 hybrid which is clonally reproduced.

advances in controlled environment technologies (e.g., automated heating, venting, misting), plastics and soilless growing mediums (Mendel 1993).

Enabled by the discovery of the laws of inheritance, the function and structure of DNA as well as many of the same technological improvements that improved clonal propagation, biotechnological innovations dramatically influenced innovations in both horticultural and agronomic crops. Although, the first commercial transgenic crop was the FlavrSavr tomato, most commercial releases of live engineered plants are for agronomic traits in feed and fiber crops. Advances in biotechnology and financial speculation with respect to the profitability of its applications were impetuses for pursuing utility patents to protect innovations in this field (Wright and Pardey 2006). Methods, procedures and tools for this emerging field (e.g., gene-gun, *Agrobacterium* and other methods for transforming crops) were developed in the 1970s and 1980s. Biotech start-up firms were first launched in the late 1970s and 1980s to pursue unlocking the seemingly limitless possibilities of recombinant DNA and capturing the returns promised by the strong intellectual property rights provided by utility patents. A number of genetically modified crops using recombinant DNA technologies were released beginning in the mid-1990s, and these crops were rapidly adopted in the United States and worldwide.

Not only have modern bioengineering technologies given rise to innovative plant material, but they have increased the appropriability of new cultivars protected by plant intellectual property rights. By enabling genetic proof of infringement, genomic science has affected the appropriability of all plants subject to intellectual property rights.

Most of the advances in plant science have had less impact on fruit crops than other horticultural plants, in part, because most fruits are woody plants. Woody plants presently require long-term breeding programs with cost inhibiting space requirements. It often takes 20 to 30 years to breed a new cultivar, and this long gestation coupled with uncertain outcomes and significant R&D investments is prohibitive for many private companies (Luby 2006, Stallman 1986). Most new woody plants cultivars are the result of discoveries of plant mutations and seedlings within domesticated plantings (Luby 2006, Stallman 1986). Much research effort has been invested in developing dwarfism and semi-dwarfism for plants and rootstocks because space is an issue for growers, farmers and consumers as well as researchers.[75] In addition, even when new cultivars are developed and stocks are produced, the grower adoption rates are slow due to the long fruiting maturation cycles of woody fruits (Stallman 1986).

Weather poses a significant risk to all plant industries. The horticultural subsector is particularly vulnerable due to substantial postharvest risks magnified by the perishability of many horticultural crops. By reducing postharvest losses, advances in postharvest technologies have greatly impacted the growth of the horticultural industries. Over the past century, a suite of technologies developed through interdisciplinary efforts have significantly reduced postharvest loses particularly for fresh fruits, vegetables and cut flowers, and ornamental plants (Kader 2002, 2003). These technologies enhanced the profitability of the horticultural industries, and the quality and variety of fresh horticultural products available to consumers. These technologies include preharvest

[75] Dwarfing alleles that do not produce deleterious consequences for plant vigor, particularly dominant forms most useful in horticulture, are very rare in natural gene pools because they are readily eliminated by natural selection.

controls, harvesting systems (e.g. precooling), packaging materials and systems, controlled or modified atmosphere for storage and transport, refrigeration and cooling systems for storage and transport, ethylene inhibitors, crop specific postharvest treatments, and vertical integration of the distribution chain to enhance collaborative postharvest care (Kader 2002, 2003).

Research has affected the demand for, not just the supply of, horticultural crops. Nutritional science and government sponsored information programs have increased public awareness of the health benefits of fruits and vegetables in general as well as the health benefits of particular crops have contributed increased demand for fresh produce. For example, the recent increases in production of berry crops reflect a growing demand due to an increased awareness of the health benefits due to the antioxidant activity of phenolic compounds that exist in higher concentrations in small fruit (Sjulin 2003).

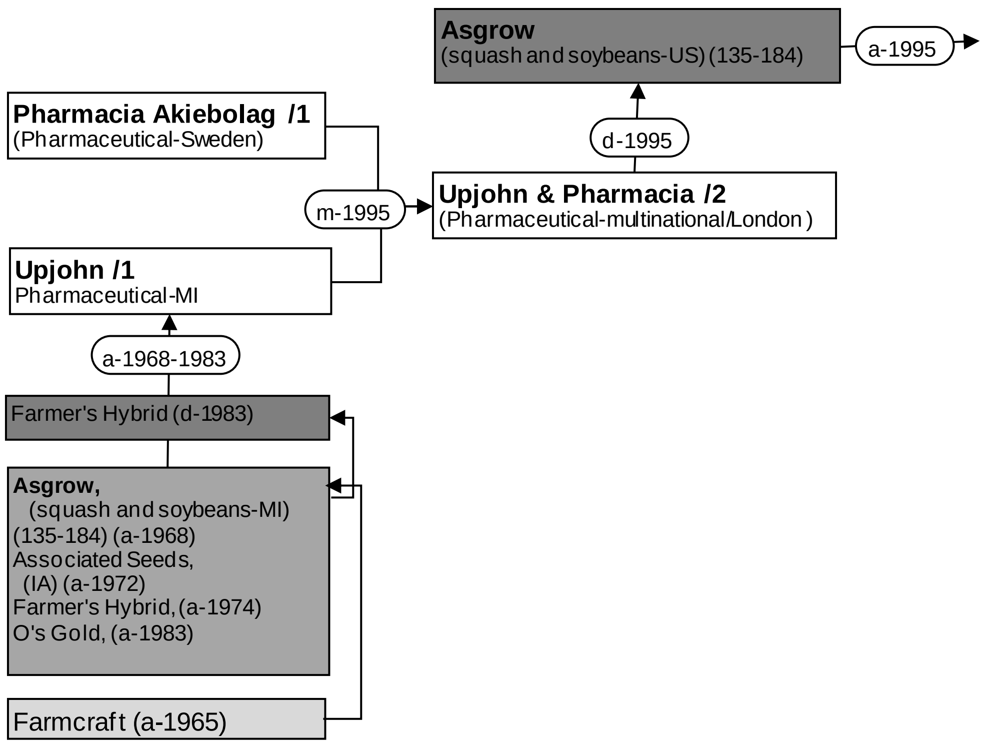
3.4. The Changing Industry Structure

3.4.1 Seed Industry Structure

This section examines the trends in market structure of the seed industry since 1970 which is now dominated by three firms: Syngenta, Monsanto, and Dupont-Pioneer (Figure 3.1 a-c). The value of the U.S. seed market has grown considerably in recent decades from an estimated 2.5 billion in the mid-1920s (Leibenluft 1981) to 8.5 billion in 2008 (ISF 2008, Table 3.2). Sales of crop seeds in the United States constitute almost one quarter of the world seed market. Fernandez-Cornejo (2004) estimated that by 1997 the top four firms namely—Pioneer-Dupont, Syngenta, Advanta, and Monsanto—

accounted for 92 percent of all US cottonseed sales, 69 percent of the corn seed market, and 47 percent of the soybean seed sales.[76]

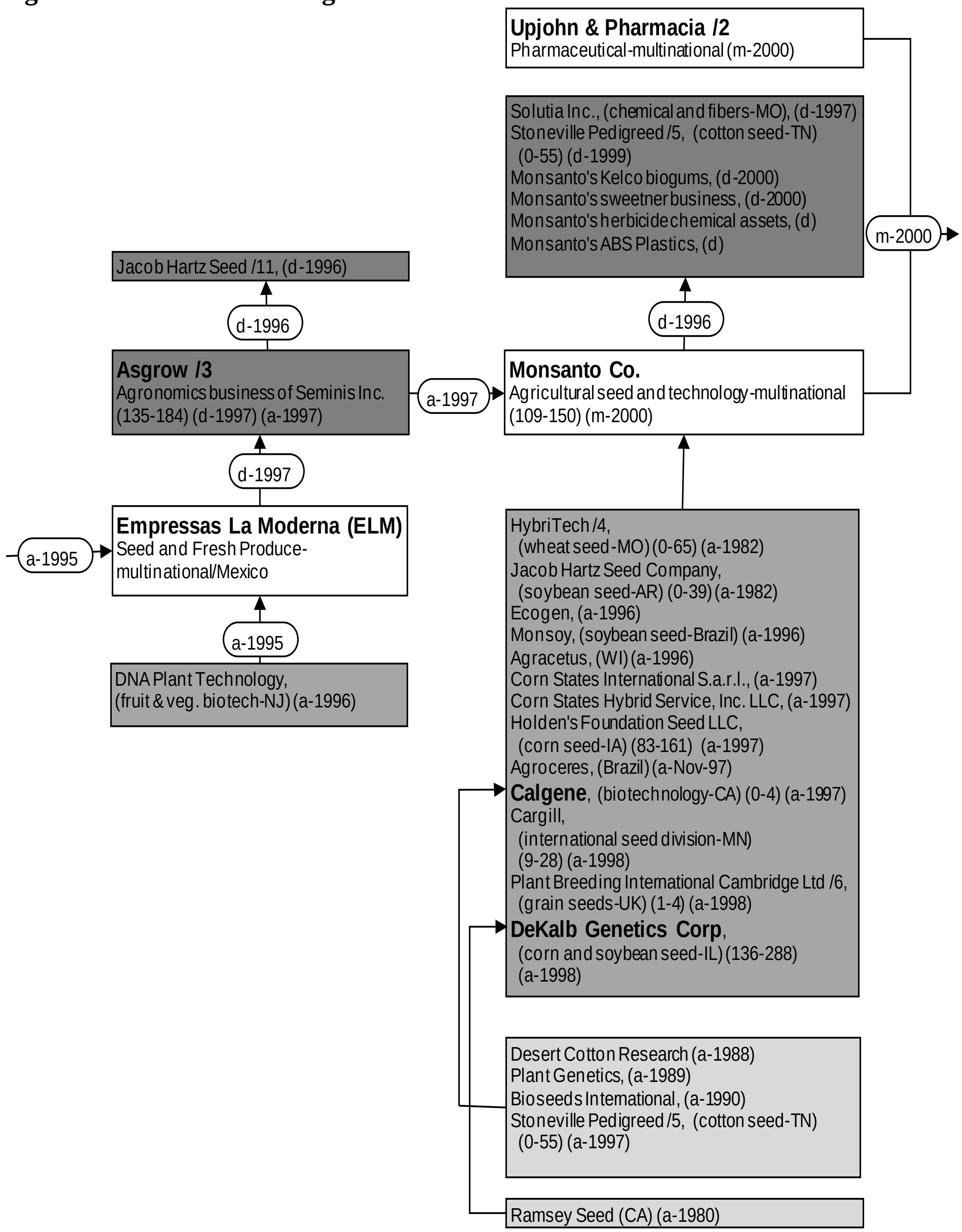
Figure 3.1a: Monsanto Pedigree



Continued next page

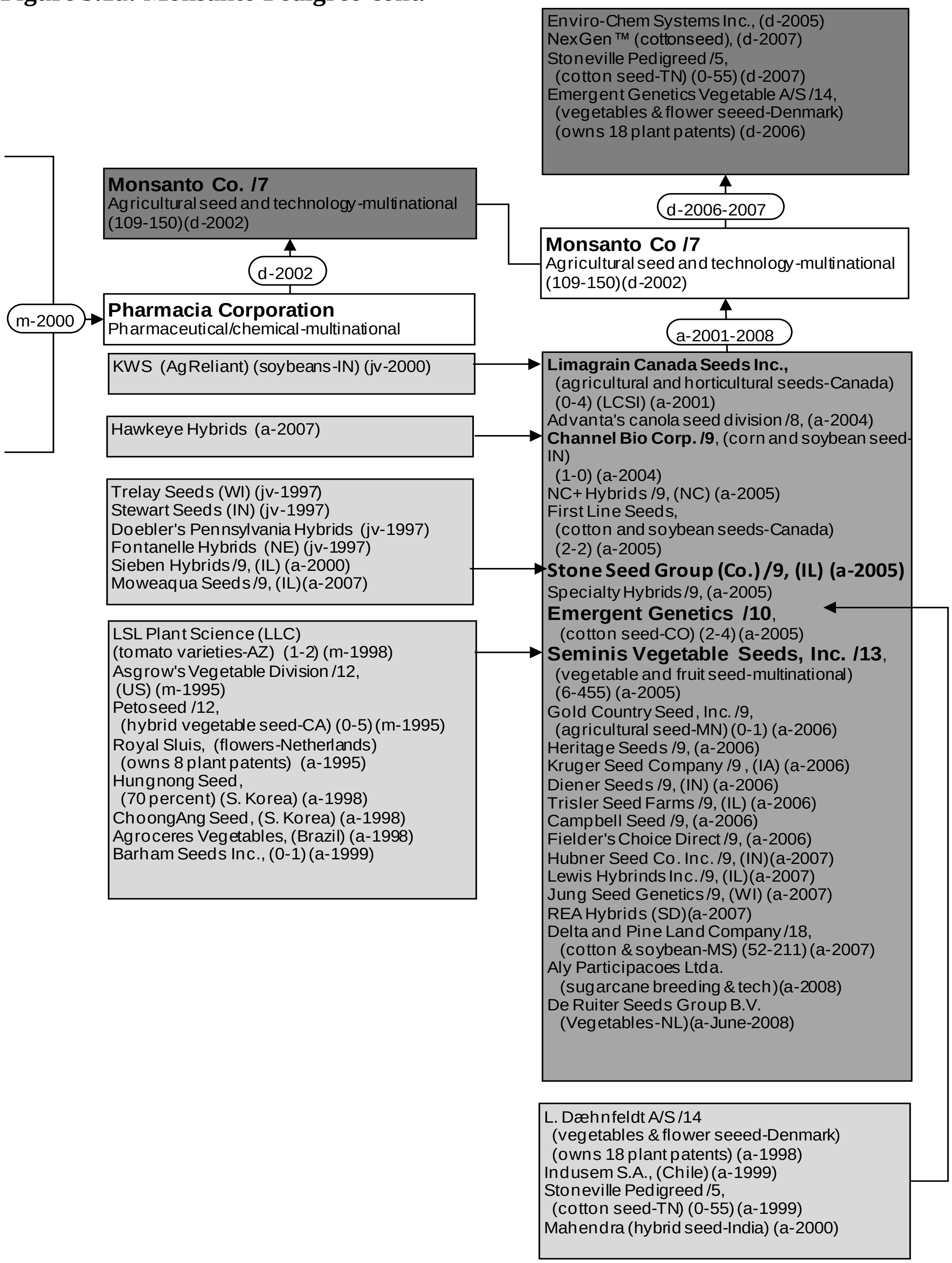
[76] Subsequent mergers have certainly increased this concentration, in particular the merger that brought Syngenta and Advanta's North American corn and soybean divisions into the same company and the acquisition of DP&L by Monsanto (Figures 3.1a-b).

Figure 3.1a: Monsanto Pedigree-cont.



Continued next page

Figure 3.1a: Monsanto Pedigree-cont.



Continued next page

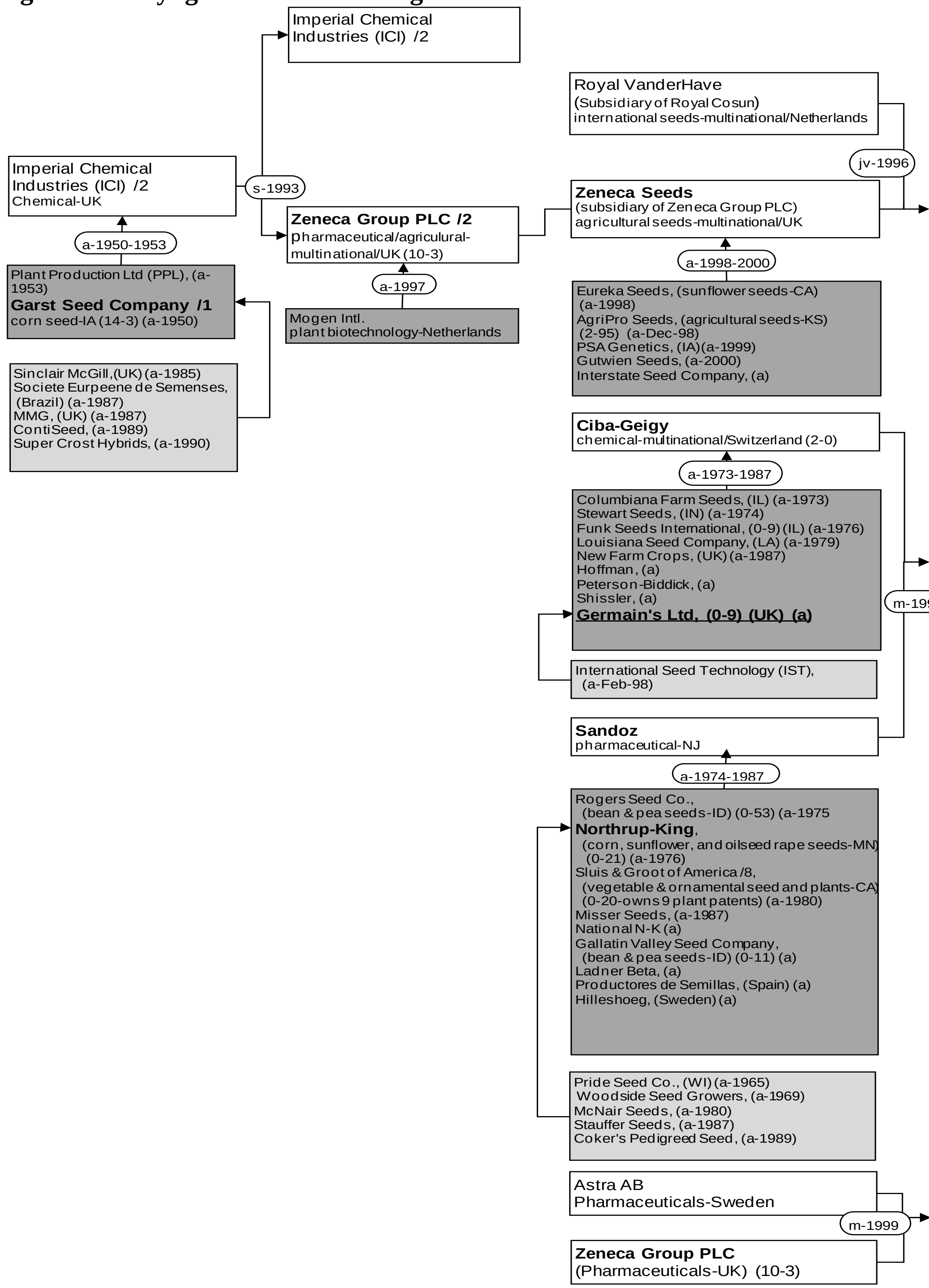
Figure 3.1a: Monsanto Pedigree-cont.

Sources: Koo, Pardey and Drew (2010a) The data used were derived from multiple sources which may include: The Impacts of Patent Protection on the U.S. Seed Industry and Public Plant Breeding (Butler and Marion 1985), Researchability of Modern Agricultural Input Markets and Growing Concentration (Fernandez-Cornejo 2004), Global Seed Industry Concentration (ETC group 2005), Global Information Services for Seed Professionals (Seedquest 1990-2009), LexisNexis Academic, Business News, Mergers and Acquisitions (LexisNexis 2007), Mergerstat review (c1989-1994 and 1996-2006),and Multinational Company (MNC) Monographs and Overview – Reports (Wield 2000/2001).

General Notes:
Firm owned intellectual property rights are given as: (number of utility patents with claims for cultivars-number of plant variety protection certificates)
Company actions are designated by a small case letter: a-acquisition, b-buy-out, d-divestiture, jv-joint venture, m-merger, s-split.

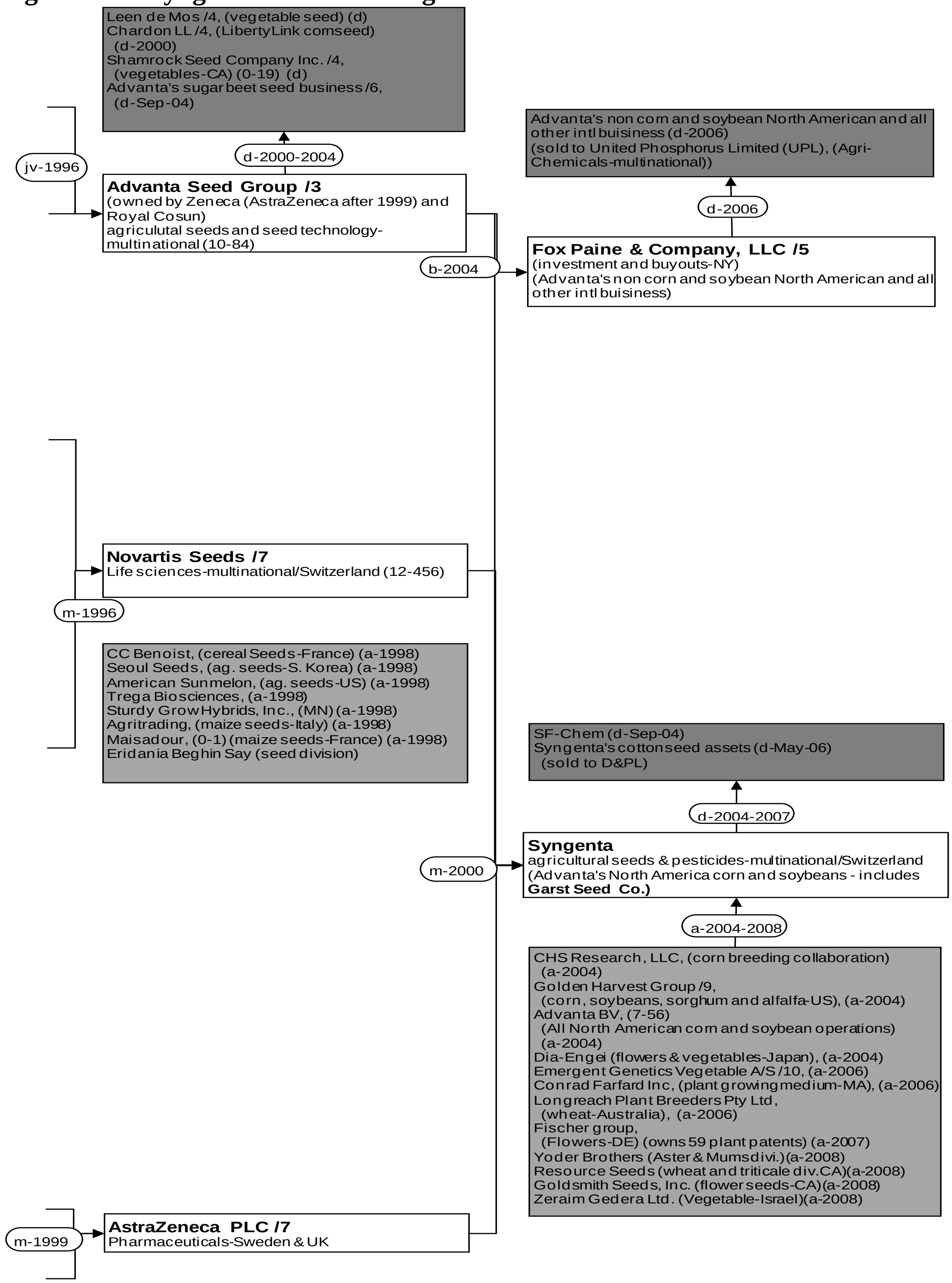
Specific Notes:
1. A merger of Pharmacia Akiebolag and Upjohn forms Upjohn & Pharmacia where Asgrow is a subsidiary.
2. Upjohn & Pharmacia sold Asgrow to Empressas La Moderna in 1994 where it becomes part of their subsidiary, Seminis, in October 1995.
3. Seminis retains the Vegetable seed division of Asgrow (See Sub-Pedigree for Seminis)
4. HybriTech Seeds International was created in 1982. HybriTech Europe SNC was created by Monsanto and Pau Euralis in 1985.
5. Stoneville Pedigreed is purchased by Calgene in 1995. Calgene is purchased by Monsanto in 1997 Monsanto sells Stoneville Pedigreed to Mahendra in 1999, and then purchases Stoneville back as a part of Emergent Genetics Inc. in 2005. June 2007 Bayer CropScience purchases Stoneville Pedigreed from Monsanto
6. PBIC never published documents in its own name; all accounts were part of Unilever.
7. Pharmacia completes spin-off of Monsanto Company
8. According to our IP files Advanta does not own IPR for canola.
9. These companies were acquired by American Seeds, Inc. (ASI), which was formed by Monsanto in 2004 and serves as a holding company for regional seed companies that market primarily corn and soybeans. Channel Bio Corp includes: Crows Hybrid Corn, Midwest Seed Genetics and Wilson Seeds
10. Emergent Genetics is Hicks, Muse, Tate & Furst Inc. management affiliate for transactions in the seed industry.
11. The fact that Jacob Hartz Seed Company, Inc was unloaded in 1996 is not a problem in counting Monsanto's IPR because the Hartz Seed Company did not have any UPs or PVPCs after this date--I think this is probably because Monsanto kept the R&D division of the company.
12. This is a merger of three companies owned by EMPRESAS LA MODERNA (ELM). Petoseed was purchased by ELM from Geo. J. Ball earlier this year.
13. Seminis Vegetable Seeds is owned by SAVIA formerly EMPRESAS LA MODERNA (ELM). SAVIA owned by PULSAR INTERNACIONAL also owns BIONOVA HOLDING CORP. BIONOVA has a number of vegetable biotechnology firms as well as packaging and distribution firms.
14. L. Dæhnfeldt A/S, an established global vegetable company owned by Emergent Genetics, Inc. changed its name to Emergent Genetics Vegetable A/S in 2004.

Figure 3.1b: Syngenta-Advanta Pedigree



Continued next page

Figure 3.1b: Syngenta-Advanta Pedigree-cont.



Continued next page

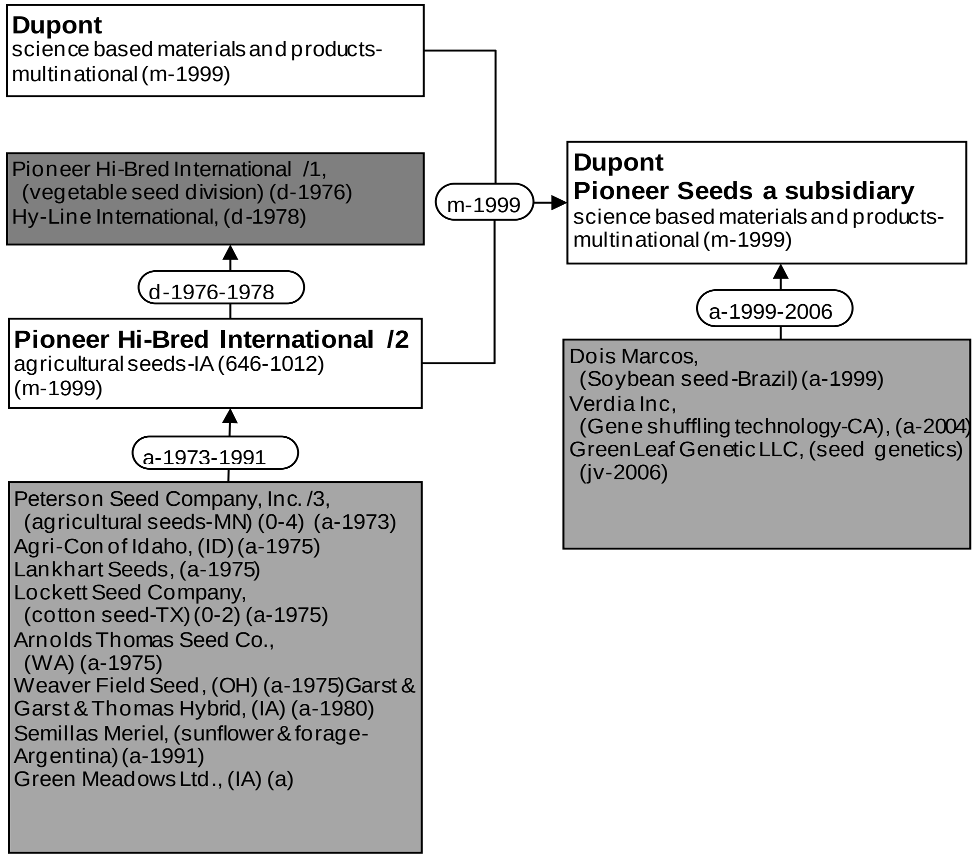
Figure 3.1b: Syngenta-Advanta Pedigree-cont.

Sources: Koo, Pardey and Drew (2010a) The data used were derived from multiple sources which may include: The Impacts of Patent Protection on the U.S. Seed Industry and Public Plant Breeding (Butler and Marion 1985), Researchability of Modern Agricultural Input Markets and Growing Concentration (Fernandez-Cornejo 2004), Global Seed Industry Concentration (ETC group 2005), Global Information Services for Seed Professionals (Seedquest 1990-2009), LexisNexis Academic, Business News, Mergers and Acquisitions (LexisNexis 2007), Mergerstat review (c1989-1994 and 1996-2006),and Multinational Company (MNC) Monographs and Overview – Reports (Wield 2000/2001).

General Notes:
Firm owned intellectual property rights are given as: (number of utility patents with claims for cultivars - number of plant variety protection certificates)
Company actions are designated by a small case letter: a-acquisition, b-buy-out, d-divestiture, jv-joint venture, m-merger, s-split.

Notes:
1. Garst Seed Company changes its name to ICI Seeds in 1991 and back to Garst 1996, but otherwise retains its operations as a separate seed company throughout the "timeline."
2. Imperial Chemical Industries splits into two companies, Zeneca producing agrochemicals and seeds and ICI. Zenneca Seeds is a subsidiary of Zeneca Group.
3. Advanta was formed as a joint venture of the Dutch company Royal VanderHave Group and the British company Zeneca Seeds after their merger in 1996.
4. These companies were sold off after the merger of Zeneca and Royal VanderHave.
5. Fox Paine & Company, LLC formed a company that sold Advanta to UPL. UPL is a large group of international ag. chemical companies
Biowin Corporation Limited is the UPL subsidiary that aquired Advanta
6. Advanta was required to sell of their sugarbeets division for the sale to Syngenta to proceed. Of the identified subsidiaries and acquisitions of Advanta, there is no IPR for sugar beets
7. Fox Paine & Company facilitated this merger between Novartis Agribusiness Division (Crop Protection and Seeds Sectors) with Zeneca Agrochemicals of AstraZeneca
AstraZeneca merged its Agrochemicals Division with Novartis Agribusiness into the spinoff, Syngenta. Advanta was left out.
AstraZeneca is a shareholder of both Advanta and Syngenta.
8. The IP is held by the parent company based in the Netherlands.
9. The Golden Harvest Group includes Garwood Seed Co., Golden Seed Co. LLC, Golden Seed Co. Inc., J. C. Robinson Seeds Inc, Sommer Bros Seed Co., Thorp Seed Co. and Golden Harvest Seeds Inc.
10. L. Dæhnfeldt A/S, an established global vegetable company owned by Emergent Genetics, Inc. changed its name to Emergent Genetics Vegetable A/S in 2004.

Figure 3.1c: Pioneer-Dupont Pedigree



Sources: Koo, Pardey and Drew (2010a) The data used were derived from multiple sources which may include: The Impacts of Patent Protection on the U.S. Seed Industry and Public Plant Breeding (Butler and Marion 1985), Researchability of Modern Agricultural Input Markets and Growing Concentration (Fernandez-Cornejo 2004), Global Seed Industry Concentration (ETC group 2005), Global Information Services for Seed Professionals (Seedquest 1990-2009), LexisNexis Academic, Business News, Mergers and Acquisitions (LexisNexis 2007), Mergerstat review (c1989-1994 and 1996-2006),and Multinational Company (MNC) Monographs and Overview – Reports (Wield 2000/2001).

General Notes:
Firm owned intellectual property rights are given as: (number of utility patents with claims for cultivars—number of plant variety protection certificates)
Company actions are designated by a small case letter: a-acquisition, b-buy-out, d-divestiture, jv-joint venture, m-merger, s-split.

Specific Notes:
1. Pioneer trades its vegetable seed division for a 20 percent interest in Sunseeds Inc.
2. Pioneer (originally known as the Hi-Bred Corn Company) and Dupont merge, and Pioneer Hi-Bred Int'l continued as a subsidiary of Dupont.
3. According to seedquest Peterson was purchased by AgriBiotech (a turf & forage seed company that went bankrupt in 2000) in June of 1998 there is no mention of purchasing the company from Pioneer.

Table 3.2: 2008 Values of Commercial Seed Markets by Country

Country	Market value
	million US $
USA	8,500
China	4,000
France	2,150
Brazil	2,000
India	1,500
Japan	1,500
Germany	1,500
Italy	1,000
Argentina	950
Canada	550
Russian Federation	500
Spain	450
Australia	400
Korea	400
United Kingdom	400
Mexico	350
Poland	350
Turkey	350
Taiwan	300
South Africa	300
Hungary	300
Netherlands	300
Czech Republic	300
Other	3,652
Total	32,002

Source: International Seed Federation (ISF 2008)

The pace of mergers and acquisitions involving multinational agrochemical companies and seed companies accelerated beginning in the late 1970s. In an environment with expanding and strengthening plant related intellectual property rights and the evolution of scientifically enhanced breeding techniques, the seed producing industry has evolved in ways that helped realize expected increases in the revenue from protected new plant products. The complexities of biotechnology and the ability of firms to protect their inventions using multiple forms of intellectual property rights have contributed to a complex knowledge market. In such markets, new products arrive through cumulative innovation processes and the application of complementary technologies (Scotchmer 2004). Specifically, for the agricultural biotechnology industry this meant that the range of technologies necessary for the development and marketing of new products was unlikely to be controlled by a single firm (Marco and Rausser 2008, Rausser and Scotchmer et al. 1998). Thus, we might expect firms to gain increased control and access to the necessary technologies. Although this discussion focuses on merger and acquisition activity, a whole host of related restructuring activities were in play, including: divestitures, joint ventures, cross-licensing, and patent pooling. Litigation and associated behaviors also play an important role in the industry restructuring where in cooperative agreements, and cross licensing arrangements may follow from infringement suits. Given that these transactions are not costless, there are concerns that an anti-commons effect may exist where in fragmented patent control may limit innovations due to the inaccessibility of necessary technologies (Marco and Rausser 2008).

Most non-hybrid crops can be grown from saved seed and readily reproduced and sold by a competing company. Thus, prior to the Plant Variety Protection Act of 1970, many seed companies relied on publicly developed crops and invested little in developing their own self fertilizing cultivars (Leibenluft 1981).[77] To a great extent, the literature recognizes that the provision of intellectual property rights for non-hybrid seed crops and the subsequent (specifically patent) provisions that extended these rights to hybrid and bioengineered crops provided an added incentive for the agglomeration of seed firms and technology providers (Leibenluft 1981, Butler and Marion 1985, Marco and Rausser 2007, Lesser 1998, Wright and Pardey 2006). Industry concentration raises concerns regarding the tendency toward monopoly pricing and other market consequences that limit social welfare and skew R&D benefits away from growers and consumers. Trading off against these welfare reducing outcomes are the potential welfare gains for increased efficiencies in R&D and marketing plus higher rates of productivity growth associated with an increased pace of new varietal releases (Fernandez-Cornejo 2007).

In the decade following the Plant Variety Protection Act of 1970, more than 50 U. S. seed companies were acquired by multinational pharmaceutical, petrochemical and food firms (Leibenluft 1981). For example in the 1970s, Ciba Geigy, a multinational chemical company, acquired four seed companies, and Sandoz, a multinational pharmaceutical firm, acquired Northrup King and Roger's Seed Company (Figure 3.1b). Perceived motivations for these acquisitions were to increase revenues through the provisions of the Plant Variety Protection Act, and to provide complementary products (e.g., pesticides,

[77] Pioneer Hi-Bred International, Inc. founded in 1926 by former U.S. Vice President Henry A. Wallace, was developed from its own hybrid corn research.

fertilizers and agricultural seeds) or synergies between plant and chemical R&D (Butler and Marion 1985, Leibenluft 1981). Bear in mind that many of the crop cultivars commonly used at this time required heavy application rate of chemical fertilizers and pesticides. In addition, some of this restructuring could have been in anticipation of the future importance of biotechnology for producing plant products. Utility patents were being granted for bioengineering methods during this period (Seay 1989).

Towards the end of the decade, the larger firms were beginning to play a dominant role in securing plant variety protection for their new seed produced cultivars. By 1982, 50 percent of the plant variety protection certificates ever issued was held by just 14 conglomerates (Butler and Marion 1985). Seed corn production was especially concentrated with 80 percent of all U. S. sales shared by just 10 firms in 1979 (Leibenluft 1981). There is evidence that private research efforts increased particularly for wheat and soybeans (Butler and Marion 1985). Competition in the seed industry was not perceived to be seriously compromised for several reasons: the seed market was still dominated by cultivars produced by public sector breeding programs, farmers were still practicing seed saving for the replanting of open pollinated varieties, and competition between the major seed companies was very intense as exemplified by the many close substitutes offered for every variety (Leibenluft 1981, Butler and Marion 1985).

Before 1980, firms were investing in biotechnology research, but following the *Diamond v. Chakrabarty* decision, which heralded the beginning of commercial applications of biotechnology, biotech startups proliferated.[78] Calgene, who introduced

[78] This Supreme Court ruling extended patent rights to genetically engineered microorganisms

the first commercialized transgenic food crop, the Flavr Savr tomato with delayed ripening, was one such start-up (Figure 3.1a).

The Supreme Court ruling in *Diamond vs. Chakrabarty* which extended utility patent protection to biological innovations spurred further merger, acquisition, and joint venture activity in the plant biotechnology sector (Tait et al. 2001, Fernandez-Cornejo 2004). Varying degrees of synergistic interactions with strong potential for economies of scale and scope were anticipated between chemical and biotechnology product development such as glysophate and glysophate resistant corn and soybean lines (Tait et al. 2001, Just and Hueth 1993). Despite the synergistic potential, by the late 1980s many pharmaceutical companies have begun to divest themselves of their seed company acquisitions (Fernandez-Cornejo 2004). The divestiture of Asgrow by Upjohn and Pharmacia in 1993 (Figure 3.1a) is one such example.

A second wave of mergers and acquisitions took off in the late 1990s to increase and consolidate market share and distribution capacity, as well as to acquire access to protected intellectual property of select high value crops (Fernandez-Cornejo 2004, Brennan et al. 2000). This time the mergers were characterized by larger agricultural seed and biotechnology firms companies acquiring smaller agricultural seed companies and plant breeding firms (King 2001, Brennan et al. 2000). There is a large body of literature analyzing this wave of industry restructuring, particularly for this decade (Lesser 1998, King 2001, Brennan et al. 2000, 2005, Fernandez-Cornejo 2004, Schimmelpfennig et al. 2004, Oehmke et al. 2005, Fernandez-Cornejo and Just 2007, Marco and Rausser 2007, Tait et al. 2001). Brennan et al. (2000) characterized these developments in part as divestitures of chemical manufacturing assets to free up funds to acquire and negotiate alliances with biotech firms, seed companies and food and feed companies. The merger between Astra AB and Zeneca Group PLC exemplifies this type of action (Figure 3.1b). Some of these restructuring efforts led to the development of "life science**"** complexes. Monsanto acquired Agracetus, Calgene and Ecogen, and ELM acquired Dna Plant Technology (Figure 3.1a)—Zeneca acquired Mogen (Figure 3.1b).

The top firms often cited in recent studies of U. S. seed markets are now Syngenta, Monsanto and Pioneer-DuPont (Figure 3.1 a-c).[79] These firms either have two main divisions, a seed and genomics (plant science) division and an agro-chemical division (Monsanto and Syngenta), or a subdivision that contains these two divisions (Pioneer-DuPont). These large firms focus on proprietary crop developments including hybrid crops and transgenic crop technologies. The transgenic technologies are licensed to (regional) seed companies who then use them in crops developed for regional markets (Rausser et al. 1999).

Merger, acquisition, and joint venture activities continue in the new millennium with slightly different trajectories. Monsanto, Syngenta and Pioneer-DuPont appear to be investing heavily in building their technology base and in acquiring firms that assure a "channel to market" (Figure 3.1 a- c, far right) (Tait et al. 2001). Monsanto appears to be aggressively pursuing a "channel to market" strategy, as evidenced by their acquisition of at least 10 regional seed companies since 2000 (Figure 3.1a). Such trends toward vertical integration of the market channel may be seen as a resolution of the uncertainties regarding the potentially litigious contracting of their technologies (Rausser et al. 19

79

Monsanto, and especially Syngenta, have been acquiring firms or divisions that specialize in horticultural crops (Figures 3.1 a-b). This may be a result of speculations regarding developments and applications of transgenic technologies to traits such as flower color, drought and heat tolerance (xeriscaping) in high valued floriculture plants (Potera 2007). Schoellhorn (2009) observed that the maturing horticulture industry is looking toward genetic transfer techniques to reduce the bottlenecks for new introductions caused by increased production demands of cultivars with relatively short product lives and their associated rising research costs.

Tait, Chataway et al. (2001), summarizing an extensive multifaceted study of multinational agro-chemical companies, report that the post 20th century firms are repositioning themselves to capture the expected high revenues from second and third generation biotechnologies. Tait, Chataway et al. (2001) conceive that the first generation is the current agronomic transferred genetic traits that benefit the farmers—the second generation will be quality traits that benefit the consumer—the third generation will be traits that enable crops to become chemical factories.

3.4.2 Horticultural Industry Structure

Fossum (1953) noted that the horticultural sector in the middle of the 20th century was similar to the state of the agricultural sector at the beginning of that century. Horticulture was just beginning to shift towards more intensively mechanized modes of production thereby reducing labor costs and increasing production to meet rising demand. The industry adjusted, particularly in floriculture, by separating plant producers from retailers and introducing wholesale markets. The horticultural sector was slow to adopt grade sizes and standards, and continued to have problems in this area into the beginning of the 21st century.

In the later part of the 20th century, the growing horticultural sector adjusted to larger and changing markets, and increasing consumer demand which was due, in part, to increased consumer wealth (Hall et al. 2005, Singh 1999). Increased industry specialization is one dimension of these adjustments. The advancements in clonal plant propagation techniques enabled the emergence of new firms and the growth of existing vegetative propagation firms. There also emerged propagule and seed brokerage firms, and distribution firms that neither breed nor propagated seeds or plants, but rather facilitate the sales and movement of increasing numbers of cultivars and expanded volume of propagative plant material through the distribution channels (Craig 2003, Higginbotham 1990).[80] In addition, international royalty administration firms or innovative plant firms have emerged to provide specialized services to breeders that include finding new markets, administering the collection of royalties, developing promotional schemes, and policing and enforcing intellectual property rights (Hamrick 2004). Specialized marketing firms have been established that develop and coordinate the branding and marketing of new cultivars throughout the marketing chain.

The growth of mass retail merchandisers like Wal-Mart or Home Depot have also had a significant structural impact on the horticultural subsector, including its fruit and

[80] The greenhouse and nursery industries, and in particular the bedding and gardening plant industries and nursery industries, consist of many competitive firms offering differentiated array of products of which only a portion is appropriate or cost effective for any particular region. The broker, with regional representatives, sorts out the confusing array of sources and available plants into a smaller subset of appropriate plants suitable for each region. The brokers arrange sales and shipping between producer firms and growers and retailers.

nut, vegetable, and ornamental plant industries (Dimitri 1999, Miller 2001, 2003, Brooker and Turner 1990, Brooker and Turner 1995, 2000 & 2005, Hall et al. 2005). The consolidation of retailers and the development of complex marketing chains can affect horticultural plant producers in several ways.[81] Large volume wholesale orders puts pressure on growers to become larger to maintain market opportunities, can make growers dependent on one major outlet, can put downward pressure on prices, and can (foreword) contract to direct purchase of plants from growers thus reducing the need for wholesale brokers and distributors. A series of nationwide statistical studies published in the Southern Cooperative Bulletin Series revealed an increasing impact of nursery plant sales through mass merchandise outlets (Brooker and Turner 1990, Brooker et al. 1995, Brooker et al. 2000, Brooker et al. 2005).[82] The growth of mass merchandisers has stimulated the growth of the ornamental plant industries (e.g. cut flowers, potted foliage, bedding and gardening plants and turfgrass). For example, in the 1980s and 1990s the focus of marketing of bedding and gardening plants by discount and home improvement chains such as Kmart, Wal-Mart, Home Depot and Lowe's greatly enhanced the growth of the floriculture industries (i.e., ornamental industries not including nursery and turfgrass) (Miller 2001). While other forces may be at work, fewer and larger producers arguably may be the result of increased capitalization requirements, reduced margins, increased demands, and the commercial risks associated with the concentration of retail sales and a limited number of mass retailers (Miller 2003). In the fruit and nut, and

---

[81] For an illustration of this marketing chain for ornamentals, refer to Chapter 2, Figure 2.2 titled "The Ornamental Plant Industry Distribution Chain."

[82] This publication is a collaborative effort among agricultural scientists of Southern states experiment stations.

vegetable industries, there have been analogous structural changes which include changes in the path that fresh produce follows from farm to consumer, a declining role of wholesale brokers and distribution firms, and an increasing average size of produce farms (Dimitri 1999).

In the past ten years, the ornamental plant industry has become increasingly global in terms of searches for new species and cultivars appropriate to market, and markets for plant innovations (Schoellhorn 2009). Increasingly, plant introductions in the United States are by firms with interests in multiple markets worldwide. This trend has resulted in a production and marketing shift which increases the requirement that new cultivars possess qualities that meet industry production standards, and increases the level of trialing, advertising and promotion for new cultivars. According to Schoellhorn, the time and costs entailed in developing and launching a new cultivar for an international plant introduction company are about 6-10 years and average about $20,000 per cultivar respectively. These factors have become a bottleneck for new plant introductions in recent years.

In conjunction with postharvest technologies, the development of railroads and other forms of modern transportation networks has enabled U.S. horticulture production to specialize and concentrate in favorable geographic locations. In 2004, the value of horticultural crops for the top 5 states account for 65 percent of the total value of production of U.S. horticultural crops. In contrast, the top 5 states for only 35 percent of the total value of agricultural crops (Alston and Pardey 2008). California and Florida produce the majority of fruit, vegetables and ornamental plants that are produced in the

United States (Janick and Goldman 2003). In the 2002 to 2004 period, California, Florida, and Texas produced the largest share of fresh vegetable and melons while the upper Midwest and northwest regions produced the largest share of vegetables for processing (Lucier, Pollack et al. 2006). California was the largest producer of winter vegetables, and Florida is the largest producer of warm season crops (Lucier, Pollack et al. 2006). California, Florida, Washington, Texas, Michigan, New York, and Oregon are the leaders in fruit production (Lucier, Pollack et al. 2006). California produced 50 percent of U.S. fruit and tree nuts, and Florida and Washington produced 10 percent each. Due to more favorable cultural conditions, the citrus industry is now concentrated in California, Texas, and Florida (Kender 2003). The strawberry industry, the largest small fruit industry, is dominated by Californian producers who accounted for 85 percent of all U.S. production in 1994 (Bertelsen 1995). In contrast, due to new varietal introductions of vaccinium spp., by public breeding programs, the blueberry industry is becoming more diffused geographically (Sjulin 2003).

Ornamental plant production has also become geographically concentrated. According to The Census of Horticultural Specialties (USDA 1998), nearly half (by value) of all ornamental production occurs in just five states: California (19 percent), Florida (16 percent), Texas and Michigan (6 percent respectively). Specific ornamental industries are also geographically concentrated with California leading in the production of bedding and gardening plants (12 percent by value), potted flowering plants (20 percent) and nursery plants (23 percent), and Florida leading in foliage plants (61 percent) and runner up in potted flowering plants (13 percent) and nursery plants (13 percent).

Presently, the seed industries that were small family owned firms at the beginning of the 20th century are now dominated by firms that operate internationally. The horticultural subsector still entails many small family firms, but in recent years a process of restructuring and consolidation has begun which is increasing firm size and orientation these firms to larger geographical markets. Multinational firms are now the source of most new horticultural cultivars (Craig 2001). For most agronomic crops, important elite germplasm is developed by large firms and then licensed to regional firms for crossbreeding with regionally adapted cultivars (Rausser, Scotchmer et al. 1999). In contrast, most horticultural cultivars are either developed by breeders and specialized innovation firms to adapt to a wide range of environments, and then propagated centrally and sold to regional growers under license agreements (Drew et al. 2008, Schoellhorn 2009), or as for fruit species, developed and adapted to a particular region best suited to the species (Luby 2006).

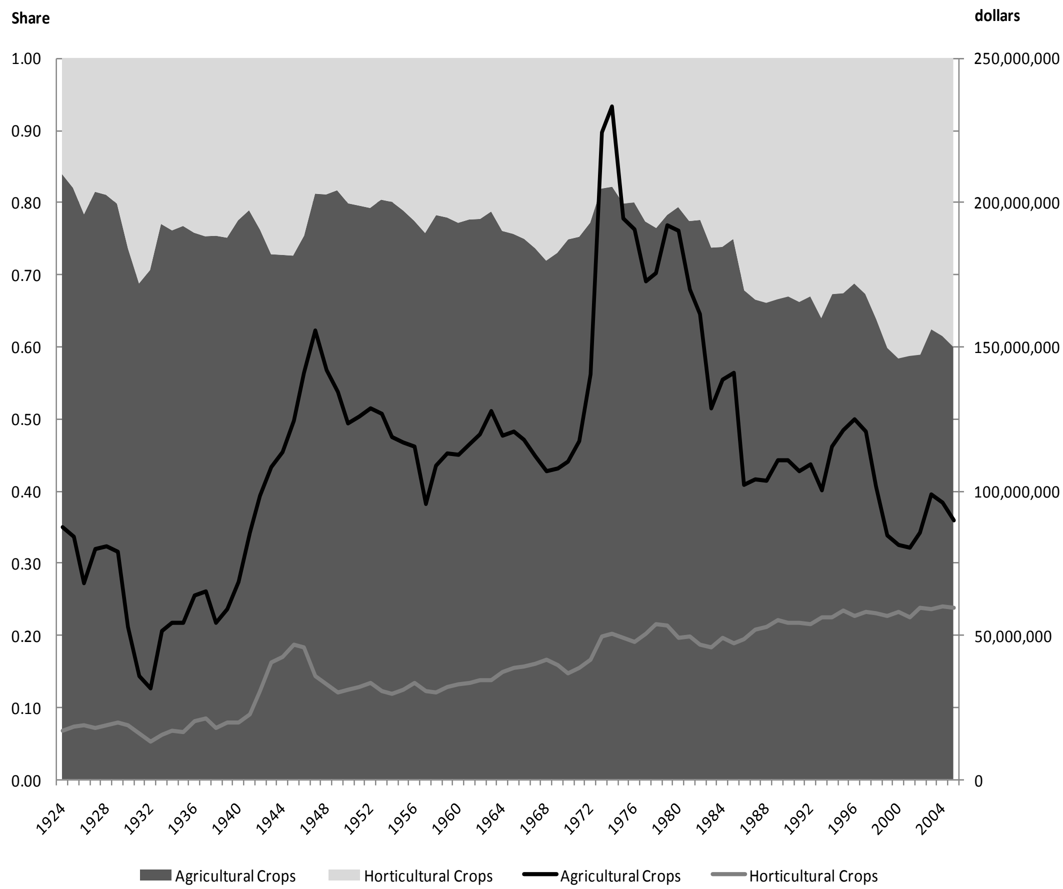
3.5. The Growth of Plant Markets

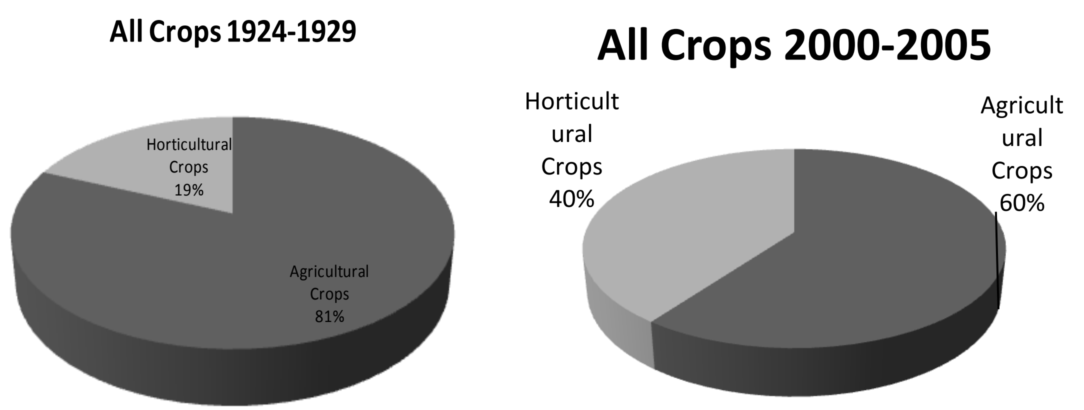
This section presents trends in relevant value of production data (Appendix C) by way of background to a quantitative assessment of trends in plant related intellectual property rights described in the next section. The relationship between intellectual property rights, innovation and market value is complex. The plant breeder's (or the owner of plant cultivars) decisions to innovate and patent innovations (or license new cultivars) are determined by their expected stream of future revenues. These expectations about future revenue streams are likely to be influenced by prior trends in the relevant value of production series. But new plant cultivars can in turn influence future market values through increased quality or agronomic characteristics. In assessing value of production trends, it is important to note that prices of horticultural crops have grown both absolutely and relative to agricultural crops (Alston and Pardey 2008). Alston and Pardey (2008) theorize that some of these price increases for specialty crops might reflect premium price contributions for changes in quality, variety, or seasonal availability.

In 1924, horticultural crops accounted for only 19 percent of the value production of all crops. Over the ensuing century, horticultural output by value grew faster than agricultural output so that in 2004 the horticultural share of the total value of production was 40 percent (Figures 3.2). Between 1924 and 2005, growth trends in the real value of production were very different between agricultural and horticultural crops.[83] The horticultural crops value grew steadily throughout the century while the aggregate value of all agricultural crops grew erratically but only slightly overall.

[83] The value of production data are adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

Figures 3.2: Agricultural and Horticultural Crops Value Trends: Share of Total (Left Axis) and Real $1000 (Right Axis)

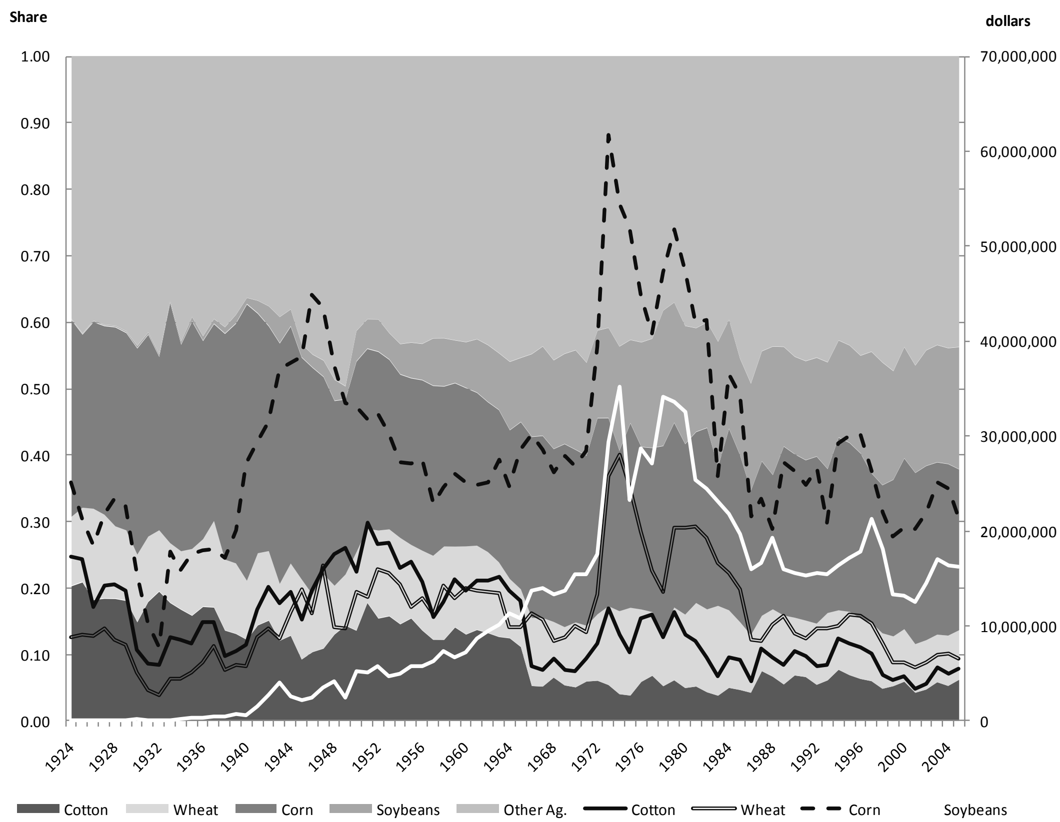


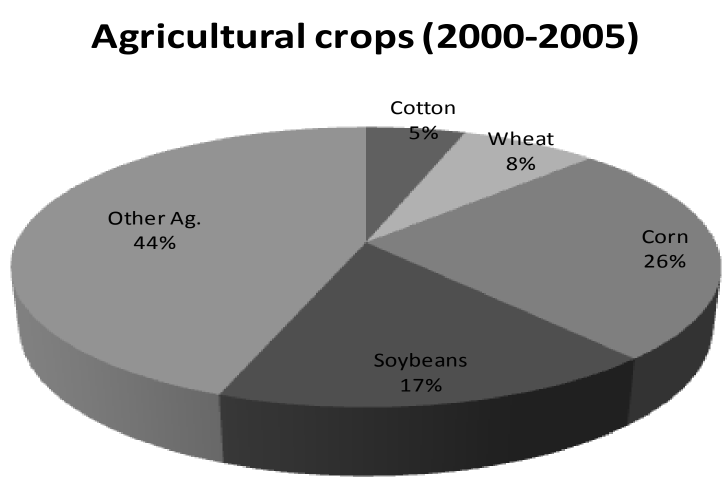


Source: calculated by author using VOP data (see Appendix C).
Notes: Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

Historically in the United States, agricultural crop production has been concentrated on a handful of crops whose value proportions remained fairly constant over the past century except for soybeans which grew from a minor crop to the second largest crop by value of production and cotton which shrunk to half of its original value (Figures 3.3). From 2000 to 2005, the four largest agricultural crops by real value of production in the United States were: corn (26 percent of all agricultural crops), soybeans (17 percent), wheat (8 percent), and cotton (5 percent). Together these crops constitute almost 60 percent of value of all the agricultural crops (Figures 3.3).

Figures 3.3: Composition of Agricultural Crops as Shares (Left Axis) and Values in Real $1000 (Right Axis)



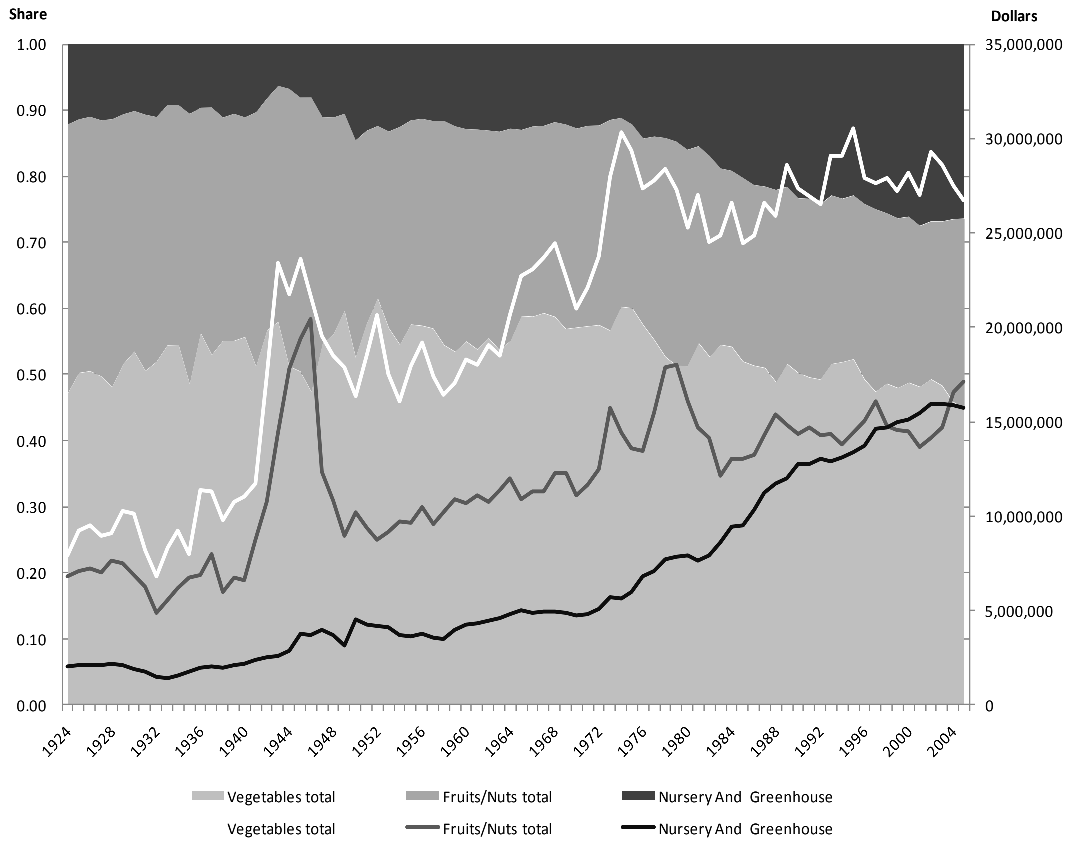


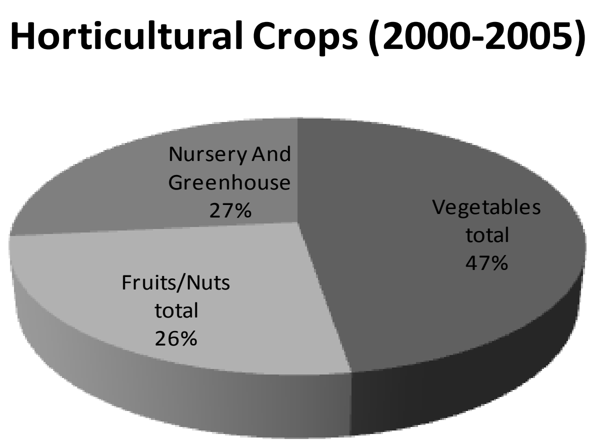
Source: Calculated by author using VOP data (see Appendix C)
Notes: Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

In contrast, horticultural crops, which are distinguished by a wide array of differentiated products, can be roughly grouped into three categories: fruit and nut crops, vegetable crops, and greenhouse and nursery crops (ornamental crops). Figure 3.4 shows that the trends in the real value of production for both fruit and nut and vegetable crops are similarly erratic and increasing throughout the 1924 to 2005 time period. However, for greenhouse and nursery crops, the real value of production grew from modest beginnings, to sharply increase in the early 1970s, and then followed by a steady incline. Nursery and greenhouse trends have the lowest starting point and the sharpest incline, of all three groups, and then overtake some of the share of vegetable and fruit and nut crop value in recent years. At the beginning of the twenty-first century, vegetables remain the largest group at 47 percent of the value of all horticultural crops, followed by nursery and greenhouse crops and fruit and nuts 27 and 26 percent respectively (Figure 3.4). From 2000 to 2005, the top five vegetable crops, potatoes (9.5 percent), lettuce (7.5 percent), tomatoes (7.3 percent), onions (3.3 percent) and mushrooms (3.2 percent), accounted for 31 percent of the value of production for all vegetable crops.[84] The top five fruit and nut crops are grapes (21 percent), apples and oranges (each 11 percent), almonds (10 percent), and strawberries (9 percent) comprising 62 percent of the value of all fruits and nuts from 2000 to 2005. Both supply and demand factors have influenced the growth of the fruit and vegetable industries in the past fifty years. These include improvements in production management and technology, growth in end the changing structure of domestic consumption, and expansion in export sales (Lucier et al. 2006).

[84] These figures were calculated from the value of production data adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

Figures 3.4: Composition of Horticultural Crops as Shares (Left Axis) and Values in Real $1000 (right axis)





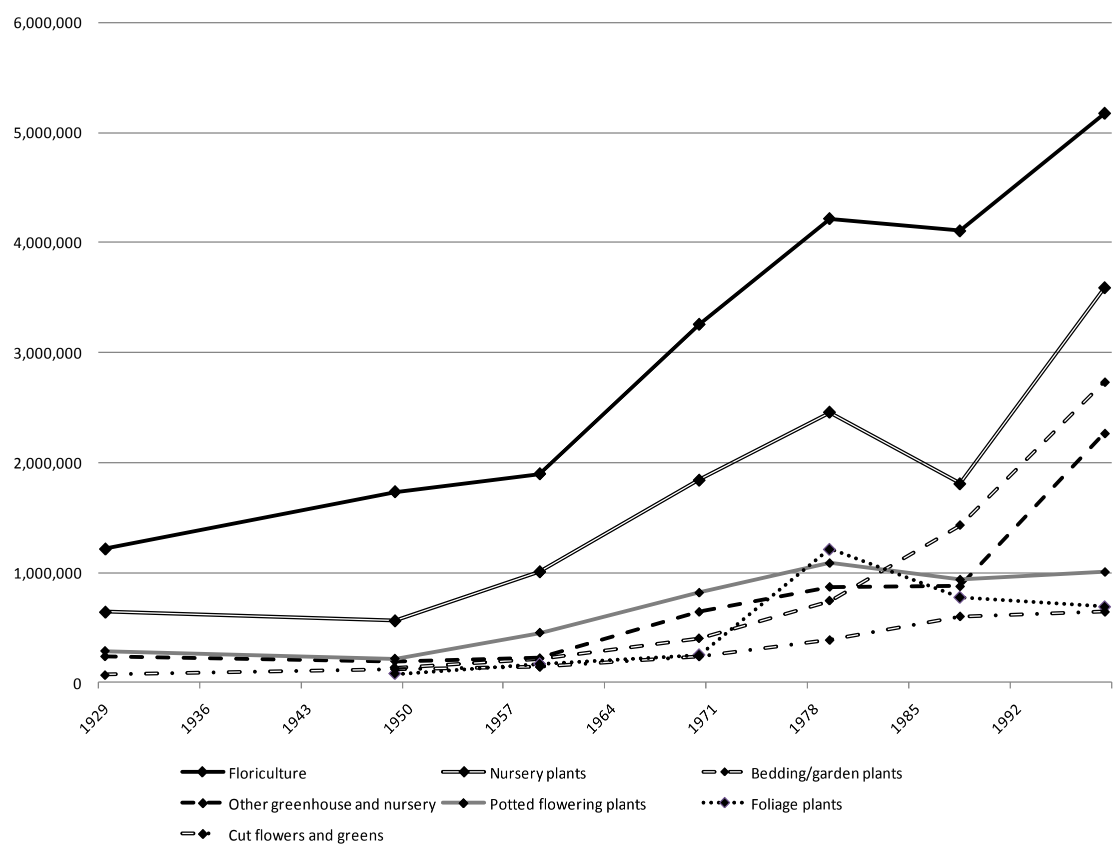
Source: Calculated by author using VOP data (see Appendix C)
Notes: Horticultural crops are made up of numerous and diverse individual crops which can be categorized into three general categories.
Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

The nursery and greenhouse sector has historically received less statistical attention than other horticultural crops and agricultural crops. Data collection and presentation has been fraught with problems that yield inconsistent and non-comparable of data over time and between different data sets (See Appendix C for details). As a result, no one source of data has proven entirely reliable for adequately representing the trends and sources of growth in this sector (Fossum 1953, Singh 1999, Hall et al. 2005). For the purpose of this study, a value of production series was constructed in which the greenhouse and nursery industry, consisting mainly of ornamental crops, includes floriculture, nursery, sod and turf, vegetable seeds, floral seeds, bulbs and tubers, greenhouse grown fruit and vegetables, mushrooms and Christmas trees. The floriculture group includes bedding and garden plants, potted flowering and foliage plants, and cut flowers and greens. Historical census data from 1929 to 1998 (USDA 2000) gives an indication of the long-run pattern of growth of the ornamental industries over the last century (Figure 3.5).[85] Notably these are the only series found to reveal the growth of the nursery component of the ornamental sector prior to 2000. As a group, the real value of nursery products grew faster than the other components of the ornamental industry between the 1950 and 1979 censuses, and a decrease between the 1979 and 1988 censuses increased more than the other groups prior to the 1998 census (Figure 3.5). For most of the century the shares of nursery, floriculture and other greenhouse and nursery crops hold fairly steady. Nursery crops, the largest sub-industry (including all individual industries in floriculture), average 30 percent of all nursery and greenhouse crops value. The floriculture crop group makes up

[85] The historical value of production data were adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

55 percent of the value of all greenhouse and nursery crops. The “other” nursery and greenhouse crop industries account for 10 percent of the nursery and greenhouse crops industry.

Figure 3.5: Historical Horticultural Sales: 1998 and Earlier Census Years in Real $1000 dollars

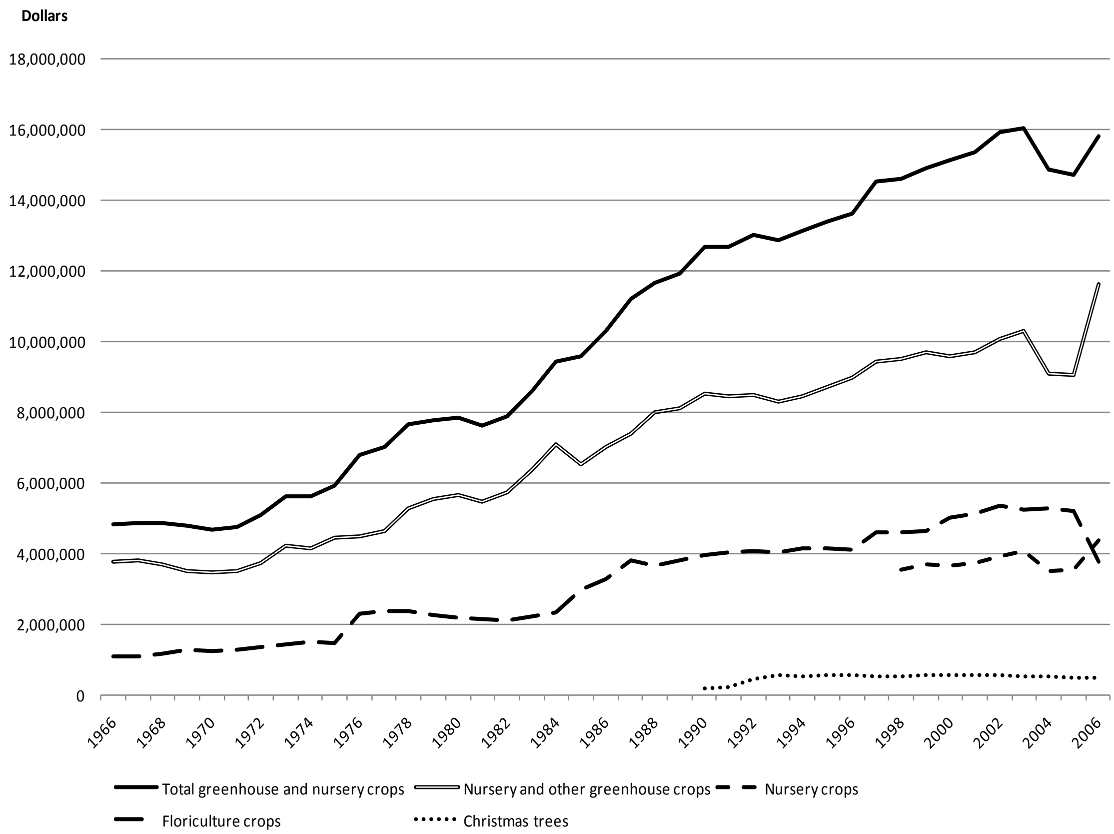


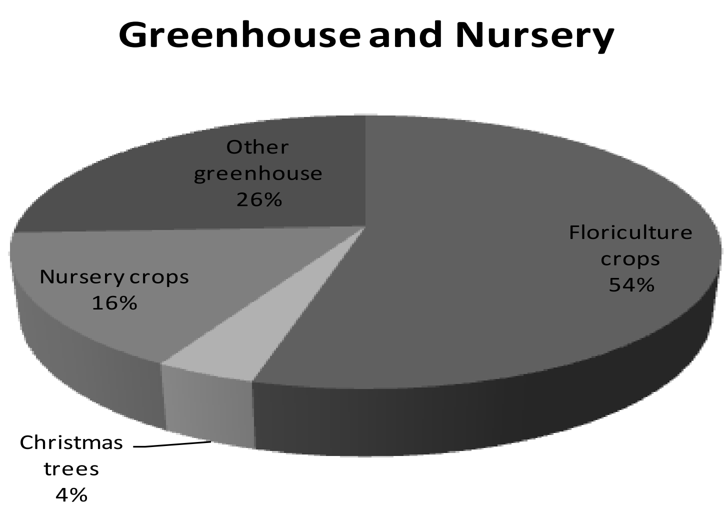
Source: Constructed by author using data from USDA, National Agricultural Statistics Service (2000).
Notes: Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).
1. For this figure floriculture includes bedding and garden plants, potted flowering plants, foliage plants, and cut flowers and greens.
2. These data were assembled from U.S. census data.
3. Prior to 1998 most perennial plants were included with nursery plants. In 1998, perennial plants are included in bedding and garden plants.
4. 1949 and 1959 values were constructed as wholesale value only, so they are not directly comparable to the other census years.
5. Prior to 1988, nursery plants included lining out stock.
6. Prior to 1998 other greenhouse and nursery did not include, aquatic plants (they were included in nursery), unfinished and propagative material, turfgrass, dried bulbs and etc., transplants for commercial purposes, vegetable and flower seeds, Christmas trees and short term woody crops.

Growth trends, since the late 1960s to 2006, are revealed by the USDA's Economic Research Service data (USDA 2007). The most significant growth in the ornamental plant industry occurred during this period (Figures 3.6). These data show the value of sales for nursery and other greenhouse crops and for floriculture crops had a significant rate of increase change in the early 1970s and very steady growth (Figures 3.6).[86] In 2004, the trend for nursery and other greenhouse crops take a dip followed by a sharp incline after 2005 while the floriculture crops trend sharply declines after 2005. These sales trends suggest that there may have been a shift in consumer preferences toward more durable woody ornamentals. Jerardo of USDA's Economic Research Service hypothesizes that this decline in sales of floriculture crops reflects a drop in demand due to rising food and energy prices and a substitution of imports for domestic production of propagation materials (Gaff 2007). Data from three surveys of the nursery industry for 2000, 2003 and 2006 reveal growth trends in cash receipts (Figure 3.6, dashed line). Gross value of sales grew 17 percent from 2003 to 2006 with growth in sales across all crop subgroups (USDA 2007).

[86] Note floriculture sales are constructed from wholesale values and nursery crop values are constructed from cash receipts (for details see Appendix C).

Figures 3.6: Greenhouse and Nursery Industry Wholesale Sales in Real $1000



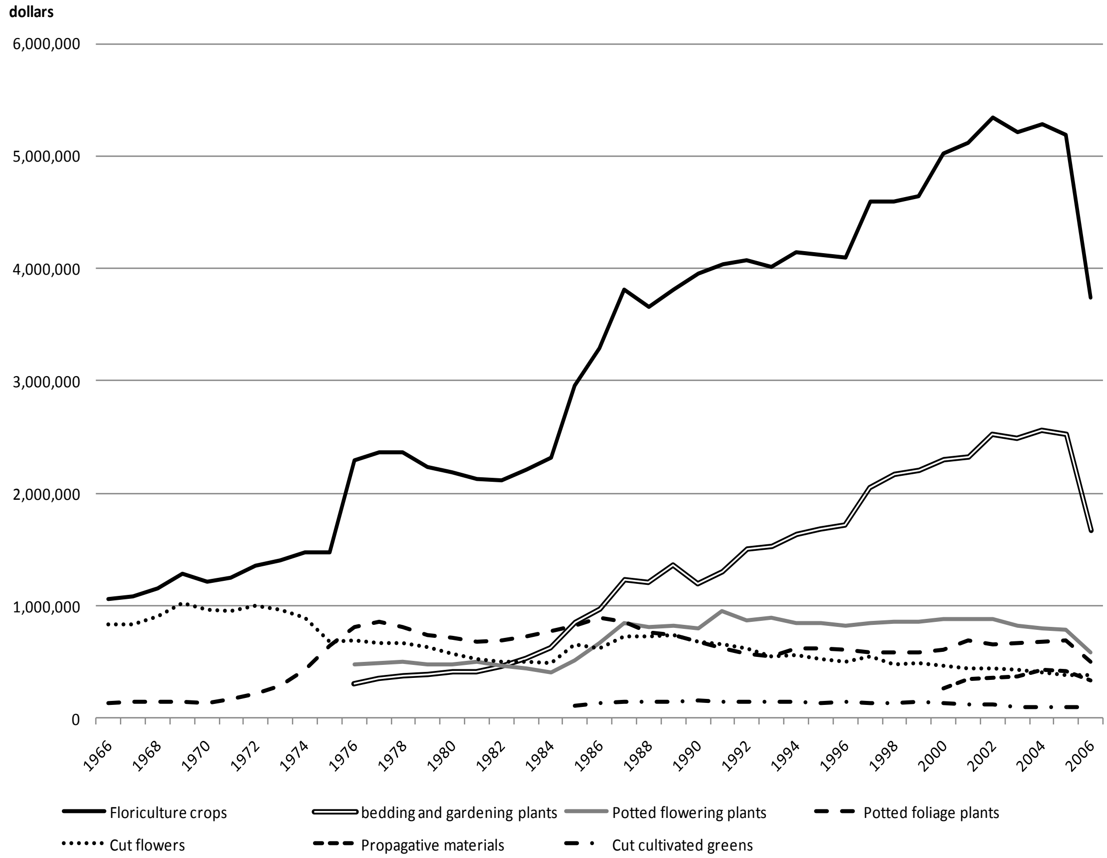


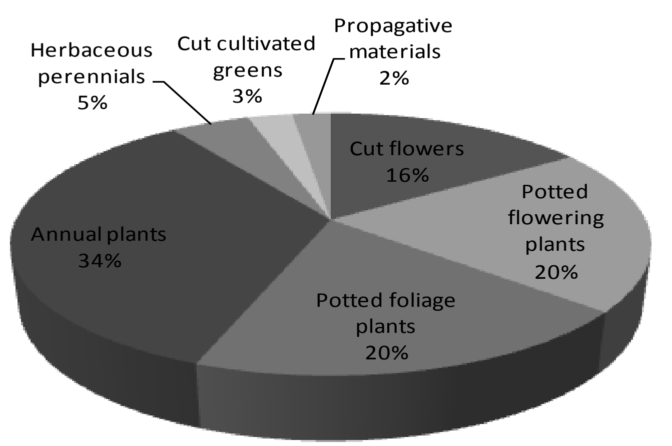
Sources: Most of the above series were constructed by the author using USDA Economic Research Service data (2007) The Nursery data (green dashed line) were constructed using USDA National Agricultural Statistics Service data (2007).
Notes: Nursery and other greenhouse crops are a residual from subtracting floriculture crops from total greenhouse and nursery.
Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

The rapid growth in the real wholesale value (4 percent per year from 1995-2005) for the bedding and gardening plants industry, which is made up of annual plants and herbaceous perennials, accounted for most of the recent value growth in floriculture crops (Figures 3.7). From 2000 to 2007, bedding and gardening plants constituted 39 percent of all the floriculture crop value followed by 20 percent for each if the interior ornamental plant groups (i.e., potted flowering and potted foliage plants). Individual crop trends cannot easily be used to account for the trends we see in these floriculture groups because the top 8 crops in value only account for 28 percent of all floriculture crops, and these have rather flat growth pattern compared to the overall trends (Figures 3.8).[87]

[87] These crops include: Poinsettia, Impatiens, Chrysanthemum, Petunia, Pansy/Viola, Orchid, Geranium, and Rose.

Figures 3.7: Floriculture Industry Wholesale Sales in Real $1000

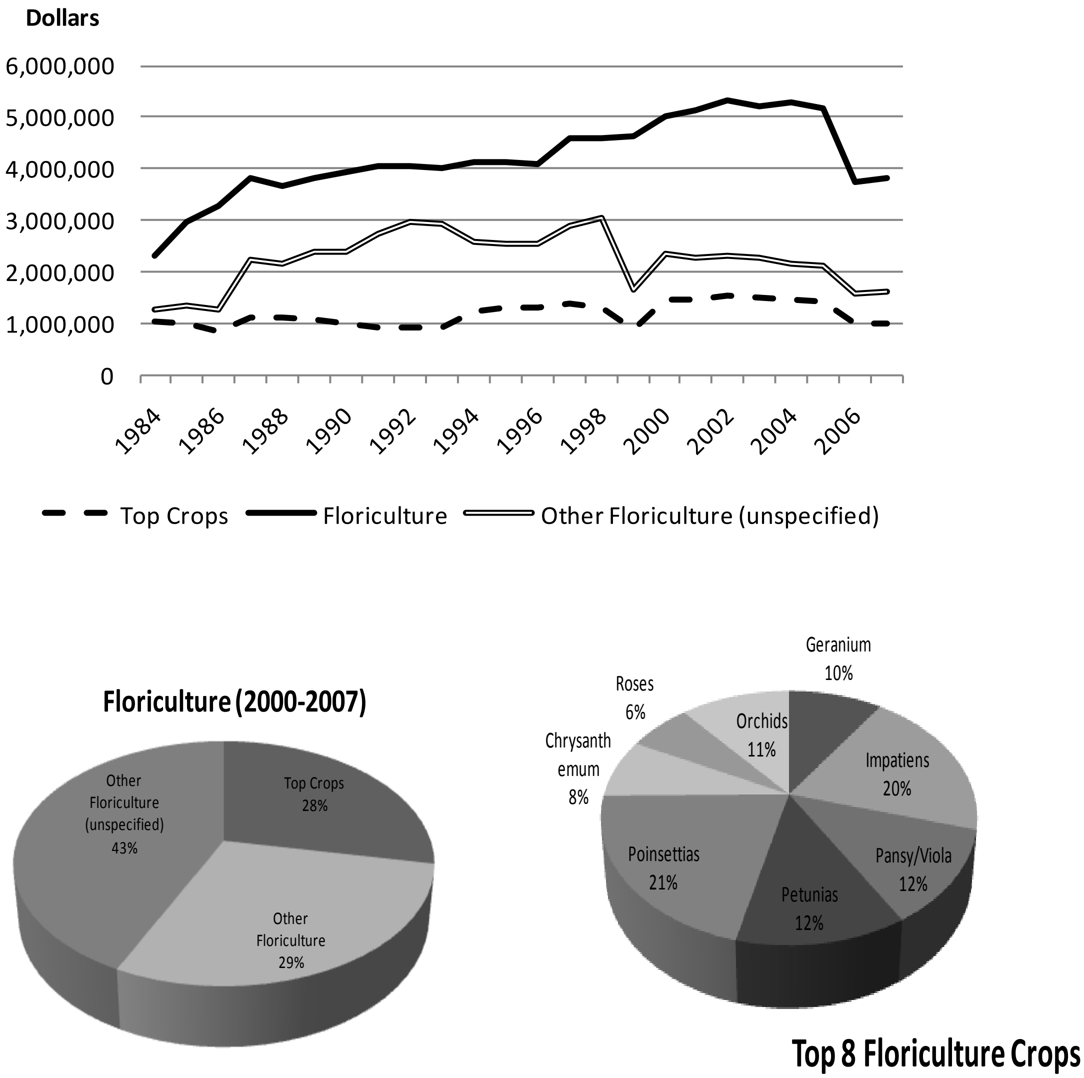




Floriculture 2000-2006

Source: The above series were constructed by the author using USDA Economic Research Service data (2007).
Notes: Annual plants and herbaceous perennials make up the group referred to as bedding and gardening plants.
Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

Figures 3.8: Top Eight Floriculture Crop Wholesale Sales in Real Millions of Dollars



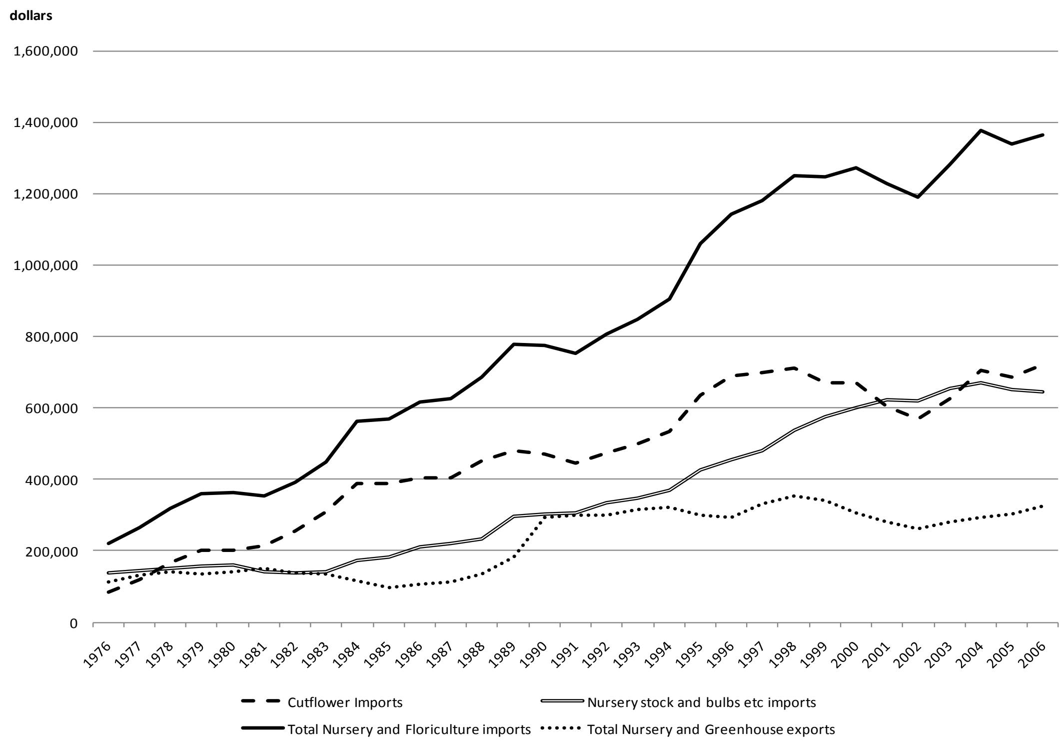
Source: The above series were constructed by the author using USDA National Agricultural Statistics Service data (1960-2007).
Notes: Some crops span more than one floriculture crop group: Chrysanthemums are bedding, potted flowering and cut flowers, roses are both cut flowers and potted flowering, and orchids are both potted flowering and cut flowers. Poinsettias belong to potted flowering, and the other crops belong to bedding plants.
Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

Most of the data within each floriculture group (i.e., bedding and gardening plants, potted flowering plants, foliage plants and cut flowers) are reported by species (i.e., rose, chrysanthemum, and petunia). The species that have annual sales too low to warrant their own category for reporting are reported in an "other" category (i.e., other bedding and gardening plants, other potted flowering plants, other foliage plants, and other cut flowers) represent groups of unspecified species sales. Miller (2003) observed that sharp rises in the "other" categories of the floriculture groups in wholesale sales can account for much of the growth in total floriculture sales. Miller suggested that this trend could reflect an increased diversity of product offerings. The "unspecified other" categories together make up 43 percent of all floriculture crops. A problem in interpreting floriculture statistics reporting arises when the category a crop is reported in may be changed over time. For example, if the crop value increases sufficiently over time for a species classed in the "other" category, that species may be moved from the "other" category to their own crop category. This means that an inferred growth of product diversity since 1984 could be even greater. These trends are consistent with an industry driven by increasing diversity, novelty and innovative plant offerings. over the past two decades, the number of horticultural cultivars offered in North America nearly quadrupled increasing from 29,000 cultivars in 1987 to 105,000 cultivars in 2008 (Drew and Anderson et al. 2008).

Horticultural markets are becoming increasingly global, mirroring developments that have long prevailed in the agricultural. The large volume and value of U.S. international trade in horticultural products is evidence of their integration into world markets (Figures

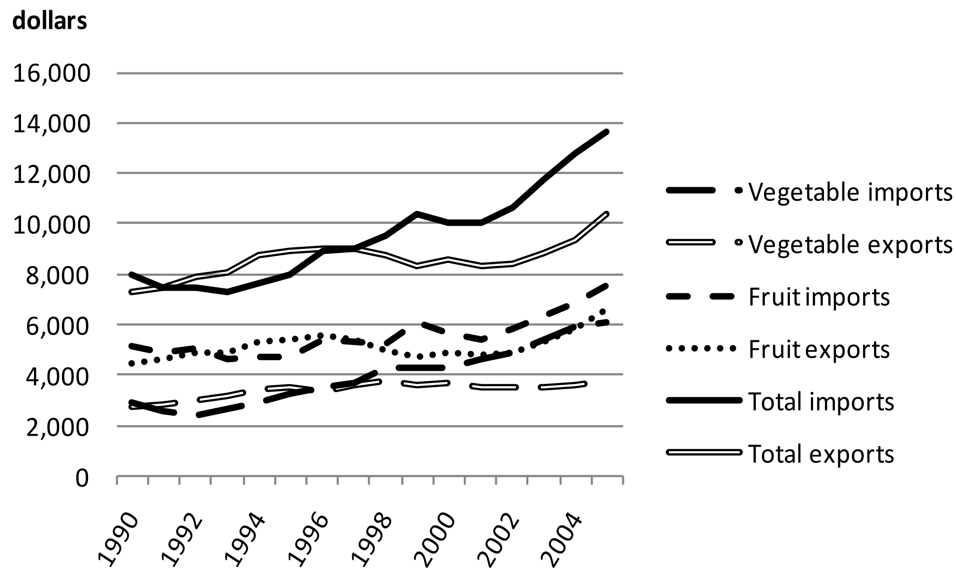
3.9 and 3.10). In 2005, agricultural exports were $62.9 billion, of which fruit and vegetables exports were $10.7 billion (Lucier et al. 2006). However, the United States also imports significant amounts of fruits and vegetables so that the net trade balance in fruits and vegetables has been negative since 1998. U.S. trade in ornamental products is one of the largest such markets in the world, but is quite small compared with trade in fruits and vegetables largely due to phytosanitary import restrictions. International trade in nursery and greenhouse products consists mainly of imports of cut flower products (i.e., cut flowers, buds, foliage and branches) and propagative materials (i.e., bulbs, tubers, live trees and plants). Figure 3.9 shows U.S. imports have increased rapidly and steadily since the mid 1970s. The significant increase in the value of cut flower imports since the mid-1980s replaces the declining value of domestic cut flower production (Figure 3.7). Imports of other greenhouse and nursery crops consist mostly of propagative inputs to domestic value-added production. Increases in imports of fruits and vegetables and floriculture products have generally outpaced exports of these three product groups (Figures 3.9 and 3.10).

Figure 3.9: U.S. Nursery and Greenhouse Industry Value of Trade in Real Millions of Dollars (1976-2006)



Source: USDA Economic Research Service (2007)
Notes: Cut flower imports include cut flowers, buds, foliage, branches, and etc. Other imports include bulbs, tubers, live trees, plants, and etc.
Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

Figure 3.10: U.S. Fruit and Vegetable Industries Value of Trade in Real Millions of Dollars (1976-2006)



Source: USDA Economic Research Service (Perez and Pollack 2008).
Note: Data are in 1,000 dollar units adjusted to 2004 dollars using U.S. consumer price indices (USDL 2010).

3.6. Plant Varietal Intellectual Property Structure

Over the past century, plant innovation and securing the rights to protect those innovations have coevolved in the context of a rich and increasingly complex science, legal, industry and market environment. An examination of plant varietal intellectual property trends in the context of the evolving innovation environment can help understand trends and patterns of protecting plant-related inventions in the United States. Recent trends are of particular interest, because the U. S. innovation environment has rapidly evolved over the last 30 years.

3.6.1 General Patterns

Patterns of intellectual property rights for new plant cultivars are revealed by a time series of intellectual property rights compiled by the author and colleagues for this and related studies (Koo 2010, Appendix D). This rich data set can address many questions regarding the changing structure of plant varietal intellectual property rights because it includes many variables for crop group, industry of use, plant type, applicant, and applicant type (i.e., corporate or private, foreign or domestic). These data encompass all forms of varietal rights and includes all available 2,949 utility patents (published from 1986 to 2009), 19,797 plant patents (published from 1930 to 2009) and 9,858 plant variety protection certificates (from 1971 to 2009).

While multiple forms of intellectual property exist for plants, not all forms are appropriate for every cultivar. Plant patents can only be used for asexually propagated cultivars and plant variety protection certificates can only be used for asexually reproduced crops and tuber propagated crops. Utility patents can be obtained for both types of reproduced crops, but due to the higher costs of obtaining and maintaining a utility patent (Table 3.1), the grantee must weigh these costs against the expected value of the invention (which may also include the value of the invention as a component of a firm's patent portfolio). Cultivars that embody elite germplasm and other introduced traits resulting from costly R&D programs are more likely to be protected by a utility patent.

Horticultural crops account for about 73 percent of all the plant varietal intellectual property rights issued in the United States until 2008 (Table 3.3). Virtually all plant patents, 39 percent of all plant variety protection certificates and 7 percent of all utility patents are for horticultural cultivars, while 61 percent of all plant variety protection certificates and 93 percent of utility patents are for agricultural cultivars. Eighty three percent of all plant patents are for ornamental plants.[88] The top horticultural plants protected by the plant patent are ornamentals *Rosa* (20 percent of all plant patents), *Chrysanthemum* (11 percent), *Pelargonium* or geranium (5 percent) and *Impatiens* (4 percent). Virtually all agricultural cultivars are seed propagated, and most horticultural cultivars are asexually propagated, with the exceptions of vegetables and some annual and herbaceous perennial bedding and gardening plants. Agricultural crops protected by plant variety protection certificates include cereals (29 percent of all plant variety protection certificates), oilseed (21 percent), grasses, (12 percent), vegetables (20 percent), and fibers (6 percent).[89] The two largest crops in terms of value are also the

---

[88] This number excludes trees.

[89] Eight percent of the 12 percent of plant variety protection certificates that are for grasses are for grasses which can be used both for agricultural and horticultural purposes.

largest protected under utility patents which are corn (48 percent of all utility patents) and soybeans (43 percent).

Table 3.3: Counts and Shares of Intellectual Property Rights for Plants by Crop

Crop type	Type Intellectual Property Right			
	PP	PVP	UP	Total
Number of rights (count)				
Horticultural total	**19,731**	**3,858**	**219**	**23,808**
Beverage & Spice	38	15	4	57
Fruit	2,800	10	2	2,812
Grass (turf)	160	1,042	16	1,218
Legumes		307	9	316
Medicinal	11	4	7	22
Ornamental	16,033	296	27	16,356
Root/tuber	6	218	15	239
Tree	451	1		452
Treenut	160			160
Vegetable	72	1,965	139	2,176
Agricultural total	**226**	**6,000**	**2,730**	**8,956**
Cereals	6	2,907	1,419	4,332
Fiber		617	60	677
Fodder		229	9	238
Grass (feed & pa:	160	147	4	311
Industrial Plant	34	58	1	93
Oilseed	7	2,037	1,228	3,272
Other crops			4	4
Sugar Crops	19	5	5	29
Grand Total	**19,797**	**9,858**	**2,949**	**32,604**
Share of rights (percent)				
Horticultural total	**99.67**	**39.14**	**7.43**	**73.02**
Beverage & Spice	0.19	0.15	0.14	0.17
Fruit	14.14	0.10	0.07	8.62
Grass (turf)	0.81	10.57	0.54	3.74
Legumes	0.00	3.11	0.31	0.97
Medicinal	0.06	0.04	0.24	0.07
Ornamental	80.99	3.00	0.92	50.17
Root/tuber	0.03	2.21	0.51	0.73
Tree	2.28	0.01	0.00	1.39
Treenut	0.81	0.00	0.00	0.49
Vegetable	0.36	19.93	4.71	6.67
Agricultural total	**1.14**	**60.86**	**92.57**	**27.47**
Cereals	0.03	29.49	48.12	13.29
Fiber	0.00	6.26	2.03	2.08
Fodder	0.00	2.32	0.31	0.73
Grass (feed & pa:	0.81	1.49	0.14	0.95
Industrial Plant	0.17	0.59	0.03	0.29
Oilseed	0.04	20.66	41.64	10.04
Other crops	0.00	0.00	0.14	0.01
Sugar Crops	0.10	0.05	0.17	0.09
Grand Total	**100.00**	**100.00**	**100.00**	**100.00**

Source: Calculated by author using intellectual property rights for plant varieties data (Koo et al. 2010, Appendix D)

Notes: PP denotes plant patent, PVPC denotes plant variety protection certificate, and UP denotes utility patent.

Likewise, the composition of applicant types is different for each type of intellectual property right for plants with more similarities shared by the plant variety protection certificates and utility patents (Koo et al., Table 3.4). The applicants for plant patents are 35 percent foreign, and the domestic composition is characterized by 44 percent corporations and 19 percent individuals. In comparison, plant variety protection certificates and utility patents are only 10 and 9 percent foreign applicants respectively, and their domestic composition is distinguished by 73 and 88 percent corporations respectively and with 2 and 1 percent individuals. The percentage of publicly owned intellectual property is negligible for the plant patent and the utility patent, but 15 percent of Plant Variety Protection applicants are university and government entities.

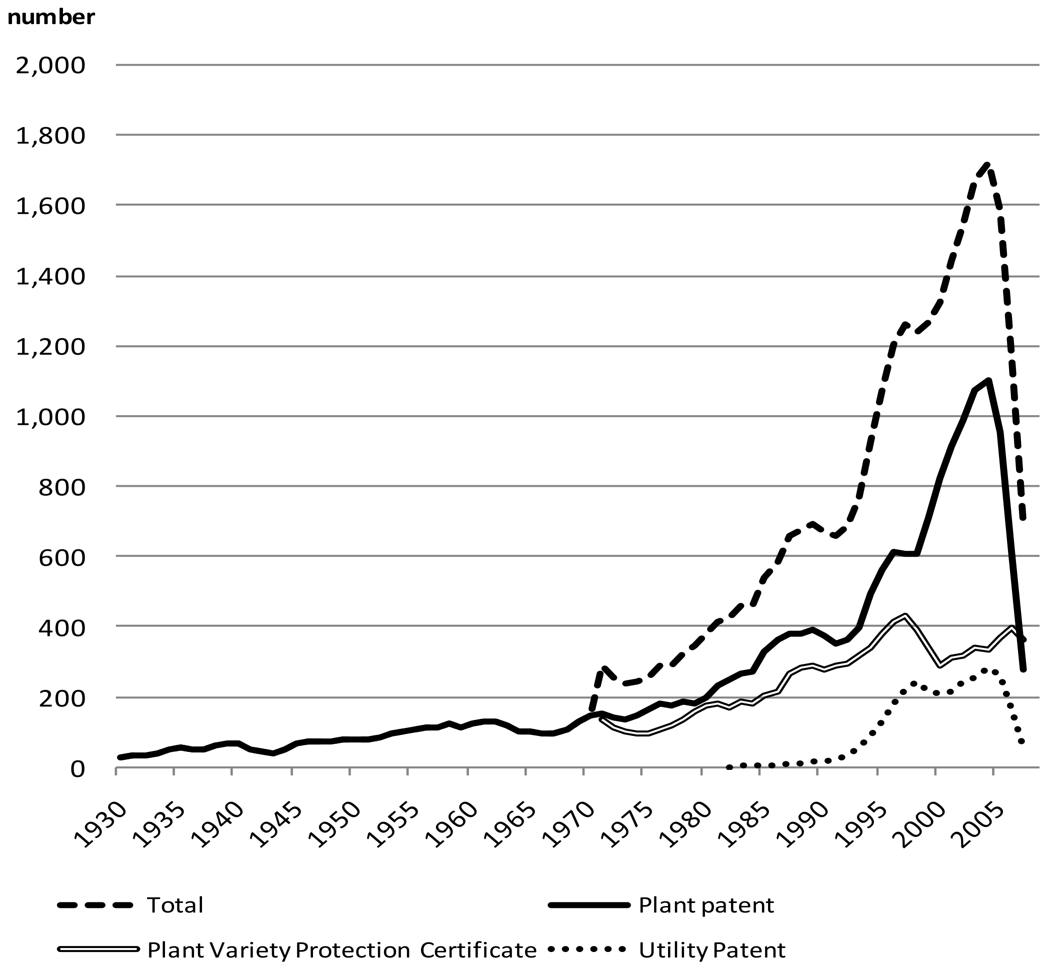
Table 3.4: Counts and Shares of Intellectual Property Rights for Plants by Type of Applicant

Type of applicants	Plant patent	Plant variety protection	Utility patent	Total
Number of rights (count)				
Domestic applicants	**12,896**	**8,823**	**2,679**	**24,398**
U.S. corporation	8,632	7,202	2,591	18,425
U.S. individual	3,697	170	40	3,907
U.S. university/station	366	1,047	24	1,437
U.S. foundation	173	294	23	490
U.S. government	28	110	1	139
Foreign applicants	**6,901**	**1,035**	**270**	**8,206**
Foreign corporation	5,284	971	242	6,497
Foreign individual	1,461	10	19	1,490
Foreign university	20	6	1	27
Foreign government	136	48	8	192
Total	**19,797**	**9,858**	**2,949**	**32,604**
Share of total (percent)				
Domestic applicants	**65**	**90**	**91**	**75**
U.S. corporation	44	73	88	57
U.S. individual	19	2	1	12
U.S. university/station	2	11	1	4
U.S. foundation	1	3	1	2
U.S. government	0	1	0	0
Foreign applicants	**35**	**10**	**9**	**25**
Foreign corporation	27	10	8	20
Foreign individual	7	0	1	5
Foreign university	0	0	0	0
Foreign government	1	0	0	1
Total	**100**	**100**	**100**	**100**

Source: Koo, Pardey, and Drew (2010a)

The trends of the total yearly application counts of all forms of intellectual property rights for plants including their total yearly counts with a 3 year moving average are shown in Figure 3.11. The total trend increases rapidly after the introductions of plant variety protection certificates in 1970 and the after the court rulings of the 1980s which developed utility patent rights for plants. The increasing trend of the plant patent appears to increase its angle of ascent around 1980 and again in the early 1990s. In contrast, the trend lines for the plant variety protection certificates and the utility patents decrease rapidly in the late 1990s after a steady ascent.

Figure 3.11: Moving Average of Annual Application Counts for Plant Patents (PP), Plant Variety Protection Certificates (PVPC) and Utility Patents (up) (1931-2007)



Source: Constructed by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Notes: These trends reflect a three year moving average of the annual counts. There are only plant patents prior to 1970. PP denotes plant patent, PVPC denotes plant variety protection certificate, and UP denotes utility patent.

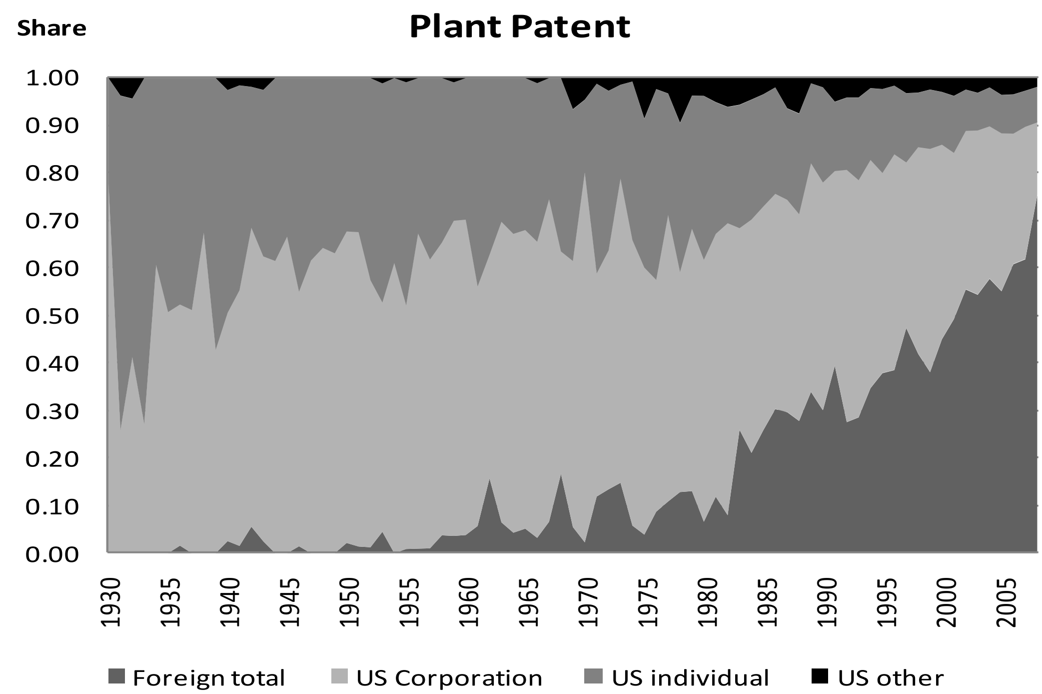
3.6.2. Plant Patent

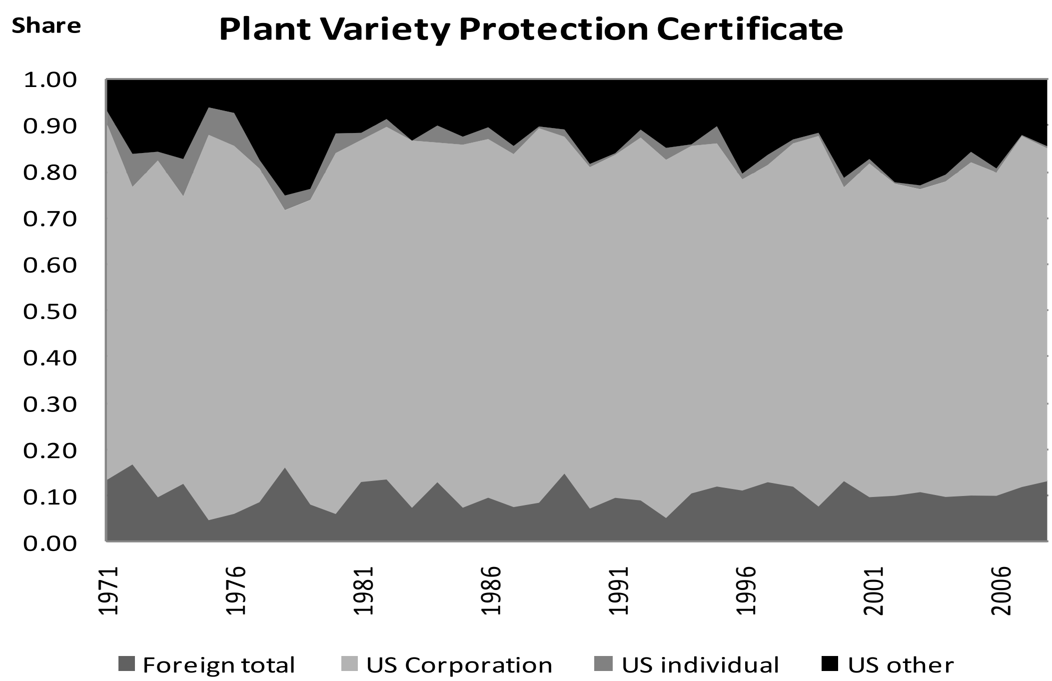
Koo, Pardey and Drew (2010b) tested the plant patent count series for structural breaks to help define the trends in the series. Their first test was to use a method which specified the largest Chow F statistic over all possible break dates as the indicator for which time period a structural break occurred. This test revealed that a structural break occurred about 1979. The other test which was a unit root test that can also be used to tests a series for an unknown structural break. This test revealed a break at 1993.

While there are no specific large single events that can explain these surges, perhaps a confluence of events and changes could explain these surges in plant patents. Similar surges in utility patents occurred in the United States in the 1980s and 1990s for which Kortum and Lerner (2003) argue that the surges were a result of technical and organizational advances. This hypothesis fits what was identified in previous sections: the evolving science for propagating and breeding horticultural plants, the emergence of the use of trademarks and branding for horticultural products and the vertical specialization with the emergence of new types of firms particularly for ornamentals. Hall and Ziedonis (2001) advance the theory that such surges could result from patent races by firms competing to acquire large patent portfolios to use for cross licensing in a pro-patent environment promoted by the establishment in 1982 of a centralized appellate court. This may have some relevance for plant patents but their weaker rights compared to a utility patent may mitigate this effect. Innovating firms tend to be leaders in the ornamental industry and their innovative cultivars earn additional revenues through licensing and royalties, and in addition, their cultivars with plant patents are often used as breeding stock by other firms to generate new cultivars.

A closer examination of the trends of applications across crops and applicants may help to get at the source of these surges in the plant patent application trend. Figure 3.12 (Koo et al. 2010) shows that the share of foreign applicants for plant patents increases rapidly, especially after the early 1980s, to account for more than 50 percent of recent applications. On the other hand, share of applications by U.S. corporations and individuals have steadily decreased to account less than 30 percent and less than 20 percent of recent applications. Since most of the plant patent applications are for greenhouse and nursery industry crops (i.e., 83 percent of the plant patents are for ornamental plants and trees), the trends for the subgroups within this industry can be useful towards explaining the recent surge in applications since the 1970s. Figure 3.13 shows the trends of the plant patent applications for different ornamental industries—most of these application series have gradual increasing trends. In contrast, but quite like the market value trend for bedding plants (Figure 3.7), the trend for bedding plant applications increases rapidly, from an average increase of 3 plant patents per year (for the period of 1979 to 1992) to an average increase of 37 plant patents per year (for the period from 1993 to 2006) (Figure 3.13).

Figures 3.12: Trends of the Type of Applicants for the Plant Patent (top) and Plant Variety Protection Certificates (bottom) As Share of the Total Applications

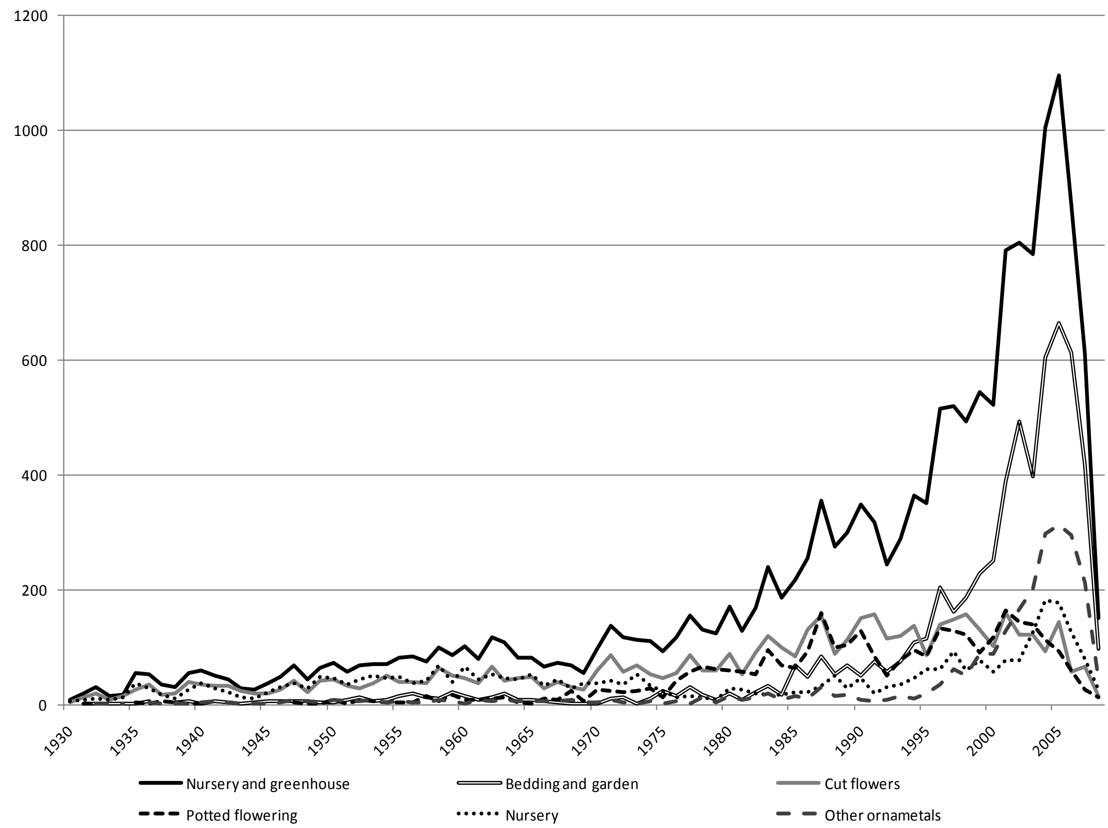




Source: Intellectual property rights for plant varieties data base (Koo et al. 2010, Appendix D)

Note: PP denotes plant patent, and PVPC denotes plant variety protection certificate.

Figure 3.13: Trends for Plant Patent Applications for industries in the Greenhouse and Nursery Industry (1930 – 2008)



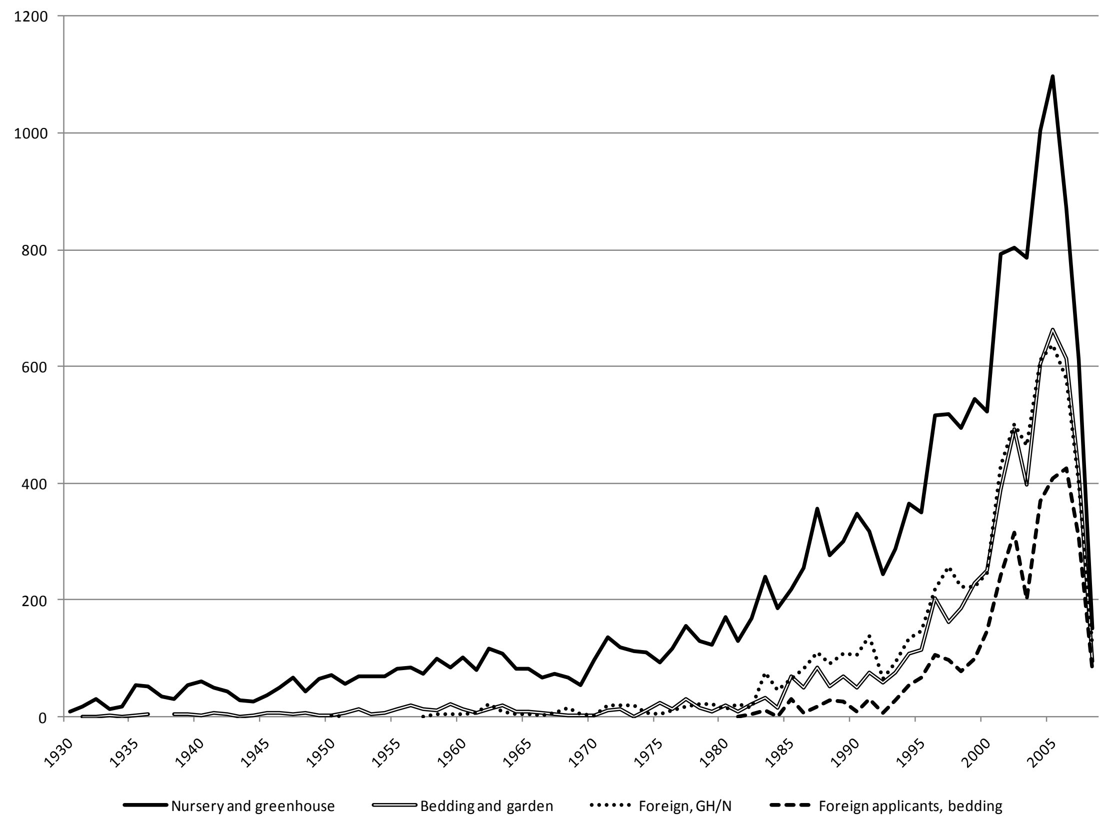
Source: Compiled by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Note: Others include foliage plants, bulbs, turf grass, etc. Bedding plants include annual and perennial gardening and bedding plants. Each ornamental crop was categorized by usage based on the description in the abstract section of patent data. Some crops can be categorized for more than one use: for example, some chrysanthemum can be categorized as bedding plants, potted plants, and nursery plants.

An explanation for the surge in the 1990s may be like that described by Kortum and Lerner (2003) where the surge is a cumulative result of advances in the market, industry structure and technologies which have disproportionately affected the bedding plant industry. Recall that the recent surge follows the production innovation referred to by the industry as the plug revolution. This revolution affected many annual crops previously marketed only by seed, by making vegetative reproduced cultivars profitable. In addition, foreign annual applicant trends have a strong influence for the ornamental and the bedding plant patent application trends (Figure 3.14). Nearly half of the bedding and gardening plant patent applications are by foreign applicants, and nearly half of the foreign applicants are for bedding and gardening plants. Note that for all nursery and greenhouse crops foreign applicants seem to increase rapidly after 1980, and for bedding and gardening plants foreign applicants increase sharply after 1992 (Figure 3.14).

The early 1990s surge in plant patent applications also coincides with international trends observed by a UPOV report (2005) on the impact of plant variety protection on UPOV countries. The period of 1993 to 2000 marks a period of rapid expansion in UPOV membership in which both older and newer members experienced a surge of both domestic and foreign applications particularly in ornamentals (UPOV 2005). In addition, in 1995, the European UPOV members instituted Community Plant Variety Protection which made one application effective for all European countries in the system. This harmonization freed breeders from administrative costs tied to European markets. Thus spillover effects from European plant intellectual property rights harmonization and surge of UPOV membership may best explain the U.S. plant patent trends.

Figure 3.14: Annual Plant Patents by Foreign Applicants (1930-2008)



Source: Compiled by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Koo, Pardey and Drew (2009b) test these application trends which change the concentrations of applicants and crops over time using a parametric test, the Pearson's correlation coefficient, and two nonparamentric tests, the Spearman's rank correlation coefficient and the Kendall's correlation coefficient, which reducing the impact of outliers (Table 3.5). All the plant patent application trends tested (i.e., increasing ornamentals and decreasing fruits, increasing foreign and decreasing U.S. corporations and individuals) were significant trends. It is interesting to note that the decline in applications for fruit cultivars is more significant than the increase in ornamentals. Note that foreign applicant trends have the strongest correlations.

Table 3.5: Plant Intellectual Property Trend Analysis for Crop and Applicant's Shares

		Parametric	Nonparametric	
Tests	Period of observation	Pearson	Spearman	Kendall
Crop				
Plant patent				
Ornamentals	1931 - 2004	0.4110**	0.4183**	0.3014**
Fruits	1931 - 2004	-0.5690**	-0.5598**	-0.4058**
PVP				
Cereal	1971 - 2004	0.6948**	0.6870**	0.5098**
Oilseeds	1971 - 2004	-0.0936	-0.0992	-0.0802
Vegetable	1971 - 2004	-0.7365**	-0.7629**	-0.5758**
Utility patent				
Cereal	1987-2004	-0.7364**	-0.7310**	-0.6275**
Oilseeds	1987-2004	0.8916**	0.8999**	0.7386**
Applicant				
Plant patent				
Foreign applicant	1931 - 2004	0.8756**	0.9335**	0.7790**
U.S. corporation	1931 - 2004	-0.3674**	-0.4349**	-0.3269**
Individual	1931 - 2004	-0.7589**	-0.7834**	-0.6064**
PVP				
Foreign applicant	1971 - 2004	-0.0452**	0.0225	0.0339
U.S. corporation	1971 - 2004	-0.0574	-0.1175	-0.1087
Individual	1971 - 2004	-0.6336**	-0.6190**	-0.4385**

Source: Koo, Pardey and Drew (2010b)
Notes: ** significant at 99%.

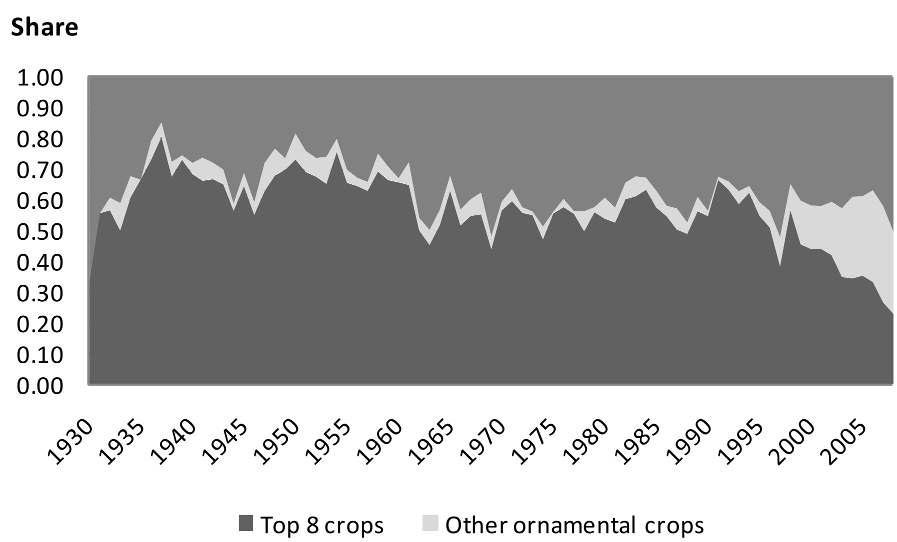
The Pearson's correlation coefficient is $t = r\sqrt{(n-2)} / \sqrt{1-r^2}$

Where r is the sample correlation coefficient between the two random variables is defined as $r = s_{xy}/s_x s_y$, where $s_{xy} = \sum(x_i - \bar{x})(y_i - \bar{y}) / (n-1)$ and n is the number of observations.

For a random variable x and y, the Spearman's coefficient is calculated as (Hogg and Craig 1995) $r_s = 1 - 6\sum_{i=1}^{n} d_i^2 / n(n^2 - 1)$ where d_i are the difference between the ranks of x_i and y_i. On the other hand, the Kendall's coefficient τ is defined as $\tau = (C - D) / n(n-1) - 1$ where C is the number of pairs that are concordant (i.e., the two rankings are consistent) and D is the number of pairs that are not concordant.

Similar to the value of production trends, the composition in plant patents changed with the top largest crops losing their application share of the total which was replaced by other crops in particular the most minor crops. Figure 3.15 shows the trend of the top 8 patented crops (i.e., Rose, Chrysanthemum, Geranium, Impatiens, Peach, Poinsettia, Carnation and Nectarine) as well as the trend for the "other" categories that appear in the nursery and greenhouse industry sales statistics (e.g., other bedding and gardening, other cut flowers and other nursery) grouped together. Since 1995 there was a sharp increase in the patent share by the other crop categories replacing the decreasing share of the top 8 patented crops. Incidentally, this reflects a sharp increase in applications for the "other" crop categories trend since 1993. These trends coincide with the market trend towards a greater diversification of cultivar offerings. This is particularly true for gardening and bedding plants whose "other" category is 8 percent of all the plant patents.

Figure 3.15: Shares of Plant Patent Applications for the Top 8 Horticultural Crops

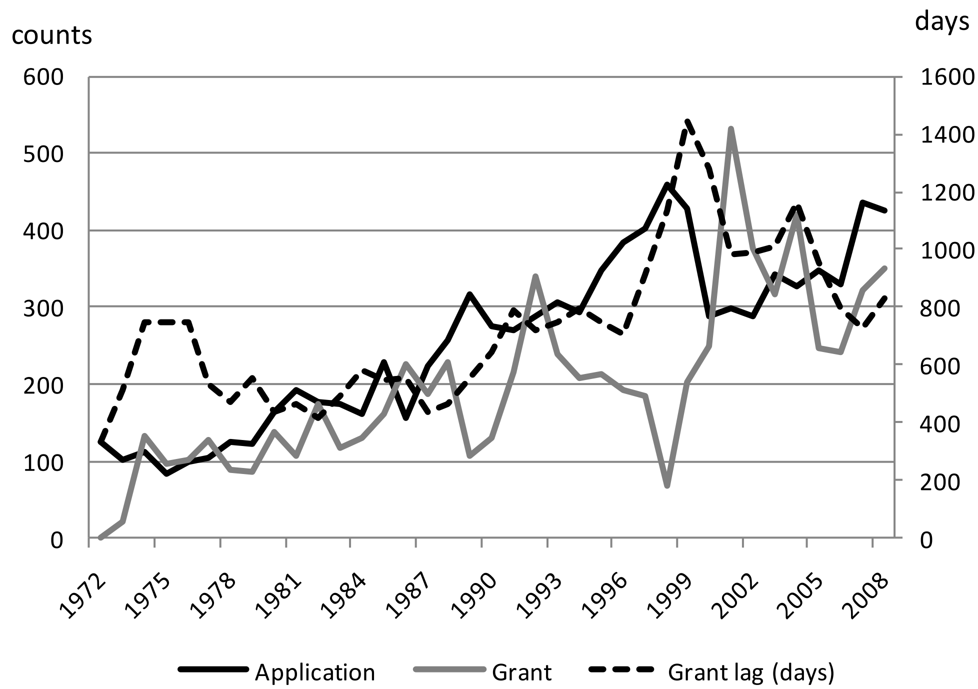


Source: Compiled by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

3.6.3. Plant Variety Protection Certificate and Utility Patent

In contrast to the sharply increasing trends that continue into the mid 2010s for the intellectual property rights used primarily by the horticultural sector, the trends for intellectual property rights used primarily by the agricultural sector sharply decrease at the end of the 1990s (Figure 3.11). Why does this drop in plant variety protection certificates after 1998 and in applications for utility patents after 1999 occur? Several explanations have emerged in the literature that could explain the drop in the plant variety protection certificate grants. First, a delay in processing the applications for the plant variety protection certificates reduced the value of the certificate (Janis and Kesan 2002, Lesser and Mutschler 2002). A close examination supports this theory (Koo et al. 2010a). Figure 3.16 (Koo et al. 2010a) shows that the trends for plant variety protection certificate grant lags (lags from application to grant in days) and applications run countercyclical to grants. The grant lag for the period or 1993 to 1999 was significantly larger than other cycles averaging 1,166 days and the number of applications was increased by 60 while grants plummeted in this period to 68 only 20 percent of the number of grants in 1992. Following this period, applications remained flat even with plummeting grant lags. Administrative delays cannot so easily explain the drop in utility patents, since the USPTO did not suffer administrative problems. According to Koo, Pardey and Drew (2010a) utility patents in other technical fields steadily increased during this period. Perhaps in this technical field, the old controversies regarding the patenting of plants have inspired more caution on behalf of the USPTO for granting patents. For example, the patent that was erroneously granted for the Enola bean in 1999 which caused a firestorm of controversy (Debouck and Hesse 2008) could have contributed to right granting conservatism.

Figure 3.16: Counts of Plant Variety Protection Certificate Applications and Grants and the Yearly Average Grant Lags (in days)



Source: Koo, Pardey and Drew. (2010a)

Note: Axis on the left hand side indicates the number of rights and on right hand side indicates grant lag (dotted line) in days.

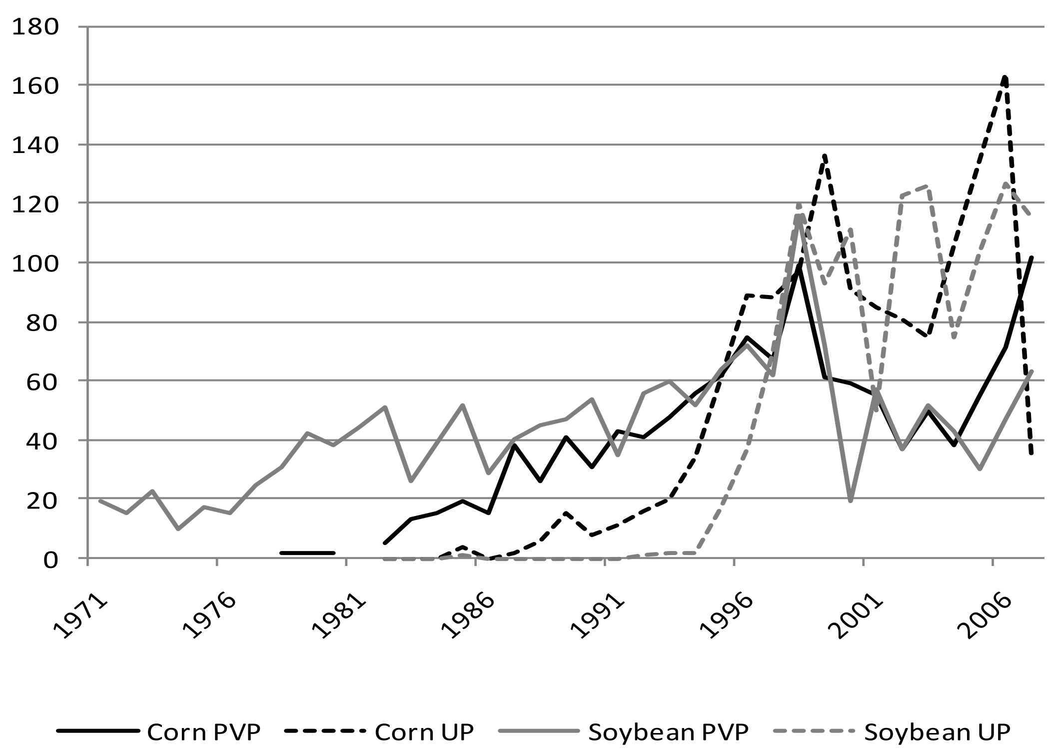
A second possible explanation for the drop in plant variety protection applications is that breeders, realizing the low value of the weak rights of the plant variety protection certificate, began to restrict their use only for marketing purposes (Alston and Venner 1999). Lesser (1998) found that the plant variety protection certificate contributed so little value to prices on a local soybean market that he theorized that its value must be in marketing. This explanation is difficult to support with the data; however, Koo, Pardey and Drew (2010a) made use of certificate information which provides the status of the application (i.e., granted, voluntarily or involuntarily withdrawn) to give the theory weak support. They found that, following a period of only 10 percent abandonment or voluntary withdrawal, voluntary withdrawal increased in the 1990s to reach 25 percent of all applications in the period from 1995 to 1997.

Third, due to the stronger property rights and rights available upon application (provided that there is a subsequent issuance) breeders began to use utility patents instead of plant variety protection certificates (Janis and Kesan 2002, Lesser and Mutschler 2002).[90] A closer examination of the trends across crops and applicants of the plant variety protection certificate and the utility patent will help to get at the source of the crowding-out effect of the utility patent should it exist. The two largest crops protected by the utility patent and the plant variety protection certificate are corn and soybeans. The application trends for the two intellectual property rights used for corn exhibit similar patterns (Koo et al. 2010a, Figure 3.17). In contrast, there are no apparent patterns in the intellectual property rights application trends for soybeans (Koo et al. 2010a, Figure 3.17). The absence of a countercyclical pattern for either crop gives no evidence for a substitution effect of utility patents for plant variety protection certificates. Likewise a look at the application patterns of applicants who have most actively applied for both types of intellectual property (i.e., Pioneer, DeKalb, Asgrow and Monsanto) show the trends for application counts of both intellectual property types move in the

[90] For more information with respect to the differences between plant variety certificates and utility patents, see Appendix B.

same direction except those for Asgrow (Koo et al. 2010a, Figures 3.18).[91] The absence of a countercyclical pattern for either crop even controlling for individual large firm activities gives no evidence for a substitution effect of utility patents for plant variety protection certificates. Koo, Pardey and Drew (2010a) formally tested for the crowding out effect of the utility patent using the Pearson correlation coefficient for the paired application series depicted in Figures 3.17 and 3.18 and found no supporting evidence for the crowding out effect neither for crops nor for applicants.

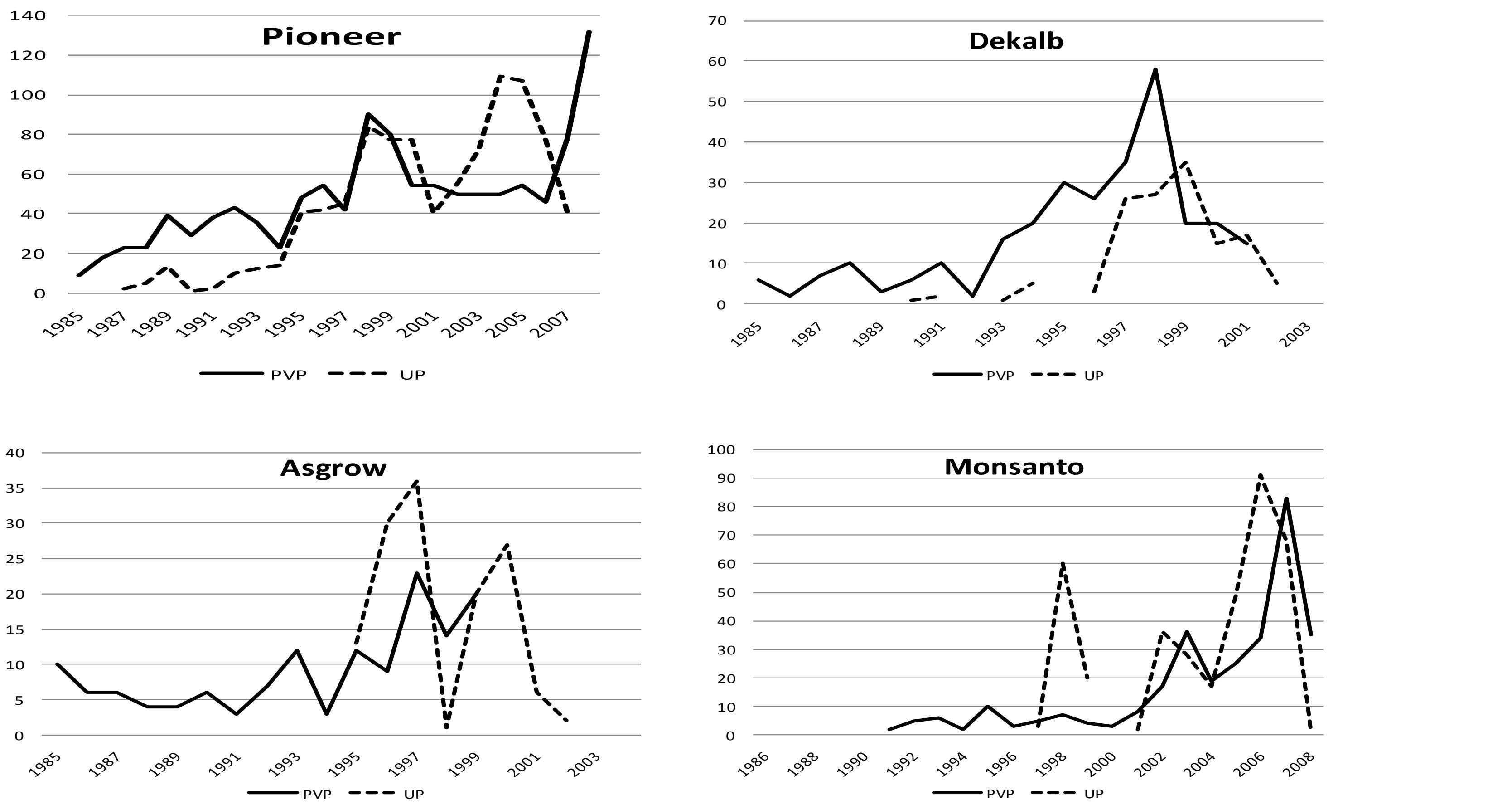
Figure 3.17: Counts per Year of Plant Variety Protection (PVP) and Utility Patent (UP) Applications for Corn and Soybeans



Source: Koo, Pardey and Drew (2010a)

[91] Note DeKalb and Pioneer are now part of Monsanto Figures 3.1a-c).

Figures 3.18: Application Trends of Plant Variety Protection Certificates (PVP) and Utility Patents (UP) for Top Applicants



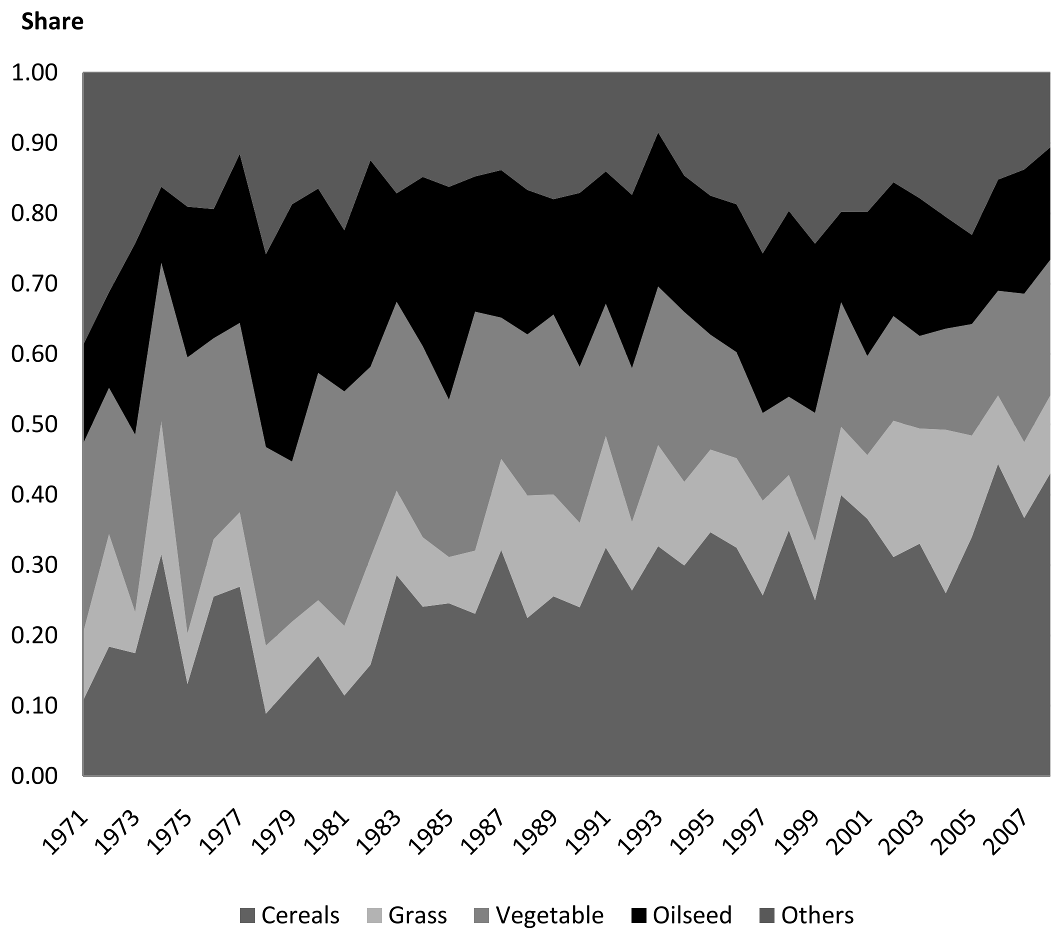
Source: Koo, Pardey and Drew (2010a)

One thing Koo, Pardey and Drew's analysis (2010a) does not capture with respect to the crowding out effect is the strong potential crowding out effect from the increasing usage of utility patents to protect transgenic technologies where in addition to the claims for newly developed cultivars, they include claims for broad classes of future cultivars. The protection derived from a single utility patent would replace multiple single claims as time progresses. For example, utility patent number 5780708, which was issued in 1996 and titled "Fertile transgenic corn plants," claims protection for all *Zea mays* plants transformed with a particular DNA encoding as well as the seeds, lines and hybrids of such transformed plants. These claims are not captured in the data set Koo, Pardey and Drew (2010a) used which included only specific cultivar claims. The long-reaching affect of such utility patent claims applied to broad classes of transgenic plants could have the potential of a crowding out effect on plant variety protection certificates and utility patents over time.

The shares of plant variety protection certificates for each crop show fairly constant patterns over time, but a close examination shows that the share for cereals has increased 50 percent and the share for vegetables has decreased 50 percent over the period of availability (Koo et al. 2010a, Figure 3.19). These changes have occurred particularly since 1980. Recall, this was a particularly significant year in the evolution of property rights for agricultural crops as well as the beginning of a decade of strengthening of the property rights for plants provided by the utility patent.   In contrast, the share of varietal related utility patents issued for soybeans grew from zero in 1992 to 60 percent while the corn share dropped from 80 percent to about 20 percent (Koo et al. 2010a, Figure 3.19).

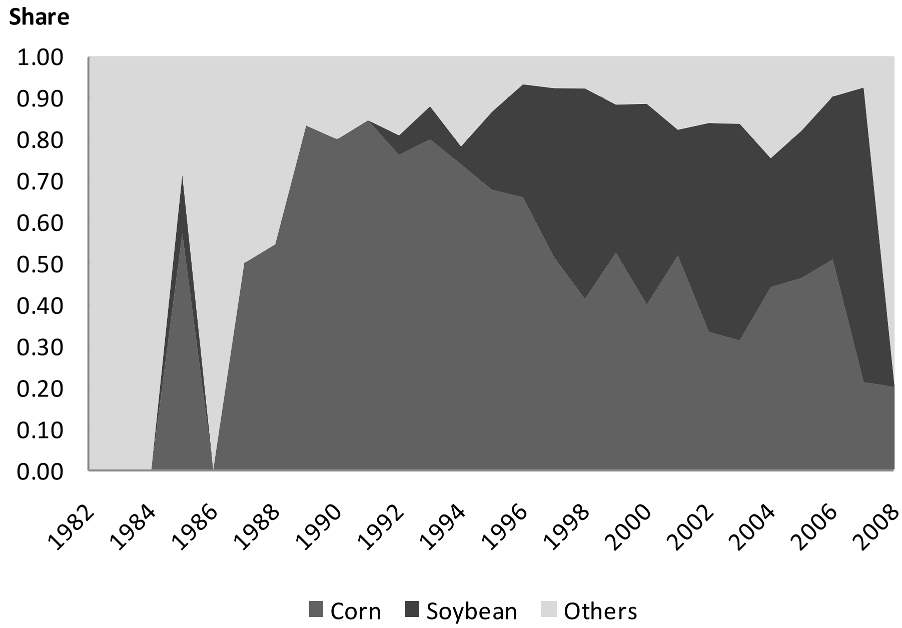
This shift may be explained by the rapid and recent shift from planting public sector varieties to private sector varieties of soybeans.   Prior to 1980, the public sector dominated the development of soybean varieties planted, but by 1980, 70 percent of the soybean crops harvested was public bred varieties, and by the mid-1990s this figure rose to 90 percent (Fernandez-Cornejo 2003).

Figure 3.19: The Crop Compositon Trend for Plant Variety Protection Certificates



Source: Koo Pardey and Drew (2010a)

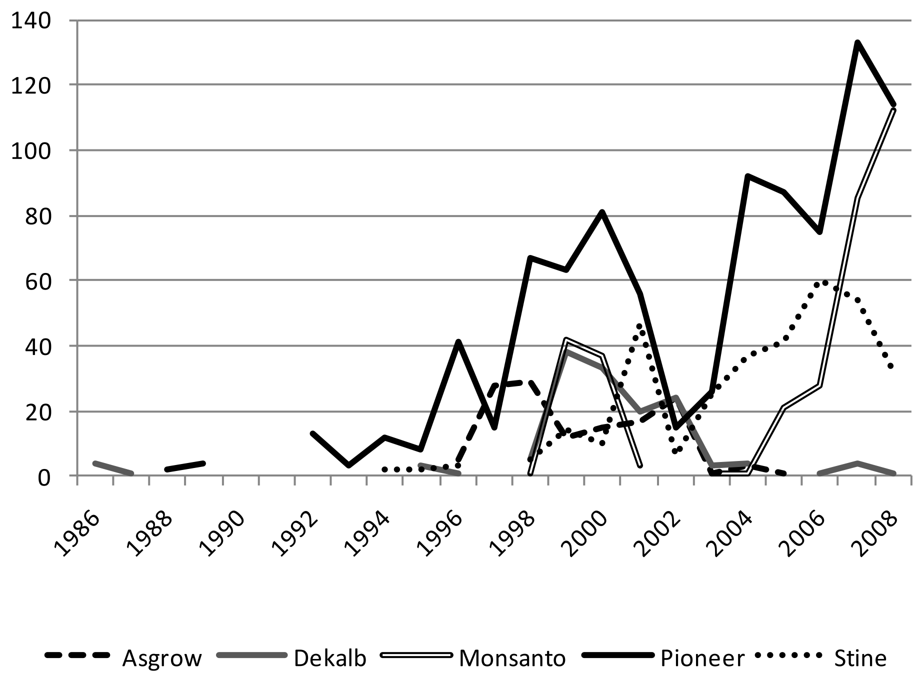
Figure 3.20: The Crop Compositon Trend for Utility Patents



Source: Koo, Pardey and Drew (2010a)

Given the structural changes in the U.S. seed industry, it is essential to examine corporate specific trends for these two forms of intellectual property. The trend of applicants is relatively constant with U.S. corporations accounting for a steady 73 percent all plant variety protection certificate applications from (Koo et al. 2010a, Figure 3.12 and Table 3.4). The annual application trends for utility patents by top applicants (Figure 3.21) show that Pioneer, with 30 percent of all applications, outranks all others for nearly the entire period (1983 to 2008). In 2007, Monsanto replaced Stine Seeds in second place and has a trend trajectory that could soon overtake Pioneer. Determination of precise market size in the seed industry is difficult, but according to industry estimations, In 2006, Monsanto has the largest sales of $3,211 million, followed by Pioneer at $2,474 million, and then by Syngenta at $1,569 million (Anonymous 2007). It is interesting to note that Pioneer Hi Bred Intl. was one of the first seed companies founded in 1926 to produce hybrid corn (Ferleger 1990). Aggressive acquisitions by Monsanto means that Advanta and DeKalb's intellectual property portfolios are now part of Monsanto's (Figure 3.1a). Stine Seeds is still an independent firm.

Figure 3.21. The Top Applicant Trends for the Utility Patent



Source: Koo, Pardey and Drew (2010a)

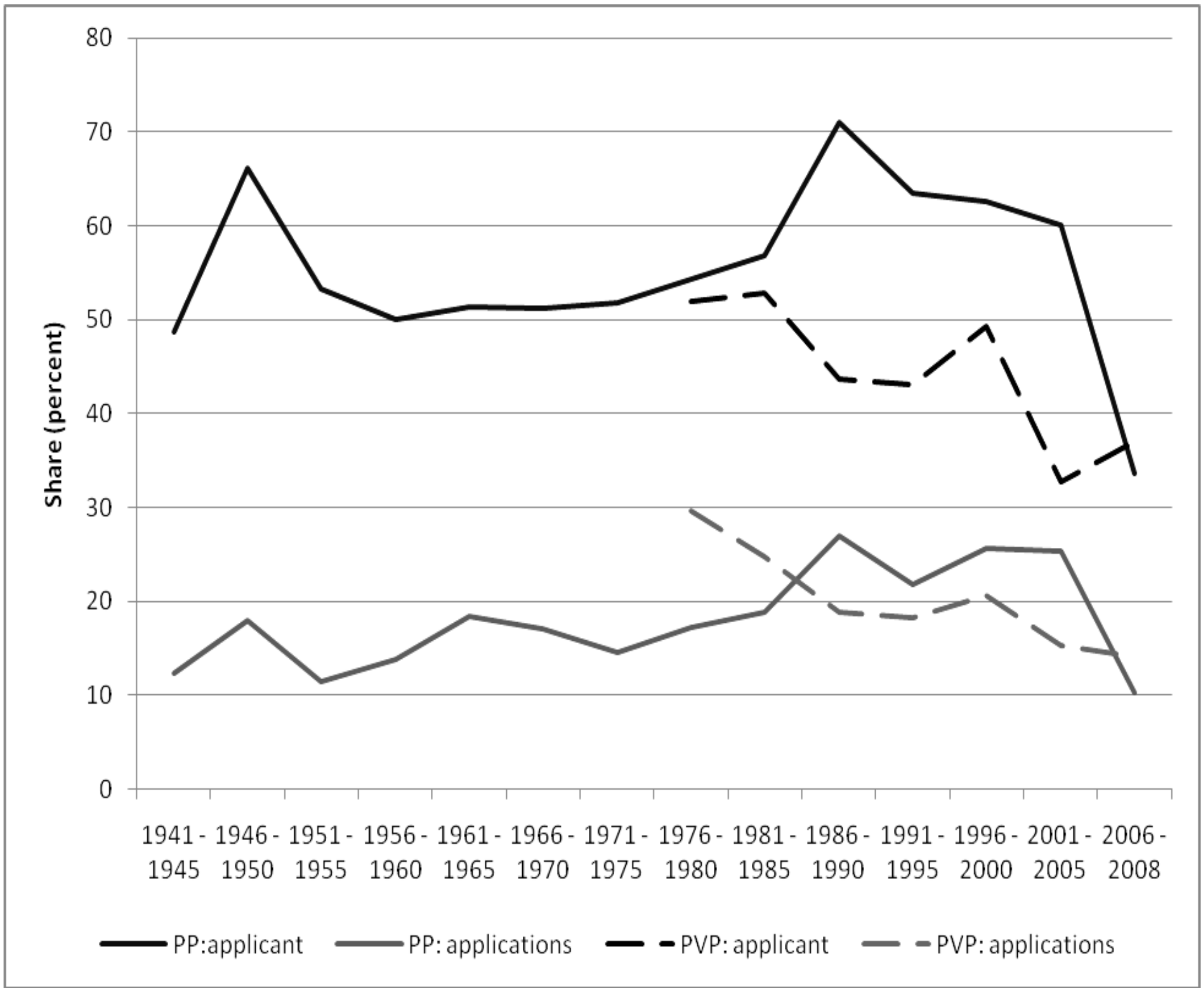
Note: Asgrow and DeKalb are now part of Monsanto (Figure 3.1a), and Pioneer has become Dupont's agronomic division (Figure 3.1c). Stine has remained independent.

Koo, Pardey and Drew (2010b) also formally tested these plant variety protection certificate and utility patent application trends using the same three tests described in the previous section (Table 3.5). Except for oilseeds, all the trend coefficients, for the shares of selective crops, and applicants are significantly positive or negative. This confirms the above observations, that there have been significant changes in the concentration of applicants and crops during the past decades.

3.6.4 Changing Ownership Structure

There are different strategies among firms and industries with respect to innovation and procurement of intellectual property for these innovations that could result in patterns that reflect the dominance of intellectual property procurement behavior of small firms over large firms (or visa versa). Small firms in general and new firms in complex product industries in particular are motivated to develop their patent portfolio to attract financing (Hall and Ziedonis 2001, Hall 2005). While this may be true for small firms, large capital intensive firms may dominate the intellectual property market (Hall and Ziedonis 2001). It may be reasonable to expect that, as an intellectual property market matures for an industry, the rate of growth of large firm intellectual property holdings would increase through litigation and acquisitions faster than those for new firms. Thus, as a market matures, the number of new firms might decrease. Koo, Pardey and Drew (2010a) test this idea using plant patents and plant variety protection certificates for small firms (entrants) and large firms (incumbents). Their findings show (Koo et al. 2010a, Figure 3.22, Table 3.6) that for plant patents new entrant applications increased from 12 percent (1941-1945 period) to 25 (2001-2005 period) percent of all applications, while the share of new applicants gradually increased from 50 percent of all applicants to 60 percent of all applicants for the same periods. For plant variety protection certificates, the new entrant applications decreased from 30 percent (1941-1945 period) to 15 percent (2001-2005 period) of all applications as well as the share of new applicants which decreased from 52 to 33 percent for the same periods. The findings for the plant patent support what we know of the industry which has evolved to support minor as well as major players in the market for plant innovations. The results for the plant variety protection certificates indicate that the dramatic restructuring of the industry may have affected the intellectual property market.

Figure 3.22: New Applicants an Applications As a Share of All Annual Applications for Plant Patents (PP) and Plant Vareity Protection Certificates (PVP) by Five Year Periods



Source: Koo, Pardey and Drew (2010a)

Table 3.6: New Entrants into Plant Intellectual Property Markets by Five Year Periods

	Applicants			Applications		
	Total applicants	New applicants	Share of new applicants	Total applic-ations	New applic-ations	Share of new applications
		(count)	(percent)		(count)	(percent)
Plant patent						
1930 - 1940	67			490		
1941 - 1945	37	18	49	243	30	12
1946 - 1950	59	39	66	380	68	18
1951 - 1955	60	32	53	443	51	12
1956 - 1960	74	37	50	575	79	14
1961 - 1965	78	40	51	597		18
1966 - 1970	86	44	51	517	88	17
1971 - 1975	83	43	52	725	105	14
1976 - 1980	94	51	54	908	156	17
1981 - 1985	111	63	57	1,196	225	19
1986 - 1990	210	149	71	1,859	502	27
1991 - 1995	230	146	63	1,910	415	22
1996 - 2000	323	202	63	3,067	786	26
2001 - 2005	418	251	60	5,067	1,283	25
2006 - 2008	205	69	34	1,820	188	10
Plant variety protection						
1971 - 1975	144			601		
1976 - 1980	152	79	52	613	182	30
1981 - 1985	199	105	53	934	231	25
1986 - 1990	236	103	44	1,230	232	19
1991 - 1995	279	120	43	1,508	274	18
1996 - 2000	290	143	49	1,960	404	21
2001 - 2005	229	75	33	1,603	246	15
2006 - 2009	162	60	37	1,409	198	14

Source: Koo, Pardey and Drew (2010a).

3.6. Conclusion

Of the U.S. plant variety intellectual property right applications, there are generally large differences in the composition of varietal intellectual property rights applications between horticultural and agricultural subsectors:

- Applications for horticultural varieties comprise most of all applications.
- Horticultural applications are characterized by a wider diversity of species compared to agricultural applications.

Over the past century and particularly in the last twenty to thirty years, there have been great shifts in the landscape of intellectual property rights for plant varieties:

- Horticultural applications have increased with recent surges, while agricultural applications have increased more slowly with a recent decline.
- The composition of intellectual property rights, for both subsectors, has changed significantly.
- Horticultural applications have increased in the diversity of composition, bedding and gardening cultivars, and foreign applicants.
- Soybeans applications have increased significantly.
- Horticultural cultivar applications showed increasing shares of new applicants and new applicant applications while agricultural application trends were just the opposite.

These differences observed between the horticultural and agricultural sectors and the changes in intellectual property rights for plant varieties are rooted in differences in the plants and differences and changes in the related plant sciences, the industry structure, the rights provide by tort and statutory law and consumer tastes and other trends reflected in the value of production. Three significant themes emerge from the examination of the evolution of intellectual property rights for plants within the greater context of tort and statutory changes in plant intellectual property rights, plant science, and plant markets:

- Innate differences between plant species and the size of their markets largely affect the appropriability of a protected new cultivar's revenue streams, and these differences are revealed in differences in the patterns that are observed in the intellectual property rights for plants.
- Plant innovation and the intellectual property rights pertaining to them have important international dimensions, due in part to the world wide harmonization of intellectual property rights for plants, which can increase both markets and appropriability for new plant innovations.
- In addition to changing the way new cultivars are created, biotechnology sciences combined with the implementation of utility patents for plants has changed the way plant cultivar innovations are protected.

- **Chapter 4**

A Hedonic Assessment of Horticultural Plant Prices

4.1. Introduction

The consensus emerging from prior studies is that intellectual property protection has little measurable effect on the rate and nature of innovation in agriculture and especially on the rate of productivity (yield) gains in the crops subject to study. However, as Koo, Nottenberg and Pardey (2004) and, more recently, Koo, Pardey, and Drew (2010 a-c) show, there have been large structural changes in the pattern of intellectual property protection for plants in the United States: specifically with respect to the form of protection being sought—be it plant patents, utility patents, or plant variety protection certificates—the agent (e.g., individuals, firms, universities, or government agencies) seeking protection; and the plant species being protected. In fact the lion's share of the plant protection in the United States is on high-valued horticultural (fruit, vegetable and ornamental, including turf grasses) plants, not cereal crops with low unit values. In addition, plant breeders' rights–the focus of most prior studies–are but one form of relevant property protection. A sizable share of the protection is via plant patents, and there is a rapidly growing effort to brand these high-valued crops and gain value from protection of cultivar innovations via other forms of legal protection such as trademarks.

Perhaps the failure to empirically reveal any significant economic or innovation effects of intellectual property rights in past studies was because these studies focused on the wrong crops or were unduly circumscribed in the types of intellectual property under consideration.[92] In addition, other plant-specific attributes such as the type of plant, their color, form, growth habit, hybrid versus non-hybrid and sexual (seed) versus asexual (vegetatively) propagated properties, resistance to biotic and abiotic stresses, and so forth may affect the magnitude of the cultivar premiums to be realized, thereby confounding or masking any price premium effects from seeking and exercising legal property right protection.

The hedonic framework provides a versatile method to relate observed prices to a product's attributes. The rich and long history of hedonic theoretical development and application offers a basis for guiding this pricing analysis. Because the consumer part of hedonic theory embraces the concept of consumption as a production activity, the hedonic model easily adapts to wholesale markets such as the ornamental wholesale plant market where the buyers are in fact producers.

This hedonic study re-examines the role of intellectual property rights pertaining to plant innovations and assesses the economic consequences of intellectual property rights for plants by analyzing their impacts on varietal values. The focus on the ornamental plant industries that account for much of the varietal-related property rights and on a number of economically important crops where price premiums provide fertile ground to reveal premiums for intellectual property attributes in plants. The estimated premiums are superior and more useful because plant-specific attributes, other forms of intellectual

[92] Notably, Singh (1999), Lee and Blank (2004) and Jerardo (2007) provide evidence of the now substantial and still rapidly growing economic value of the ornamental plant sector, particularly the bedding/gardening plant and nursery plant components of that sector. Alston and Pardey (2008) and Koo ,Pardey and Drew (2009) elaborate in more detail on these little appreciated economic developments reshaping the U.S. food and agriculture sector.

property used independently or in conjunction with plant varietal intellectual property, as well as firm and promotional attributes are controlled for using the hedonic framework and a large and fully descriptive price data set.

4.2. Theoretical Framework

The wholesale price of a particular plant cultivar may vary for a whole host of reasons which are the basis for wholesale plant buyer's plant choices. The plant product attributes included in Table 4.1 summarizes important attributes used by wholesale buyers to choose ornamental plants. These attributes not only include phenotypic and product form attributes, but also includes marketing and different forms of intellectual property protection attributes (i.e., plant patent, trademark and branding features.[93]

[93] Retail prices are subject to a myriad of additional aspects (like region, location, weather, and season) that affect the wholesale-retail price premiums. To enable these often immeasurable factors to be set aside, this study will focus on an analysis on posted wholesale prices in the catalog listings of several large propagating firms. In addition, aspects such as shipping costs, and the size and timing of a plant order are likely to affect the actual wholesale price paid. These factors are quantifiable additions to or subtractions from the basic wholesale price and so would not add important information to our analysis. Furthermore, to include these factors would require unavailable or costly information. Thus, this study's focus is on posted wholesale prices.

Table 4.1: Plant Product Attributes

Plant Attributes	Plant Attributes cont.
Plant classification	***Sensory* cont.**
Species	Flower fragrance
Plant type	Bloom season
Plant crop class	Everblooming or repeat
Phenotype Attributes	Flower color and color pattern
Environmental	Leaf color
Heat & cold hardiness	Leaf type
Exceptional heat tolerance	Leaf shape
Exceptional cold tolerance	Evergreen
Light tolerances/requirements	Leaf texture
Drought tolerant	Berries
Salt tolerant	Twig color
Insect and/or disease resistance	**Product Offering Attributes[a]**
Use	Product type
Attracts wildlife	Size
Attractive in winter	Form
Easy to care for	Quality
Useful as a cut flower	Location
Useful as a container plant	***Plant Health attributes***
Useful as a hedge	**Market, Intellectual Property , and Branding Attributes**
Growth	
Growth rate	Plant patent
Growth habit	Expired plant patent
Growth potential	Age of patent
Sensory	Name trademark
Flower type	Promotional information
Flower cluster type*	Registered with plant association
Flower size	Firm name
	Price

Source: Categorized by author using an ornamental plant producer price data base compiled and constructed for this study.

Note: a. The same cultivar offered by two different firms may have the all the same phenotypical attributes, but the firm's product offering attributes may vary greatly and contribute significant differences in value rankings of buyers.

A key aspect of competition in the ornamental plant industries is not only product differentiation but also the innovation to achieve product differentiation. Innovation is used to bring new amounts and combinations of attributes together in a single plant. In a competitive environment, a firm that has developed or acquired a plant with new and potentially desirable attributes will employ a variety of means to ensure awareness of the new plant in the marketplace as well as secure a return for their investment through price premiums. The plant patent may provide a means to achieve market power directly with the awarding of monopoly rights or indirectly as a signal of a new and perhaps improved product variant. Branding and advertising are associated with market power when used to inform buyers about high cost search attributes of differentiated goods (Nelson 1970). Increasingly, trademarks are used in combination with patents, branding and advertising to raise and hold awareness of and associate value to offered cultivars.

The conceptual underpinnings of this empirical research is an equilibrium framework of a wholesale ornamental market that allows for market power on behalf of the input suppliers (i.e., propagation firms) of differentiated ornamental plants, while the firms purchasing plant inputs (i.e., the wholesale growers) take prices as given.

This research builds on Rosen's equilibrium theory (1974) which Ladd and Martin (1976) and Ladd and Savannunt (1976) extended to focus on the role of the attributes of a firm's inputs and refined to accommodate price-quality relationships for agricultural goods which, in this case, are plant offerings. This is a competitive equilibrium model for both input producers and buyers, and here it is applied to a wholesale plant market with competitive price setting propagation firms and wholesale growers that take prices as given. In this model, growers make plant input purchasing decisions based on the attributes embodied in each plant cultivar offering listed by the propagation firms.[94] Ladd and Martin (1976) noted attributes of agricultural products may be chosen by producers, but must be taken as given by buyers. In this study, most often, attributes are also taken as given by propagation firms as well.[95]

Take a profit maximizing wholesale grower that produces multiple, differentiated products where each product-specific production function is considered independent. From this assumption, it follows that each differentiated plant product produced, by the plant purchasing wholesale grower, has a nonjoint production function and there are no cost spillovers between production operations.[96] Inputs are useful in production because of the attributes embodied in them; thus, the contribution of a plant input to a grower's production depends on the amount of each characteristic embodied in that plant input. For this model, v_{ih} is the quantity of the ith input used to produce the h^{th} product[97]—r_i is the price paid for the i^{th} input—p_h is the price received for product h—q_h is the quantity of the h^{th} product produced—x^{γ}_{jih} is the amount of the j^{th} characteristic in one unit of the

[94] A firm may offer a single cultivar in a number of different offering forms and sizes. For example, a maple tree cultivar, *Acer freemanii* "Jeffersred," may be offered by Bailey's Nursery in various bareroot, caliper and length sizes, as well as a number of container sizes.

[95] While propagation firms may be innovators of some of their offered cultivars, many cultivars are obtained from other firms, plant breeders or plant breeding firms, or their offerings could include older traditional cultivars.

[96] This assumption is used to allow for a tractable mathematical analysis of the equilibrium. True joint production would allow for cost dependencies and make the cost function unnecessarily complicated (Rosen, 1974).

[97] In this study the focus is on the inputs which are small plantlets or even larger potted plants that are grown to a marketable product.

ith input used in producing the h^{th} product. (j = 1,2,…,J; i = 1,2,…,I; h =1,2,…,H).[98] Each characteristic can be further defined according the cost associated with discovering information for that attribute. Thus an attribute is designated with a superscript γ which denotes the attribute cost level: $\gamma = a, b$ *or* c, with a the lowest cost level, b a more costly level, and c the highest cost level. An attribute with the highest cost may in fact serve as a signal for attributes that are especially costly to ascertain, in addition to any direct attribute information it may convey.

For example, in the nursery and greenhouse industry, many wholesale growers purchase plants that they repot and grow to maturity or bring into bloom before retailing. Inputs besides the plant include labor, capital, and material inputs such as pots, potting medium, and fertilizers.[99] So for this case, q_h might represent the number of potted azalea cultivars produced, x^b_{jih} might be the length of spring bloom time embodied in that particular azalea cultivar plantlet input, and $x^b_{j\bullet h}$ ($i = \bullet$ indicates a total across all inputs for the quantity of attribute j) is the total amount of bloom time embodied in all the azalea plantlet inputs used to produce q_h.[100] For length of spring bloom time, $\gamma = b$ because this attribute is usually known only through experiential knowledge or research and so is more costly to obtain.

[98] Note that the i^{th} input does not necessarily embody an attribute amount greater than zero for all J characteristics.

[99] Note that the outputs of focus in this wholesale plant production function embody most of the same characteristics as the plant inputs, since the phenotype characteristics important to ornamentals are primarily genetically determined.

[100] While this model implies continuous variables, this study as with many hedonic price studies characteristics may be identified by their presence or absence in an input or by the category that they belong to.

Both the producer of the plants (and other inputs) and the buyer of these inputs recognize the value of the attributes embodied in them. The input purchasing firm's production function for product *h* is then:

$$(1) \quad q_h = G_h(x^{\gamma}_{1\bullet h}, x^{\gamma}_{2\bullet h}, ..., x^{\gamma}_{J\bullet h}), \qquad \forall h = 1,2,...,H, \quad \gamma = a, b, or \quad c,$$

where q_h is quantity of a plant product . This equation tells us that the output of product *h* is a function of the total amounts of each of the attributes derived from inputs used in production. Thus for example, the quantity of a particular cultivar of finished azalea plants is a function of the phenotype traits bred into the plant such as flower color, potential size and growth form, as well as the health and vigor of the plants resulting from the initial purchased plants and additional grower inputs. The total amount of each attribute can be expressed as a function of the quantities of the inputs used to produce plant product *h* and the amounts of the characteristic contained in a unit of each input:

$$(2a) \quad \begin{aligned} &x^{\gamma}_{j\bullet h} = X_{jh}(v_{1h}, v_{2h}, ..., v_{Ih}, x^{\gamma}_{11h}, x^{\gamma}_{21h}, ..., x^{\gamma}_{J1h}, x^{\gamma}_{12h}, x^{\gamma}_{22h} ... x^{\gamma}_{J2h}, ..., x^{\gamma}_{1Ih}, x^{\gamma}_{2Ih}, ..., x^{\gamma}_{JIh}), \\ &\forall h = 1,2,...,H \qquad \gamma = a, b, or \quad c, \end{aligned}$$

where the v's represents inputs like energy, labor, greenhouses and x's are the attributes embodied in the inputs. Since q_h is quantity of a plant product, then there will be a quantity of a plant inputs v_{ih} where $q_h = v_{ih}$.[101] Note that each attribute can be classed along a cost dimension represented by γ. Then the production function for the h^{th} product can then be expressed as a function of the quantity of each input and the quantities of each characteristic contained in each input:

---

[101] This study assumes that grower firms do not propagate their plant inputs, but will grow each plant to a resalable size and form. Unlike other inputs such as labor, heat, fertilizer and water, ornamental plants do not get used on many products as they are incorporated into the finished plant product.

(3) $q_h = G_h(v_{1h}, v_{2h}, \ldots, v_{Ih}, x_{11h}^{\gamma}, x_{21h}^{\gamma}, \ldots, x_{J1h}^{\gamma}, x_{12h}^{\gamma}, x_{22h}^{\gamma} \ldots x_{J2h}^{\gamma}, \ldots, x_{1Ih}^{\gamma}, x_{2Ih}^{\gamma}, \ldots, x_{JIh}^{\gamma}; A).$

where a is an index of wholesale input buying firm attributes which influence production and therefore the wholesale grower's choice of inputs. The profit function, which the grower input purchasing firm maximizes, can be expressed as:

(4)
$$\pi = \sum_{h=1}^{H} p_h G_h(v_{1h}, v_{2h}, \ldots, v_{Ih}, x_{11h}^{\gamma}, x_{21h}^{\gamma}, \ldots, x_{J1h}^{\gamma}, x_{12h}^{\gamma}, x_{22h}^{\gamma} \ldots x_{J2h}^{\gamma}, \ldots, x_{1Ih}^{\gamma}, x_{2Ih}^{\gamma}, \ldots, x_{JIh}^{\gamma}; A) - \sum_{h=1}^{H}\sum_{i=1}^{I} r_i v_{ih}.$$

where the *r*'s are input prices. The grower maximizes equation 4 by choosing input quantities. So, differentiating equation 4 with respect to input quantities using the chain rule for differentiation, and setting the differentiated equation equal to zero, gives us $I \times H$ (number of inputs times number of products) first order conditions for profit maximization:

(5) $$\partial \pi / \partial v_{ih} = p_h \sum_{j=1}^{J} (\partial G_h / \partial x_{j \bullet h})(\partial x_{j \bullet h} / \partial v_{ih}) - r_i = 0, \forall i = 1,2,\ldots,I \quad \forall h = 1,2,\ldots,H$$

There are *M* (*M* < I) number plant inputs, then there are M number first order conditions for these. Assume that the second order conditions for optimization are satisfied, and then the $I \times H$ demand equations can be written as:

(6) $$v_{ih} = V_{ih}(p_1, \ldots, p_H, r_1, \ldots, r_I, x_{11h}^{\gamma}, x_{21h}^{\gamma}, \ldots, x_{J1h}^{\gamma}, x_{12h}^{\gamma}, x_{22h}^{\gamma} \ldots x_{J2h}^{\gamma}, \ldots, x_{1Ih}^{\gamma}, x_{2Ih}^{\gamma}, \ldots, x_{JIh}^{\gamma}; A),$$
$$\forall\ i = 1,2,\ldots,I, \qquad and\ \forall\ h = 1,2,\ldots,H,$$

where the p's are output prices and the r's are input prices. In general, $\partial v_{ih} / \partial x_{jih} \neq 0.$ Equation 6 shows that demand for each plant input is a function of the plant input's attributes and equilibrium prices, and the attributes and equilibrium prices of all other inputs used for production. Profits and prices of the firm's multiple products along with the firm's attributes (*A*) appear in this model in lieu of consumer preferences and consumer utility that appear in classical hedonic pricing models. If there are *N* firms producing each of *H* finished products then aggregate demand for each input can be expressed as:

$$\sum_{n=1}^{N} v_{ih}^{n} = d_{ih} =$$

$$D_{ih}(p_1,\ldots,p_H, r_1,\ldots,r_I, x_{11h}^{\gamma}, x_{21h}^{\gamma},\ldots,x_{J1h}^{\gamma}, x_{12h}^{\gamma}, x_{22h}^{\gamma}\ldots x_{J2h}^{\gamma},\ldots,x_{1Ih}^{\gamma}, x_{2Ih}^{\gamma},\ldots,x_{JIh}^{\gamma}; A^1,\ldots,A^N), \quad (7)$$

$$\forall \quad firms \quad n = 1,2,\ldots,N.$$

For ornamental plant propagation firms, this study uses a model somewhat like the model Pakes (2002) developed which accounts for market power that reveals itself through price premiums. This model allows for premiums to result either from market power associated with the differentiated product or from inputs used to produce the product. Ornamental plant producers producing differentiated products for the wholesale market may gain additional market power for their plant products because either they own intellectual property rights in the form of the plant patent on the plants they produce or they license the right to produce the plant from the owner of the patented plant.

Like the Pakes model, this model assumes that the wholesale input buying firm's production functions are defined by the attributes of the plant cultivar products they produce , and that the plant propagation firm has cost functions with marginal costs as a function of attributes of the wholesale plant input they sell, factor prices, scale of production and productivity.[102] In addition, this model assumes a marginal cost price equilibrium that is constant over the quantities produced and variable over the product attributes. For simplicity, this model assumes all firms producing plant inputs (*i=1,2,…,S* were *S<I)* are single product firms.[103] Attributes are defined by the inputs in which they are embodied and by the attribute cost classification described in the previous section. Plant producing firms compete in a Bertrand price competition posting prices.

Using vector notation, let

$$\bar{x}_i = (\bar{x}_i^a, \bar{x}_i^b, \bar{x}_i^c), where \quad \bar{x}_i^\gamma = (x_{1i}^\gamma, x_{2i}^\gamma, \ldots, x_{Jii}^\gamma), \quad \forall i = 1,2,\ldots,H, \quad \gamma = a,b, or \quad c, \tag{8}$$

denote vectors of attribute quantities for plant input *i* which can be categorized into vectors of attributes with cost types that pertain to ornamental plants. Let *J* be the number of attributes embodied in the ornamental plant production inputs, and *H* be the number plant products produced by the wholesale growers in this market, then *H* is equal to the number of plant inputs produced by the S number of propagation firms. The superscript γ denotes the attribute cost level: $\gamma = a,b$ *or c* with *a* the lowest cost level, *b* a higher cost level, and *c* is the highest cost level. Let $(\bar{x}_i, r_i)$ denote the vector of attributes and the price for plant input *i* and $(\bar{x}_{-i}, \bar{r}_{-i})$ denote the vector of attributes and prices of other competing plant inputs. Then the demand (equation 7) for input *i* can be written as:

$$d_i(\cdot) = D_i(\bar{x}_i, r_i, \bar{x}_{-i}, r_{-i}; \tilde{A}), \quad \forall i = 1,2,\ldots,H, \tag{9}$$

[102] Pakes (2002) used a consumer preference assumption for this part.

[103] Here we are only discussing the number plant input producing firms, where for the wholesale grower inputs included other inputs besides plant inputs.

where $\tilde{A}$ is an index of all the buyer attributes which determine their input attribute rankings. This equation tells us the wholesale demand for input *i* depends on the price of input *i* and the amount of each characteristic embodied in input *i*, as well as the price and attributes of all other differentiated inputs. Marginal costs, $mc(\bar{x}_i)$, are constant over the quantity produced (but vary with product attributes). The profit function for plant input *i* for the firm is then:

(10) $$\pi(\cdot) = r_i D_i(\cdot) - mc_i(\cdot) D_i(\cdot),$$

where marginal costs may also have production market structure variables such as factor prices, scale of production and productivity. The firm's equilibrium conditions (best responses) are:

(11) $$\frac{\partial \pi}{\partial r_i} = D_i(\cdot) + r_i \frac{\partial D_i(\cdot)}{\partial r_i} - MC_i \frac{\partial D_i(\cdot)}{\partial r_i} = 0, \ \forall \ i = 1,2,\ldots,I.$$

These firm best response equations give what price a firm will post given every competing firms inputs and prices, $(\bar{x}_{-i}, \bar{r}_{-i})$. Solving for the price of input *i* gives the following *I* number of first order conditions (reaction functions):

(12) $$r_i = mc(\bar{x}_i) - \frac{D_i(\cdot)}{\partial D_i(\cdot)/\partial r_i}$$, for all other competing inputs,

The denominator for the second term on the right hand side is negative, so the Bertrand price equilibrium can also be written as:

(13) $$r_i = mc(\bar{x}_i) + \frac{D_i(\cdot)}{|\partial D_i(\cdot)/\partial r_i|},$$

The hedonic price function, $p(\bar{x}_i)$, is the expectation of equation 12 conditional on $\bar{x}_i$:

(14) $$p(\bar{x}_i) = E[r_i|\bar{x}_i] = mc(\bar{x}_i) + E[\frac{D_i(\cdot)}{|\partial D_i(\cdot)/\partial r_i|}|\bar{x}_i].$$

These firm reaction functions give the production firm's price for a given $(\bar{x}_{-i}, \bar{r}_{-i})$. Note that when the second term equals zero, equation 14 satisfies the first order conditions of a competitive equilibrium conditions such that marginal costs equal marginal revenue, so that the hedonic price function is the marginal cost function that summarizes the relationship between an input's prices and that input's characteristics. When the second term, the price premium function, is nonzero then equation 13 is the hedonic price equation of a Bertrand equilibrium which is the sum of the marginal cost function a price premium function. This price premium function summarizes a complex relationship between the characteristics of competing plant inputs and the characteristics of grower firms purchasing the plant inputs. Thus, this model accommodates products that do not have premium prices as well as those with price premiums, as is usual in a vertically differentiated product market, where some cultivars may not garner price mark-ups. Such is the case with infinite (or nearly infinite) elastic demand curves, where two or more products develop with identical (or nearly identical) characteristics. This case results in no market power with an equilibrium price the same as the model with perfect competition.

Output prices are driven by the firm's ability to set prices above marginal costs. Marginal costs are a function of attributes with lower cost searchable information (such as type of plant), and the price premium is a complex function of higher costs attributes associated with ascertaining information regarding them (such as patent protection) and other attributes which enable the firm to extract price premiums. The departure in this work is that the variables associated with the highest search costs are quite clearly related to the ability to price above marginal cost. Thus, this model accommodates products that do not have price premiums as well as those with premiums as is usual in a horizontally differentiated product market where some cultivars may not garner price premiums.

Price premiums provide incentives for innovation of new products. The R&D costs of new cultivars are included in the marginal cost function, as well as their results (i.e., new innovative cultivars) could be included in the price premium function. Then we should expect that both changes in marginal costs and changes in the price premium, to be possibly reflected in changes of the coefficients in the hedonic equation 14. This is an important extension of Rosen's (1974) theoretical model. It means, given market power in pricing, the marginal value for each characteristic is not necessarily separable in the hedonic price equation. Moreover, estimations of any coefficients should not necessarily be interpreted as implicit prices, and expected to be positive values. Furthermore, interaction terms are likely to play a role in estimation.

The characteristics of this model explain some of the more persistent problems observed with hedonic price estimations. Parameter instability can result between market years because hedonic functions can change over time and space accounting for new products filling in product space where previous premiums had been high and for product offerings changing with changing buyer attributes. Also, the estimated coefficients may not necessarily vary positively with attributes and may take-on unexpected values. This can occur because buyers and sellers may not perceive attributes in the same way, or because the attributes may act as proxies for other variables.[104] The plant patent is a good

[104] Cockburn and Janis's (1998) study of two arthritis drugs with the same marginal costs emphasized this point when they found a high positive coefficient for toxicity for the drug with higher toxicity, because

example of the complexities involved. Propagation firms may perceive the plant patent as a positive source of value that can be derived directly from the intellectual property rights or indirectly as a signal for information about a cultivar's attributes. On the other hand, the wholesale growers that buy the plants may perceive the plant patent as a negative source of value derived directly from the intellectual property rights because propagation is prohibited without a license and often license agreements for patented plants entail additional costs such as royalties and tags. An argument could be made that a high positive signaling value for the plant patent may trump any possible negative value from implied propagation limitations. This is because plant grower's choices are ultimately based on consumer's preferences. The hedonic price function is also complex because growers may differ in their methods of producing and ordering attribute value. This may be in part because some wholesale growers have more ability to create value for consumers by combining products and attributes.[105] Pakes warns that care should be used in interpretation of estimated coefficients of estimation models with an underlying complex theories because the marginal "willingness to pay" interpretation may not be correct for every coefficient. This is because non-linear estimations of parameters in a nonlinear specification are not necessarily the marginal responses to the changes in the regressors.

---

competition for mark-ups of the lower toxic drug eliminated the mark-up while a single firm producing the drug with higher toxicity had sufficient market power to garner a mark-up.

[105] For example, Bailey Nurseries offers many rose cultivars as parts of collections of other rose cultivars with similar sets of use characteristics (see Table 4.1).

4.3. Data and Model Specification

4.3.1. The Hedonic Empirical Model

There is little economic theory that can be used *a priori* to suggest an appropriate functional form for the regression analysis (Rosen 1974; Brown and Rosen 1982). Consequently, the choice of the functional form for the hedonic price equation largely remains an empirical issue. The semi-log function will be employed for this analysis. This is a popular form which is argued to be superior for hedonic models (Diewert 2003), and is often used (e.g., Estes and Smith 1996; Palmquist 1984; Steiner 2004). The semi-log function accommodates nonlinearities between the dependent and independent variables of hedonic price models as well as lends itself to an economic interpretation of the estimated coefficients. The second right-hand term in equation 14 suggests second order (and perhaps third order) variables should also be included. Thus, the general hedonic price empirical model for equation 14 for the price of ornamental plants, P_k, was specified as:

$$(15) \qquad P_k = \sum_i^I \beta_i x_{ik}^{\gamma} + \sum \beta_{ij} x_{ik}^{\gamma} x_{jk}^{\gamma} + \varepsilon, \ \forall \ k = 1,2,\ldots,K, \quad \gamma = a,b, or \quad c,$$

where P_k is the price of observation *k, K* is the number of observations, x_{ik}^{γ} is an attribute variable, *i=1…I,* which are of low costs or higher costs to ascertain, γ denotes the attribute cost level: $\gamma = a,b$ *or c* with *a* the lowest cost level, *b* a higher cost level, and *c* is the highest cost level, and ε_i is an error term which is assumed to have a normal distribution. The *β*'s are the coefficients to be estimated in the empirical model, and are identified by the attribute or attributes in the case of an interaction between two variables.

4.3.2. Data Details

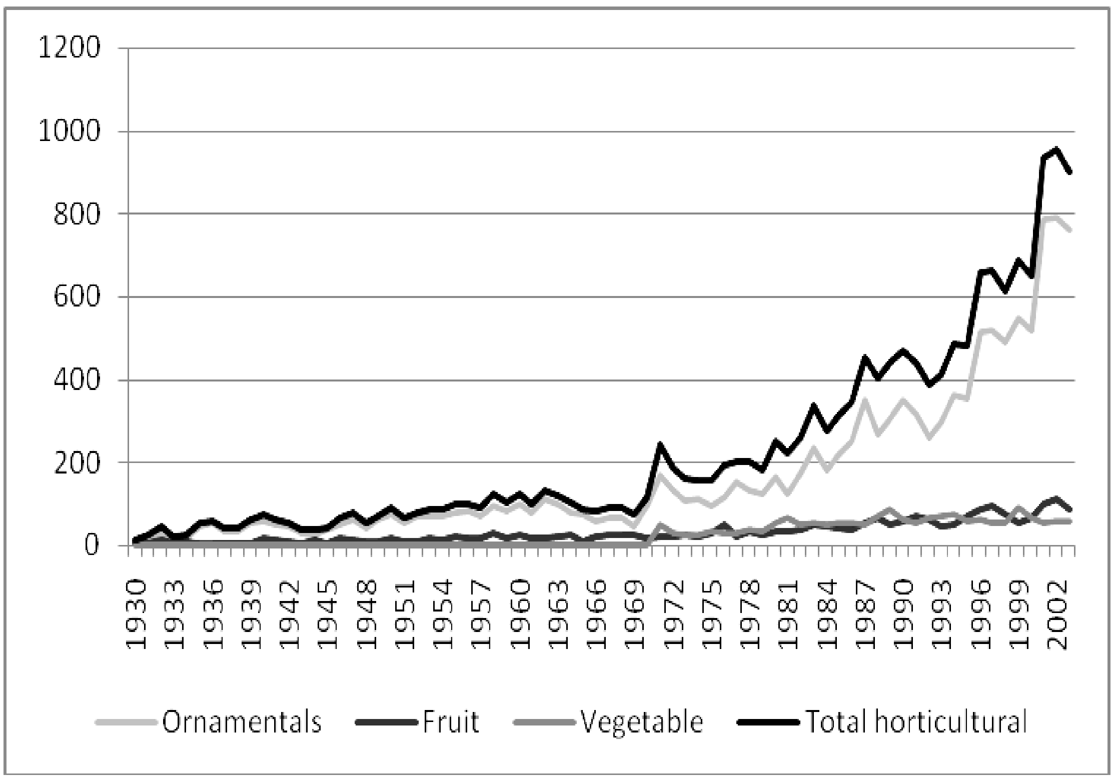
Sources and Compilation

There are no ready-made cultivar specific price databases for ornamental plants, so a time consuming and laborious process was undertaken to construct such a database. The approached used for this study was as follows.

The data set developed for this study consists of cultivar specific observations on the annual wholesale listed price of selected ornamental plants for the period from 2005 to 2007. Data were compiled on phenotypic traits, product size and form, as well intellectual property and promotional information for each entry in the plant cultivar database. Development of the database required carefully collecting and merging data from several, and not always immediately compatible, data sources. The sampling design was structured to include sufficiently large numbers of observations with a relatively complete set of plant product attributes.

The first task was to settle on the set of plant species to include in the study. Just prior to the time period covered by this study (2004), the horticultural sector for the United States and Canada marketed an estimated 90,000 plant cultivars, consisting of fruits, vegetables and ornamentals (Drew, Anderson et al. 2010). Each of these cultivars often involves multiple size offerings by multiple firms, so it was clearly impractical to include all marketed cultivars in this analysis. Because the market structure and implied determinants of price differences vary substantially among horticultural subsectors (i.e., fruits vs. vegetables vs. ornamentals), we opted to filter out this source of variation by focusing on industries in the ornamental subsector, the nursery plants industry and the bedding/gardening plants industry.[106] Furthermore, as discussed in Chapter 3, the value of product for the ornamental plant subsector is a large and growing share of the horticultural sector. Also, applications for intellectual property rights, in the ornamental sector, contribute to the largest and fastest growing share of all intellectual property rights for horticultural plants (Figure 4.2).[107]

Figure 4.1: Annual Intellectual Property Application Counts for Horticultural Plants, 1930-2003



Source: Source: : Compiled by author using the intellectual property rights for plant varieties data base (Koo et al 2010, Appendix D).

Note: The intellectual property include are plant patents, plant variety protection certificates, and utility patents.

---

[106] These factors also vary considerably within the ornamental industries.

[107] Approximately 76 percent of all intellectual property rights for horticultural plants are for ornamental plants.

Table 4.2 summarizes the criteria used to chose the species for this study which include *Acer* (maple), *Azalea* (*Rhododendron*), *Clematis, Coreopsis*, *Echinacea*, *Hemerocallis* (daylily), *Heuchera* (*Heucherella*), *Hibiscus*, *Hosta*, *Hydrangea, Ilex* (holly), *Juniperus, Phlox*, *Rosa* (rose), and *Spiraea*. These species were chosen to represent popular, higher-valued plant types, and to include species known to entail substantial breeding or patenting efforts. *Acer, Azalea and Rosa* are the highest valued and *Rosa Azalea and Hibiscus* are the most patented species (Table 4.2 column 4 – 7). In addition, a balance was struck between woody and herbaceous perennial species, as well as older established crops and newly popularized crops (Table 4.2 columns 2 & 3). Attributes were researched and entered for approximately 2,300 different cultivars. Care was taken to avoid duplicate entries for the same cultivar, which can be a problem because a single cultivar can be sold under different names. For each cultivar, a broad range of phenotypic attributes were collected, as well as information on the cultivar's intellectual property status, branding and promotional details.

Table 4.2: Criteria Statistics for Species Choices

species	plant type	age attribute[a]	U.S. wholesale value 1998	value rank[b] order	number plant patents	patent rank[b] order
			($1,000 U.S.)		(count)	
Acer (Maple)	woody	old	132,349	3	54	5
Azalea/Rhododendron[c]	woody	old	153,092	1	250	2
Clematis	h. perennial	old	13,734	11	49	6
Coreopsis	h. perennial	new	8,948	12	8	15
Echinacea (Coneflower)	h. perennial	new	5,800	14	13	14
Hemerocallis (Daylily)	h. perennial	old	23,071	9	27	10
Heuchera (Coral Bells)[d]	h. perennial	new	4,353	15	45	7
Hibiscus (Althea)	both	new	24,918	8	105	3
Hosta	h. perennial	old	29,050	7	23	12
Hydrangea	woody	old	20,176	10	44	8
Ilex (Holly/Inkberry)	woody	old	102,862	5	65	4
Juniperus (Juniper)	woody	old	114,664	4	25	11
Phlox	h. perennial	old	8,116	13	36	9
Rosa (Rose)	woody	old	147,362	2	3600	1
Spiraea	woody	new	32,929	6	13	13

Sources: Wholesale value calculated by author form National Agricultural Statistics Service, USDA (NASS 2000, Tables 6,7,13). The plant patent figures which represent the total count for the 1930-2006 period were compiled by author from intellectual property rights for plant varieties data base (Koo et al. 2010; Appendix D).

Notes:
a. Old refers to older established crops, and new refers to more recently popularized crops.
b. Rankings for U.S. wholesale value and number plant patents are from highest values to lowest values.
c. *Azalea* and *Rhododendron* species were once thought to be separate species, but now are considered the same species.
d. *Heucherella* are an interspecific cross of *Heuchera* and *Tiarella*. *Heucherella*are included because they are often listed in catalogs together with *Heuchera*.

The second task was to choose a list of propagation firms that serve the conterminous United States market, so to provide prices for as many of the chosen species as possible for each firm. This list includes four firms that are primarily perennial plant producers and four firms that are primarily nursery plant producers and one firm that is known both as a perennial and a nursery plant producer. They are Greenleaf Nurseries, Monrovia Nursery, Bailey Nurseries, Zelenka Nursery, Walters Gardens, Inc., Yoder Green Leaf, Creek Hill Nursery, Sawyer Nursery and Fisher Farms.[108] Firm choice was constrained by the fact that most nursery and perennial plant producers are still privately owned, so firm specific financial (and other) information is not readily available. Furthermore, most producers do not serve the entire United States market with a complete line of products, and not all firms cooperated to supply plant price data. Random selection among the pool of all U.S. plant wholesalers was not a feasible option because it would result in the selection of some firms that serve only regional markets or firms that would not supply price data. Thus, the approach for this research was to obtain data for a set of firms for a defined group of plants that included largest nursery and herbaceous perennial plant producers (or producer and distributor) from which price data for the targeted set plant species could be obtained. A list of firms was assembled using the American Nursery and Landscapers Association (ANLA) member list, input from Steven Still of the Perennial Plant Association (PPA), and suggestions from industry experts and representatives. Online information supplied by producer firms such as type of plants produced (e.g., herbaceous perennials, woody shrubs, and trees), numbers of workers, numbers of cultivars, numbers of plants sold, acres planted, market, and number of greenhouses was used to select this list.[109] The basic firm criteria that each company met was to be a plant producer for the wholesale ornamental plant market, to market their plants nationally, reported or estimated to exceed $10 million in yearly sales, and to offer a wide range of products including the particular plant species chosen for the study. The firms were also chosen to achieve a balanced list, in terms of type of plants produced and

---

[108] The shortened version of firm names will be used.

[109] The type of online data provided by each firm was inconsistent across firms.

a balance of specialists for herbaceous perennial and woody nursery products. Fortunately, most of the firms chosen for inclusion in this study cooperated by supplying their price data or data could be obtained from the University of Minnesota's Andersen Horticultural Library. Price data for each firm was collected for the years 2005, 2006, and 2007. The primary data set compiled consisted of 21,200 firm offerings. An observation or firm offering is one plant of a cultivar which is offered in a particular size and form by a specific firm in a specific year.

The cultivar data and the price data were collected as two separate sets and entered in a relational database (Microsoft Access). Both cross tabulation and scanning subpopulations (i.e., species, firms, woody plants, herbaceous perennials) of the compiled data were used to check and correct for errors. Box plots were used on the combined data to show the distribution of categorical data with respect to continuous data. The more important attributes (e.g., species, plant type, offering size, plant patent, and name trademark) and their cross tabulations were plotted against price (See Appendix E) to identify extreme values. Then the recorded values were checked against the original data sources, and to correct for any inaccuracies. A total of 76 outlier observations were removed due to offering size and forms which could not be sufficiently described by the selected set of offering attributes.

Summary of Data

The cross checked and corrected data were combined to form one set of 21,124 observations. Characteristic information was used to make ~184 variables.[110] These

[110] 103 of these variables are indicator variables—see Appendix e Table 1.

variables were classified as integer, continuous, and categorical and are detailed in Appendix E, Table 1.

Price **–** Price data includes posted wholesale prices for every plant offering for every cultivar chosen for this study that was offered by each of the nine firms for the years 2005, 2006, and 2007. These data were obtained from online or print nursery catalogs and price lists.

Product Size and Form**–** Plant offering attributes such as offering type, size, form, grade, or value added (e.g., staked tree, multiple plants per pot, and topiary shapes for *Juniperus*) were entered for every firm offering for each cultivar. Of these firm distinguishing attributes, the most basic is the product offering type (i.e., container plant, plant division, bareroot plant, unrooted cutting, and rooted cutting). Also included were the product offering attributes of size, secondary forms, and grade, were included for each of the basic offering types when applicable.

Phenotypic Information **–** The phenotypic attribute information was obtained from many sources including each nursery's catalog, online nursery descriptions, plant association listings, plant patents and leading plant references (Dirr 1998; Still 1994). A broad range of 50 attributes were collected. These phenotypic attributes include flower, leaf, growth, and environmental requirement (or tolerance) attributes, as well as use attributes. Flower attributes include flower size, flower type, and flower color variables. Leaf attributes include leaf shape, leaf texture, and leaf color variables. Growth rate, mature height, growth form attributes are included as growth variables. Indicator variables for pest resistant, sun tolerant, salt tolerant and easy to grow are included for tolerance attributes.   Indicator variables for container, hedge, and easy to grow are included as use attributes. While most phenotypic information is represented by an indicator variable, some attributes which have multiple dimensions with values for all observations (e.g., leaf color, growth form, light level and growth rate) are represented by a set of categorical variables with one category chosen as the reference group. Other phenotypic information with multiple dimensions (e.g., flower color and leaf attributes), which are not applicable to all observations are represented by indicator variables. For example, a range of leaf attributes are more mostly applicable to *Hosta*, *Heucher*a and *Rosa* where as multiple flower color attributes are more important to *Hemerocallis*, while flower attributes are not important to *Acer*, *Ilex*, and *Juniperus.*

***Plant Patent Status* –** Plant patent information was collected for each cultivar where applicable. This information includes the specific plant patent numbers and information regarding pending applications. The firm's annual wholesale catalogs and price lists indicate if there is an application for a plant patent pending by the acronym PPAF (plant patent applied for).   The plant patent data were checked against plant patent records (see Appendix D) to determine the date of application, the date granted, whether the plant patent was expired or active at the date of observation, and to verify whether the pending applications were still pending or granted at the date of observation. Thus, the plant patent variable was constructed to indicate whether the observation cultivar had an active plant patent or a plant patent pending at the time of observation (i.e., 2005, 2006, or 2007).[111] The date of application was used to construct the age of each plant patent for

[111] Expired plant patents are a separate variable which perhaps can help explain the value of those tried and true plants where plant patent numbers are often listed in catalogs even after they have expired.

the year observed for every cultivar offering. This variable includes the age in years for cultivar observations with valid, expired and pending patents.[112] The patent pending variable indicates those plants for which the plant patent has been applied for, but not yet granted. Expired plant patent indicates those plants which have been protected by the plant patent put the period of protection has expired.

***Promotional and Trademark Status* –** Trademark name information as well as promotional information was collected for each cultivar when applicable. Cultivar names, cultivar series names or plant series names were collected and noted if a trademark either registered or unregistered (™ or ®) was used.[113] A simplified name trademark variable was constructed for analysis that indicates whether the observation had a name trademark or series name trademark in 2007. It was assumed that if the name trademarks were used in 2007 they were also in use for 2005 and 2006. In addition, data regarding trademarked promotions, which include collections, market firm promotions, and promotional organization endorsements, as well as other promotional information such as the breeder or nursery-of-origin, awards, noted popularity or reliability, where collected. The number for each trademarked and non-trademarked promotions were used to construct integer variable for each type of promotion. Also, data were collected for cultivars that were registered through a plant association (e.g., the American Rose Society).

***Data Structure* –** Table 4.3 describes the coding structure for most of variables considered for analysis of the approximately 184 variables collected or constructed for

[112] A guess was made for the pending plant patent age using the average lag time for plant patent grants of the cultivars in the data (see Appendix 3.C).

[113] Both registered and unregistered trademarks are legally treated the same.

hedonic price data (Appendix E Table 1). Most of the variables represented here are categorical (i.e., either binomial or multilevel), continuous or integer variables. The binomial indicator variables such as the plant patent and trademark are coded 1 for the presence of that attribute and 0 otherwise. All observations of the data belong to one level of the multilevel categorical variables such as species, firm, and year. Other categorical variables may appear in the table as multilevel categorical variables such as container form and bareroot form, but are in fact groups of related indicator variables because each “level’s” reference group is all observations where that level is not applicable. Plant patent age and its square, bareroot caliper, container size, plant division size, and minimum height are continuous variables, and the number of trademarked and un-trademarked promotions, bareroot length and the minimum USDA hardiness zone are integer variables. A few of the many cultivar attributes are represented such as those for expected growth rate and optimum light.

Table 4.3: Variable Coding Structure of Hedonic Data

	Variable Name				Variable Name		
Variable class	Continuous/Integer	Categorical	Category	Variable class	Continuous/Integer	Categorical	Category
Group		Species	Acer	IP & market		Year	**2005**
			Azalea	IP & market			2006
			Clematis	IP & market			2007
			Coreopsis	IP & market		Plant patent	PP[a]
			Echinacea	IP & market	PP age (years)		
			Hemerocallis	IP & market	PP age sq.		
			Heuchera	IP & market		Trademarked	TM name[a]
			Hibiscus	IP & market		Patent Pending	Patent pending[a]
			Hosta	IP & market		Expired PP	Expired PP
			Hydrangea	IP & market		Plant association	Plant assoc.[a]
			Ilex	IP & market	Number TM promos		
			Juniperus	IP & market	Number promos (no TM)		
			Phlox	Firm offering		Rooted cutting	Rooted cutting[a]
			Rosa	Firm offering		Unrooted cutting	Unrooted cut.[a]
			Spiraea	Firm offering	Bareroot length		
Group		Firm	Greenleaf	Firm offering	Bareroot caliper		
			Monrovia	Firm offering		Bareroot form	branched[a]
			Bailey	Firm offering			lt branch[a]
			Zelenka	Firm offering			tree[a]
			Walters	Firm offering			TT [a]
			Yoder	Firm offering			whip[a]
			Sawyer	Firm offering			pdq[a]
			Fisher	Firm offering	Container Size		
			Creek Hill	Firm offering		Container grade	High[a]

Continued next page

Table 4.3: Variable Coding Structure of Hedonic Data (Continued)

	Variable Name				Variable Name		
Variable class	Continuous/Integer	Categorical	Category	Variable class	Continuous/Integer	Categorical	Category
Firm offering		Container Form	2 ball/spiral[a]	Firm offering		Region	East[a]
Firm offering			3ball/2spiral[a]	Firm offering			South[a]
Firm offering			complex shape[a]	Firm offering			West[a]
Firm offering			simple shape[a]	Firm offering			Dayton (OR)[a]
Firm offering			small[a]	Firm offering			Gaston (OR)[a]
Firm offering			medium[a]	Firm offering			imported[a]
Firm offering			large[a]	Cultivar attribute	USDA zone (min)		
Firm offering			trained tree[a]	Cultivar attribute		Light	**full sun**
Firm offering			bonsai[a]				part sun
Firm offering			support[a]				part shade
Firm offering			topiary basket[a]				full shade
Firm offering			tree[a]	Cultivar attribute		Growth rate	Slow
Firm offering			multi stem[a]				**Medium**
Firm offering			bud & bloom[a]				Fast
Firm offering			decor pot[a]	Cultivar attribute	Height (min)		
Firm offering			vernalized[a]	Cultivar attribute		pest resistant	pest resistant[a]
Firm offering	Plant div. size			Cultivar attribute		drought tolerant	drougt tolerant[a]
Firm offering		Plant div. grade	High	Cultivar attribute		reblooming	reblooming[a]
				Cultivar attribute		fragrant	fragrant[a]

Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.

Notes:

Bold indicates the reference level of multilevel categorical variables.

For a complete list and description of the variables available for this study see Appendix E Table 1.

a. indicates binomial indicator variables where the reference category is for observations where that particular attribute is not present.

The large number of offering variables reflects a diversity of offerings in the wholesale ornamental plant market which are due to different requirements for species and cultivar plant propagation as well as differences in demand by buying firms (i.e., growers, retailers, and landscapers). Plants are offered in a variety of offering types (i.e., bareroot, container, plant division, rooted and unrooted cuttings). Except for rooted and unrooted cuttings, none of these types have uniform metrics across firms. For example *Hydrangea* plants are offered in 16 different container sizes and 6 different lengths of bareroot. Bailey, the only firm offering bareroot *Hydrangea* plants, offers lengths ranging between 6 to 24 inches and *Hydrangea* plants in 1, 2, 3, 5 and 7 gallon containers. Greenleaf offers *Hydrangea* plants in all the size containers as does Bailey, but additionally offers them in 1.5, 10 and 20 gallon containers. Zelenka offers *Hydrangea* plants in 0.5, 1, 1.5 and 3 gallon containers, while Walters only offers one cultivar in a 2.5 inch pot.

A recent trend toward offering wholesale plants in containers is reflected in the data where almost 80 percent of the observations are containers with 23 different size containers and 16 different container plant forms are represented. The larger woody plants and more popular species and cultivars tend to be offered in larger number of offering types, sizes and forms particularly by the largest firms (i.e., Greenleaf, Monrovia and Bailey). For examples, in 2006, Bailey listed 29 different *Acer* “Autumn Blaze” offerings, and Monrovia listed 24 different *Juniperus* “Mint Julep” offerings of which 12 are distinguished by the container plant form.[114] Yet with all this diversity, fifty percent of all observations are distributed among just 4 container sizes (1, 2, 3, and 5 gallon).

4.3.3. Descriptive statistics

Distribution of Observations over Groups

The data are complex and hierarchical in structure. Many plant and market variables affect plant prices, and these variables likely differ across three major groupings, plant type groups, species groups and firms. There is an uneven distribution of observations across these groupings (Table 4.4). The different ways firms specialize as described in Chapter 3 are revealed in the numbers of observed plant types across firms and species. For example, Walters' specialty is herbaceous perennials, which is evidenced by their 1,204 herbaceous perennial observations of their total 1,207 observations. Greenleaf, Monrovia, Bailey, Zelenka and Fisher offer a larger proportion of woody offerings, and Yoder, Sawyer, and Creek Hill along with Walters offer a larger proportion of herbaceous perennials. Most observations (70 percent) are woody plants, and 30 percent of all price observations are herbaceous perennials. Fifty six percent of the woody plant observations are for shrubs. Nearly 80 percent of all observations belong to just four of the nine firms: Greenleaf (23 percent), Monrovia (17.2 percent), Bailey (25.1 percent) and Zelenka (13.6 percent). There are fewer observations for Creek Hill (1.6 percent), Yoder (4 percent), and Sawyer (4.1 percent).

[114] *Juniperus* is shaped into a variety of shapes such as spiral and ball poodle.

Table 4.4: Hedonic Plant Data Distribution by Firm, Species and Plant Type (Counts and Shares of Total Counts)

	Herbaceous Perennials		Woody plants				Herbaceous Perennials		Woody plants			
Group	Herbaceous Perennials	Herbaceous Perennial (vine)	Woody (vine)	Woody (shrub)	Tree	All Types	Herbaceous Perennials	Herbaceous Perennial (vine)	Woody (vine)	Woody (shrub)	Tree	All Types
Firms	(count)			(count)		(ct.)	(percent)			(percent)		(percent)
Greenleaf	559	32	8	3,687	569	4,855	2.6	0.2	0.0	17.5	2.7	23.0
Monrovia	740	251	12	2,111	525	3,639	3.5	1.2	0.1	10.0	2.5	17.2
Bailey	244	566	9	2,887	1,589	5,295	1.2	2.7	0.0	13.7	7.5	25.1
Zelenka	615	166	9	1,900	185	2,875	2.9	0.8	0.0	9.0	0.9	13.6
Walters	1,024	180	3	0	0	1,207	4.8	0.9	0.0	0.0	0.0	5.7
Yoder	717	0	0	129	0	846	3.4	0.0	0.0	0.6	0.0	4.0
Sawyer	855	11	0	0	0	866	4.0	0.1	0.0	0.0	0.0	4.1
Fisher	84	9	6	1,008	102	1,209	0.4	0.0	0.0	4.8	0.5	5.7
Creek Hill	219	0	0	113	0	332	1.0	0.0	0.0	0.5	0.0	1.6
Firm Total	5,057	1,215	47	11,835	2,970	21,124	23.9	5.8	0.2	56.0	14.1	100.0
Species												
Acer	0	0	0	0	2,258	2,258	0.0	0.0	0.0	0.0	10.7	10.7
Azalea	0	0	0	1,981	0	1,981	0.0	0.0	0.0	9.4	0.0	9.4
Clematis	0	1,215	0	0	0	1,215	0.0	5.8	0.0	0.0	0.0	5.8
Coreopsis	588	0	0	0	0	588	2.8	0.0	0.0	0.0	0.0	2.8
Echinacea	330	0	0	0	0	330	1.6	0.0	0.0	0.0	0.0	1.6
Hemerocallis	1,142	0	0	0	0	1,142	5.4	0.0	0.0	0.0	0.0	5.4
Heuchera	516	0	0	0	0	516	2.4	0.0	0.0	0.0	0.0	2.4
Hibiscus	219	0	0	857	0	1,076	1.0	0.0	0.0	4.1	0.0	5.1
Hosta	1,379	0	0	0	0	1,379	6.5	0.0	0.0	0.0	0.0	6.5
Hydrangea	0	0	47	1,605	0	1,652	0.0	0.0	0.2	7.6	0.0	7.8
Ilex	0	0	0	1,410	92	1,502	0.0	0.0	0.0	6.7	0.4	7.1
Juniperus	0	0	0	1,404	620	2,024	0.0	0.0	0.0	6.6	2.9	9.6
Phlox	883	0	0	0	0	883	4.2	0.0	0.0	0.0	0.0	4.2
Rosa	0	0	0	3,277	0	3,277	0.0	0.0	0.0	15.5	0.0	15.5
Spiraea	0	0	0	1,301	0	1,301	0.0	0.0	0.0	6.2	0.0	6.2
Species Total	5,057	1,215	47	11,835	2,970	21,124	23.9	5.8	0.2	56.0	14.1	100.0

Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.

The distribution of observations across species is also variable, but is more even that the distribution of the data across firms (Table 4.4). However, 45 percent of all observations cluster into just 4 species groups: *Acer* (10.7 percent), *Azalea* (9.4 percent), *Juniperus* (9.6 percent) and *Rosa* (15.5 percent). Some species have relatively few observations such as *Echinacea* (1.6 percent), *Heuchera* (2.4 percent), *and Coreopsis* (2.8 percent).

Distribution intellectual property over cultivars

Summarizing the distribution intellectual property rights over cultivars the 2,242 unique cultivars included in this study provides an important insight into the data structure (Table 4.5). [115] The number of observations of a single cultivar across firms and firm offerings can be either very large (134) or very small (1); thus a species with a relatively few cultivars with large numbers of offerings (different sizes and forms) per firm can inflate the number of observations in the species group. This is particularly true for the tree species, *Acer* and *Juniperus* where there are much higher than the average number of observations and lower than average number of cultivars as a percentage of observations (Table 4.5). On average for each species, the number of cultivars is 11.1 percent of the number of observations for that species with a range across species from 3.5 percent (*Spiraea*) to 24 percent (*Hemerocallis*). There is a wide range of number of cultivars per species. The highest counts are for *Rosa* (521), *Hemerocallis* (274), *and Hosta* (265), and are about at or over twice the average number of cultivars. The lowest

[115] This summary includes some counts expired plant patents in the plant patent counts. The expired plant patents are separate for the previous summaries of data observations.

counts are for *Coreopsis* (31), *Echinacea* (41), and *Spiraea* (46), and are well under the average of 149 cultivars.

Table 4.5: Intellectual Property Structure of Data by Species, Cultivars and Plant Intellectual Property (Counts and Shares)

Species	observations		cultivars		intellectual property attributes: number			intellectual property attributes: share of number of cultivars		
	number	share of all obs.	number	share of obs.	plant patent[a]	trade mark[b]	both[c]	plant patent	trade mark[b]	both[c]
	(count)	(percent)	(count)	(percent)	(count)			(percent)		
Acer (Maple)	2,258	10.7	94	4.2	10	28	9	10.6	29.8	9.6
Azalea/Rhododendron	1,981	9.4	227	11.5	19	25	18	8.4	11.0	7.9
Clematis	1,215	5.8	163	13.4	37	36	32	22.7	22.1	19.6
Coreopsis	588	2.8	31	5.3	12	0	0	38.7	0.0	0.0
Echinacea (Coneflower)	330	1.6	41	12.4	25	14	13	61.0	34.1	31.7
Hemerocallis (Daylily)	1,142	5.4	274	24.0	9	12	4	3.3	4.4	1.5
Heuchera (Coral Bells)[d]	516	2.4	101	19.6	49	2	2	48.5	2.0	2.0
Hibiscus (Althea)[e]	1,076	5.1	70	6.5	20	12	8	28.6	17.1	11.4
Hosta	1,379	6.5	265	19.2	23	0	0	8.7	0.0	0.0
Hydrangea	1,652	7.8	104	6.3	27	32	22	26.0	30.8	21.2
Ilex (Holly/Inkberry)	1,502	7.1	86	5.7	18	28	15	20.9	32.6	17.4
Juniperus	2,023	9.6	92	4.5	6	13	4	6.5	14.1	4.3
Phlox	883	4.2	127	14.4	23	11	11	18.1	8.7	8.7
Rosa (Rose)	3,278	15.5	521	15.9	260	286	214	49.9	54.9	41.1
Spiraea	1,301	6.2	46	3.5	7	11	5	15.2	23.9	10.9
Species average	1408	6.7	149	11.1	36	34	24	24.5	19.0	12.5
Total	**21,124**	**100.0**	**2,242**	**10.6**	**545**	**510**	**357**	**24.3**	**22.7**	**15.9**

Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.
Notes:
a. Includes cultivars with a valid plant patent or a plant patent pending.
b. Includes cultivars with a cultivar or series name trademark.
c. Includes cultivars with a valid plant patent or a plant patent pending and a series or cultivar or series name trademark.
d. Heucherella are included with this species.
e. This group is made up of mostly woody plants, but with some herbaceous perennials.

The propensity for patenting varies across species. The species with the highest shares of patents are *Echinacea* (61 percent) and *Rosa* (49.9 percent), and the species with the lowest shares of patents are *Hemerocallis* (3.3 percent) and *Juniperus* (6.5 percent) (Table 4.5). The intellectual property rights that pertain to a cultivar's name, trademarks (both registered and unregistered and for both the cultivar name and/or the serial name), also vary across species. Rose cultivars have the highest share trademarked plant names (54.9 percent) while Coreopsis and Hosta have no trademarked names. Over all cultivars, plant patents are more prevalent (24.3 percent) than trademarks (22.7 percent). This higher use of plant patents among commercialized cultivars may indicate that patents have higher value than trademarks for commercial breeders and plant innovation firms. The fact that over half of the cultivars that have a plant patent also have a name trademark (15.9 percent) may indicate additional value is derived by the innovator from using both forms of intellectual property for a single cultivar.

Distribution of prices

Summary statistics on the distributions of real prices over selected categorical variables that were considered as candidates for inclusion in a regression analysis were compiled.[116] These statistics include the number of observations, the statistical mean, median, coefficient of variation (this is the ratio of the standard deviation to the mean), and the minimum and maximum of price for the selected variables. Bold type indicates the reference group of categorical variables (see Table 4.6, 4.7, 4.8 and 4.9 in the following pages). The sign after the category name (+/-) indicates the expected sign of a

[116] Prices for the summary tables were converted to 2006 prices using the U.S. consumer price indices (USDL 2010).

hedonic model regression coefficient based on the price mean summary information and the chosen reference group.

The distributions of real prices are right skewed across species as evidenced by the mean prices higher than the median (Table 4.6). *Phlox*, *Coreopsis* and *Echinacea* have the lowest average prices with $1.58, $2.68 and $3.94 respectively while *Acer, Juniperus*, and *Ilex* have the highest average prices with $34.01, $25.33, and $20.28 respectively. Except for *Spiraea*, the mean prices for all woody species are higher than the mean for *Rosa* ($8.89). Woody species together average $17. *Rosa* averages higher than every herbaceous perennial species. Herbaceous perennials together average $5. When considering these summary statistics, keep in mind the observations are unevenly distributed across species. Prices also vary considerably within each species, especially for woody species which account for over 70 percent of all observations. The coefficient of variability, the ratio of the standard deviation to the mean, reveals that the normalized variability of the distribution of plant prices across different species is lowest for *Spiraea*, *Rosa*, and *Heuchera* at 0.59, 0.62 and 0.68, and highest for *Ilex*, *Juniperus*, and *Phlox* at 1.12, 1.09 and 1.04 respectively.

Table 4.6: Summary of Cultivar Unit Prices by Species Plant Type and Firm

Group	Number of observations	Summary statistics for price: Mean	Median	Coefficient of Variation	Range: Min	Max
Species						
Acer+	2,258	34.01	26.64	0.81	0.49	212.28
Azalea+	1,981	13.03	11.88	0.70	0.70	82.23
Clematis-	1,215	7.54	5.20	0.79	2.42	30.80
Coreopsis-	588	2.68	1.38	0.93	0.11	14.95
Echinacea-	330	3.94	3.17	0.82	0.41	14.95
Hemerocallis-	1,142	4.07	3.69	0.76	0.66	16.40
Heuchera-	516	3.78	3.24	0.68	0.37	12.08
Hibiscus+	1,076	10.21	6.72	0.89	0.59	64.79
Hosta-	1,379	4.98	3.86	0.89	0.56	42.68
Hydrangea+	1,652	11.49	10.22	0.88	0.84	108.97
Ilex+	1,502	20.28	12.80	1.12	0.35	185.00
Juniperus+	2,023	25.33	13.37	1.09	2.75	237.53
Phlox-	3,278	1.58	1.10	1.04	0.08	8.18
Rosa	883	8.89	8.38	0.62	0.50	95.50
Spiraea-	1,301	7.33	5.61	0.59	0.11	20.31
Plant type						
Herbaceous perennial	6,272	5	3.65	0.99	0.08	42.68
Woody+	14,852	17	11.16	1.17	0.11	237.53
Firm						
Greenleaf+	4,855	14.22	10.44	1.01	0.35	123.42
Monrovia+	3,639	24.25	13.88	1.13	1.89	237.53
Bailey	5,295	14.03	6.95	1.26	0.49	212.28
Zelenka-	2,875	9.52	6.73	0.91	0.16	82.23
Walters-	1,207	2.83	2.73	0.44	0.78	9.26
Yoder-	846	0.68	0.55	0.61	0.08	2.66
Sawyer-	866	1.95	1.57	0.59	0.41	7.80
Fisher-	1,209	12.32	10.50	0.87	3.39	64.79
Creek Hill-	332	1.18	1.19	0.39	0.42	2.57
Total	21,124	13.25	8.15	1.34	0.08	237.53

Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.

Notes:
Bold indicates the reference level of multilevel categorical variables.
+ denotes higher mean per unit values of price and – denotes lower mean per unit values of price.
For the purpose of the data summary, price data has been adjusted to 2006 values using U.S. consumer price indices (USDL 2010).
These data reflect three years (2005, 2006 and 2007) of wholesale market prices.

Price distributions are also right skewed across firms, as evidenced by the median prices being lower than the mean price for every firm except Creek Hill where the median price is slightly higher than the mean (Table 4.6). Likewise, the observations are clustered unevenly among firms with just four firms (Bailey (5,295), Greenleaf (4,855), and Monrovia (3,639) accounting for a majority of the 21,124 observations. The rank order of average prices for firms closely parallel the rank order importance of the number of observations across firms with Yoder, Creek Hill and Sawyer showing the lowest average prices of $0.68, $1.18 and $1.95 per plant respectively, and Monrovia, Greenleaf and Bailey with the widest range and highest average prices at $24.25, $14.22 and $14.03 per plant respectively. Creek Hill, Walters and Sawyer have the lowest coefficient of variability of prices at 0.39, 0.44 and 0.59 respectively, and Bailey, Monrovia and Greenleaf have the highest at 1.26, 1.13, and 1.01 respectively. Perhaps not surprisingly, given the complex sample structure discussed above, firms that specialize in woody plants (i.e., Greenleaf, Monrovia, Bailey, Zelenka and Fisher) tend to account for a greater share of observations and have higher and more variable prices.

Table 4.7 stratifies prices according to the cultivar intellectual property and associated attributes for each plant in the sample. All these distributions of price over intellectual property and related variables are skewed to the right as indicated by the mean price being higher than the median price. Plants that are trademarked or have a plant patent have wider dispersion of prices than plants with just new or expired plant patents. Notably, the mean price of observations with a plant patent ($12.47) is lower than for those with no plant patent ($13.44). The mean price for plants with a trademark is over $4 higher than those with no name trademark. The mean price for plants having both forms of intellectual property ($14.45) is between the plant patent and the trademarked plant means ($13.44 and $16.83). So, whether this evidence indicates if the trademark contributes to the value of a plant patent or the plant patent decreases the value of plants with a name trademark is not clear. Factors relating to the age of the plant patent may contribute to its value as indicated by the higher mean price for plants with an expired plant patent ($15.67), and the lower mean price for plants with a patent pending ($9.42).

Table 4.7: Summary of Cultivar Unit Prices Intellectual Property and Related Variables

		Summary statistics for price				
				Coefficient	Range	
IP Variable	Number of observations	Mean	Median	of Variation	Min	Max
Plant patent[a]						
plant patent-	4,109	12.47	10.15	1.16	0.26	212.28
no plant patent	17,015	13.44	7.70	1.37	0.08	237.53
Name trademark[b]						
trademark+	4,956	16.83	11.47	1.14	0.11	212.28
no trademark	16,168	12.15	6.12	1.41	0.08	237.53
Plant Patent and name trademark						
both IP+	2,939	14.45	11.35	1.08	0.30	212.28
otherwise	18,185	13.05	6.94	1.38	0.08	237.53
Patent pending						
patent pending-	452	9.42	8.97	0.71	0.39	62.22
Expired plant patent+						
PP expired	1,193	15.67	9.41	1.14	0.50	168.72
Total	21,124	13.25	8.15	1.34	0.08	237.53

Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.

Notes:
Price data has been calculated as real 2006 dollars using U.S. consumer price indices (USDL 2010).
These data reflect three years (2005, 2006 and 2007) of wholesale market prices.
+ denotes higher mean per unit values of price and – denotes lower mean per unit values of price.
a. Included are cultivars that have current plant patent rights which include all non-expired plant patents and all plant patents applied for.
b. Included are cultivars with trademarks either for the cultivar name or for the series name.

A more nuanced look at statistical mean prices for intellectual property and related variables of the price data stratified by species and firm groups can uncover important details that the complexities of the data can mask (Table 4.8). Generally, these conditioned mean prices for woody plants (*Acer*, *Azalea, Hydrangea*, *Ilex*, *Juniperus, Rosa* and *Spiraea*) at every combination of name trademark and patent are higher (except for *Clematis*) than mean prices for nonwoody plants (*Coreopsis, Echinacea, Hemerocallis, Heuchera, Hibiscus, Hosta and Phlox*). Controlling for differences in species, the average unit price for patented plants exceeds the average unit price for plants with no patent except for *Hibiscus* and *Juniperus* where the average unit price is lower for plant patented observations. This is contrary, to the findings that over all observations, where the mean price with a plant patent ($12.47) is lower than the mean for observations with no plant patent ($13.44). This contradiction could be explained in part by the large mean value for observations without a plant patent for *Juniperus* ($25.68) for which there may be a disproportionately large number of observations.

Table 4.8: Average Unit Prices Stratified by Species, Firm and Intellectual Property Attributes

Group	Number of observations	Plant patent		Name trademark		Plant patent and trademark		Total
		with	without	with	without	both	otherwise	
Species								
Acer	2,258	34.14	33.98	36.43	32.32	33.80	34.04	34.01
Azalea	1,981	16.85	12.71	15.43	12.79	16.92	12.76	13.03
Clematis	1,215	8.07	7.47	7.95	7.49	7.76	7.52	7.54
Coreopsis	588	3.02	2.46		2.68		2.68	2.68
Echinacea	330	5.80	2.59	5.66	3.26	5.80	3.25	3.94
Hemerocallis	1,142	6.50	4.01	7.68	3.93	7.17	4.02	4.07
Heuchera	516	4.90	2.97	3.20	3.79	3.20	3.79	3.78
Hibiscus	1,076	7.54	11.19	8.96	10.61	9.27	10.43	10.21
Hosta	1,379	5.26	4.97		4.98		4.98	4.98
Hydrangea	1,652	13.08	11.04	12.52	11.14	13.25	11.09	11.49
Ilex	1,502	27.09	19.13	19.54	20.75	28.36	19.08	20.28
Juniperus	2,023	16.79	25.68	27.46	25.11	20.27	25.44	25.33
Phlox	3,278	3.92	1.30	5.75	1.33	5.75	1.33	1.58
Rosa	883	10.51	7.42	10.18	7.46	10.84	7.57	8.89
Spiraea	1,301	7.66	7.27	7.86	7.14	8.13	7.23	7.33
Firm								
Greenleaf	4,855	12.74	14.63	14.06	14.28	13.37	14.41	14.22
Monrovia	3,639	18.06	25.46	25.58	23.88	21.27	24.66	24.25
Bailey	5,295	15.67	13.54	19.40	11.56	16.37	13.50	14.03
Zelenka	2,875	9.01	9.65	11.09	8.97	9.33	9.55	9.52
Walters	1,207	3.34	2.74	3.04	2.83	3.04	2.83	2.83
Yoder	846	1.03	0.56	1.29	0.62	1.46	0.62	0.68
Sawyer	866	4.17	1.87	4.72	1.93	4.72	1.93	1.95
Fisher	1,209	11.35	12.45	10.79	12.62	11.61	12.39	12.32
Creek	332	1.43	1.09	1.98	1.11	2.18	1.11	1.18
Total	21,124	12.47	13.44	16.83	12.15	14.45	13.05	13.25

Source: "Ornamental Plant Producer Price Data" compiled and constructed by author for this study.
Notes:
Price data has been calculated as real 2006 dollars using U.S. consumer price indices (USDL 2010).
These data reflect three years (2005, 2006 and 2007) of wholesale market prices.

For species with trademarked cultivars, the average unit price is higher than for plants without name trademarks, except for *Heuchera, Hibiscus* and *Ilex*, where the average unit price is lower for trademarked cultivars(Table 4.8). *(Coreopsis* and *Hosta* do not have any trademarked names.) Average unit prices for observations for *Azalea, Echinacea, Hydrangea, Ilex, Phlox, Rosa* and *Spiraea* are higher when both a plant patent and a trademark are associated with the cultivar than when either one or the other or neither applies. However, using both intellectual properties for a single cultivar may not be so beneficial to price. For *Heuchera, Hemerocallis, Clematis, Juniperus* and *Acer*, the average unit prices are higher when just one of the intellectual property types applies to the product. The average unit price is highest for *Hibiscus* when there are no forms of intellectual property associated with the product.

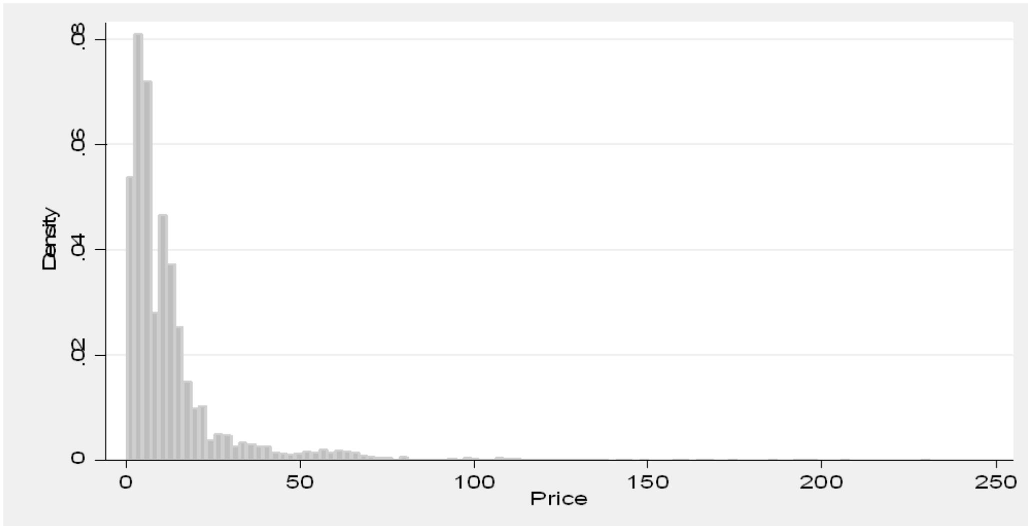
Average unit prices for observations with intellectual property attributes, controlling for firm, also reveal some interesting data structure characteristics (Table 4.8). For Bailey, Walters, Yoder, Sawyer, and Creek Hill, the average unit price for patented observations exceeds the average unit price for observations with no plant patent, and for all Greenleaf, Monrovia, Zelenka, and Fisher the average unit price for patented observations is lower than for those with no patent. Recall, Greenleaf, Monrovia, Bailey, Zelenca, and Fisher have wider and higher unit price distributions, and these distributions tend to be right skewed (Table 4.6).

For all firms except Greenleaf and Fisher, the average unit price for trademarked plants is higher than the average unit price for observations that have no trademarks (Table 4.8). Average unit plant prices for Bailey, Walters, Yoder, Sawyer and Creek Hill are higher when both a plant patent and a trademark are associated with the cultivar than when either one or the other or neither applies. Surprisingly, the average unit price is higher for Fisher and Greenleaf when there are no forms of intellectual property associated with the product, and is higher for and Monrovia when there is no plant patent.

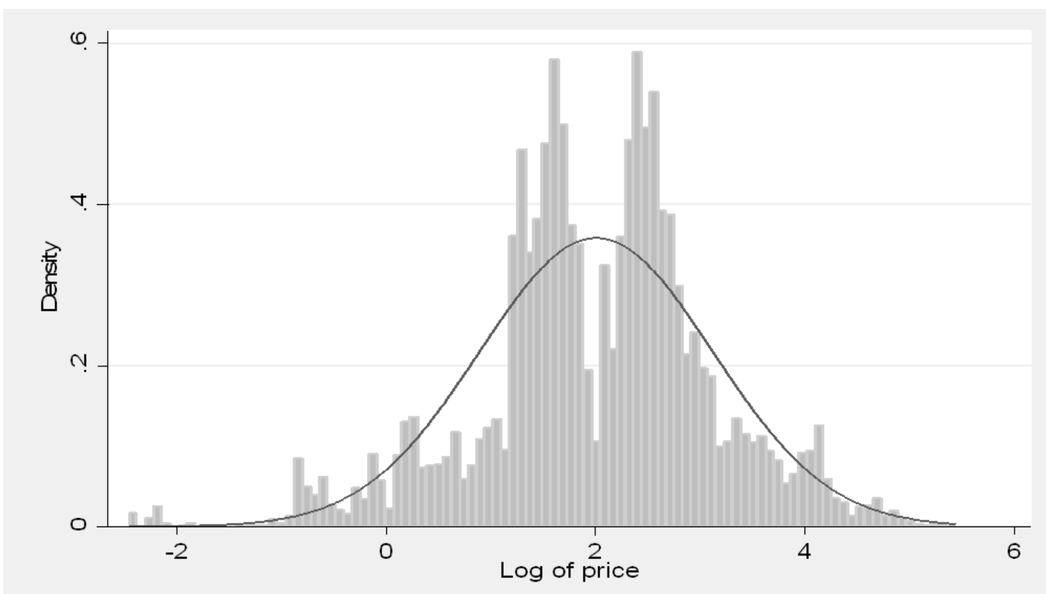
As we have seen many of the conditioned price distributions are right skewed (i.e., the mean is larger than the median price). In general, the data displays a wide range of prices with the price distribution right skewed with a concentration of lower prices and a long right-hand tail (Figure 4.3, Panel a). A primary statistical concern for fitting a model to this price data is how far the dependent variable, price, deviates from a normal distribution. Taking the logarithm of price gives a distribution that is not as strongly skewed toward low prices and brings the distribution closer to normal (Figure 4.3, Panel b). However, abnormalities still exist with larger than normal numbers of observations to either side of the logarithmic mean which has less than normal numbers of observations. Such a pattern could indicate the existence of two subpopulations in the data each with a different distribution, mean, standard deviation, minimum and maximum; however, with extensive careful examination of the data, no two such populations could be identified.

Figure 4.3: Distributions of Plant Prices

Panel a: Histogram-price tabulated frequencies.



Panel b: Histogram-logarithm of price tabulated frequencies with normal distribution.



Source: Source: Constructed by author using an ornamental plant producer price data base compiled and constructed for this study.

Notes:
Panel a: The mean of the price is $13.22, the standard deviation is $17.64, the minimum value is $.086, and the maximum value is $230.95. The histogram shows the distribution of price with a high concentration near zero and a very long right-hand tail.
Panel b: The mean of the log of price is 2.01, the standard deviation is 1.11, the minimum value is 2.45, and the maximum value is 5.44. This transformation improves the distribution portrayed by the histogram. There is gap at the center of the distribution with higher than normal values at either side of this gap.

4.3.4. Model specification

There are a set of intellectual property attributes and intellectual property related variables that are believed to account for variation in prices. This study focuses on all these attributes especially to reveal the nature and extent of any price affects attributable to the plant patent and name trademark after controlling for a myriad of other factors that influences price. Of these other variables, this study is particularly interested in uncovering if and to what extent the plant species and the firm influences the value of the plant intellectual property value.

Hedonic price theory and the data suggest a multiple variable regression approach is appropriate because more than one factor can play a significant role in accounting for the observed variation in the price of ornamental plants. Ordinary least squares (OLS) multivariate regression, if basic assumptions are met, will provide unbiased and the most efficient (minimum variance) linear estimates of the relative contributions to price of each explanatory variable. This approach will also tell us how much of the variation in price can be explained by a particular set of explanatory variables using measurements such as the coefficient of determination (R^2), or the Akaike Information Criterion (AIC).[117]

Equation 15, from section 4.3.1, gave the empirical hedonic equation to estimate:

(15) $$P_k = \sum_{i}^{I} \beta_i x_{ik}^{\gamma} + \sum \beta_{ij} x_{ik} x_{jk} + \varepsilon, \quad \forall \; k = 1,2,\ldots,K, \quad \gamma = a, b, or \;\; c,$$

[117] This criterion favors a parsimonious model choice and discourages overfitting a model.

and, the theory suggests that nonlinearities may exist without giving an explicit functional form.[118]

Functional form

To address the assumptions which needed to be met to use a linear regression, a semi-log model was considered and adopted. Error plot figures of a basic linear and semi-log model suggest the semi-log errors are much closer to the OLS assumptions (Figure 4.4). The first pair of plots which compare each model's residuals against their fitted values shows that the semi-log model's residuals are a much closer to those of a normal distribution then the fanned out residuals of the linear model. Likewise, comparing the second pair of histogram plots shows that the distribution of residuals of the log-price model conforms more closely to the normal distribution which is depicted by the lower curve in each plot. The lower plot pairs are the quantile probability plots (Q-Q plot) and the normal probability plots (P-P plot) of the estimated model's residuals.[119] [120] For both plots, the closer the data points follow the diagonal line the closer the data is to a normal distribution. In particular, the Q-Q plot helps identify the influence of extreme values and outliers, and so the decreased deviations in the extremes at either corner of the plot indicate the semi-log model an improvement but with some remaining problems. The P-P plot helps identify overall normality where the plotted line

---

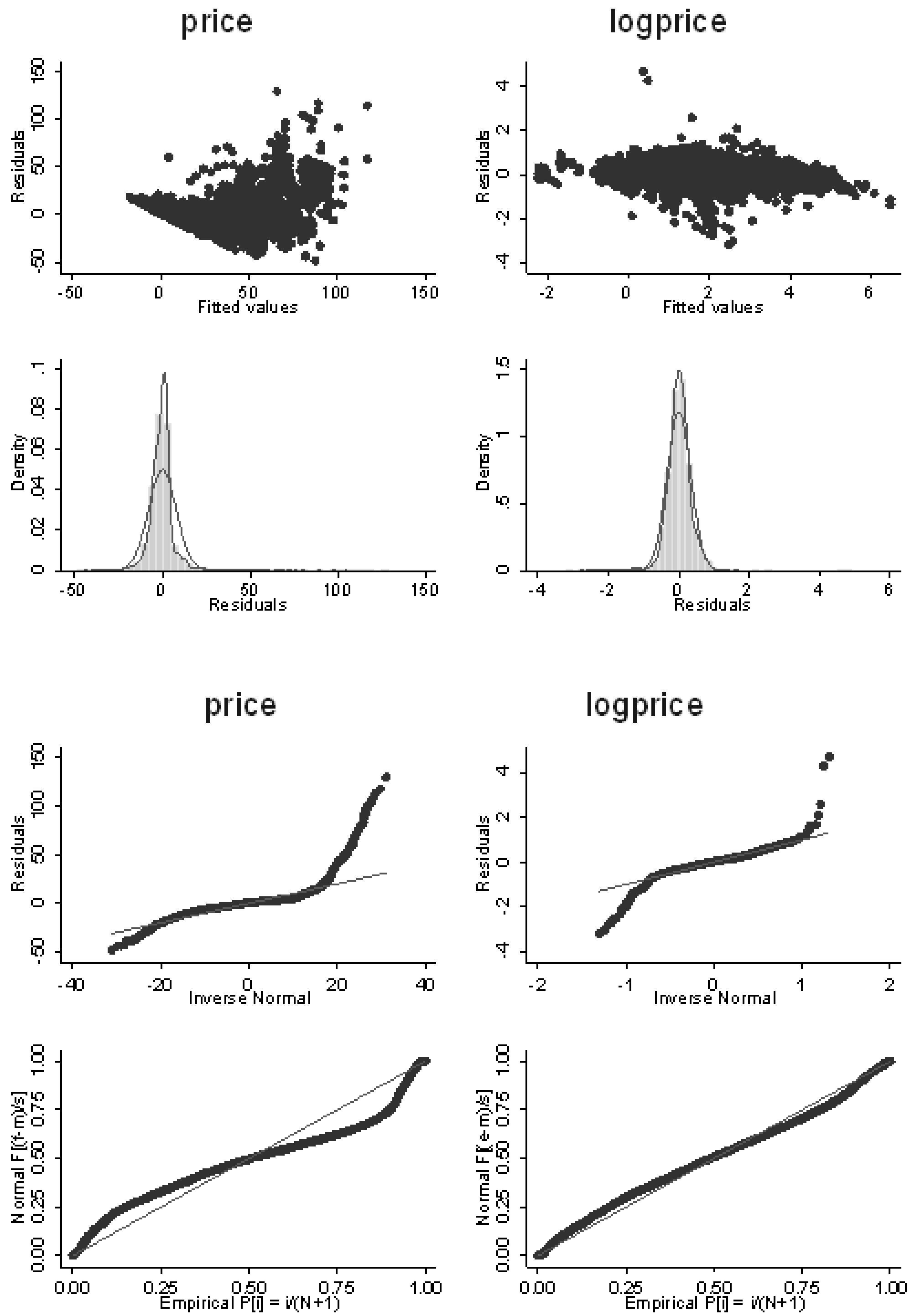
[118] P_k is the price of observation k, K is the number of observations, x_{ik}^{γ} is an attribute variable, $i=1...I$, which are of low costs or higher costs to ascertain, γ denotes the attribute cost level: $\gamma = a,b$ *or* c with a the lowest cost level, b a higher cost level, and c is the highest cost level, and ε_i is an error term which is assumed to have a normal distribution. The β's are the coefficients to be estimated in the empirical model.

[119] The quantiles of the normal distribution are plotted against the quantiles of the distribution of the residuals in a Q-Q plot.

[120] The residuals e_i are ordered from smallest to largest, for i = 1, 2, ..., n. For the normal probability distribution, F, $F(e_1,e_2,\ldots,e_n)$ is plotted against (i-0.5)/n in a P-P plot.

being closer to the diagonal in the central regions of the plot indicate the semi-log model, close to a normal distribution. Furthermore, the logarithmic model offers a convenient economic interpretation of the coefficients as the percentage contribution to price per unit change in the variable.

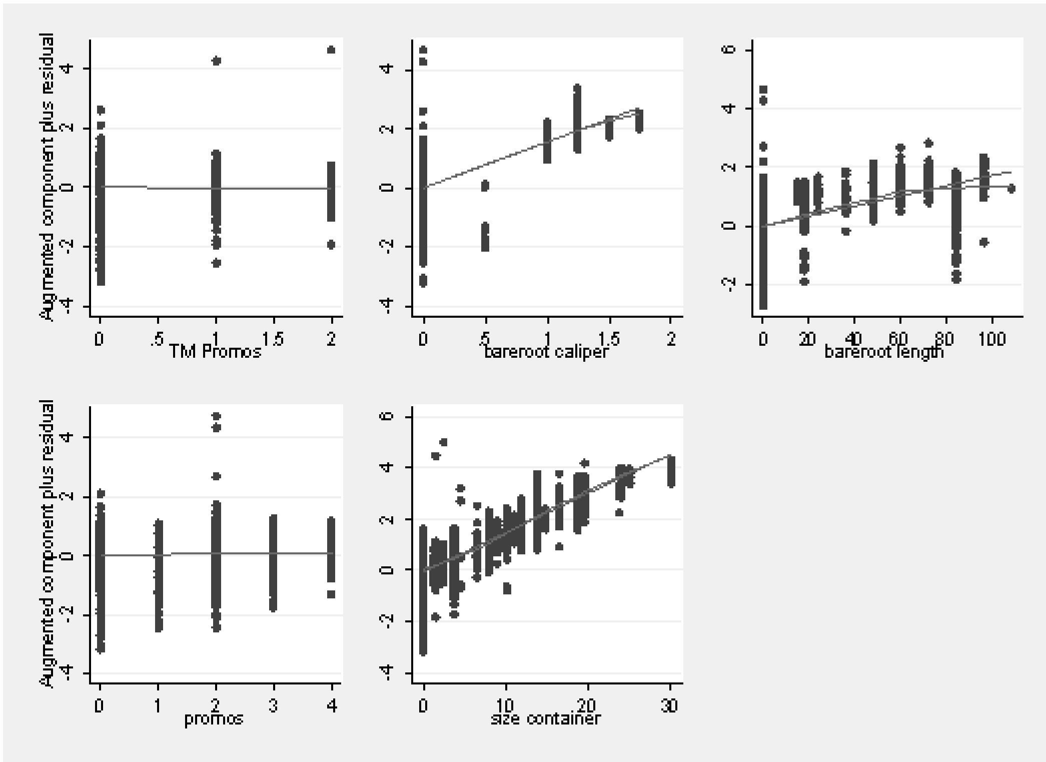
Figure 4.4: Comparisons of Linear and Semi-log Model Residuals



Source: Constructed by author using an ornamental plant producer price data base compiled and constructed for this study

To further explore the linearity assumption, for the continuous and integer regressors the augmented principal component plus residuals are plotted. This step explores the possibility for specific non-linear relationships between log price and the explanatory variables. The augmented principal components plus residuals for the variables container size, bareroot length, bareroot caliper, the number of trademarked and the number of non-trademarked promotions were graphed (Figure 4.5). These figures strongly reinforce the assumption of a linear relationship between these regressors and the log of price. The linear curve and the lowess curve were included in the plot for each of these figures. Only for bareroot caliper and bareroot length do these lines deviate slightly at the high extreme values.

Figure 4.5: Augmented Principal Component Plus Residual Plots for Continuous and Integer Variables



Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.

Note: The linear curve and the lowess curve were plotted for each of the above graphs. Only for bareroot caliper and bareroot length do these lines deviate where the lowess curve is slightly lower at the high extreme values.

Multicollinearity

The majority of the explanatory variables chosen to specify model 15 are categorical (See Table 4.3) and so are entered into the equation as a dichotomous variable coded one if that observation has the particular attribute and coded zero when that attribute is not present. Some of these indicator variables belong to a set attributes where the zero for each variable represents a particular reference category which was omitted from the model to avoid perfect collinearity. The indicator variables are used to measure the effects of the other categories in the set relative to the reference category. In this study's regressions, the intercept estimates the dependent variable for a plant offering that has all the "attributes" of all the reference categories as well as the zero values of all the integer and continuous variables.

This study uses integer variables for the number of promotions, and the number of trademarked promotions used to promote the cultivar. The continuous variables are: plant patent age, plant patent age squared, container size, bareroot length, bareroot caliper, and minimum height for growth potential.

The procedure for specifying the regression model began with a small set of regressors that were a priori deemed important. These selected variables for the basic model were firm offering, intellectual property and market variables (Table 4.3). Variables were thereafter sequentially added to the basic model in order of importance: firm, species, interaction for the plant patent and trademark, interaction for the plant patent and firm, interaction for the plant patent and species, interaction for the name trademark and firm, interaction for the name trademark and species, and finally cultivar attributes beginning with those in Table 4.3.

The coefficients were assessed for their stability in size and sign. Simultaneously, the succession of regressors were checked for multicollinearity using the condition index and variance decomposition proportions calculated with a Stata program (StataCorp 2007) command written by John Hendrickx of UCLA. According to Belsley, Kuh, and Welsch (1980), who developed the procedure, a condition index of 5 to 10 reveals weak dependencies while a number of 30 to 100 is associated with strong to severe collinearity.[121] The variance proportions calculated for each variable which are greater than 0.5 and are associated with an index greater than 30 are used to identify the variable causing multicollinearity. Additionally, the R-squared and AIC statistics were used to compare the explanatory power of nested models. The weight of determining which collinear variables to keep or discard was towards keeping the variables that were determined important to this study. Candidate variables to discard were those found to contribute high levels of multicollinearity with variables central to this investigation (i.e., plant patent and species). Variables that were discarded are the minimum height, USDA [hardiness] zone, and a number of flower and plant attributes. All the proposed interaction variables were accepted into the full model except for the interaction between the name trademark and species.

[121] The conditioned index is the ratio between a specific eigenvalue and the maximum of all eigenvalues of the data matrix. The variance decomposition proportions are the proportion of the variance of the each regression coefficient associated with the conditioned index of its decomposition. The index number can be interpreted as a multiplication factor by which imprecision in the data can work its way through to imprecision in the solution to a linear equation (or system of equations). In the case of one exact linear dependency among the columns of the data matrix (perfect collinearity of two variables), there is one zero singular value. Extending this property to near-dependencies suggests that these will lead to small nearly singular values. (Belsley, Kuh, and Welsch 1980)

A decision was made not to include any of the cultivar attribute variables for several reasons. First, many of the cultivar attributes had issues of collinearity with different species, firm offering or intellectual property variables. Also, the small motley set of cultivar attributes left after eliminating those that had severe collinearity issues, did not contribute much towards raising the R-squared value or lowering the AIC statistic, and they lacked meaningful interpretation without inclusion of the broad range of phenotype attributes used in the decision making process.

Early in the analysis, several ordinal factor variables were converted to integer or continuous variables. This step allowed inclusion of more of the variables considered important to this study. Size variable measures (i.e., container size, bareroot length, bareroot caliper, minimum height) were converted to continuous and integer variables using the upper bound measure in inches for each category as each observation's measure. The size coding for the variables for plant division size and USDA minimum hardiness zone were entered as integer measures.

Heteroskedasticity

The previous discussions tested and explored a linear or semi-log functional form to be used to estimate a common set of parameters to all observations of the data. Implicitly, this assumes that the different explanatory variables have independent, additive and fixed (for the indicator variables only) effects on the dependent variable. Thus, the idea that these effects are constant across all firms and species, as well as constant across all other factors which as discussed in earlier chapters may not be true.

To address the potential variability of the effects in the model, interaction terms with other variables should be included. However even if multicollinearity would not present specification problems, due to the large numbers of variables (even with such a large data set) there would not be sufficient degrees of freedom for such inclusions. Furthermore, such inclusions would increase the complexity of the analysis many fold. Therefore only a few interaction effects based on a priori evidence of potential shared effects with the plant intellectual property variables were chosen.

The Breusch-Pagan aka Cook-Weisberg Test, a test that is suitable for use with large samples, was performed to test for heteroskedasticity on the semi-log model. Not surprisingly, the null hypothesis of constant variance was rejected with 100 percent confidence.[122] Homoskedasticity is an important assumption in ordinary least squares (OLS) regression. The estimator of the regression parameters in OLS regression is still unbiased when the homoskedasticity assumption is violated; however, the estimator of the covariance matrix of the parameter estimates can be biased and inconsistent under heteroskedasticity, which can produce inaccurate error variances. This problem can effect significance tests and confidence intervals which in turn can cause rejection a null hypothesis when the null hypothesis is true, or accept the null hypothesis when the null hypothesis is false. Clearly with much heteroskedasticity—the type where error variance increases with price—was eliminated with the log transformation (Figures 4.4, first set), however much of the discussion in the previous section points to the multilevel nature of the data (firms and species) as a potential source of systematic heteroskedasticity. In fact, the plant price data more closely resembles data which are hierarchical in nature with the

[122] The Chi-squared statistic was 276.72 with one degree of freedom.

firm as the primary sampling unit and the species as the stratum within each primary sampling unit.

Independence of observations

In addition to heteroskedasticity, such data sets are also subject to violations of the assumption of statistical independence of observations. In this case there may be a number of offerings for one cultivar (i.e., different sizes and forms) where prices are set by a firm in relation to their other cultivar offerings as well as the expected prices set by their competitors. In this way other variables may also be statistically dependent on other observations. Therefore, we should expect to find a common variance and some covariance among certain clusters of errors such as those coming from the same firm or those coming from the same species—yet the common variance within clusters are independent of and have different variances from other errors or clusters of errors.

When both types of error problems are anticipated, it would be difficult to tell what the overall effect might be on the estimated standard errors or how to correct for these differences using the standard methods of correcting variance estimation, such as the White covariance correction, which adjusts the diagonal elements of the covariance matrix to account for the data's structure. Bootstrapping or jack-knife techniques can be used to estimate a covariance matrix for clusters. However, in our case there are two important variables to choose as the clusters to use, and it is not possible to determine which one, if either, would be effective to correct the variance problem. Thus this study must rely on the large number of observations which were carefully obtained to be representative of the population of wholesale plant offerings, and use the White covariance correction appropriate for large observations to correct the variance covariance matrix for the data's structure.

Influence of outliers

The data was carefully screened by the author for obvious measurement and entry type errors, particularly for extreme values. Recall the Q-Q plot showed that outliers could be a problem with their influence on a regression analysis. An analysis was made to determine if the outlier data had undue influence on the coefficient estimates using plotted leverage scores. Leverage is the proportion of the total sum of squares of the explanatory variables contributed by the k^{th} observation. Leverage measures the multivariate distance between the explanatory variables for observation k and the average of all observations, accounting for the correlation structure. Leverage scores showed that no observation's residuals exceeded a 0.2 cutoff which if exceeded would indicate where outliers would have a significant consequence on the coefficients or in the predicted values. As a check, a regression was performed minus 20 observations with the highest leverage scores with no discernable difference on the estimates. Thus the following analysis was performed on all 21,124 observations.

4.4. Empirical findings

Eleven separate regressions of mostly nested semi-log models were performed with partial results listed in Table 4.9, 4.10 and 4.11.[123] The first 5 models examine the plant patent while building to the basic model. Models 6 and 7 examine the price effects of the plant intellectual property rights while controlling for firm and species groups. Models 8

[123] For the full results which include all the firm offering and cultivar attribute variable coefficients see Appendix F Table 1, 2 and 3.

thru 11 examine the variation of plant intellectual property across groups by using interaction terms. In these tables, each model is numbered, briefly described and the model's F, R-squared and AIC statistics are reported. In addition, where applicable, these tables include the F-statistics for the Wald test used to compare each nested model with its prior simpler form. These tests for all the models indicated that the added variables were important for accounting for variation in plant prices. The results of the Wald tests specifically showed and that, for the J coefficients of added sets of variables, the null hypothesis—H_0: β_1 =, … ,= β_J = 0, for all i =1,..,J—can be rejected with 100 percent confidence. The first column of each table gives the reference category for each categorical variable. The reference category is the group chosen to serve as the comparison group. This group was assigned a zero coding and thus is included in the intercept estimate which estimates the expected price when all the variables equal zero.[124] The coefficients of the categorical variables have been adjusted so they can be interpreted as the percentage contribution to price of those observations with the presence of that variable compared with (above or below) the contribution to price of those observations of the reference category. The coefficients of the continuous and integer variables have been multiplied by 100, and can then interpreted as the percentage increase (or decrease) in price with a per unit change in that variable.

4.4.1. Interpreting Semi-log Model Coefficients

Because the semi-log model is used, a further refinement of the interpretation of the coefficients was necessary. Where the explanatory variable, x_{ik}, is continuous or an integer measure (i.e., trademarked promos, promos, size container, length bareroot and

[124] In regressions such as these, as the number of explanatory variables grow by adding integer and continuous variables, the plant group represented by the intercept becomes difficult to define.

caliper bareroot), we interpret the regression coefficient as the relative (proportional) change in price for a given absolute per unit change in x_{ik}. For example, if the regression estimate for β were 0.0135, we could interpret that the predicted price increases by 1.4 percent for each additional cultivar promotion (Table 4.9 Model 5). For indicator variables, Halvorsen and Palmquist (1980) showed that this is not a correct interpretation because such variables utilize discrete codes (i.e., 0 and 1), so the coefficient defines no slope. Also, the coefficient captures the difference in subgroup means between the reference category and the indicated group in dependent variable units. Halvorsen and Palmquist showed that a more accurate interpretation of the semi-logarithmic regression coefficient would be:

$$\beta_1 = \ln \frac{1 + \hat{P}_1 - \hat{P}_{reference}}{\hat{P}_{reference}},$$

where $\hat{P}_1$ is the predicted value of $\hat{P}$ for the group coded 1, and $\hat{P}_{reference}$ is the predicted value of $\hat{P}$ for the reference group. Thus, to find the percentage effect of an indicator variable on price measured in dollars, we used the following formula:

$$100*[\exp(\beta) - 1], \text{ for each } \beta.$$

For example, the estimated coefficient of the indicator variable for year 2007 for model 5, which is 0.0258, the expected value of price for 2007 would be 2.58 percent higher than the reference year, 2005. All the raw regression coefficients in Table 4.9, 4.10 and 4.11 have been transformed according to the above formulas, so they can be interpreted as discussed.

4.4.2. Statistical Significance

The standard 95 percent level of confidence for statistical significance of an estimated coefficient is used as the standard for this study; however both the 90 and 99 percent levels are reported in Table 4.9, 4.10 and 4.11. Statistical significance for an estimated coefficient means that a variable contributes positively to price if it has an estimated positive coefficient. Statistically, this means that at most there is a 5 percent statistical probability of this coefficient being zero (or at a least 95 percent level of confidence that it is not). For categorical variables, a statistically positive coefficient means that category's contribution is larger than the reference category's contribution to price. Likewise when a variable has a negative coefficient in the regression that is statistically significantly different from zero, the inference is that the variable has a lower contribution to price that the reference category. If the reference category is all other observations for a categorical variable, then that variable's contribution to price is negative.

4.4.3. Price Premiums for Plant Intellectual Property

In this section we will explore 5 regression models to examine the affect of ornamental plant intellectual property variables on price while controlling for the effects of other variables. The first model is considered as a standard, and was constructed to be like the regression used by Lesser (1994) to estimate the value of the plant variety protection certificate used on soybeans.

Lesser's Model

Lesser's hedonic price model had explanatory variables for public (or private), protected (or not), height, lodges (or not), and yield. Likewise, Model 1 (Table 4.9) has three of what were deemed the most important plant attributes, and so includes year, plant patent, minimum height, species, and growth habit. *A priori* this model was considered to not be a good fit for a variety of reasons which include: this study uses a broader range of species and cultivars, and there is a big difference between soybean farmers and greenhouse growers and the attributes by which they choose their crops. In fact, an ornamental plant's offering type, size and form are very important for determining price as indicated by Model 2, a minimal model, which includes only these firm offering variables, and has an R-squared statistic of 82 percent (Table 4.9). Nonetheless, while Lesser's model had but an R-squared of 0.45, Model 1 has an R-squared of 0.52. The converted coefficient for the plant patent shows that plants with a plant patent have 35 percent higher prices than plants without a patent. This is a very high price premium for protect plant cultivars compared with Lesser's estimated 2.3 percent premium for protected soybeans. The large result for the plant patent in Model 1 is suspect because many of what was determined to be important variables for price, such as the plant offering variables and firm, were not included.

Table 4.9: Hedonic Price Regression Results for Semi-log Models 1 - 5 (Coefficients Converted)[ab]

Model		Model 1		Model 2		Model 3		Model 4		Model 5	
Variables added		(Lesser)		(offering)		(plant patent)		trademark)		(IP & market)	
R-squared		0.5178		0.8183		0.8211		0.8226		0.8293	
F-statistic[a]		762.15		3364.23		3606.32		3394.33		2937.95	
2 model Wald test[b]						387.80		197.28		115.06	
AIC		49125.23		28533.00		28205.13		28029.88		27232.16	
Reference	variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
	constant	175.52	89.73 ρ	27.43	20.31 ρ	77.21	16.96 ρ	75.91	17.06 ρ	21.55	14.76 ρ
2005	2006	8.28	6.06 ρ	1.55	1.79	0.77	0.90	0.45	0.52	0.77	0.93
	2007	5.88	4.26 ρ	3.35	3.78 ρ	2.48	2.83 ρ	2.39	2.74 ρ	2.58	3.01 ρ
All other observations	Plant Patent (PP)	35.03	21.52 ρ			16.37	19.69 ρ	8.01	8.07 ρ	12.75	7.26 ρ
All other observations	Trademarked (TM) name							13.54	14.05 ρ	19.04	17.35 ρ
All other observations	patent pending									-1.26	-0.59
All other observations	expired PP									-6.75	-1.83 τ
none	PP age (years)									-0.09	-0.45
none	PP age squared (yrs)									0.00	-1.22
none	TM promos									-18.74	-19.31 ρ
none	promos									1.35	3.43 ρ
All other observations	plant association									10.54	11.92 ρ
Rose	Acer	153.96	24.92 ρ								
	Azalea	58.47	22.72 ρ								
	Clematis	-18.72	-6.1 ρ								
	Coreopsis	-76.16	-31.91 ρ								
	Echinacea	-66.03	-20.42 ρ								
	Hemerocallis	-50.42	-31.56 ρ								
	Heuchera	-58.90	-23.45 ρ								
	Hibiscus	-16.58	-4.78 ρ								
	Hosta	-38.35	-19.96 ρ								
	Hydrangea	19.85	7.35 ρ								
	Ilex	50.17	13.34 ρ								
	Juniperus	141.12	31.49 ρ								
	Phlox	-83.50	-48.99 ρ								
	Spiraea	-10.80	-4.19 ρ								
All other observations	rooted cutting			-18.31	-4.43 ρ	-17.66	-4.73 ρ	-18.67	-4.95 ρ	-21.04	-6.19 ρ
All other observations	unrooted cutting			-90.14	-53.34 ρ	-90.08	-59.27 ρ	-90.04	-56.56 ρ	-88.45	-51.54 ρ
NA	size container			19.07	172.19 ρ	19.09	171.74 ρ	18.90	168.22 ρ	18.85	169.37 ρ
NA	length (bareroot)			2.48	43.36 ρ	2.48	43.89 ρ	2.44	43.57 ρ	2.46	43.03 ρ
NA	caliper (bareroot)			247.84	77.4 ρ	248.31	79.03 ρ	245.84	80.13 ρ	248.57	78.99 ρ
All other observations	lg plt division			43.34	37.97 ρ	43.29	38.21 ρ	42.72	37.94 ρ	40.40	36.39 ρ

See end of table for notes Continued next page

Table 4.9: Hedonic Price Regression Results for Semi-log Models 1 - 5 (Coefficients Converted) [ab] — Continued

Model		Model 1		Model 2		Model 3		Model 4		Model 5	
Reference	variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
All other observations	2 ball/spir			189.69	40.2 ρ	198.09	41.23 ρ	201.76	43.68 ρ	212.01	45.24 ρ
All other observations	3ball/2spir			206.22	16.28 ρ	215.17	16.66 ρ	223.49	17.19 ρ	234.97	17.69 ρ
All other observations	complex shape			228.11	41.75 ρ	237.83	42.57 ρ	238.79	41 ρ	250.38	41.07 ρ
All other observations	simple shape			130.16	17.14 ρ	137.00	17.74 ρ	135.49	17.51 ρ	142.74	18.1 ρ
All other observations	sm			16.42	4.26 ρ	16.25	4.09 ρ	14.75	3.61 ρ	16.93	4.01 ρ
All other observations	med			17.10	5.96 ρ	15.45	6.62 ρ	15.46	6.57 ρ	16.83	6.95 ρ
All other observations	lg			29.04	11.61 ρ	28.56	11.25 ρ	26.57	9.95 ρ	28.76	10.47 ρ
All other observations	trained tree			108.74	37.89 ρ	104.10	34.01 ρ	104.19	33.69 ρ	102.95	29.75 ρ
All other observations	bonsai			165.75	29.32 ρ	173.86	30.2 ρ	179.59	30.84 ρ	191.05	31.91 ρ
All other observations	support			98.69	15.68 ρ	103.13	16.04 ρ	106.60	16.28 ρ	110.24	16.07 ρ
All other observations	topiary bask			296.98	70.45 ρ	308.91	70.05 ρ	284.54	53.81 ρ	309.23	50.74 ρ
All other observations	tree			26.77	16.49 ρ	28.08	16.79 ρ	29.30	17.09 ρ	31.00	17.63 ρ
All other observations	multi			37.54	6.17 ρ	41.59	6.73 ρ	45.87	7.32 ρ	50.59	8.29 ρ
All other observations	b&b			13.83	4.72 ρ	5.63	2.02 σ	2.64	0.96	1.11	0.39
All other observations	decor pot			-11.27	-4.83 ρ	-14.18	-6.28 ρ	-13.45	-6.03 ρ	-18.72	-8.67 ρ
All other observations	vernalized			-52.59	-26.31 ρ	-52.56	-30.77 ρ	-52.30	-30.53 ρ	-45.63	-24.12 ρ
All other observations	branched			87.52	7.74 ρ	-40.76	-12.08 ρ	-39.74	-11.97 ρ	95.33	8.31 ρ
All other observations	lt branch			97.10	18.58 ρ	12.47	1.53	16.16	1.91 τ	92.34	18.62 ρ
All other observations	tree			159.32	12.18 ρ	16.06	4.56 ρ	15.49	4.62 ρ	174.91	12.76 ρ
All other observations	TT			2.44	0.26	57.90	6.01 ρ	64.18	6.62 ρ	-4.51	-0.51
All other observations	whip			68.99	11.96 ρ	-39.87	-5.33 ρ	-41.93	-5.81 ρ	66.11	12 ρ
All other observations	high grade plant div.			110.59	5.94 ρ	117.52	6.2 ρ	118.99	6.31 ρ	132.64	6.97 ρ
All other observations	pdq			105.50	16.06 ρ	103.17	15.96 ρ	96.75	15.6 ρ	93.79	15.15 ρ
All other observations	East			-32.85	-24.91 ρ	-32.49	-25.03 ρ	-32.57	-25.4 ρ	-28.90	-23.06 ρ
All other observations	South			-18.73	-28.11 ρ	-18.28	-27.83 ρ	-18.14	-27.78 ρ	-16.45	-24.31 ρ
All other observations	West			-62.90	-21.26 ρ	-62.92	-21.56 ρ	-62.37	-21 ρ	-57.11	-19.28 ρ
All other observations	Dayton (OR)			18.51	2.92 ρ	18.69	2.88 ρ	20.31	3.11 ρ	20.45	3.46 ρ
All other observations	Gaston (OR)			-15.72	-6.92 ρ	-18.70	-8.1 ρ	-18.79	-7.58 ρ	-10.89	-4.2 ρ
All other observations	imported			-9.06	-3.63 ρ	-6.71	-2.68 ρ	-6.23	-2.49 σ	-7.78	-3.17 ρ
none	minimum height	0.55	8.9 ρ								
round	columnar	44.04	11.7 ρ								
	groundcover	-24.07	-9.23 ρ								
	prostrate	-37.02	-5.73 ρ								
	pyramidal	54.97	11.9 ρ								
	upright	7.79	4.62 ρ								
	vine	-2.54	-0.68								
	weeping	131.82	14.16 ρ								

Notes:
τ denotes the student-t statistic is significant at the 90 percent confidence level.
σ denotes the student-t statistic is significant at the 95 percent confidence level.
ρ denotes the student-t statistic is significant at the 99 percent confidence level.
a. For a full report of all estimated variables see Appendix F, Table 1.
b. Estimated coefficients for the intercept, integer and continuous variables have been multiplied by 100.
The coefficients for the categorical variables in the semi-log model were converted using the following formula:

$$100*[\exp(\beta)-1].$$

c. All F-statistics are significant at the 100 percent confidence level (p-value=0.0000).
d. All Wald statistics are significant at the 100 percent confidence level (p-value=0.0000).

Model 3 adds the plant patent variable to Model 2 to determine whether this intellectual property is a useful predictor of plant prices (Table 4.9). The R-squared statistic is essentially the same, but the Wald statistic for Model 3 shows that the plant patent belongs in the model. By controlling for the important firm offering variables, the price value contribution of the plant patent is less than half of the Lesser model (16 percent). This means that the expected value for patented plants is 16 percent higher than for unpatented plants when holding all other variables in this model constant.

Model 4 additionally accounts for the variation in price due to the name trademark Table 4.9). The interpretation of the plant patent in Model 3 is based on the assumption that plant patents were uniformly distributed across trademarked plants. This model allows for the plant patents to not be uniformly distributed across trademarked plants. The significant coefficient for the plant patent (8 percent) is half of that for Model 3. This lower coefficient confirms, what the data summaries in Table 4.7 reveals, that plant patents are concentrated in the higher mean priced trademarked plant group. The significant coefficient for the name trademark is the expected proportional value added to price after controlling for the plant patent and the firm offering variables. For this model, trademarked plants garner 13.5 percent higher prices than plants with no trademark. The t-tests for these two variable's coefficients test the difference between the indicated group (plant patented plant offerings or name trademarked offerings) and the reference group (plants with no patent or trademark).

Controlling for the price variation attributed to the other intellectual property and market related variables (i.e., patent pending, expired plant patent, plant patent age, plant patent age squared, plant association, number of trademarked promotions and number of non-trademarked promotions) increases the coefficients for both the plant patent (4.5 percent) and the name trademark (5.5 percent) over the previous model (Table 4.9, Models 4 & 5). Only three of the added coefficients in Model 5 have significant coefficients, but like all the models presented, the Wald statistic favors the unrestricted model.

Premiums and Firm and Species Price Effects

A good firm reputation is known to have a positive effect on price for agricultural products such as wine (Ali, Lecocq, et al., 2005; Schamel 2003; Schamel and Anderson 2003). Firm reputation is built upon highly variable and costly to ascertain attributes such as: customer service, quality of product (particularly innovative qualities), cultivar selection and plant performance. Model 6, adds a set of 8 firm categorical variables, with Bailey as the reference group, to controls for these important attributes (Table 4.10). In this model, the plant patent and the name trademark variable coefficients are reduced to levels like those in Model 4, and the other age related intellectual property variable coefficients gain in size and significance over the previous model. The coefficient for patent pending increasing from -1.26 to 6.43 indicates that cultivar observations with newly applied for patents are concentrated in firms which have lower priced products (i.e., herbaceous perennial specializing firms) (Table 4.6). Conversely the coefficient for the expired plant patent decreases from -6.75 to -9.36 which indicates that previously protected plant cultivar observations are concentrated in firms which have higher priced products (i.e., woody plant specializing firms) (Table 4.6). Holding all other variables in this model constant—most importantly, holding the firm offering variables constant—the negative and significant coefficients for firms reveal that average firm prices range from 21.9 to 64.45 percent lower than average prices for Bailey. Bailey Nursery commands the highest prices. Markedly, Greenleaf and Monrovia prices are lower than Bailey prices while the data summary means indicated that the opposite was true (Table 4.4).

Table 4.10: Hedonic Price Regression Results for Semi-log Models 6 & 7 (Coefficients Converted)[ab]

Model		Model 6		Model 7	
Variables added		(firms)		(species)	
R-squared		0.8722		0.9021	
F-statistic[a]		3861.75		4341.98	
2 model Wald test[b]		774.10		415.37	
AIC		21124.91		15536.46	
Reference	variable	coef.	t-stat.	coef.	t-stat.
	constant	68.78	45.51 ρ	69.70	32.82 ρ
2005	2006	3.12	4.29 ρ	2.77	4.47 ρ
	2007	4.69	6.28 ρ	4.86	7.48 ρ
All other observations	Plant Patent (PP)	9.28	6.11 ρ	23.32	15.89 ρ
All other observations	Trademarked (TM) name	13.36	14.01 ρ	2.53	3.02 ρ
All other observations	PP x TM name				
All other observations	patent pending	6.43	3.33 ρ	-1.15	-0.71
All other observations	expired PP	-9.36	-2.8 ρ	3.73	1.18
none	PP age (years)	0.36	1.99 σ	-0.60	-3.85 ρ
none	PP age squared (yrs)	-0.01	-2.56 ρ	0.01	2.78 ρ
none	TM promos	-10.21	-13.02 ρ	-2.62	-3.65 ρ
none	promos	1.68	4.87 ρ	2.97	9.47 ρ
All other observations	plant association	0.38	0.50	1.48	1.23
Bailey	Greenleaf	-38.04	-45.14 ρ	-30.77	-35.61 ρ
	Monrovia	-21.27	-21.04 ρ	-10.16	-10.24 ρ
	Zelenka	-43.20	-47.42 ρ	-36.19	-41.55 ρ
	Walters	-21.90	-17.46 ρ	-10.35	-8.04 ρ
	Yoder	-74.06	-55.55 ρ	-66.73	-44.65 ρ
	Sawyer	-63.98	-29.3 ρ	-50.35	-20.85 ρ
	Fisher	-36.57	-34.32 ρ	-30.03	-29.89 ρ
	Creek Hill	-64.45	-48.59 ρ	-60.11	-48.06 ρ
Rose	Acer			110.16	29.45 ρ
	Azalea			5.27	3.99 ρ
	Clematis			27.20	19.48 ρ
	Coreopsis			-33.26	-18.45 ρ
	Echinacea			-21.09	-7.97 ρ
	Hemerocallis			-18.75	-14.17 ρ
	Heuchera			-21.57	-11.53 ρ
	Hibiscus			3.67	1.97 σ
	Hosta			-15.68	-11.15 ρ
	Hydrangea			13.07	7 ρ
	Ilex			12.31	6.76 ρ
	Juniperus			11.50	6.2 ρ
	Phlox			-35.97	-21.47 ρ
	Spiraea			-8.69	-4.57 ρ
All other observations	rooted cutting	-49.82	-17.25 ρ	-52.26	-19 ρ
All other observations	unrooted cutting	-74.43	-31.49 ρ	-72.62	-33.57 ρ
none	size container	17.79	149.75 ρ	16.02	114.79 ρ
none	length (bareroot)	1.80	31.67 ρ	1.32	26.2 ρ
none	caliper (bareroot)	206.12	70.03 ρ	150.13	50.37 ρ
All other observations	lg plt division	26.23	28.35 ρ	23.95	23.81 ρ

See end of table for notes Continued next page

Table 4.10: Hedonic Price Regression Results for Semi-log Models 6 & 7 (Coefficients Converted)[ab] — Continued

Model		Model 6		Model 7	
Reference	variable	coef.	t-stat.	coef.	t-stat.
All other observations	2 ball/spir	209.47	53.9 ρ	220.61	58.49 ρ
All other observations	3ball/2spir	223.15	19.02 ρ	235.25	21.51 ρ
All other observations	complex shape	221.87	42.2 ρ	229.26	51.42 ρ
All other observations	simple shape	136.97	18.73 ρ	143.97	19.72 ρ
All other observations	sm	-8.80	-1.94 τ	-29.93	-5.92 ρ
All other observations	med	-10.52	-4.83 ρ	-29.86	-6.93 ρ
All other observations	lg	-1.30	-0.52	-25.68	-8.27 ρ
All other observations	trained tree	93.92	31.55 ρ	100.47	36.26 ρ
All other observations	bonsai	180.96	29.82 ρ	175.92	24.46 ρ
All other observations	support	107.03	16.62 ρ	71.79	14.51 ρ
All other observations	topiary bask	260.60	62.63 ρ	265.74	79.45 ρ
All other observations	tree	45.11	24.46 ρ	46.70	15.47 ρ
All other observations	multi	59.58	6.82 ρ	16.25	1.20
All other observations	b&b	-26.34	-10.65 ρ	-18.23	-7.06 ρ
All other observations	decor pot	-7.35	-3.52 ρ	12.37	4.86 ρ
All other observations	vernalized	7.87	2 σ	15.73	4.1 ρ
All other observations	branched	91.06	8.49 ρ	35.25	4.45 ρ
All other observations	lt branch	87.04	18.7 ρ	39.01	12.23 ρ
All other observations	tree	161.31	14.26 ρ	77.31	13.93 ρ
All other observations	TT	9.51	1.21	24.00	3.89 ρ
All other observations	whip	62.44	12.4 ρ	10.55	3.07 ρ
All other observations	high grade plant div.	82.59	6.18 ρ	67.59	5.08 ρ
All other observations	pdq	102.14	16.92 ρ	76.24	19.84 ρ
All other observations	East	1.01	0.75	-0.75	-0.62
All other observations	South	-2.45	-3.01 ρ	-3.20	-4.25 ρ
All other observations	West	-18.10	-7.22 ρ	-13.84	-6 ρ
All other observations	Dayton (OR)	6.15	0.99	0.43	0.08
All other observations	Gaston (OR)	-6.35	-2.28 σ	-7.57	-2.31 σ
All other observations	imported	96.94	17.09 ρ	76.76	15.19 ρ

Notes:
τ denotes the student-t statistic is significant at the 90 percent confidence level.
σ denotes the student-t statistic is significant at the 95 percent confidence level.
ρ denotes the student-t statistic is significant at the 99 percent confidence level.
a. For a full report of all estimated variables see Appendix F, Table 1.
b. Estimated coefficients for the intercept, integer and continuous variables have been multiplied by 100.
The coefficients for the categorical variables in the semi-log model were converted using the following formula:

$$100*[\exp(\beta)-1].$$

c. All F-statistics are significant at the 100 percent confidence level (p-value=0.0000).
d. All Wald statistics are significant at the 100 percent confidence level (p-value=0.0000).

Model 7, which adds a set of species categorical variables, represents the full model for this study. Model 7 has no interaction terms (Table 4.10, Model 7). This model has an R-squared statistic of 90 percent. In addition to representing different plant groups, the species variables are likely to proxy combinations of cultivar attributes which are not included in the models. So, premiums for attributes proxied by specific species may be reflected in the species premiums. As expected, prices range across species. Holding all other variables in the model constant, compared to the average price for *Rosa* offerings, woody plants such as *Acer, Azalea, Hydrangea, Ilex* and *Juniperus* garner higher price premiums, and herbaceous perennials such as *Coreopsis, Echinacea, Hemerocallis, Heuchera, Hosta* and *Phlox* garner lower price premiums. Notably, *Clematis*, an herbaceous perennial, averages 27.2 percent higher prices than *Rosa*—*Spiraea*, a woody plant, averages 8.69 percent lower prices that *Rosa*—and for *Hibiscus* plant offerings, which are composed of 75 percent woody plant observations, average prices are not significantly different than *Rosa*.

Also, as expected, the coefficients for the plant patent and the name trademark are modified after controlling for species, but unexpectedly the coefficient for plant patent is more than double that of Model 6, and the coefficient for the name trademark is reduced to less than a quarter of the previous model. These results indicates that greater a portion of patented plants are distributed among species where the patent is less likely to command a high premium, and that a greater portion of trademarked plants are distributed among species where the trademark is more likely to command a high premium. The patent distribution (along with the plant patent applications distribution revealed by model 5) confirms the theory that plant innovation and the rate of plant innovation should be higher where the breeding costs are lower that is in herbaceous perennials.[125] This model shows that plants, with a plant patent, average 23.32 percent higher prices than plants without a plant patent, and those plants, with a name trademark, average only 2.53 percent higher prices than plants with no trademarks. This result was anticipated because the data summary showed the overall price mean for patented plants ($12.47) is less than the overall data mean price ($13.25), but then conditioned across species the means for most species are higher (Table 4.7).

In Model 7 that additionally controls for species, the trademarked promotions do not have a positive effect on price. In fact, on average, each additional trademarked promotion decreases a cultivar's value by 2.62 percent (Table 4.10). Interestingly, other promotional notes such as the breeder's name or a popular cultivar increase a cultivar's value by 2.97 percent with each addition. This is a higher premium than that for a name trademark (2.53 percent). These results may indicate that wholesale buyers are influenced by more tangible promotional information as opposed to less tangible information associated with branding. This could also mean that promoters that are heavily into branding such as Proven Winners® may not reliably supply substance behind their claims which may sour their reputation with wholesale buyers. These results, combined with the modest premiums for the name trademark suggest that the value of branding may not have as much impact on price as firms might expect.

Cultivar offerings registered with a plant association have no significant premiums (Table 4.10). The regression results for the plant patent age related variables tells us how the age of the plant patent relates to its premium. Holding the other variables in this model constant, the insignificant t-statistics show that neither the newest protection

[125] For a discussion on breeding costs and plant innovation see chapter 2.

(patents pending) or the expired patents have any value to add to price. The significant negative coefficient for the plant patent age tells us that for every year the price is reduced by a small 0.6 percent.

Plant Patent and Trademark Interaction

An assumption, with previous multivariate models (Models 1-7), is that the effect of any single explanatory variable (i.e., plant patent and name trademark) is the same across the range of any other explanatory variable (i.e., patent, name trademark, species and firms). Now we will investigate regression models that add variables for the interaction between the plant intellectual property variables, firm and species. While the firm and species variables were important for controlling for the variability of the distribution of plant intellectual property, their interaction effects are useful for examining how the price premiums of plant patent and the name trademark vary across groups.

When product terms enter into the specification of a model the, the original set of variables used in the interactions refer to comparisons involving the reference categories. For example in this study, each added interaction added for the plant patent forces the plant patent variable to lose its generality and increasingly become a very specific comparison. By including interactions with the trademark, firm and species, the plant patent variable would be the indicator variable that compares patented non-trademarked Bailey roses with non-trademarked Bailey roses with no patent. In this manner, additional interactions further complicate interpretation of the coefficients of the original set of variables as well as all their interactions. For more reasonable and manageable analysis of the differences of plant patent effects across groups, the interaction terms are added using separate models.

With the Models 1-7 we assumed the effect of the plant patent is the same with and without the presence of a name trademark and visa versa, but there is evidence to the contrary. The increasing use of branding, which uses name trademarks in conjunction with the plant patent in the ornamental industry suggests that combining the two for a single cultivar adds value to the plant offerings. Over 50 percent of all plant patented cultivars also have a name trademark (Table 4.5). Most of the summary statistics show both the mean and median are higher for cultivar offerings with both types of intellectual property rights than for those with no intellectual property, just a plant patent or just a name trademark (Table 4.8).

Model 8 allows for the plant patent effects to vary between the observation groups with and without a name trademark by using an interaction term between the two indicator variables for plant patent and name trademark (Table 4.11). In this model, the effects of the plant patent are parsed out between two variables, the plant patent and the variable for the interaction between the plant patent and name trademark (*PP x TM*), and the effects of the trademark are parsed out between two variables, the name trademark and *PP x TM*. The coefficients of the plant patent and the name trademark have different meanings in Model 8 than those of Model 7. The plant patent coefficient (27.57) is the expected proportional change in price for observations with no name trademark and a plant patent compared to observations with neither a name trademark nor a plant patent. This coefficient (27.57) compared with that of Model 7 (23.32) tells us that the average plant patent premium is higher when the cultivar name is not associated with a trademark. The coefficient for the name trademark (5.18) is the expected proportional change in price for trademarked observations with no plant patent compared to the reference group which has no intellectual property associated with the name or the cultivar. This coefficient (5.18) compared with that of Model 7 (2.53) tells us that the average trademark premium is higher when the cultivar is trademarked but not patented. Thus controlling for the effects of the plant patent and the name trademark used separately, the coefficient for *PP x TM* (-6.89) is the expected proportional difference in price if both a plant patent and a trademark are used on the plant cultivar compared to when neither are used. The negative sign indicates that the combined intellectual property does not garner a price premium but instead reduces the expected price by 7 percent.

This surprising price damaging effect raises the question, “Why should the combination of a plant patent and a trademark used on a plant cultivar result in a lower price premium then if only one or the other were used." Table 4.5 also revealed that most of the cultivars with both a plant patent and a name trademark were roses and *Rosa* accounts for a large proportion of the data. Exploring the data further accounting for the distribution of intellectual property across all observations and not just the cultivar listings of the data (Table 4. 11) we find that 13 percent of all observations have both a plant patent and a name trademark and that 44 percent of these belong to the *Rosa* species. Further research is needed to determine if this negative effect for combining intellectual property is the same for every species and to what extent producer firms influence this effect.

Table 4.11: Intellectual Property Structure of Data by Species Observations and Plant Intellectual Property (Counts and Shares)

	Number				Share			Share		
Species	Observ ations	Plant Patent	Trade mark	Both IP	Plant Patent[a]	Trade mark[b]	Both IP[c]	Plant Patent[a]	Trade mark[b]	Both IP[c]
	(Count)				(Percentage of Species Obs.)			(Percentage of all obs.)		
Acer	2258	357	929	313	15.8	41.1	13.9	8.7	18.7	10.6
Azalea	1981	156	180	131	7.9	9.1	6.6	3.8	3.6	4.5
Clematis	1215	140	142	122	11.5	11.7	10.0	3.4	2.9	4.2
Coreopsis	588	230			39.1	0.0	0.0	5.6	0.0	0.0
Echinacea	330	139	94	90	42.1	28.5	27.3	3.4	1.9	3.1
Hemerocallis	1142	31	44	19	2.7	3.9	1.7	0.8	0.9	0.6
Heuchera/Heucherella	516	217	3	3	42.1	0.6	0.6	5.3	0.1	0.1
Hibiscus	1076	287	257	204	26.7	23.9	19.0	7.0	5.2	6.9
Hosta	1379	57			4.1	0.0	0.0	1.4	0.0	0.0
Hydrangea	1652	359	415	301	21.7	25.1	18.2	8.7	8.4	10.2
Ilex	1502	217	584	194	14.4	38.9	12.9	5.3	11.8	6.6
Juniperus	2024	78	196	43	3.9	9.7	2.1	1.9	4.0	1.5
Phlox	883	96	50	50	10.9	5.7	5.7	2.3	1.0	1.7
Rosa	3277	1558	1721	1319	47.5	52.5	40.3	37.9	34.7	44.9
Spiraea	1301	187	341	150	14.4	26.2	11.5	4.6	6.9	5.1
Total	**21124**	**4109**	**4956**	**2939**	**19.5**	**23.5**	**13.9**	**100.0**	**100.0**	**100.0**

Source: Compiled and constructed by author using an ornamental plant producer price data base compiled and constructed for this study.
Notes:
a. Includes all observations with a valid plant patent or a plant patent pending.
b. Includes all observations with a cultivar or series name trademark.
c. Includes all observations with a valid plant patent or a plant patent pending and a series or cultivar or series name trademark.
d. Heucherella are included with this species.
e. This group is made up of mostly woody plants, but with some herbaceous perennials.

Table 4.12: Hedonic Price Regression Results for Semi-log Models 8 - 11 (Coefficients Converted)[ab]

Model		Model 8		Model 9		Model 10		Model 11	
Variables added		(PPxTM)		(PPxFirm)		(PPxSpecies)		(TMxFirm)	
R-squared		0.9022		0.9034		0.9040		0.9028	
F-statistic[a]		4302.08		4163.60		3671.78		3782.72	
2 model Wald test[b]		20.67		37.51		35.45		22.93	
AIC		15519.18		15365.63		15144.98		15389.77	
Reference	variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
	constant	69.77	32.88 ρ	70.54	32.99 ρ	72.23	32.57 ρ	69.22	32.24 ρ
2005	2006	2.79	4.49 ρ	2.72	4.41 ρ	2.65	4.31 ρ	2.76	4.46 ρ
	2007	4.86	7.49 ρ	4.98	7.7 ρ	4.54	7.07 ρ	4.90	7.55 ρ
All other observations	Plant Patent (PP)	27.57	17.21 ρ	17.70	8.42 ρ	9.10	4.75 ρ	22.47	15.48 ρ
All other observations	Trademarked (TM)	5.18	5.14 ρ	4.42	5.26 ρ	4.16	4.77 ρ	8.14	5.33 ρ
All other observations	PP x TM name	-6.89	-4.31 ρ						
All other observations	patent pending	-0.95	-0.59	-1.73	-1.10	1.84	1.16	-0.54	-0.34
All other observations	expired PP	1.61	0.50	-2.41	-0.78	-7.81	-2.42 σ	1.86	0.6
none	PP age (years)	-0.61	-3.9 ρ	-0.35	-2.27 σ	-0.07	-0.43	-0.51	-3.29 ρ
none	PP age squared (yrs)	0.01	3.03 ρ	0.00	1.65 τ	0.00	-0.07	0.01	2.44 σ
none	TM promos	-2.33	-3.19 ρ	-2.90	-3.98 ρ	-1.80	-2.42 σ	-3.09	-4.25 ρ
none	promos	2.86	9.06 ρ	2.82	8.93 ρ	3.14	9.79 ρ	2.89	9.2 ρ
All other observations	plant association	1.61	1.33	1.61	1.34	2.46	2.01 σ	0.99	0.82
PPxBailey	PPxGreenleaf			-0.82	-0.49				
	PPxMonrovia			-10.31	-5.73 ρ				
	PPxZelenka			8.61	4.63 ρ				
	PPxWalters			1.75	0.57				
	PPxYoder			39.38	7.39 ρ				
	PPxSawyer			81.58	7.67 ρ				
	PPxFisher			0.26	0.09				
	PPxCreek Hill			28.09	6.5 ρ				
PPxRose	PPxAcer					13.92	4.53 ρ		
	PPxAzalea					22.22	8.49 ρ		
	PPxClematis					3.20	1.61		
	PPxCoreopsis					20.53	6.48 ρ		
	PPxEchinacea					84.41	13.43 ρ		
	PPxHemerocallis					28.26	3.85 ρ		
	PPxHeuchera					9.46	3.22 ρ		
	PPxHibiscus					-3.04	-1.34		
	PPxHosta					60.91	11.2 ρ		
	PPxHydrangea					5.37	2.25 σ		
	PPxIlex					-1.33	-0.46		
	PPxJuniperus					-16.28	-4.55 ρ		
	PPxPhlox					25.75	7.67 ρ		
	PPxSpiraea					-1.77	-0.59		
TMxBailey	TMxGreenleaf							-8.37	-5.36 ρ
	TMxMonrovia							-12.48	-7.31 ρ
	TMxZelenka							-3.16	-1.88 τ
	TMxWalters							-3.42	-0.45
	TMxYoder							15.68	1.85 τ
	TMxSawyer							89.40	7.52 ρ
	TMxFisher							-10.40	-4.57 ρ
	TMxCreek Hill							51.14	4.93 ρ

See end of table for notes

continued next page

Table 3: Hedonic Price Regression Results for Semi-log Models 8 – 11 (Coefficients Converted)[ab] — Continued

Model		Model 8		Model 9		Model 10		Model 11	
Reference	variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
Bailey	Greenleaf	-30.70	-35.53 ρ	-30.67	-32.2 ρ	-30.96	-35.96 ρ	-29.20	-30.34 ρ
	Monrovia	-10.12	-10.21 ρ	-8.77	-8.21 ρ	-9.75	-9.9 ρ	-7.47	-7.07 ρ
	Zelenka	-36.12	-41.45 ρ	-37.24	-40.03 ρ	-36.17	-41.84 ρ	-35.69	-37.9 ρ
	Walters	-10.49	-8.17 ρ	-10.92	-7.93 ρ	-10.92	-8.53 ρ	-9.15	-6.85 ρ
	Yoder	-66.74	-44.66 ρ	-69.82	-56.31 ρ	-65.92	-43.78 ρ	-67.09	-47.9 ρ
	Sawyer	-50.15	-20.73 ρ	-51.84	-21.74 ρ	-48.46	-20.22 ρ	-49.81	-20.53 ρ
	Fisher	-29.93	-29.75 ρ	-29.97	-28.34 ρ	-29.87	-29.83 ρ	-28.43	-26.14 ρ
	Creek Hill	-60.15	-47.98 ρ	-62.72	-50.85 ρ	-60.21	-52.49 ρ	-61.05	-52.33 ρ
Rose	Acer	108.86	28.97 ρ	107.07	28.66 ρ	103.17	26.52 ρ	107.81	29.03 ρ
	Azalea	5.11	3.86 ρ	4.15	3.15 ρ	0.75	0.49	4.42	3.36 ρ
	Clematis	27.16	19.48 ρ	26.18	18.9 ρ	23.35	14.43 ρ	26.83	19.23 ρ
	Coreopsis	-34.27	-18.61 ρ	-34.18	-18.95 ρ	-38.18	-18.97 ρ	-32.96	-18.27 ρ
	Echinacea	-21.36	-8.07 ρ	-22.24	-8.9 ρ	-38.74	-15.14 ρ	-24.46	-9.28 ρ
	Hemerocallis	-18.85	-14.24 ρ	-18.61	-14.04 ρ	-22.11	-15.45 ρ	-18.79	-14.19 ρ
	Heuchera	-22.68	-11.86 ρ	-19.52	-10.27 ρ	-23.78	-10.39 ρ	-21.76	-11.63 ρ
	Hibiscus	3.28	1.76 τ	2.16	1.16	3.77	1.77 τ	3.06	1.65 τ
	Hosta	-15.85	-11.26 ρ	-15.81	-11.37 ρ	-19.95	-13.16 ρ	-15.95	-11.4 ρ
	Hydrangea	12.80	6.84 ρ	12.79	6.86 ρ	10.66	5.04 ρ	12.37	6.61 ρ
	Ilex	12.02	6.59 ρ	11.40	6.27 ρ	10.88	5.43 ρ	12.10	6.62 ρ
	Juniperus	11.10	5.96 ρ	9.93	5.38 ρ	9.81	4.87 ρ	10.17	5.51 ρ
	Phlox	-36.18	-21.53 ρ	-33.65	-20.7 ρ	-39.53	-22.09 ρ	-35.60	-21.26 ρ
	Spiraea	-9.10	-4.77 ρ	-9.65	-5.09 ρ	-10.24	-4.85 ρ	-9.21	-4.84 ρ
All other observations	rooted cutting	-52.37	-19.42 ρ	-52.28	-18.84 ρ	-52.63	-18.63 ρ	-52.15	-19.17 ρ
All other observations	unrooted cutting	-72.65	-34.05 ρ	-72.06	-40.04 ρ	-72.79	-34.73 ρ	-72.45	-33.41 ρ
none	size container	16.03	114.85 ρ	16.05	115.49 ρ	16.02	114.92 ρ	16.04	115.03 ρ
none	length (bareroot)	1.32	26.22 ρ	1.32	26.27 ρ	1.30	25.79 ρ	1.31	26.26 ρ
none	caliper (bareroot)	150.50	50.48 ρ	150.65	50.56 ρ	149.57	50.21 ρ	150.20	50.64 ρ
All other observations	lg plt division	23.88	23.73 ρ	23.95	23.88 ρ	23.59	23.44 ρ	23.81	23.71 ρ
All other observations	2 ball/spir	220.24	58.72 ρ	217.10	58.27 ρ	217.22	57.94 ρ	219.10	56.99 ρ
All other observations	3ball/2spir	235.69	21.54 ρ	231.07	21.31 ρ	232.10	21.22 ρ	230.37	21.22 ρ
All other observations	complex shape	228.44	50.35 ρ	223.66	49.8 ρ	223.94	50.15 ρ	228.75	52.81 ρ
All other observations	simple shape	143.01	19.61 ρ	141.04	19.62 ρ	140.43	19.43 ρ	145.22	19.94 ρ
All other observations	sm	-29.88	-5.9 ρ	-29.99	-5.94 ρ	-30.62	-6.03 ρ	-30.80	-6.05 ρ
All other observations	med	-29.82	-6.89 ρ	-29.82	-6.93 ρ	-30.73	-6.89 ρ	-30.55	-6.87 ρ
All other observations	lg	-25.63	-8.26 ρ	-25.71	-8.29 ρ	-26.41	-8.37 ρ	-26.61	-8.3 ρ
All other observations	trained tree	100.75	36.4 ρ	105.01	41.21 ρ	101.37	36.47 ρ	102.67	38.1 ρ
All other observations	bonsai	176.34	24.53 ρ	173.59	23.9 ρ	172.98	23.95 ρ	172.65	23.97 ρ
All other observations	support	71.63	14.52 ρ	70.40	14.33 ρ	72.12	14.32 ρ	70.17	14.24 ρ
All other observations	topiary bask	262.27	78.06 ρ	258.05	77.78 ρ	259.78	73.76 ρ	278.81	65.08 ρ
All other observations	tree	46.96	15.55 ρ	46.15	15.4 ρ	44.91	15.16 ρ	46.01	15.67 ρ
All other observations	multi	16.61	1.23	15.37	1.13	16.22	1.21	14.56	1.08
All other observations	b&b	-17.85	-6.92 ρ	-17.62	-6.5 ρ	-16.24	-6.26 ρ	-20.35	-7.58 ρ
All other observations	decor pot	12.65	4.97 ρ	11.30	4.67 ρ	14.31	5.5 ρ	11.87	4.82 ρ
All other observations	vernalized	16.04	4.21 ρ	17.36	4.56 ρ	17.24	4.65 ρ	16.03	4.22 ρ

See end of table for notes

Continued next page

Table 3: Hedonic Price Regression Results for Semi log Models Eight-11 (Coefficients Converted)[ab]–— Continued

Model		Model 8		Model 9		Model 10		Model 11	
Reference	variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
All other observations	branched	35.38	4.46 ρ	35.46	4.47 ρ	36.54	4.61 ρ	36.55	4.54 ρ
All other observations	lt branch	38.91	12.23 ρ	39.15	12.28 ρ	38.70	12.19 ρ	37.85	12.08 ρ
All other observations	tree	77.98	13.98 ρ	77.85	13.9 ρ	80.31	14.08 ρ	80.50	14.18 ρ
All other observations	TT	24.12	3.91 ρ	24.54	3.96 ρ	25.47	4.12 ρ	20.90	3.41 ρ
All other observations	whip	10.63	3.1 ρ	10.66	3.1 ρ	10.63	3.11 ρ	10.00	2.96 ρ
All other observations	high grade plant div.	68.38	5.13 ρ	67.32	5.03 ρ	67.05	5.14 ρ	70.00	5.23 ρ
All other observations	pdq	75.96	19.93 ρ	76.08	19.85 ρ	75.84	19.5 ρ	73.59	19.59 ρ
All other observations	East	-0.81	-0.67	-0.47	-0.39	-0.38	-0.31	-0.69	-0.57
All other observations	South	-3.23	-4.28 ρ	-3.34	-4.43 ρ	-3.08	-4.05 ρ	-3.57	-4.74 ρ
All other observations	West	-13.91	-6.06 ρ	-13.52	-6.13 ρ	-13.87	-6.21 ρ	-13.33	-6.02 ρ
All other observations	Dayton (OR)	0.30	0.06	1.27	0.25	-0.56	-0.11	-0.06	-0.01
All other observations	Gaston (OR)	-7.64	-2.36 σ	-6.86	-2.02 σ	-5.84	-1.78 τ	-6.10	-1.87 τ
All other observations	imported	76.51	15.17 ρ	75.62	15.08 ρ	72.22	14.82 ρ	75.64	15.06 ρ

Notes:
τ denotes the student-t statistic is significant at the 90 percent confidence level.
σ denotes the student-t statistic is significant at the 95 percent confidence level.
ρ denotes the student-t statistic is significant at the 99 percent confidence level.
a. For a full report of all estimated variables see Appendix F, Table 1.
b. Estimated coefficients for the intercept, integer and continuous variables have been multiplied by 100.
The coefficients for the categorical variables in the semi-log model were converted using the following formula:

$$100*[\exp(\beta)-1].$$

c. All F-statistics are significant at the 100 percent confidence level (p-value=0.0000).
d. All Wald statistics are significant at the 100 percent confidence level (p-value=0.0000)

Premium Differences between Firms

In the previous models we have assumed that the plant patent had no differential effect on price across firms. However the summary data suggested otherwise—perhaps the plant patent's contribution to price varies across firms (see Table 4.8). Model 9 adjusts the model specification to allow a relationship between the plant patent and firms to test for differential effects of a plant patent across firms by including interaction variables between the plant patent and firms (Table 4.11 *PP x Firmname*).

With the inclusion of the firm interaction terms in Model 9, the meanings of the coefficient for plant patent has changed because it is now firm-specific to Bailey (Table 4.11). Holding other variables constant, the coefficient for the plant patent (17.70) estimates the expected proportional difference in price between patented Bailey offerings with Bailey offerings with no patent. Likewise, the coefficients for the firm dummy variables (all negative, significant and slightly different than previous models) no longer estimate the average effect for patented and unpatented plants together of a particular firm verses Bailey. Instead, holding all other variables constant, the firm variable coefficients are the expected proportional difference in price for a cultivar with no patent sold by that particular firm compared to a cultivar with no patent sold by Bailey. The t-tests, associated with these original firm variables, test for differences of prices of unpatented plants among firms. All of these are significant. The regression coefficients for the product variables estimate the differential (price) effect of the plant patent by firm, or alternatively the differential (price) effect of firms on patents. The t tests for only 5 of these effects are significant of which four correspond to positive coefficients and one corresponds to a negative coefficient. A Wald test that tests the joint equivalence of the interaction coefficients show that this null hypotheses should be rejected with 100 percent confidence.

This model tells us that price effects vary somewhat across firms for unpatented plants, and plant patent effects do vary considerably across all firms. While Bailey may garner a 17.70 percent premium for patented plants, Zelenka, Yoder, Sawyer and Creek Hill exceed their premiums for patented plants by 8.61 percent, 39.38 percent, 81.58 percent and 28.09 percent respectively. In addition to what the previous models have shown, that these herbaceous perennial specializing firms have more and newer plant patents, this model shows that herbaceous perennial specializing firms have more valuable plant patents. All the firm patent premiums can be calculated by adding their interaction coefficient to that of the plant patent.[126] Sawyer garners the highest premium of 99.28 percent for patented plants while Monrovia receives the lowest premium of only 6.3 percent premium (Table 4.12).

[126] Table 4.12 gives the price premiums which were calculated from the regression coefficients of Models 9-11 in Table 4.11.

Table 4.13: Estimated Intellectual Property Premiums as a Percent of Plant Price

Group	Plant patent premium		Name trademark premium	
Firm				
Greenleaf	16.87	λ	-0.23	
Monrovia	7.39		-4.34	
Bailey	**17.70**		**8.14**	
Zelenka	26.31		4.98	λ
Walters	19.45	λ	4.72	λ
Yoder	57.08		23.82	λ
Sawyer	99.28		97.54	
Fisher	17.95	λ	-2.26	
Creek Hill	45.79		59.28	
Species				
Acer	23.02			
Azalea	31.32			
Clematis	12.30	λ		
Coreopsis	29.63			
Echinacea	93.51			
Hemerocallis	37.36			
Heuchera	18.56			
Hibiscus	6.06	λ		
Hosta	70.01			
Hydrangea	14.47			
Ilex	7.77	λ		
Juniperus	-7.18			
Phlox	34.85			
Rosa	**9.10**			
Spiraea	7.33	λ		
All groups	23.32		2.53	

Notes:
Estimated coefficients for intellectual property and intellectual property interaction variables were used to calculate these premiums. Premiums were calculated by adding the regression coefficients of the intellectual property interaction variables to their respective intellectual property coefficients which are the reference group premiums. The intellectual property premiums for all groups together are those estimated coefficients from Model 7.
Bold type designates the reference group.
λ denotes estimations which may equal the reference group premium, because the t-statistic associated with the estimated coefficient was below the 95 percent confidence level.

Model 11 allows for the effects of name trademarks to vary across firms by adding interaction variables between name trademarks and each species (Table 4.11 *TM x Species*). For this model, the coefficients for the firm dummy variables (all negative, highly significant and similar in value to the previous models), are the expected proportional difference in price for a cultivar with no trademark sold by that particular firm compared to a cultivar with no trademark sold by Bailey. Like for the plant patent intellectual property rights in Model 9, the t-tests and the joint Wald test suggest that there are differences in prices of plants with no trademarks among firms. Like for the plant patent in Model 9, the coefficient for the name trademark (8.14) has a different meaning and estimates the expected proportional difference in price between trademarked Bailey offerings with Bailey offerings with no trademark. In this model the regression coefficients for the product variables estimate the differential (price) effect of the trademark by firm, or alternatively the differential (price) effect of firms on trademarks. The significant 5 of the 8 coefficient t tests and the Wald test for joint significance support the there is a differential effect of the name trademark across firms. On average, Sawyer and Creek Hill's trademarked plants have the highest expected markups of 97.54 and 59.28 percent respectively. Monrovia, Fisher and Greenleaf's trademarked plants are expected to be lower than average prices with expected -4.34, -1.26 and -0.23 percent deficits respectively (Table 4.12).

Premium Differences between Species

Like for firm groups, we have reason to doubt that the plant patent effects are the same across species groups since the summary data show that mean prices for patented plants vary across species groups (Table 4.6 column 2). Model 10 allows for these effects to vary by adding variables for the interaction between the plant patent and each species (Table 4.11 *PP x Species*).

For Model 10 and holding other variables constant, the coefficient for the plant patent (9.10) estimates the expected proportional difference in price between patented *Rosa* offerings with *Rosa* offerings with no patent (Table 4.11). The coefficients for the species variables, holding all other variables constant, are the expected proportional difference in price for a plant of a particular species with no patent compared to a rose plant with no patent. The species coefficients are similar to the previous model. Their variability of size and associated significant t tests (except for *Azalea*) show that price effects vary from *Rosa*. A separate Wald test confirms that the hypothesis that there is no variation of unpatented plants across species can be rejected with 100 percent confidence.[127] The regression coefficients for the added product variables estimate the differential (price) effect of the plant patent by species, or alternatively the differential (price) effect of species on patents. The t tests for all but three of these effects (i.e., *Clematis*, *Hibiscus and Hydrangea*) are significant. The reported Wald test rejected the joint equivalence hypothesis for the interaction coefficients with 100 percent confidence which is supporting evidence that plant patent effects vary across species. Indeed the coefficients vary from -16.28 for patented *Juniperus* to 60.91 for *Hosta* and 84.41 for *Echinacea*. Ironically, rose cultivars have the highest percentage of patents (49.9 percent) of all the species cultivars, but all other species with patents garner larger premiums as a share of price except for *Juniperus* (See Table 4.5). Calculating premiums

[127] This test simultaneously tested all the species coefficients: H_0: $\beta_i = \beta_j$ such that i does not equal j.

reveal that patented *Echinacea* and *Hosta* plants garner the highest premiums of 93.51 percent and 70.01 percent respectively, and exceptionally, patented *Juniperus* plants are discounted 7.18 percent (Table 4.12).

Premiums and Royalties

There was some limited data available on ornamental cultivar royalties.[128] These royalties range from $0.02 to $0.75 per plant with a mean price of $0.48 for woody plants and a median price of $0.22 for herbaceous perennials. If the average estimated premium for the plant patent (23.3 percent) is applied to the minimum, mean and maximum plant price prices with no plant patent (i.e., $0.08, $13.44, and $237.53 respectively) found in Table 4.7 we get estimated minimum, mean and maximum premiums of $0.02, $3.13 and $55.34 respectively. These calculations indicate that premiums, for most levels of premiums, are much larger than royalties that must be paid to the owners of the intellectual property rights. This is strong incentive for propagating firms to offer patented plants. Premiums may not be much greater than royalties for the smallest premiums which are perhaps obtained where plants are sold as rooted or unrooted cuttings. Even if these small markups may not be sufficient to motivate plant producers, if the larger mark-ups can be obtained by the growers producing larger finished plants, patented plants will be demanded on the wholesale market.

4.6. Summary and Conclusion

The purpose of this study was to determine if there are premiums for plants with plant intellectual property rights by looking in two larger and faster growing ornamental

[128] Royalty data were provided by two of the firms used in this study, but due to disclosure issues, specific documentation cannot be provided.

industries. For these ornamental plant industries, the number of cultivars, as well as the number of plant patents used to protect them, has greatly expanded. Also, in these industries, there is more potential for higher per unit prices. So, the intuition is that there should also be a higher potential for plant patent premiums.   The large number of observations allowed enough degrees of freedom to include a large and more complete set of explanatory variables that affect price variability in the regression model; thereby, strengthening the analysis.

The OLS multivariate regression models account for a large share of the observed variation in plant prices. For popular ornamental woody and herbaceous perennial plants in the U.S., the key findings are:

1. Model 7, the full model, showed the plant patent contributes 23.3 percent to the plant price. The difference in the value of patented plants over non-patented plants is surprisingly high—especially considering the results of previous studies of intellectual property rights for plant varieties (Table 4.10 Model 7).
2. When only a plant patent is used (i.e., there is no name trademark), the price averages 27.6 percent higher than those cultivars with neither a plant patent nor a trademark (Table 4.11 Model 8).
3. The full model also showed that the name trademark value contribution to price was a modest 2.5 percent. Surprisingly, its contribution to price was considerably less (20.5 percent) than that of the plant patent (Table 4.10 Model 7).
4. When only a name trademark is used (i.e., there is no plant patent), the price

averages 5.1 percent higher than those cultivars with neither forms of intellectual property (Table 4.11 Model 8).

5. Contrary to expectations, the price of ornamental plants with a name trademark and a plant patent are on average 6.9 percent lower than plants with neither forms of intellectual property (Table 4.11 Model 8).
6. An additional noteworthy finding regarding trademarks is that trademarked promotional schemes on average detracted from the price of a plant (Table 4.10 Model 7).
7. Both plant patent and name trademark premiums vary across firms (Table 4.11 Models 9 and 11).
8. Plant patent premiums vary between species (Table 4.11 model 10)

The low premium differences between the plant patent and the name trademark may be due in part to the relatively recent usage of the name trademark compared with the long history of plant patent use in the industry. Industry agents have not had the long experience of extracting premiums from trademarks.

Most importantly this study has shed some light on an industry and subject that has been little studied in the professional literature. This study has produced robust results that should be useful to policymakers, and particularly useful to firms dealing with plants with intellectual property rights. In particular, these results could perhaps be a caution against expecting too much from investments in trademarks and branding programs.

Chapter 5

Conclusion

The connection between domestic plants, the divine, human sustenance and the nature of plants themselves underlies the sustained interest in plant-related intellectual property rights and their economic effects (i.e., firm concentration, rates of innovation, the amount of R&D spending, the number and size of product quality improvements and price premiums). Because most plant innovations have manifold and variable costs associated with them, because plant innovations embody public good qualities, and because plant patents and plant variety protection certificates are considered weaker forms of intellectual property, theory and prior research suggest the economic effects of plant-related intellectual property rights may vary among plant industries.

Motivated by U.S. historical trends in value of production and plant varietal intellectual property rights which point to increased value and patenting activity (indicating possible increased innovation activity) in the horticultural sector, this study uses a unique approach to evaluate the effects of plant-related intellectual property. This study looks the differences between the horticultural and the agricultural subsectors of the U.S. for plant-related industries and in particular examines price premiums related to intellectual property in the ornamental industry.

Chapter 3 takes brings together many historical statistical and event elements from two new data sources and other diverse sources to examine roots of the evolution of intellectual property rights for plants from the early 1900s to the present. The elements examined are the evolution of intellectual property rights for plants, the evolution of plant science and plant industries, a statistical description of the changing domestic markets for plants and plant products, and a description and an analysis of the statistical structure of the relevant intellectual property patterns. This descriptive analysis juxtaposes these statistical and event elements to expand our knowledge of the U.S. sector for plant-related industries and determine the forces and direction of change in the patterns of intellectual property rights and their associated plant markets.

Three significant themes emerge from this contextual examination of the evolution of intellectual property rights for plants. First, innate differences between plants, and the size of their markets largely determines the appropriability of a protected new cultivar's revenue streams, and these differences are revealed in differences in the patterns that are observed in the intellectual property rights for plants. Innovation for woody plants have greater appropriability problems due to the higher costs of breeding and marketing resulting from their larger sizes and longer juvenile periods relative to other plants.

Second, the world wide harmonization of intellectual property rights for plants that may have both increased markets and appropriability for new plant innovations has given an international dimension to U.S. plant innovation and varietal intellectual property trends. Because ornamental breeders scour the world for new widely adaptable plants, this international dimension is particularly apparent in the patterns in applications of intellectual property rights for ornamental cultivars. Motivated to gain control of the genetic material, the tools for genetic change, and the world seed markets of a few agricultural field crops, the agricultural subsector has evolved to be dominated by large multinational firms.

Third, biotechnology sciences have greatly changed the plant industries by changing the way new cultivars are created and the way plant cultivar innovations are protected. This protection includes the intellectual property enforcement advantages derived from genetic coding, the use of broad utility patent claims that extend to future generations of innovative plants, and industry structural changes that include agglomeration, joint ventures and licensing contracts.

In Chapter 4, a hedonic study looked for the fruits of intellectual property rights for plants by decomposing prices to see if plant patents and trademarks garnered price premiums. This hedonic decomposition of ornamental plant prices from 2005-2007 revealed significant price premiums for plant-related intellectual property. These premiums for plant patents were quite high—plants that were protected with a plant patent garner prices that averaged 23 percent higher than for plants that were not protected. The premium for the plant patent was even higher (28 percent) for patented plants that used no name trademark. The premium for trademarks used on the cultivar's name garnered an average of only 2.5 percent higher prices than the prices of plants which had no name trademark. When only a name trademark is used (i.e., there is no plant patent), the price premium averaged 5 percent higher than those cultivars with neither forms of intellectual property. These findings give support to what the value of production and intellectual property rights for plant varieties data suggested: the plant patent may have more potential for appropriability in the ornamental industry where there are growing markets and yearly counts of intellectual property.

The low premium differences between the plant patent and the name trademark may be due, in part, to the relatively recent usage of the name trademark compared with the long history of plant patent use in the industry. The detrimental effect of using the plant patent and name trademark together is an unexpected result that deserves further research.

The significant differences in the price premiums of the plant patent (and the name trademark) between different species and between different firms supports the theory that differences between technologies, species and firms may affect the appropriability of intellectual property rights. Generally, premiums were highest for herbaceous perennials and firms specializing in herbaceous perennials, and lowest for woody plants and firms specializing in woody plants (See Table 4.12). This supports the theory that patented woody plant innovations are less appropriable. The differences in premiums between the firms that carry almost exclusively herbaceous perennials and firms that carry more woody plants may indicate differences in firm capacity to extract value from the patented plants that were offered, but confirmation would require formal tests.

The results of the hedonic regressions stimulate some interesting questions for further research. What is the source of value derived from the plant patent? Is it from the combination of phenotypical attributes, or from the quality standard signaled by a plant patent? Why is the value of name trademarks in ornamental plants so low compared to the value of a plant patent?

The richness of scope and size of the data set present opportunities to explore and answer related questions:

1. Due to model specification issues this study was not able to fully address whether

other variables such as physical plant attributes enhance the plant patent. Species specific hedonic models (in particular *Rosa* species) could be used to test which physical plant attributes and attribute combinations contribute directly to price.

2. Likewise more specific hedonic models could be fitted to the data to address a variety of ornamental firm and industry questions.
3. The multilevel hierarchical nature of the data could be addressed by augmented the data with population weight estimates, and then fit a model that makes use of the data variance structure. This approach could be an important contribution to hedonic modeling in general. [129]

While outside the scope of this data set to answer, the basic questions of this study could be explored at a retail market level and compared with the results of this study to determine differences in the valuation of plant intellectual property at different levels of the complex market chain.

[129] Multilevel modeling is an increasingly popular approach to modeling hierarchically-structured data, which outperforms classical regression in predictive accuracy. This is no surprise, given that multilevel modeling includes least-squares regression as a special case. One intriguing feature of multilevel models is their ability to separately estimate the predictive effects of an individual predictor and its group-level mean, which are sometimes interpreted as “direct" and “contextual" effects of the predictor. However, key to successful modeling, using these techniques is the construction weights for each observation based on their sampling probability. This requires knowledge of the size and proportions of groups (e.g., number of firms, number of species and number of observations) at the population level. Because of the cost involved in obtaining this information for the plant price data, this type of analysis must be reserved for a future study.

Bibliography

Aguirre, P. "Protection: Plant Patents, Utility Patents, Plant Breeders' Rights, Trademarks, Branding, Royalties." In Plant Breeding and Crop Domestication as Sources of New Invasive Species, edited by N.O. Anderson and S.M. Galatowitsch, 2006.

Akerlof, G.A. "The Market for Lemons: Quality Uncertainty and the Market Mechanism." Quarterly Journal of Economics 84, no. 3 (1970): 488-500.

Ali, H.H., S. Lecocq, and M. Visser. "The Impact of Gurus: Parker Grades and En Primeur Wine Prices." 24, 2005.

Allen, G. E. "Hugo De Vries and the Reception of the "Mutation Theory"." Journal of the History of Biology 2, no. 1 (1969): 55-87.

Alston, J.M., and P.G. Pardey. "Public Funding for Research into Specialty Crops." HortScience 43, no. 5 (2008): 1461-70.

Alston, J.M., and R.J. Venner. "The Effects of the US Plant Variety Protection Act on Wheat Genetic Improvement." Research Policy 31 (2002): 527-42.

Alston, J.M., C. Chan-Kang, M.C. Marra, G.P. Pardey, and TJ Wyattt. "A Meta-Analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem?" IFPRI Research Report No. 113. Washington D.C.: International Food Policy Research Institute, 2000.

Altman, A., and B. Loberant. "Micropropagation: Clonal Plant Propagation in Vitro." In Agricultultural Biotechnology, edited by Arie Altman, 19-42. New York: Marcel Dekker, Inc, 1998.

Anderson, N.O. "Prevention of Invasiveness in Floricultural Crops." In Flower Breeding & Genetics: Issues Challenges, and Opportunities for the 21st Century, edited by Neil O. Anderson, 177-214. Dordrecht: Springer, 2006.

Anderson, N.O. Personal Interview, Spring 2004.

Anderson, N.O. Personal Interview, December 2008.

Anglin, P.M., and R. Gencay. "Semiparametric Estimation of a Hedonic Price Function." Journal of Applied Econometrics 11, no. 6 (1996): 633-48.

Anonymous. "Proven Winners Customer - Grower Agreement: Terms and Conditions Accepted by Customer Upon Receipt of Proven Winners® and/or Proven Selections® Plants." Royalty Administration International, 2007/2008.

Anonymous. "Sizing up the Seed Market." SeedWorld, October 2007, 10-12.

Anonymous. 2006. The Legacy of W. Atlee Burpee. W. Altee Burpee & Co., http://www.burpee.com/jump.jsp?itemID=574&itemType=CONTENT_ARTICLE&apage=1. (accessed 7/20/2006).

Antonivitz, F., and D. Liu. "A Hedonic Price Study of Pesticides in Fruits and Vegetables." In Fifth Joint Conference on Agriculture, Food and the Environment, 20, 1996.

Arrow, K. J. "Economic Welfare and the Allocation of Resources for Invention." In The Rate and Direction of Inventive Activity: Economic and Social Factors, edited by National Bureau of Economic Research, 609-25. Princeton: Princeton University Press, 1962.

Bagwell, K. "The Economic Analysis of Advertising." In Handbook of Industrial Organization, edited by M. Armstrong and R. Porter, 1701-844. Amsterdam: North-Holland, 2007.
Bailey, G. Personal Interview, August 2006.
Beytes, C., and J.A. Shaw. "1937-1997: 60 Years of Growertalks." GrowerTalks 61, no. 1 (1997): 34-51.
Bierlen, R., and O. Grunwald. "Price Incentives for Comercial Fresh Tomatoes." Journal of Agricultural and Applied Economics 27, no. 1 (1995): 138-48.
Bijman, J., and M.J. Bogaardt. "Advanta Monograph." In PITA project: policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-27: European Commission, 2000.
Blackley, P., J.R. Follain Jr., and J. Ondrich. "Box-Cox Estimation of Hedonic Models: How Serious Is the Iterative OLS Variance Bias?" The Review of Economics and Statistics 66, no. 2 (1984): 348-53.
Bloch, F., and D. Maceau. "Persuasive Advertising in Hotelling's Model of Product Differentiation." International Journal of Industrial Organization 17, no. 4 (1999): 557-74.
Boldrin, M., and D. Levine. "The Case against Intellectual Property." American Economic Review 92, no. 2 (2002): 209-12.
Brennan, M.F., C.E. Pray, and A. Courtmanche. "Impact of Industry Concentration on Innovation in the U.S. Plant Biotech Industry. In "Transitions in Agbiotech: Economics of Strategy and Policy"." Paper presented at the NE-165 Conference, Washington, D.C. 2000.
Brennan, M.F., C.E. Pray, A. Naseem, and J.F. Oehmke. "An Innovation Market Approach to Analyzing Impacts of Mergers and Acquisitions in the Plant Biotechnology Industry." AgBioForum 8, no. 2/3 (2005): 89-99.
Brooker, J.R., D. Eastwood, C. Hall, K. Morris, A. W. Hodges, and J.J. Haydu. "Trade Flows and Marketing Practices within the United States Nursery Industry: 2003." Southern Cooperative Series Bulletin. xyz, The University of Tennessee Agricultural Experiment Station: Southern Regional Research Project 2005.
Brooker, J.R., R.A. Hinson, and S.C. Turner. "Trade Flows and Marketing Practices within the United States Nursery Industry." Southern Cooperative Series Bulletin. 358, The University of Tennessee Agricultural Experiment Station: Southern Regional Research Project S.103, 1990.
Brooker, J.R., R.A. Hinson, and S. C Turner. "Trade Flows and Marketing Practices within the United States Nursery Industry:1998." Southern Cooperative Series Bulletin. 397, The University of Tennessee Agricultural Experiment Station: Southern Regional Research Project S.290, 2000.
Brooker, J.R., S. C. Turner, and R.A. Hinson. "Trade Flows and Marketing Practices within the United States Nursery Industry:1993." Southern Cooperative Series Bulletin. 384, The University of Tennessee Agricultural Experiment Station: Southern Regional Research Project S.103, 1995.
Brown, J. N., and H. Rosen. "On the Estimation of Structural Hedonic Price Models." Econometrica 50, no. 3 (1982).

Brown, R.S. "Advertising and the Public Interest: Legal Protection of Trade Symbols." The Yale Law Journal 57, no. 7 (1948): 1165-206.
Bureau of the Census, U.S. Department of Commerce. "1987 U.S. Census of Agriculture; Volume 4, Special Reports, Part 7, Census of Horticultural Specialties (1988)." Washington D.C.: Government Printing Office, 1991.
Butcher, C.R. "An Exploration of the Unintended Temporal Extension of the Plant Patent Term." Duquesne Law Review 42, no. 1 (2003): 137-58.
Butler, L. J., and B. W. Marion. "The Impacts of Patent Protection on the U.S. Seed Industry and Public Plant Breeding." 1-128. Madison: College of Agricultural and Life Sciences, University of Wisconsin-Madison, 1985.
Butterfield, B., (Director). National Gardening Survey 2002. South Burlington: Harris Interactive for The National Gardening Association, 2003.
Byron, R.P., and O. Ashenfelter. "Predicting the Quality of an Unborn Grange." The Economic Record 71, no. 212 (1995): 40-53.
Carpenter, J.D. "Intellectual Property: The Overlap between Utility Patents, Plant Patents, the PVPA, and Trade Secrets and the Limitations on That Overlap." North Dakota Law Review 81, no. 1 (2005): 171-98.
Caswell, J.A., and E.M. Mojduszka. "Private Strategies, Public Policies & Food System Performance." In A Joint USDA Land Grant University Research Project, 17. Amherst: University of Massachusetts, 1996.
CFIA. 2002. 10-Year Review of Canada's Plant Breeder's Rights Act. Canadian Food Inspection Agency, http://www.inspection.gc.ca/english/plaveg/pbrpov/10yre.shtml. (accessed March 2009).
Chang, T. "II.A.7 Rice." In The Cambridge World History of Food, edited by K.F. Kiple and K.C. Ornelas, 112-49. New York: Cambridge University Press, 2000.
Chataway, J., and J. Tait. "Monsanto Monograph." In PITA project policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-49: European Commission, 2000.
Chen, J. "The Parable of the Seeds: Interpreting the Plant Variety Protection Act in Furtherance of Innovation Policy." Notre Dame Law Review 81 (2005-2006): 105(62).
Chisum, D.S. Chisum on Patents: A Treatise on the Law of Patentability, Validity, and Infringement. Vol. 8:24. New York: LEXIS Pub., 2002.
Combris, P., S. Lecocq, and M. Visser. "Estimation of a Hedonic Price Equation for Bordeaux Wine: Does Quality Matter?" The Economic Journal 107, no. March (1997): 390-402.
Cornelli, F., and M. Shankerman. "Patent Renewals and R&D Incentives." RAND Journal of Economics 30, no. 2 (1999): 197-213.
Correll, M.R., J.H. Lillydahl, and L.D. Singell. "The Effects of Greenbelts on Residential Property Values: Some Findings on the Political Economy of Open Space." Land Economics 54 (1978): 207-17.
Court, A. T. "Hedonic Price Indexes." In The Dynamics of Automobile Demand, 99-117. New York: General Motors Corporation, 1939.

Craig, R. "Creating a More Beautiful World: A Century of Progress in the Breeding of Floral and Nursery Plants." HortScience 38, no. 5 (2003): 928-36.
Cropper, M., L. Deck, and K. McConnel. "On the Choice of Functional Form for Hedonic Price Functions." Review of Economic and Statistics 70 (1988): 668-75.
de Laat, E. "Patents or Prizes: Monopolistic R&D and Asymmetric Information." International Journal of Industrial Organization 15, no. 3 (1997): 369-90.
Debouck, D., and E. Hesse. "US Patent Office Rejects US Company's Patent Protection for Bean Commonly Grown by Latin American Farmers." In Newsroom release, edited by CIAT: International Center for Tropical Agriculture, 2008.
Diewert, Erwin. "Hedonic Regressions: A Review of Some Unresolved Issues." Univeristy of British Columbia, Vancuver, B.C., 2003.
Diez, M.C.F. "The Impact of Plant Varieties Rights on Research: The Case of Spain." Food Policy 27 (2002): 171-83.
Dil, A. Norman Borlaug on World Hunger. San Diego: Bookservice Inernational, 1997.
Dimitri, C. "Integration, Coordination and Concentration in the Fresh Fruit and Vegetable Industry." Economic Research Service U.S. Department of Agriculture, 1999.
Dirr, M.A. Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. 5th ed. Champaign: Stipes Publishing L.L.C., 1998.
Drew J., Anderson N.O. and Andow D. "Conundrums of a Complex Vector for Invasive Species Control: A Detailed Examination of the Horticultural Industry." *Biological Invasions* Online First™ (2010): 1573-464.
Duvick, D.N. "Plant Breeding, an Evolutionary Concept." Crop Science 36 (1996): 539-48.
Ekeland, I, J.J. Heckman, and L.P. Nesheim. "Identification and Estimation of Hedonic Models." Journal of Political Economy 112, no. 1 (2004): 60-109.
ERS. "Farm Income: Cash Receipts, 1924-2006." Economic Research Service U.S. Department of Agriculture, 2008.
Estes, E.A. "Estimating Implicit Prices of Green Pepper Quality Characteristics Using Hedonic Techniques." Journal of Food Distribution Research 17, no. 2 (1986): 22-30.
Estes, E.A., and V.K. Smith. "Price, Quality, and Pesticide Related Health Risk Considerations in Fruit and Vegetable Purchases: A Hedonic Analysis of Tucson, Arizona Supermarkets." Journal of Food Distribution Research 27 (1996): 59-76.
ETC Group. 2005. Global Seed Industry Concentration-2005. September/October 2005, ETC Group, http://www.etcgroup.org/article.asp?newsid=524. (accessed February 2006).
FAO. "Appendix 3 - Classification of Crops." In World Program for the Census of Agriculture 2010, edited by Food and Agricultural Organization of the United Nations, 140-44. Rome: FAO, 2005.
Feldman, M. "Origin of Cultivated Wheat." In The World Wheat Book, edited by Alain P. Bonjean and William J. Angus, 3-56. Paris: Tec & Doc, 2001.

Ferleger, L. (ed.). Agriculture and National Development: Views on the Nineteenth Century, The Henry A. Wallace Series on Agricultural History and Rural Studies. Ames: Iowa State University Press, 1990.
Fernandez-Cornejo, J. "The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development." 1-71. Washington, DC: Economic Research Service, U.S. Department of Agriculture, 2004.
Fernandez-Cornejo, J., and R.E. Just. "Researchability of Modern Agricultural Input Markets and Growing Concentration." American Journal of Agricultural Economics 89, no. 5 (2007): 1269-75.
Fossum, T.M. "Horticultural Specialties: A Neglected Segment of U. S. Agriculture." Journal of Farm Economics 35, no. 4 (1953): 622-28.
Fowler, C. "The Plant Patent Act of 1930: A Sociological History of Its Creation." Journal of the Patent and Trademark Office Society 82, no. 9 (2000): 621-44.
Fowler, C. Unnatural Selection: Technology, Politics, and Plant Evolution. Switzerland: Gordon and Breach, 1994.
Frazao E. (ed.). America's Eating Habits: Changes and Consequences. Washington D.C.: Economic Research Service, United States Department of Agriculture, 1999.
Fuglie, K., N. Ballenger, K. Day, C. Klotz, M. Ollinger, J. Reilly, U. Vasavada, and J. Yee. "Agricultural Research and Development: Public and Private Investments under Alternative Markets and Institutions." 88. Washington D.C.: Economic Research Service, U.S. Department of Agriculture, 1996.
Gaff, R. "Floriculture Sales Drop 4 Percent in 2006." GMPRO, December 2007.
Gallini, N. "Patent Policy and Costly Imitation." The RAND Journal of Economics 23, no. 1 (1992): 52-63.
Gaskins, Jr., D.W. "Dynamic Limit Pricing: Optimal Pricing under Threat of Entry." Journal of Economic Theory 3 (1971): 306-22.
Gilbert, R., and C. Shapiro. "Patent Policy and Costly Imitation." The RAND Journal of Economics 21, no. 1 (1990): 106-12.
Gioia, V.G. "Plant Patents--R.I.P." Journal of the Patent and Trademark Office Society 79, no. 7 (1997): 516-28.
Gioia, V.G. "Protection through Patents." American Nurseryman 184, no. 7 (1996).
Godden, D. "Growing Plants, Evolving Rights: Plant Variety Rights in Australia." Agribusiness Rev. 6 (1998): 1-54.
Grávalos, E., A. Garcia, and J.C. Carlos. "Seminis Vegetable Seeds Monograph." In PITA project policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-27: European Commission, 2000.
Green, J.R., and S. Scotchmer. "On the Division of Profit in Sequentioal Innovation." RAND Journal of Economics 26, no. 1 (1995): 20-33.
Green, W.H. Econometric Analysis. 5th ed. New Jersey: Prentice Hall, 2003.
Griliches, Z. "Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change." In The Price Statistics of the Federal Government, 137-96. New York: National Bureau of Economic Research, 1961.

Griliches, Z. "Hybrid Corn: An Exploration in the Economics of Technological Change." Econometrica 25 (1957): 501-22.

Griliches, Z. "Market Value, R&D and Patents." Econ. Letters 7 (1981): 183-87.

Griliches, Z. "Patent Statistics as Economic Indicators: A Survey." In R&D and Productivity: The Econometric Evidence, 287-343. Chicago: The University of Chicago Press, 1990.

Griliches, Z. R&D and Productivity: The Econometric Evidence. Chicago: The University of Chicago Press, 1998.

Griliches, Z., B.H. Hall, and A. Pakes. "R&D, Patents, and Market Value Revisited: Is There a Second (Technological Opportunity) Factor?" Economics of Innovation and New Technology 1 (1991): 183-201.

Grossman, G.M., and C. Shapiro. "Informative Advertising with Differentiated Products." The Review of Economic Studies 51, no. 1 (1984): 63-81.

Haeger, J.W., and K. Storchmann. "Prices of American Pinot Noir Wines: Climate, Craftmanship, Critics." Agricultural Economics 35 (2006): 67-78.

Hall, B.H. "Exploring the Patent Explosion." Journal of Technology Transfer 30, no. 1/2 (2005): 35-48.

Hall, B.H., and R.H. Ziedonis. "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995." Rand Journal of Economics 32, no. 1 (2001): 101-28.

Hall, C.R., A.W. Hodges, and J.J. Haydu. "Economic Impacts of the Green Industry in the United States: Final Report to the National Urban and Community Forestry Advisory Committee." 1-88. Gainesville, FL: University of Florida IFAS Extension, 2005.

Halvorsen, R., and R. Palmquist. "Interpretation of Dummy Variables in Semilogarithmic Equations." American Economic Review 70 (1980): 474-75.

Hamrick, D. "The State of Breeder's Rights." FloraCulture International, February 2004: 1-3.

Hansen, L., and M. Knudson. "Property Right Protection of Reproducible Genetic Material." Review of Agricultural Economics 18, no. 3 (1996): 403-14.

Hardy, M.A. *Regression with Dummy Variables*. Edited by Michael S. Lewis-Beck, *Quantitative Applications in the Social Sciences*. Newbury Park: Sage Publications, 1993.

Harlan, J.R. Crops & Man. Madison, WI: American Society of Agronomy Crop Science Society of America, 1975.

Hartmann, H.T., D.E. Kester, F.T. Davies Jr., and R.L. Geneve. Plant Propagation: Principles and Practices. Seventh ed. New Jersey: Prentice Hall, 2002.

Hausman, J., B.H. Hall, and Z. Griliches. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship." Econometrica 52, no. 4 (1984): 909-38.

Heckman, J.J., R. Matzkin, and L.P. Nesheim. "Nonparametric Estimation of Nonadditive Hedonic Models." unpublished (2005).

Heckman, J.J., R. Matzkin, and L.P. Nesheim. "Simulation and Estimation of Nonadditive Hedonic Models." National Bureau of Economic Research Working Paper Series, 103. Cambridge, 2003.
Heller, M., and R.S. Eisenberg. "Can Patents Deter Innovation? The Anticommons in Biomedical Research." Science, May 1998 1998, 698-701.
Heisey, P.W., C.S. Srinivasan, and C. Thirtle. "Public Sector Plant Breeding in a Privatizing World." 19. Washington D.C.: Economic Research Service, U.S. Department of Agriculture, 2001.
Hendrickx, J. Coldiag2: Stata Module to Evaluate Collinearity in Linear Regression. Boston College Department of Economics, Boston, 2004.
Higginbotham, J.S. "Four Centuries of Planting and Progress: A History of the U.S. Nursery Industry." American Nurseryman 171, no. 12 (1990): 36-59.
Huang, C.L., and L. Biing-Hwan. "A Hedonic Analysis on the Impllicit Values of Fresh Tomatoes." Paper presented at the International Association of Agricultural Economists Conference, Gold Coast, Australia 2006.
Isaacson, R.T., (ed). Andersen Horticultural Library's Source List of Plants and Seeds. 4th Ed. 4th ed. Minneapolis: Andersen Horticultural Library, University of Minnesota, 1987, 1989, 1993, 1996, 2000, 2004 & 2008.
Isaacson, R.T., and K. Allen, (eds.). "Plant Information Online." Andersen Horticultural Library, University of Minnesota, 2008.
ISF. "Estimated Value of the Domestic Seed Market in Selected Countries." Nylon, Switzerland: International Seed Federation, 2008.
Janick, J., and I.L. Goldman. "Horticulture, Horticultural Science, and 100 Years of Asha." HortScience 38, no. 5 (2003): 883-900.
Janis, M.D., and J.P. Kesan. "U.S. Plant Variety Protection: Sound and Fury...?" Houston Law Review 39, no. 2 (2002): 727-78.
Janis, M.D., and J.P. Kesan. "U.S. Plant Variety Protection: Sound and Fury...?" Houston Law Review 39, no. 2 (2002): 727-78.
Jerardo, A. "Floriculture and Nursery Crops Situation and Outlook Yearbook." Economic Research Service. Washington D.C.: U.S. Department of Agriculture, 2007.
Juma, C. The Gene Hunters. Princeton: Princeton University Press, 1989.
Just, R.E., and D.L. Heuth. "Multimarket Exploitation: The Case of Biotechnology and Chemicals." American Journal of Agricultural Economics 75, no. 4 (1993): 936-45.
Kader (ed.), A.A. Postharvest Technology of Horticultural Crops. Oakland: University of California, Agriculture and Natural Resources, Publication 3311. 2002.
Kiewiet, B. 2006. Developments as Regards the Community PVR System. Community Plant Variety Office, http://www.cpvo.fr/default.php?res=1&w=1015&h=523&lang=en&page=../documents/articles/index.php and http://www.cpvo.europa.eu/. (accessed May 29, 2006).
Kihlstrom, R.E., and M.H. Rordan. "Advertising as a Signal." The Journal of Political Economy 92, no. 3 (1984): 427-50.

King, J.L. "Concentration and Technology in Agricultural Input Industries." 1-13. Washington D.C.: United States Department of Agriculture, Economic Research Service, 2001.
Kitchen, J. W., and W.S. Hendon. "Land Values Adjacent to an Urban Neighborhood Park." Land Economics 43 (1967): 157-360.
Klemperer, P. "How Broad Should the Scope of Patent Protection Be?" The RAND Journal of Economics 21, no. 1 (1990): 113-30.
Knudson, M., and C.E. Pray. "Plant Variety Protection, Private Funding, and Public Sector Research Priorities." American Journal of Agricultural Economics 73, no. 3 (1991): 882-86.
Kondo, Y., and M. Lee. "Hedonic Price Index Estimation under Mean-Independence of Time Dummies from Quality Characteristics." The Econometrics Journal Online 6, no. 1 (2003): 28-45.
Koo, B., C. Nottenberg, and P.G. Pardey. "Plants and Intellectual Property: An International Appraisal." Science 306 (2004): 1295-97.
Koo, B., P.G. Pardey, and J. Drew. "Protecting Plant Varieties in the United States: Institutional Development and Changing Structure." International Food Policy Research Institute (IFPRI)/University of Minnesota Department of Applied Economics, Working Paper, in preparation, 2010a.
Koo, B., P.G. Pardey, and J. Drew. "Protecting Plant Varieties in the United States: Tests of Structural Change." International Food Policy Research Institute (IFPRI)/University of Minnesota Department of Applied Economics, Working Paper, in preparation, 2010b.
Koo, B., P.G. Pardey, and J. Drew. "Protecting Plant Varieties in the United States: Changing Trend of Concentration." International Food Policy Research Institute (IFPRI)/University of Minnesota Department of Applied Economics Working Paper, in preparation, 2010c.
Kortum, S., and J. Lerner. "What Is Behind the Recent Surge in Patenting." Research Policy 28 (1999): 1-22.
Ladd, G.W., and M.B. Martin. "Prices and Demands for Input Characteristics." American Journal of Agricultural Economics 58, no. 1 (1976): 21-30.
Ladd, G.W., and V. Suvannunt. "A Model of Consumer Goods Characteristics." Amererican Journal of Agricultural Economics 58, no. 3 (1976): 504-10.
Lancaster, K.J. "A New Approach to Consumer Theory." The Journal of Political Economy 74 (1961): 132-57.
Landes, W.M., and R.A. Posner. "Trademark Law: An Economic Perspective." Journal of Law and Economics 30, no. 2 (1987): 265-309.
Lanjouw, J.O. "Patent Protection in the Shadow of Infringement: Simulation Estimations of Patent Value." The Review of Economic Studies 65, no. 4 (1998): 671-710.
Lee, H, and S.C. Blank. "A Statistical Profile of Horticultural Crop Farm Industries in California." 1-55: University of California, Davis, 2004.
Leibenluft, R.F. "Competition in Farm Inputs: An Examination of Four Industries." edited by Office of Policy Planning United States Federal Trade Commission, i-163: Government Printing Office, 1981.

Lemarié, S. "Pioneer Hi-Bred International Monograph." In PITA project policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-24: European Commission, 2000.
Lemley, M.A. "The Modern Lanham Act and the Death of Common Sense." The Yale Law Journal 108, no. 7 (1999): 1687-715.
Lesser, W. "The Impacts of Seed Patents." North Central Journal of Agricultural Economics 9, no. 1 (1987): 37-48.
Lesser, W. "Valuation of Plant Variety Protection Certificates." Review of Agricultural Economics 16, no. 2 (1994): 231-38.
Lesser, W. "Assessing the Implications of Intellectual Property Rights on Plant and Animal Agriculture." American Journal of Agricultural Economics 79, no. 5 (1997): 1584-91.
Lesser, W. "Intellectual Property Rights and Concentration in Agricultural Biotechology." AgBioForum 1, no. 1 (1998): 56-61.
Lesser, W., and M. Mutschler. "Lessons from the Patenting of Plants." In Intellectual Property Rights in Animal Breeding and Genetics, edited by Max Rothschild and Scott Newman, 103-18. New York: CABI Publishing, 2002.
LexisNexis Academic, Business News, Mergers and Acquisitions, 1997-2007. http://web.lexis-nexis.com. (accessed Spring 2007).
Liedl, B.E., and N.O. Anderson. "Reproductive Barriers: Identification, Uses and Circumvention." Plant Breeding Reviews 1 (1993): 11-154.
Luby, J. "Fruit-Breeding at the University of Minnesota." 1-3. Saint Paul: University of Minnesota, 2006.
Luby, J. (2006). personal interview. J. Drew. Saint Paul.
Lucier, G., S. Pollack, M. Ali, and A. Perez. "Fruit and Vegetable Backgrounder." In Electronic Outlook Report of the Economic Research Service, edited by United States Department of Agriculture Economic Research Service, 1-56. Washington: United States Department of Agriculture, 2006.
Lyon-Jennes, C. "Planting a Seed: The Nineteenth Century Horticultural Boom in America." The Business History Review 78, no. 3 (2004): 381-421.
Machlup, Fritz, and Edith Penrose. "The Patent Controversy in the Nineteenth Century." The Journal of Economic History 10, no. 1 (1950): 1-20.
Marco, A.C., and G. C. Rausser. "The Role of Patent Rights in Mergers: Consolication in Plant Biotechnology." American Journal of Agricultural Economics 90, no. 1 (2008): 133-51.
McCown, B.H. "Biotechnology in Horticulture: 100 Years of Application." HortScience 38, no. 5 (2003): 1026-30.
Mendel, K. "The History of Plant Propagation Methods During the Last 70 Years." Acta Horticulturae 314 (1992).
Mergerstat review / Chicago, Ill. : W.T. Grimm & Co., 1989-1994.
Mergerstat review / Chicago, Ill. : W.T. Grimm & Co., 1996-2006.
Merges, R.P., and G. Nelson. "On the Complex Economics of Patent Scope." Columbia Law Review 90 (1990): 839-916.

Messer, E. "II.A.4 Maize." In The Cambridge World History of Food, edited by K.F. Kiple and K.C. Ornelas, 97-111. New York: Cambridge University Press, 2000.
Miller, M.N. "Double Duty, Double Detail." Grower Talks 64, no. 3 (2003): 90-108.
Miller, M.N. "Floriculture Industry Overview: Production, Sales and Marketing in North America." Acta Horticulturae 543 (2001): 23-29.
Miller, M.N. "Opportunities and Challenges for Floricultural Producers Selling to a Changing Marketplace." In Agricultural Outlook Forum 2003: United States Department of Agriculture, 2003.
Mowery, D.C., R.R. Nelson, B.N. Sampat, and A.A. Ziedonis. "The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980." Research Policy 30, no. 1 (2001): 99-119.
Nelson, P. "Information and Consumer Behavior." The Journal of Political Economy 78, no. 2 (1970): 311-29.
Nelson, P. "Advertising as Information." Journal of Political Economy 82, no. 4 (1974): 729-54.
Nelson, P. "Advertising as Information Once More." In Issues in Advertising: The Economics of Persuasion, edited by D.G. Tuerck, 133-60. Washington, DC: American Enterprise Institute for Public Policy Research, 1978.
Netusil, N.R., and B. Bolitizer. "The Impact of Open Space on Property Values in Portland Oregon." Journal of Environmental Management 59 (2000): 185-93.
Nordhaus, W.D. Invention, Growth, and Welfare. Cambridge: The M.I.T. Press, 1969.
Oczkowski, E. "A Hedonic Price Function for Australian Premium Table Wine." Australian Journal of Agricultural Economics 81, no. 5 (1994): 93-110.
O'Donoghue, T. "A Patentability Requirement for Sequential Innovation." RAND Journal of Economics 29, no. 4 (1998): 654-79.
O'Donoghue, T., S. Scotchmer, and J. F. Thisse. "Patent Breadth, Patent Life and the Pace of Technological Progress." Journal of Economics and Management Strategy 7 (1998): 1-32.
Oehmke, J.F., C.A. Wolf, and K.C. Raper. "On Cyclical Industry Evolution in Agricultural Biotechnology R&D." Journal of Agricultural & Food Industrial Organization 3, no. 2 (2005): Article 1.
Pakes, A. "On Patents, R&D, and the Stock Market Rate of Return." Journal of Political Economy 93, no. 2 (1985): 390-409.
Pakes, A. "A Reconsideration of Hedonic Price Indexes with an Application to PC's." American Journal of Agricultural Economics 93, no. 5 (2003): 1578-96.
Pakes, A, and Z. Griliches. "Patents and R&D at the Firm Level: A First Look." In R&D, Patents and Productivity, edited by Zvi Griliches, 55-72. Chicago: The University Chicago Press, 1984.
Pakes, A., and M. Schankerman. "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources." In R&D, Patents and Productivity, edited by Zvi Griliches, 73-88. Chicago: The University of Chicago Press, 1984.
Palmquist, R.B. "Estimating the Demand for the Characteristics of Housing." The Review of Economics and Statistics 66, no. 3 (1984): 394-404.

Pardey, P.G., B. Koo, and C. Nottenburg. "Creating, Protecting, and Using Crop Biotechnologies Worldwide in an Era of Intellectual Property." 1-42. St. Paul, Washington D.C.: World Intellectual Property Organization (WIPO), 2003.
Penna, A.L. da Rocha. "An Analysis of the Impact of Plant Breeders' Rights Legislation on the Introduction of New Varieties in Uk Horticulture." Ph.D. dissertation, University of London, 1994.
Perrin, R.K., K.A. Kunnings, and L.A. Ihnen. "Some Effects of the Us Plant Variety Act of 1970." Raleigh, NC: North Carolina State University, 1983.
Pfeiffer, T.W. "From Classical Plant Breeding to Modern Crop Improvement." In Plants, Genes, and Crop Biotechnology, edited by Maarten J. Chrispeels and David E. Sadava, 360-89. Boston: Jones and Bartlett, 2003.
Plant, A. "The Economic Theory Concerning Patents for Inventions." Economica 1, no. 1 (1934): 30-51.
Pollack, S., and A. Perez. "Fruit and Tree Nut Situation and Outlook Yearbook." Washington DC: Economic Research Service, U.S. Department of Agriculture, 2008.
Potera, Carol. "Blooming Biotech." Nature Biotechnology 25, no. 9 (2007): 963-65.
PVPO. "Rules and Regulations." Washington D.C.: Agricultural Marketing Service United States Department of Agriculture, 2003.
PVPO. 2006. Plant Variety Protection Office (PVPO) - How to Apply: Application Requirements. United States Department of Agriculture. (accessed 10/31/2006).
Quick, J. "Intellectual Property: Plants Patentable under the Utility Patent Statute, PPA, and PVPA ." Journal of Law, Medicine & Ethics 30, no. 2 (2002): 317-18.
Rangnekar, D. "R&D Appropriability and Planned Obsolescence: Empirical Evidence from Wheat Breeding in the UK (1960-1995)." Industrial and Corporate Change 11, no. 5 (2002): 1011-29.
Rausser, G.C., S. Scotchmer, and L.K. Simon. "Intellectual Property and Market Structure." CUDARE Working Paper, 1-50: Department of Agricultural and Resource Economics, UCB, 1999.
Requena-Silvente, F., and J. Walker. "Calculating Hedonic Price Indices with Unobserved Product Attributes: An Application to the UK Car Market." Economica 73 (2005): 509-32.
Rosen, S. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." The Journal of Political Economy 82, no. 1 (1974): 34-55.
Ruder, T., and T. To. "Brand Dummy Variables in Hedonic Regressions: A Study Using Stereo Receiver Scanner Data." 21. Washington D.C.: U.S. Bureau of Labor Statistics, 2004.
Ruttan, V.W. Technology, Growth, and Development: An Induced Innovation Perspective. New York: Oxford University Press, 2001.
Samuelson, P. A. "Prices of Factors and Goods in General Equilibrium." The Review of Economic Studies 21, no. 1 (1953): 1953.
Schamel, G. "International Wine Trade: Analyzing the Value of Reputation and Quality Signals." Paper presented at the AAEA Annual Meeting, Berlin, Germany, May, 2003.

Schamel, G., and K. Anderson. "Wine Quality and Varietal, Regional and Winery Reputations: Hedonic Prices for Australia and New Zealand." Economic Record 79, no. 246 (2003): 257-69.
Scherer, F.M. "Nordhaus' Theory of Optimal Patent Life: A Geometric Reinterpretation." *The American Economic Review* 62, no. 3 (1972): 422-27.
Scherer, F.M. Industrial Market Structure and Economic Performance. second ed. Chicago: Rand McNally College Publishing Company, 1988.
Schimmelpfennig, D.E., C.E Pray, and M.F. Brennan. "The Impact of Seed Industry Concentration on Innovation a Study of US Biotech Market Leaders." Agricultural Economics 20 (2004): 157-67.
Schoellhorn, R. "Strategies for Plant Introduction and Market Trends in the US." Acta Horticulturae 813 (2009): 101-06.
Scotchmer, S. "On the Optimality of the Patent Renewal System." RAND Journal of Economics 30 (1999): 181-96.
Scotchmer, S. Innovation and Incentives. London: MIT Press, 2004.
Seay, N.J. "Patenting Plants." American Intellectual Property Law Association Quarterly Journal 16 (1989): 418-41.
Seedquest®. 2009. Global Information Services for Seed Professionals (1997-2009), http://www.seedquest.com/News.htm. (accessed Spring 2007 and Fall 2008).
Shavell, S., and T. Van Ypersele. "Rewards versus Intellectual Property Rights." The Journal of Law and Economics 44 (2001): 525-47.
Singh, S.P. "The Changing Structure of the U.S. Green Industry: Factors Influencing Opportunities and Issues." Journal of International Food & Agribusiness Marketing 10, no. 2 (1999): 65-83.
Sjulin, T.M. "The North American Small Fruit Industry 1903-2003. II. Contributions of Public and Private Research in the Past 25 Years and a View to the Future." HortScience 38, no. 5 (2003): 960-197.
Smith, M.S. "Chronological Landmarks in Agriculture." 1-103. Washington D. C.: United States Department of Agriculture, 1979.
Stallmann, J.I. "Impacts of the 1930 Plant Patent Act on Private Fruit Breeding Investment." Ph.D dissertation, Michigan State University, 1986.
Stallmann, J.I. "Plant Patents & Public Research Priorities." Choices 5, no. 3 (1991): 8-11.
STATA® Statistics/Data Analysis Version 10. StataCorp, College Station, Texas (2007).
Steiner, B.E. "Australian Wines in the British Wine Market-a Hedonic Price Analysis." Agribusiness 20, no. 3 (2004): 287-307.
Stigler, G.J. "The Economics of Information." The Journal of Political Economy 69, no. 3 (1961): 213-25.
Still, S.M. Manual of Herbaceous Ornamental Plants. Fourth ed. Champaign: Stipes Publishing L.L.C., 1994.
Sutter, E. 2006. Micropropagation. In, University of California-Davis, http://trc.ucdavis.edu/egsutter/plb171/lecturespdf4/13-Micropropagation.pdf. (accessed 9/13/2006, 2006).

Tait, J., and J. Chataway. "Novartis Agribusiness Monograph." In PITA project policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-42: European Commission, 2000.
Tait, J., and J. Chataway. "Zeneca Agribusiness Monograph." In PITA project policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-42: European Commission, 2000.
Tait, J., J. Chataway, and D. Weild. "Final Report." In PITA project policy influences on technology for agriculture: chemicals, biotechnology and seeds, 1-86: European Commission, 2001.
Thomas, J. R. "Plants, Patents, and Seed Innovation in the Agricultural Industry." 1-20: Congressional Research Service, 2002.
Unwin, T. "Hedonic Price Indexes and the Qualities of Wines." Journal of Wine Research 10, no. 2 (1999): 95-104.
UPOV. "UPOV Report on the Impact of Plant Variety Protection." edited by International Union for the Protection of New Varieties of Plants, 2005.
USDA (United States Department of Agriculture), National Agricultural Statistics Service. “1998 Census of Horticultural Specialties.” In 1997 Census of Agriculture. Volume 3, Special Studies Part 2: Government Printing Office, 2000.

USDA (United States Department of Agriculture), National Agricultural Statistics Service. "Nursery Crops 2000 Summary." Sp Cr 6-2. Washington, 2001
USDA. History of Research at the U.S. Department of Agriculture and Agricultural Research Service. Agricultural Research Service, U.S. Department of Agriculture, http://www.ars.usda.gov/is/timeline/comp.htm. (accessed Dec. 28, 2008).
USDL, BLS. 2010. "Consumer Price Index History Table." United States Department of Labor, Bureau of Labor Statistics, http://www.bls.gov/CPI/#tables. (accessed 2/2/2010).
USPTO. "Trademark Electronic Search System (TESS)." United States Patent and Trademark Office, 2009.
USPTO. 2003. USPTO Fees - FY 2003. In, United States Patent and Trademark Office, http://www.bannerwitcoff.com/press_releases/ptcfees.pdf. (accessed 7/16/2006).
USPTO. 2006. Changes to Patent Fees under the Consolidated Appropriations Act, 2005 (H.R. 4818/P.L. 108-447). In, United States Patent and Trademark Office, http://www.uspto.gov/main/howtofees.htm and http://www.uspto.gov/web/patents/hr4818/caatext.html. (accessed July 2006).
USPTO. 2006. Manual of Patent Examining Procedure (MPEP). Eighth Edition, Revision 4, United States Patent and Trademark Office, http://www.uspto.gov/web/offices/pac/mpep/index.htm. (accessed 7/10/2006, 2006).
UPOV. 2010. The UPOV System of Plant Variety Protection. In, International Union for the Protection of New Varieties of Plants (UPOV), http://www.upov.int/en/about/upov_system.htm. (accessed Feb. 2010).

Waugh, F.V. "Quality Factors Influencing Vegetable Prices." Journal of farm Economics 10, no. 2 (1928): 185-96.

Weitzman, M.L. "Price Vs. Quantities." Review of Economic Studies 41, no. 4 (1974): 477-91.

Wield, D. (director). "Multinational Company (MNC) Monographs and Overview - Reports " In Policy Influences on Technology for Agriculture: Chemicals, Biotechnology and Seeds (PITA) 2000/2001.

Wilson, W.W. "Hedonic Prices in the Malting Barley Market." Western Journal of Agricultural Economics 9, no. 1 (1984): 29-40.

WIPO. 2006. WIPO Treaties-General Information. World Intellectual Property Organization, http://www.wipo.int/treaties/en/general/. (accessed 20/29/2006).

Wright, B. "The Economics of Invention Incentives: Patents, Prizes, and Research Contracts." American Economic Review 73, no. 4 (1983): 691-707.

Wright, B.D, and P.G. Pardey. "Changing Intellectual Property Regimes: Implications for Developing Country Agriculture." International Journal of Technology and Globalization 2, no. 1/2 (2006): 93-114.

Wright, B.D., and P.G. Pardey. "The Evolving Rights to Intellectual Property Protection in the Agricultural Biosciences." International Journal of Technology and Globalization 2, no. 1/2 (2006): 12-29.

Wright, B.D., P.G. Pardey, C.N., and B. Koo. "Agricultural Innovation: Economic Incentives and Institutions." In *Handbook of Agricultural Economics*, edited by R.E. Evenson, P. Pingali and T.P. Schultz. Amsterdam: Elsevier, 2007.

Zeleny, T. "Property Rights in Living Things: Difficulties with Reproduction and Infringement" Sand Diego Justice Journal 2, no. 1 (1994): 209-37.

Zimmerman, R.H. "Status of the Commercial Micropropagation Industry." Paper presented at the Combined Proceedings International Plant Propagators' Society, 2001.

Zimmerman, R.H., and J.B. Jones. "Commercial Micropropagation in North America." In Micropropagation, edited by P.C. Debergh and R.H. Zimmerman, 173-79. Dordrecht: Kluwer Academic Publishers, 1991.

Appendix A: The Evolving U.S. Regulatory Framework for Intellectual Property Rights for Plants

Date	Legislation, ruling, or event	Notes
1789	The United States Constitution (Article 1, Section 8)	The constitution gives the US Congress powers to grant intellectual property (IP) rights.
1790	Patent Act of 1790 (P.L. 82-593, 66 Stat. 792 (codified at Title 35 U.S.C.)	The first intellectual property rights did not include plant varieties because they were "products of nature."
1862	Congress establishes the U.S. Department of Agriculture (Act of May 15, 1862, ch. 72, 12 Stat. 387)	This legislation mandated that the USDA "collect new and valuable seeds and plants: to propagate such as may be worthy of propagation: and to distribute them among agriculturalists." This mandate was thought by many to be antithetical to the intellectual property rights of the seed industry. (Thomas 2002)
1862	Morrill Land-Grant College Act. (Act of July 2, 1862, ch. 130, 12 Stat. 503, 503-505)	Established land grant colleges as agricultural research institutions, and to provide new varieties of seed in conjunction with USDA. (Smith 1979)
1883	Paris Convention for the Protection of Industrial Property of 1883	An attempt to "harmonize" IP regimes of its 100 member countries. (Fernandez-Cornejo 2004)
1906-1910	A series of bills were introduced to establish patent-like rights to horticultural products, but none passed	These were unorganized attempts of the industry to appropriate rights over new varieties. (Janis and Kesan 2003)
1923	The American Association of Nurserymen (AAN) organized efforts to gain varietal protection along with American Seed Trade Association (ASTA) and the Society of American Florists.	Paul Stark of Stark Brothers Nurseries had intellectual property legislation written that excluded sexually reproducing plants as a strategy to make it more acceptable. (Fowler 1994)
1930	The Townsend-Purcell Plant Patent Act (46 Stat. 376 (1930) (codified at 35 U.S.C. § 161-164))	The first legislation to give IP rights to plant breeders for asexually reproduced plants. Exclusivity rights for 17 years. Coverage does not extend to seeds or seedlings of plant patented plants. The new variety must be distinct and nonobvious. (Chisum 2002)
1939	Federal Seed Act (7 U.S.C. § 1551-1611)	"An act to regulate interstate and foreign commerce in seeds: to require labeling and to prevent misrepresentation of seeds in interstate commerce: to require certain standards with respect to certain imported seeds and for other purposes." (Butler and Marion 1985)
1946	Trademark Act (Lanham Act) (15 U.S.C. § 1127)	Federal statutes of trademark law
1952	Patent Act of 1952 (P.L. 82--593 , 66 Stat. 792)	This act extends patent rights to agricultural innovations, opening the door to biotechnology and genetic engineered innovations. Thus including "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvements thereof." (Thomas 2002)
1953	German Seed Act	This act granted patent like variety protection for original varieties that were stable and nonobvious, but had a breeder's exemption. (Janis and Kesan 2003)
1954	Amendment to the Plant Patent Act (Act of Sept. 3, 1954, P.L. 83-775, 68 Stat. 1190)	This amendment allows for chance seedlings and mutants found in an uncultivated state to be covered by the plant patent. (Chisum 2002)

continued-next page

Appendix A: The Evolving US Regulatory Framework for Intellectual Property Rights for Plants-cont.

Date	Legislation, ruling, or event	Notes
1961	International Union for the Protection of New Varieties of Plants (UPOV) was established for member countries.	This instituted a version of the German Seed Act for member countries. For varieties that were novel, distinct, uniform and stable. (Janis and Kesan 2003)
1964	The UK established plant breeder's rights legislation	This legislation established a legal language for such IP rights. (Butler and Marion 1985)
1960s	The American Seed Trade Association (ASTA) developed a lobby power.	Their objective was to extend IP rights to open-pollinated plant varieties. (Fowler 1994)
1969	Legislation that was to become the PVPA was written by an ASTA patent lawyer.	US industry is influential in establishing law. (Fowler 1994)
1970	The Plant Variety Protection Act (PVPA) (7 U.S.C. §2321-2583)	This act grants breeders of open-pollinated varieties, and tuber propagated plants a Certificate of Protection and gives 17 years of exclusive rights. Researchers and farmers are exempt from this exclusivity. New varieties must be new, distinct, uniform and stable. (Chisum 2002)
1970	Patent Cooperation Treaty (PCT) administered by the World Intellectual Property Organization (WIPO)	Intent is to simplify the process for obtaining international IP rights so a breeder filing in a national office could designate filings with multiple member nation states. (WIPO 2006)
1976	*Yoder Brothers, Inc. v. California-Florida Plant Corp.* (573 F.2d 1347, 193 USPQ § 264 (5th Cir. 1976))	A federal court of appeals upheld a decision that ruled that there was no meaningful way to decide if a new variety was nonobvious to qualify for the plant patent. (Chisum 2002)
1980	Amendment to the Plant Variety Protection Act (96 P.L. 574; 94 Stat. 3350, (codified at 7 U.S.C. § 2321 et seq))	This amendment extended the term from 17 to 18 years and added the previously excluded "soup vegetables" of: okra, carrots, celery, tomatoes, peppers, and cucumbers to the list of varieties covered by the Plant Variety Protection Act.
1980	U.S. Supreme Court decision in *Diamond v. Chakrabarty* (447 U.S. 303; 100 S. Ct. 2204 (1980))	This ruling extends patent rights to genetically engineered microorganisms. (Fernandez-Cornejo 2004)
1980	Bayh-Dole Act (P.L. 97-517, (codified at 35 U.S.C. § 200-212))	This act allows US universities, small businesses and non-profits to own intellectual property rights for inventions that resulted from federal government-funded research. (Mowery and Nelson et al. 2001)
1980	Renewal fees for utility patents	Renewal fees or maintenance fees are instituted for utility patents that are paid 3½, 7½ and 11½ years after the grant of the patent. (USPTO 2003, 2006)
1982	The establishment of the Court of Appeals for the Federal Circuit	This strengthened patent rights by strengthening the judicial treatment of patent rights. (Hall and Ziedonis 2001)
1985	*Ex parte Hilbberd* (227 U.S.P.Q. 443 (P.T.O. Bd. App. & Inter. 1985))	This ruling for the appeal of the case *Diamond v. Chakrabarty* held that seeds, plants, and tissue cultures were patentable. (Seay 1989)

continued-next page

Appendix A: The Evolving US Regulatory Framework for Intellectual Property Rights for Plants-cont.

Date	Legislation, ruling, or event	Notes
1986	Uruguay Round of the General Agreement on Tariffs and Trade (GATT)	Established trade-related aspects of intellectual property rights (TRIP) that required members of the World Trade Organization to adopt a system of intellectual property rights for plant varieties.
1991	The 1991 Act of the UPOV Convention	This act designates three exemptions to breeder's rights: a non-commercial purposes exception, Experimental purposes exception and a breeder's exception, as well as an optional farmer's seed saving exception. This act also allows for dual protection of a patent and UPOV breeder's rights. (Janis and Kesan 2003)
1994	The 1994 Act amendment to the Plant Variety Protection Act (effective April 1995) (P.L. 103-349 amended section generally, subsections (a)-(j))	This amendment "harmonizes" US IP plant protection with UPOV and GATT. Plant Variety Protection Act rights are extended to 20 years for non-woody species and to 25 years for woody species. Farmers are precluded from selling seed of protected varieties. Potatoes and F1 hybrids become eligible for the Plant Variety Protection Certificate. (Chisum 2002)
1994	Amendment to The Townsend-Purcell Plant Patent Act	Also, harmonizes US IP plant protection with UPOV and GATT. The plant patent term is extended from 17 to 20 years. (Gioia 1996)
1994	Federal District Court ruling in *Pioneer Hi-Bred International v. Holden* (31 USPQ2d 1385 (8th Cir. 1994))	This ruling established the genetics of inbred lines may be protected as trade secrets. (Chisum 2002)
1995	Community Plant Variety Office (CPVO) is established	This office was established to provide varietal rights throughout the European Union with one application. (Kiewiet 2006)
1995	The Federal Circuit Court decision in *Imazio Nursery Inc. v. Dania Greenhouse* (36 USPQ2d 1673 (Fed.Cir. 1995))	This ruling established that plant patents can only cover clonal copies of a plant patented plant, and requires patent owner to establish proof of genetic infringement. (Gioia 1996)
1995	Supreme Court decision in *Asgrow v. Winterboer* (513 U.S. 179; 115 S. Ct. 788)	This decision prohibited farmers from selling protected varieties without a license for varieties developed before 1994. (Zeleny 1994)
1995	Community Plant Variety patenting system	A European Union wide system through the Community Plant Variety Office, (CPVO), was instituted that allowed a breeder to gain IP rights for their variety in all member countries. (Kiewiet 2006)
1998	Plant Patent Amendments Act of 1998 (P.L. 105-289, 112 Stat. 2780 (Oct. 27, 1998), (codified at 35 U.S.C. § 154(a)(2)))	This amendment extended the plant patent's exclusionary rights to coverage plant parts in particular fruit and cut flowers. (Butcher 2003)
1999	Utility Patent No. 5,894,079 is granted for Enola popping bean	This began a number of controversies about the novelty requirement of the utility patent and the about the ethics of patenting cultivars derived from indigenous.
2001	US Federal Court of Appeals ruling in *J.E.M. Ag Supply, Inc v. Pioneer Hi-Bred* . (122 S. Ct. 593 596 (2001))	This ruling allows plant breeders may have multiple and concurrent IP rights, including a utility patent. (Quick 2002)
2008	Enola bean patent is rejected (April 2008)	

Source: Compiled by author

Appendix B: Comparison between the Different U.S. Plant Intellectual Property Rights and UPOV Breeder's Rights

	Utility Patent	Plant Patent	Plant Variety Protection Cert.	Breeder's Rights (UPOV)
Applicant	Inventor files	Inventor files	The principal is treated as a breeder so corporations may file for applications. (Chisum §24.05)	"The person who bred, or discovered and developed, a variety… The breeder might be a plantsman, a farmer, a company or a scientist" (UPOV 2006)
Applicant	Available to foreign nationals	Available to foreign nationals	Available without condition to UPOV treaty member nationals, and with condition of reciprocity to other foreign nationals (Chisum §24.03[1][a])	Available without condition to UPOV treaty member nationals
Requirements		A variety name is required since 1981 (Chisum §24.01)	The variety must be named (Chisum §24.03[3][b])	A variety name is required (Chisum §24.01)
Requirements	Novel	New as well as novel	New	New = Novel
Requirements		Distinct as well as novel (This is established by the USPTO with the assistance of the USDA (and the courts) using the description component of the application (Chisum §24.02[1] and §24.02[3]))	Distinct (This is established by the applicant in Exhibit B of the PVP application. (Chisum 24.03[3][b]))	Distinct (established by showing distinct from varieties that are common knowledge)
Requirements	Non-obvious	Non-obvious (It is widely acknowledged that this would be difficult to apply to the PP. (Seay 1989)) (Distinctiveness and asexual reproduction are regarded by the original legislators as substantive requirements for plants; furthermore inferior or superior characteristics are both acceptable for the PP, where superiority is regarded as important for nonobviousness. (Chisum §24.02[2][f]))	Can be obvious "[D]esirability is not a requirement for protection…"(Heart Seed Company Inc. v. Seeds Inc., 4USPQ2d 1324, 1325-26 (E.D. Wash. 1987)	
Requirements	Utility			
Requirements		Asexually reproduction clearly established		

Continued next page

Appendix B: Comparison between the different U.S. Plant Intellectual Property Rights and UPOV breeder's rights-cont.

	Utility Patent	Plant Patent	Plant Variety Protection Cert.	Breeder's Rights (UPOV)
Requirements	Disclosure is complete enough to allow recreation of the variety by one with knowledge of the art.	Restricted to clones only	Uniform & stable	Uniform & stable (a variety is uniform if near all propagated plants of a set are the same, and a variety is stable if repeated propagated sets display near the same uniform results)
Descriptions & Deposits	Enabling complete disclosure—seed deposit (required) can provide enabling disclosure (Exparte C, 27 USPQ2d 1492 (Bd. Pat. App. & Int'l 1993))	Disclosure as complete as possible, Drawings--specimens or inspections of the plant may be required Deposits of plant material not required.	Genealogy and breeding procedure if known (Chisum § 24.03[3][a]) Seed deposit (not accessible to the public), and a description of characteristics in general and specifically of characteristics that sets forth the distinctness and newness of the variety (Chisum 24.03[3][b])	"In the course of the examination, the authority may grow the variety or carry out other necessary tests, cause the growing of the variety or the carrying out of other necessary tests, or take into account the results of growing tests or other trials which have already been carried out."
Length of	20 yrs	20 yrs (more trees and vines are covered	20 yrs (25 yrs trees & vines)	20 yrs (25 yrs trees & vines)
Time of coverage	Rights conferred upon application	Rights conferred upon application	Rights conferred upon issuance or prior to issuance by distribution of seeds with a proprietary notice. (Chisum 24.03[4][a])	
Fees	Periodic fees	One time fees for application and issuance	One time fees for application and issuance	Fee structure may include periodic fees
Claims and coverage	Multiple claims can extent to "multiple parts of a plant, including genomes, coding for non-plant proteins, cells, and cell cultures, plant tissue and wholly differentiated plants." (Chisum)	The PP contains a single claim to the whole plant which is asexually reproduced (1998 extended to parts)	The PVPC can claim a sexually reproduced or tuber propagated plant variety, includes parts of plant used for reproduction (since 1994).	The plant variety, including seeds--includes parts of plant and tubers used for reproduction.
Varietal claims and coverage	Includes bacteria, fungi and F1 hybrids	Includes discoveries, sports, mutations, hybrids (in the broadest interpretation), and fungi	Includes tuber propagated plants and F1 hybrids since 1994 (Chisum 24.03[1][b])	
Varietal claims		Excludes bacteria, tuber propagated plants,	Excludes bacteria and fungi	

Continued next page

Appendix B: Comparison between the Different US Plant Intellectual Property Rights and UPOV Breeder's Rights-cont.

	Utility Patent	**Plant Patent**	**Plant Variety Protection Cert.**	**Breeder's Rights (UPOV)**
Claims and coverage	Doctrine of equivalents—covers all inventions with the same characteristics. A protected variety cannot be used to create a new variety except for basic	Covers single plant only varieties undistinguishable with the same genome are not infringing.	Since1994, the PVPA protects "essentially derived varieties" "hybrids created from protected plant varieties are also protected; however it is not infringement to use a protected variety for the development of a hybrid (534 U.S. at 139-40)." This means new inbred lines can be developed from a protected variety.	Covers: 1. varieties which are essentially derived from the protected variety, where the protected variety is not itself an essentially derived variety; 2. varieties which are not clearly distinguishable from the protected variety; and 3. varieties whose production requires the repeated use of the protected variety.
Infringement	Like the PVPC infringement includes unauthorized sexual and asexual reproduction for varieties claimed Chisum §24.05	Infringement is restricted to clones and fruit, flowers, and stems of clones of original plant.	Infringement includes unauthorized selling, importing, multiplying, using in producing another variety, and using the seed for propagating or distribution (and other related acts).	Infringement includes: 1. production or reproduction (multiplication), 2. conditioning for the purpose of propagation, 3. offering for sale, 4. selling or other marketing, 5. exporting, 6. importing, 7. stocking for any of the purposes mentioned in 1 to 6, above
Bar	Bar is for first to invent	Bar is for first to invent	Bar is for first to breed	Bar is for first to breed
Bar	Bar for plant used or sold 1 yr prior anywhere	Bar for plant known, used or sold 1 yr prior anywhere	Bar for plant used or sold 1 yr prior US and anywhere, since 1981 bar is for 4 yrs prior other than US (conform to UPOV)	

Continued next page

Appendix B: Comparison between the Different US Plant Intellectual Property Rights and UPOV Breeder's Rights-cont.

	Utility Patent	**Plant Patent**	**Plant Variety Protection Cert.**	**Breeder’s Rights (UPOV)**
Exemption	No farmer’s exemption	A farmer can save seed from a protected variety for their future crop but may not asexually propagate a protected variety for a future crop.	Farmer’s exemption	Subsistence farming “acts done privately and for non-commercial purposes” An optional provision known as the "farmers' privilege” is allowed if carefully regulated.
Exemption	Using a protected variety for breeding is an infringing act	Covers single plant only (plants can be used for breeding and developing new varieties)	Breeder’s exemption	“Acts done for the purpose of breeding other varieties and, for the purpose of exploiting these new varieties provided the new variety is not a variety essentially derived from another protected variety (the initial variety).”
Exemption	Research exemption	Research exemption	Research exemption	“acts done for experimental purposes”
Allowable State Interference			Compulsory licensing with equitable remuneration may be imposed for purposes of food security. (Chisum §24.03[4][a]	“Except where expressly provided in the Convention, no member of the Union may restrict the free exercise of a breeder's right for reasons other than of public interest.” (equitable remuneration is required)

Source: compiled by author

Note: PP denotes plant patent, PVPC denotes Plant Variety Protection Certificate

Appendix C: Value of Production Data Series

I. Value of Production data for the United States (2008)

Contributors: Philip G. Pardey and Julian M. Alston

Documentation and Sources

This dataset covers 215 commodities for the period 1924 to 2005 and was assembled using multiple sources.

1. For 72 commodities (see list in table 1), output quantity and price data were obtained from various publications of the United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS), in reports titled, Agricultural Statistics (Ag Stats), as well as data reported on the website of Cornell University (unless noted otherwise). Most of the quantity data are the reported quantities produced per state, and the price data are the state-specific prices received on farms. Some quantity data were derived implicitly from value and price data.

2. For greenhouse and nursery and marketing, there was no consistent series on quantities and prices for this output category. An implicit quantity series was derived using published value series in Census of Agriculture (Ag Census) and the Census of Horticulture and a constructed price index series by the authors. From 1949 to 1991, the following publications were used to construct the greenhouse and nursery and marketing price series:

This research uses a sub-set of the VOP data which excludes all farm animals and forest products. These data, which reflect the "farm gate" value of production, are used to compare the totals for agricultural crops and horticultural crops value. Agricultural crops include fiber, grain, oilseed, pasture and seed, sugar, tobacco and other field crops. Agricultural crops include fruit and nut, vegetable and nursery and greenhouse crops (ornamental crops). Because of the incomplete nature of the ornamental crops part of this data set, particularly for the nursery industry, and the importance of this group, this research uses several other sources to help to clarify the actual value trends within this group. These data are described below.

II. Ornamental value data

Ornamental crops mostly make up greenhouse and nursery crops which include a range of crops and products: floriculture (i.e., bedding and garden plants, cut flowers, cut cultivated greens, potted flowering plants, potted foliage plants, and propagative materials), nursery, sod and turf, vegetable seeds, floral seeds, bulbs and tubers, greenhouse grown fruit and vegetables, mushrooms and Christmas trees. Because this is an industry which has evolved and defined over the time period for this research, the statistical collection and presentation has also evolved over this period.

The nursery and greenhouse sector values have emerged from relative obscurity over time and products of this group have been mostly considered luxury products. As a result, these industries have been historically a low priority for statistical tracking compared to other horticultural crops and agricultural crops. For this industry, data collection has been plagued with inconsistent patterns of data collection, not being inclusive of all states and poor response rates to surveys. For example, bedding and garden plants until recent years did not include herbaceous perennial plants outside of hardy chrysanthemums. Herbaceous perennials had been included with nursery plants. Data presentation has not been consistent in its categorization of crops across time and industries and the accounting methods used for reporting (i.e., wholesale value, gross value and cash receipt value). An example is that the censuses for horticultural specialties for the years 1949 and 1959 were all converted to wholesale value making them inconsistent with the other censuses which were a total of wholesale and retail values.

As a result of these problems, no one source of data has proven reliable for capturing the trends and sources of growth in this sector (Fossum 1953, Singh 1999; Hall, Hodges, et al. 2005). Thus this research uses the following sources to paint a picture of the value trends in this industry.

Historical census data (USDA 2000)

The data series constructed by the USDA (2000) is comprised of totals for the specific ornamental sub-industries obtained for all the censuses for horticultural specialty crops from 1889 to 1998. In general, data from these censuses, for a variety of reasons, is not considered directly comparable. This aspect becomes clear from an examination of the many notes used to qualify the table entitled "Historical Highlights: 1998 and Earlier Census years" (see table at the end of section). However, this series portrays a rough picture of the growth in the greenhouse and nursery industry in value and in "spin-off" sub-industries. In particular, these data reveal the growth of the nursery industry prior to 2000.

Source:

United States Department of Agriculture, National Agricultural Statistics Service. "Table 1. Historical Highlights: 1998 and Earlier Census Years." In *1998 Census of Horticultural Specialties.* In 1997 Census of Agriculture. *Volume 3,* Special Studies Part 2: Government Printing Office, 2000.

Floriculture and nursery crops data (USDA, ERS 2007)
Growth trends since the late 1960s to 2003 are revealed by the USDA's Economic Research Service data (USDA 2007). These data include the value of sales for nursery and other greenhouse crops and for floriculture crops. Presently, the ERS data is constructed using a yearly 15 state survey all known growers. The number of states included in the survey has varied over time (e.g., prior to 2000, 36 states were included). The value series for floriculture crops is constructed as wholesale values. The states include reflect the states with the highest concentration of floriculture crops. Nursery crop statistics which are cash receipts are constructed jointly with the National Agricultural Statistic Service (NASS) branch of the USDA and are included in "nursery and other greenhouse crops." The "nursery and other greenhouse crops" group also includes non-floriculture crops such as greenhouse vegetables, vegetable transplants, and ornamental grasses. Also, due to the construction of this group as a residual, it also includes floriculture crops for the states not surveyed. Thus, to obtain a reasonable idea for the recent trends for the nursery industry it is necessary to look at the NASS surveys of nursery crops which have been conducted since 2000.

Source:

Jerardo, Andy. " Table A-1 Greenhouse and nursery crops: Grower sales receipts, by crop group, 1966 to date." In *Floriculture and Nursery Crops Situation and Outlook Yearbook.* Washington D.C.: U.S. Department of Agriculture, 2007.

Nursery crops data (USDA, NASS 2001, 2006)
Recent trends in the value of the nursery industry are represented by data from surveys of 17 states for three years, 2000, 2003 and 2006. The sales data are reported as gross sales. Nursery crop groups included are broadleaf evergreens, coniferous evergreens, deciduous flowering trees, deciduous shade trees, deciduous shrubs, fruit and nut plants, ornamental grasses, "other woody ornamentals, vines and grown covers", palms, propagative nursery materials, transplants for commercial vegetable and strawberry production, and Christmas trees.

Sources:

1. United States Department of Agriculture, National Agricultural Statistics Service. "Nursery Crops: Total Value of Sales by Category, by State, for Operations with $100,000+ Sales, 2000." In *Nursery Crops 2000 Summary*. Sp Cr 6-2. Washington: United States Department of Agriculture, 2001.

2. United States Department of Agriculture, National Agricultural Statistics Service. "Nursery Crops Summary Gross Sales by Plant Category, by State for Operations with $100,000+ Sales, 2003 and 2006." In *Nursery Crops 2006 Summary*. Sp Cr 6-3. Washington: United States Department of Agriculture, 2007.

Table 1. **Historical Highlights: 1998 and Earlier Census Years**

[For meaning of abbreviations and symbols, see introductory text]

Item	1998	1988	1979	1970	1959 [16]	1949 [17]	1929	1889
Operations....number	**23,758**	**21,088**	**22,347**	**12,962**	**17,999**	**17,400**	**(NA)**	**(NA)**
Sales....$1,000	**10,599,298**	**4,791,893**	**3,212,010**	**960,919**	**515,681**	**300,638**	**192,105**	**26,212**
Floriculture:[1]								
Operations....number	13,809	(NA)	(NA)	7,969	11,772	12,427	14,982	4,659
Sales....$1,000	4,462,860	2,570,005	1,619,974	501,473	292,302	218,521	109,895	14,175
Bedding/garden plants:								
Operations....number	10,629	9,098	8,070	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	2,357,185	896,196	285,520	61,627	32,844	16,925	(NA)	(NA)
Annual bedding/garden plants:[2]								
Operations....number	9,215	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	1,729,949	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Herbaceous perennial plants:								
Operations....number	7,391	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	627,236	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Potted flowering plants:[3]								
Operations....number	5,080	6,405	7,645	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	868,131	586,302	418,007	125,826	69,469	26,901	25,652	(NA)
Foliage plants:								
Operations....number	3,074	4,201	5,463	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	594,760	485,910	466,913	38,376	25,607	9,842	(NA)	(NA)
Cut flowers:[4]								
Operations....number	2,067	3,120	3,900	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	512,570	506,677	353,415	229,944	140,207	123,574	67,430	(NA)
Cut cultivated greens:[5]								
Operations....number	758	787	674	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	130,213	94,920	33,595	8,827	2,433	(NA)	1,712	(NA)
Nursery plants:								
Operations....number	8,305	7,000	7,436	3,764	6,757	4,643	7,207	4,510
Sales....$1,000	3,096,723	1,132,387	944,920	283,636	155,506	71,053	58,183	12,036
Unfinished plants and propagation materials:[6 7]								
Operations....number	1,868	1,681	880	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	493,049	190,090	62,524	36,873	21,742	13,667	2,717	(NA)
Turfgrass sod, sprigs, or plugs:[8 9]								
Operations....number	1,143	825	1,060	545	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	835,212	247,775	206,611	43,366	(NA)	(NA)	(NA)	(NA)
Dried bulbs, corms, rhizomes, or tubers:[10]								
Operations....number	254	179	372	270	861	870	1,935	(NA)
Sales....$1,000	55,389	29,175	23,544	10,375	9,964	9,237	5,364	(NA)
Cultivated mushrooms:								
Operations....number	264	230	477	546	665	444	516	(NA)
Sales....$1,000	861,672	509,360	348,251	95,191	35,770	14,566	5,141	(NA)
Greenhouse produced food crops:[11 12]								
Operations....number	1,015	581	866	2,555	819	768	(NA)	(NA)
Sales....$1,000	222,624	31,743	26,685	18,359	19,546	13,046	12,384	(NA)
Transplants for commercial production:								
Operations....number	493	523	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	156,273	50,660	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Vegetable seeds:[13]								
Operations....number	436	352	528	232	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	93,147	23,113	37,562	6,874	(NA)	(NA)	12,809	(NA)
Flower seeds:								
Operations....number	120	93	84	(NA)	85	60	(NA)	(NA)
Sales....$1,000	19,480	7,585	4,463	1,645	2,593	1,823	713	(NA)
Other:[14 15]								
Operations....number	3,785	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)
Sales....$1,000	302,869	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)

[1] Data for 1949 include greenhouse vegetables and mushroom operations.
[2] Data for 1970 include vegetable plant sales of $16,802,715.
[3] Data for 1929 include flowering and foliage plants.
[4] Data for 1949 include cut flowers and cut cultivated greens.
[5] Data for 1959 include only asparagus plumosus.
[6] Data for 1929 include bedding plants.
[7] Data prior to 1988 do not include nursery lining out stock.
[8] Data prior to 1998 only include sod harvested.
[9] Data for 1970 include pasture sod from 70 operations with sales of $4,280,370.
[10] Data for 1929 include sales of flowers cut from bulbs grown in the open and from forced bulbs.
[11] Data for 1929 include vegetable plants grown in hotbeds and covered frames with sales of $2,076,498.
[12] Data for 1970 include 1884 vegetable plant operations. Sales included with annual bedding plants.
[13] Data for 1970 include 261 vegetable and flower seed operations.
[14] Data prior to 1998 do not include cut Christmas trees, short term woody crops, and tobacco transplants sold.
[15] Data prior to 1998 summarized aquatic plants with nursery plants under other environmentals.
[16] Data for 1959 at wholesale prices. Actual total sales were $585,751,415 and wholesale sales were $435,052,807.
[17] Data for 1949 at wholesale prices. Actual total sales were $467,346,986 and wholesale sales were $249,814,924.

Appendix D: Intellectual Property Rights for Plant Varieties Data Base

Bibliographic data sets were assembled for all three types of intellectual property schemes for plants for this analysis. The plant patent data were obtained from the Office of Electronic Information Products of the USPTO for all plants granted after 1977 from their digitized database. The data for the plant patents (granted from 1930-1977) were collected individually from image files at the USPTO website.[130] The entire data file contains 19,797 entries which include virtually all the plant patents granted from 1930 to 1977 and all those granted through June 2009.[131] Although application information is now public—before the American Investors Protection Act of 1999 all patent information was confidential—this dataset contains only granted patents. This means that all patents that were rejected, withdrawn or under examination are not included in this dataset.

Likewise, digital data for issued utility patents were also obtained from the USPTO. There are 4,506 patents for plants issued from January 1, 1975 through June, 2009. Since a utility patent can claim seeds, plants, plant parts, chemical extracts, genes, traits, and biotechnological processes, to create a comparable dataset, only 2,949 patents for a new plant, variety, cultivar or line, were retained from the original set of data. The selection of utility patents for plants for this data set was made using a narrow definition of varieties which excludes most transgenic plants that were covered within the claims of primarily designated for methods and procedures. Patents like these can include more than a few cultivars which would mean if these were included some sort of weighting scheme would need to be used according to the number of cultivars covered. In addition, some excluded patents have claims are so broad that they cover cultivars yet to be developed.

Data for each Plant Variety Protection Certificate application was obtained one certificate at a time from the USDA Plant Variety Protection Office online database.[132] There are 9,858 applications from March 1971 through June 2009. Since the Plant Variety Protection Office periodically updates their records for ownership, the individually collected data was amended by obtaining a data query from the office for current owners and historic ownership.

Each plant intellectual property right record was categorized by crop type according to the Food and Agriculture Organization classification scheme (FAO 2005) and USDA crop groupings (USDA 2000; USDA 2006). In addition, the data was categorized according to the industry of intended use. This categorical scheme is in accord with the USDA's current agricultural categorization as revealed by the *1997 Census of Agriculture* (USDA 2000). Care should be taken in interpreting statistics using these categories within the nursery and greenhouse industry because within this industry a single new species cultivar can be intended for more than one sub-industry. For example

---

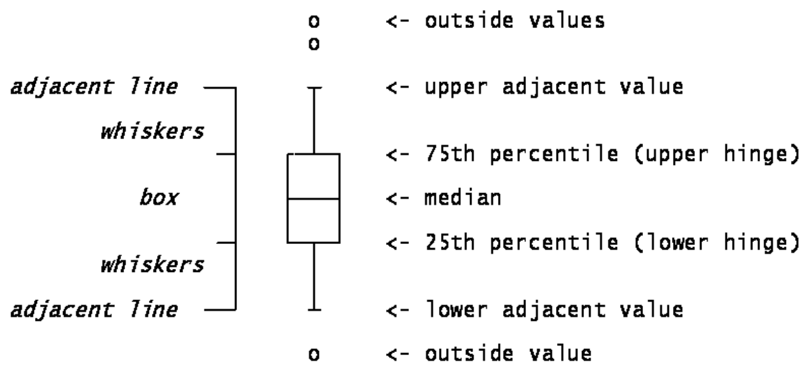
[130] The present web site where these image files can be obtained is http://patft.uspto.gov/.
[131] A few image files were illegible and were omitted.
[132] This information can presently be obtained at http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl.

a single rose cultivar could have an intended uses in three separate sub-industries as a potted flowering plant, a cut flower and a nursery plant.

Appendix E: Ornamental Plant Producer Price Data

Documentation: Figures in this appendix were produced using the Stata (release 10) statistical program (StataCorp 2007) and Ornamental Plant Producer Price Data compiled by author.

Reading a Box plot diagram



Source: Stata statistical program documentation
Notes: The above figure explains the box plot figures where each category of a categorical variable is represented by a box. This is a visual description of the continuous y axis variable distribution (which is in this case the plant price) over a category represented by a box.

Table 1: Variable coding structure of hedonic data

Variable class	Variable Name: Continuous/Integer	Variable Name: Categorical	Category	Variable class	Variable Name: Continuous/Integer	Variable Name: Categorical	Category
Group		Species	Acer			Year	2005
			Azalea				2006
			Clematis				2007
			Coreopsis	IP & market		Plant patent	PP [a]
			Echinacea	IP & market	PP age (years)		
			Hemerocallis	IP & market	PP age sq.		
			Heuchera	IP & market		Trademarked name	TM name[a]
			Hibiscus	IP & market		Patent Pending	Patent pending[a]
			Hosta	IP & market		Expired PP	Expired PP[a]
			Hydrangea	IP & market		Plant association	Plant association[a]
			Ilex	IP & market	Number TM promos		
			Juniperus	IP & market	Number promos (no TM)		
			Phlox			Offering type	Container
			Rosa				Bareroot
			Spiraea				Plant division
Group		Firm	Greenleaf				Rooted cutting
			Monrovia				Unrooted cutting
			Bailey	Firm offering	Bareroot length (")		
			Zelenka	Firm offering	Bareroot caliper (")		
			Walters	Firm offering		Bareroot form	branched[a]
			Yoder	Firm offering			lt branch[a]
			Sawyer	Firm offering			tree[a]
			Fisher	Firm offering			TT [a]
			Creek Hill	Firm offering			whip[a]

See end of table for notes

Continued next page

Table 1: Variable coding structure of hedonic data (continued)

	Variable Name				Variable Name		
Variable class	Continuous/Integer	Categorical	Category	Variable class	Continuous/Integer	Categorical	Category
Firm offering	Container Size			Group		Plant type	woody plant
Firm offering		Container Form	2ball/spiral[a]				herbaceous perennial
Firm offering			3ball/2spiral[a]	Group		Plant type-detail	herbaceous perennial
Firm offering			complex shape[a]				Vine-perennial
Firm offering			simple shape[a]				Vine -Woody
Firm offering			small[a]				Woody-shrub
Firm offering			medium[a]				Tree
Firm offering			large[a]	Cultivar attribute	USDA Zone (min)		
Firm offering			trained tree[a]	Cultivar attribute		Light requirment	full sun
Firm offering			bonsai[a]				part sun
Firm offering			support[a]				part shade
Firm offering			topiary basket[a]				full shade
Firm offering			tree[a]	Cultivar attribute		Growth rate	Slow
Firm offering			multi-stem				Medium
Firm offering			bud & bloom[a]				Fast
Firm offering			decor pot[a]	Cultivar attribute		Growth form	upright
Firm offering			vernalized[a]				groundcover
Firm offering		Container grade	High[a]				round
Firm offering		Fast delivery	pdq[a]				vine
Firm offering	Plant division size						column
Firm offering		Plant div. grade	High[a]				pyramid
Firm offering		Region	East[a]				weeping
Firm offering			South[a]				prostrate
Firm offering			West[a]	Cultivar attribute		Growth habit	clumping[a]
Firm offering			Dayton[a]	Cultivar attribute			suckering/stolen[a]
Firm offering			Gaston[a]	Cultivar attribute			wide[a]
Firm offering			imported[a]	Cultivar attribute			compact[a]

See end of table for notes

Continued next page

Table 1: Variable coding structure of hedonic data (continued)

	Variable Name				Variable Name		
Variable class	Continuous	Categorical	Category	Variable class	Continuous	Categorical	Category
Cultivar attribute	Height (min)			Cultivar attribute		Bloom time	spring bloom[a]
Cultivar attribute	Height (max)			Cultivar attribute			summer bloom[a]
Cultivar attribute		Tolerance attributes	pest resistant[a]	Cultivar attribute			fall bloom[a]
Cultivar attribute			drought tolerant[a]	Cultivar attribute			winter bloom[a]
Cultivar attribute			salt tolerant[a]	Cultivar attribute		reblooming	reblooming[a]
Cultivar attribute			sun tolerant[a]	Cultivar attribute		fragrant	fragrant[a]
Cultivar attribute		Use attributes	easy to grow[a]	Cultivar attribute		Flower Color	blue[a]
Cultivar attribute			attracts wildlife[a]	Cultivar attribute			blue-purple[a]
Cultivar attribute			cut or dried flower[a]	Cultivar attribute			purple[a]
Cultivar attribute			containter[a]	Cultivar attribute			purple-red[a]
Cultivar attribute			hedge[a]	Cultivar attribute			red[a]
Cultivar attribute		Flower type	single[a]	Cultivar attribute			orange-red[a]
Cultivar attribute			semi-double[a]	Cultivar attribute			orange[a]
Cultivar attribute			double[a]	Cultivar attribute			yellow-orange[a]
Cultivar attribute		Flower type 2	cluster[a]	Cultivar attribute			yellow[a]
Cultivar attribute			spray[a]	Cultivar attribute			green[a]
Cultivar attribute			daisy[a]	Cultivar attribute			white[a]
Cultivar attribute			anemone[a]	Cultivar attribute		Multi flwr color	multi-flower color[a]
Cultivar attribute			bell[a]	Cultivar attribute		Pastel flwr color	pastel flower color[a]
Cultivar attribute			novel[a]	Cultivar attribute		Dark flwr color	dark flower color[a]
Cultivar attribute		Petal type	novel[a]	Cultivar attribute	Flower size		
Cultivar attribute		Cluster type	lace[a]	Cultivar attribute		Leaf type	needle[a]
Cultivar attribute			mop[a]	Cultivar attribute			broadleaf[a]
Cultivar attribute			pyramid[a]				

See end of table for notes

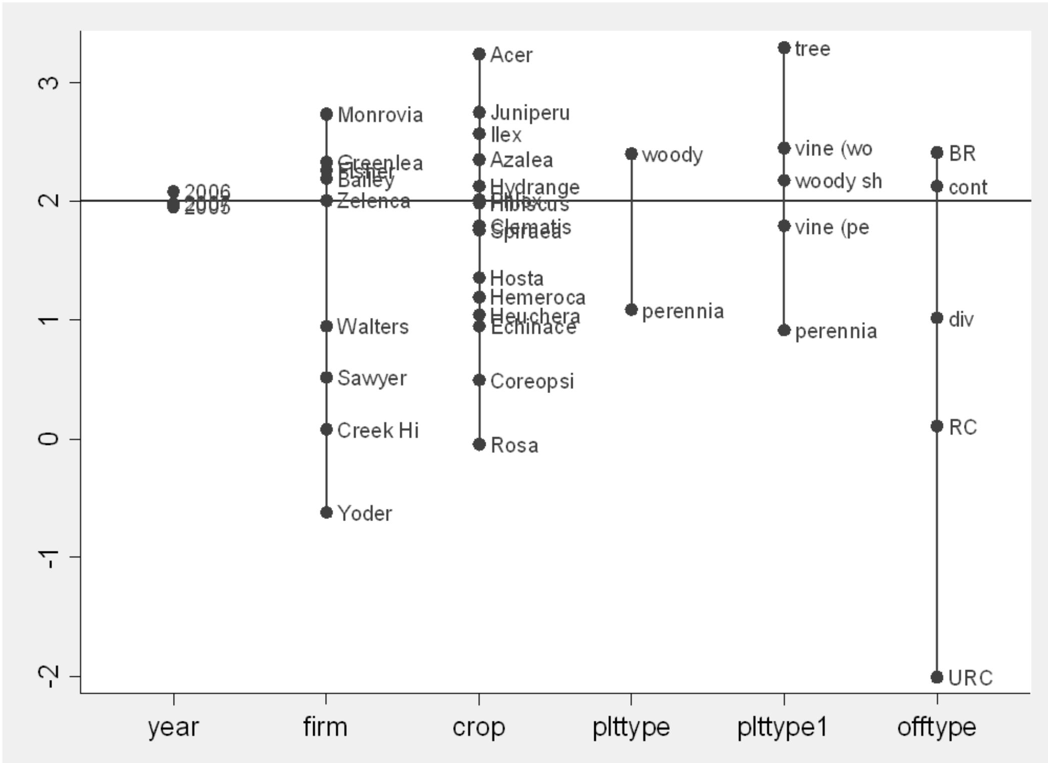
Continued next page

Table 1: Variable coding structure of hedonic data (continued)

	Variable Name				Variable Name		
Variable class	Cont./Int.	Categorical	Category	Variable class	Cont./Int.	Categorical	Category
Cultivar attribute		Leaf shape	heart[a]	Cultivar attribute		Leaf color	blue-green
Cultivar attribute			lance[a]				bronze
Cultivar attribute			maple[a]				deep green
Cultivar attribute			oak[a]				grey green
Cultivar attribute			unique[a]				green
Cultivar attribute		Leaf texture	deep cut leaf[a]				lime
Cultivar attribute			lacy leaf[a]				orange-gold
Cultivar attribute			ruffled leaf[a]				red-purple
Cultivar attribute			shiny leaf[a]				silver
Cultivar attribute			spiny leaf[a]				white
Cultivar attribute			leathery leaf[a]	Cultivar attribute		Other unique features	Evergreen[a]
Cultivar attribute			rugose leaf[a]	Cultivar attribute			Winter interest[a]
Cultivar attribute		Multi leaf color	multi leaf color[a]	Cultivar attribute			Berries[a]
Cultivar attribute		Spring leaf color	Spring leaf color[a]	Cultivar attribute			Twig color[a]
Cultivar attribute		Fall leaf color	Fall leaf color[a]	Cultivar attribute			Thornless[a]
				Cultivar attribute			Arching branches[a]
				Cultivar attribute			Other unique features[a]

Source: "Ornamental Plant Producer Price Data" compiled and constructed by author for this study.
Notes:
This is a complete list of the variables constructed for this study
a. indicates binomial indicator variables where the reference category is for observations where that particular attribute is not present.

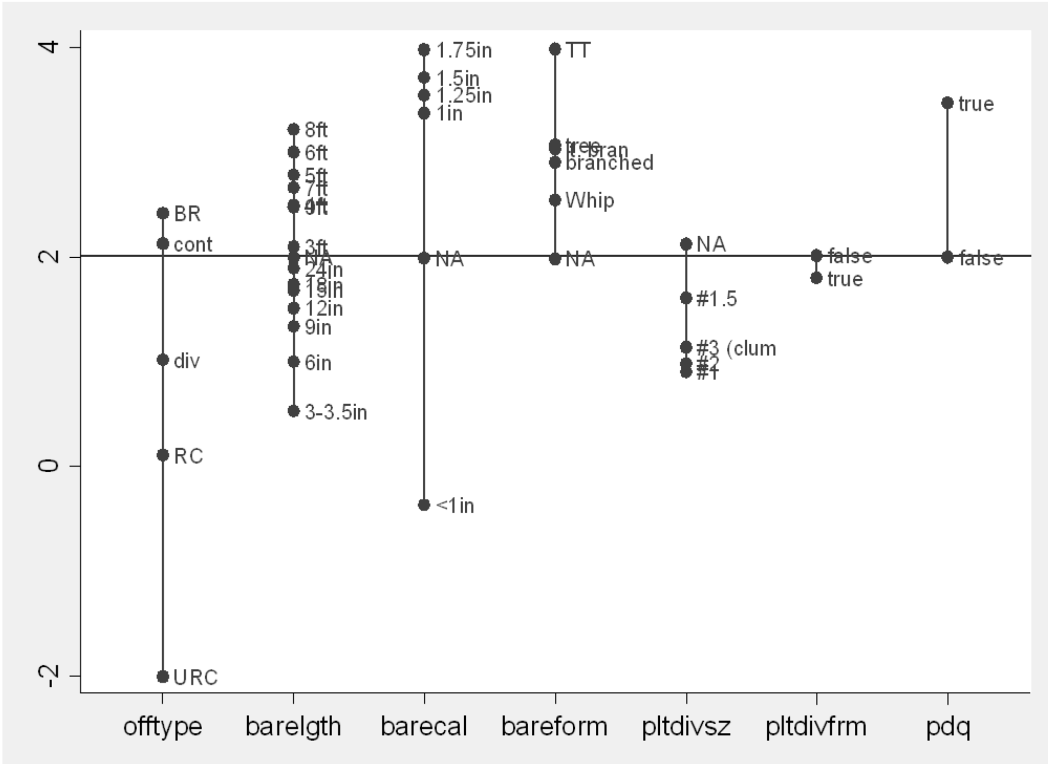
Figure 1: Price means plot of grouped characteristics



Source: Ornamental Plant Producer Price Data compiled by author.

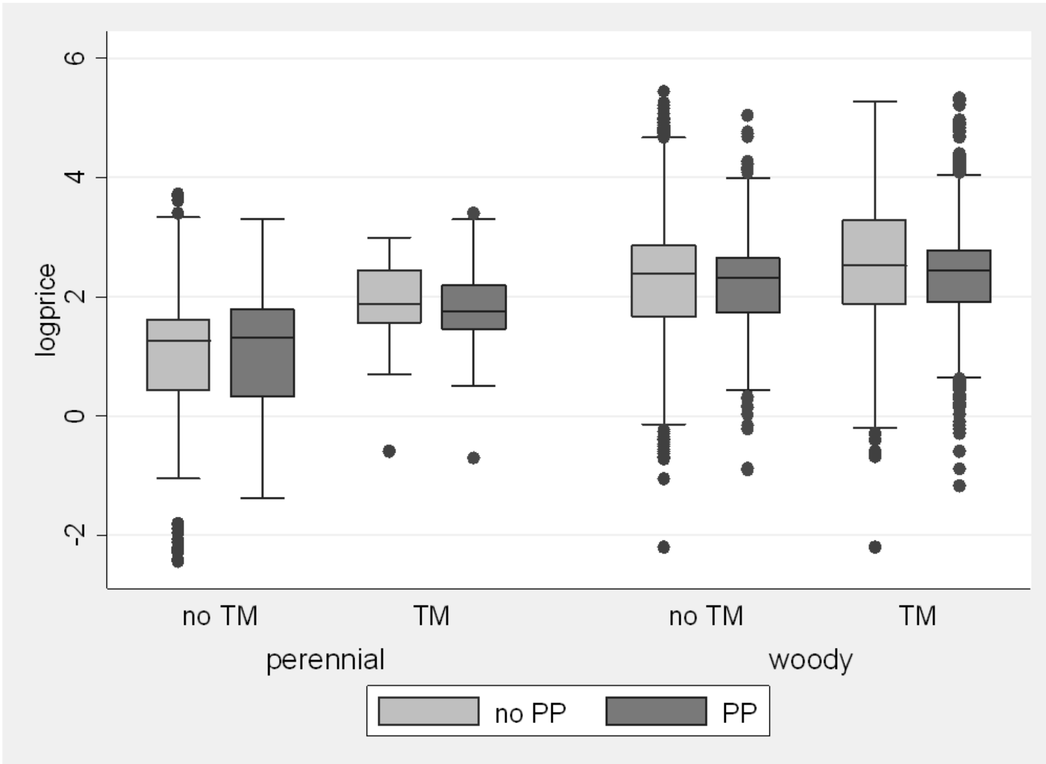
Notes: The means of each category for each variable is represented by a round node. Top to bottom labels: year- 2006, 2007, 2005; firm- Monrovia, Greenleaf, Bailey, Fisher, Zelenka, Walters, Sawyer, Creek Hill, Yoder; crop- Acer, Juniperus, Ilex, Azalea, Hydrangea, Hibiscus, Phlox, Clematis, Spiraea, Hosta Heuchera Echinacea, Hemerocallis, Coreopsis, Rosa; plttype- woody, perennial; plttype1- tree, vine (woody), woody shrub, vine (perennial), perennial; offtype (offering type)- BR denotes bare root nursery stock, cont denotes plants offered in containers (these include plants offered in celled flats, small and large pots), div denotes plants offered as divisions, RC denotes rooted cuttings, and URC denotes unrooted cuttings. The red line denotes the overall mean of price.

Figure 2: Price means plot of grouped characteristics-firm offerings (unpotted)



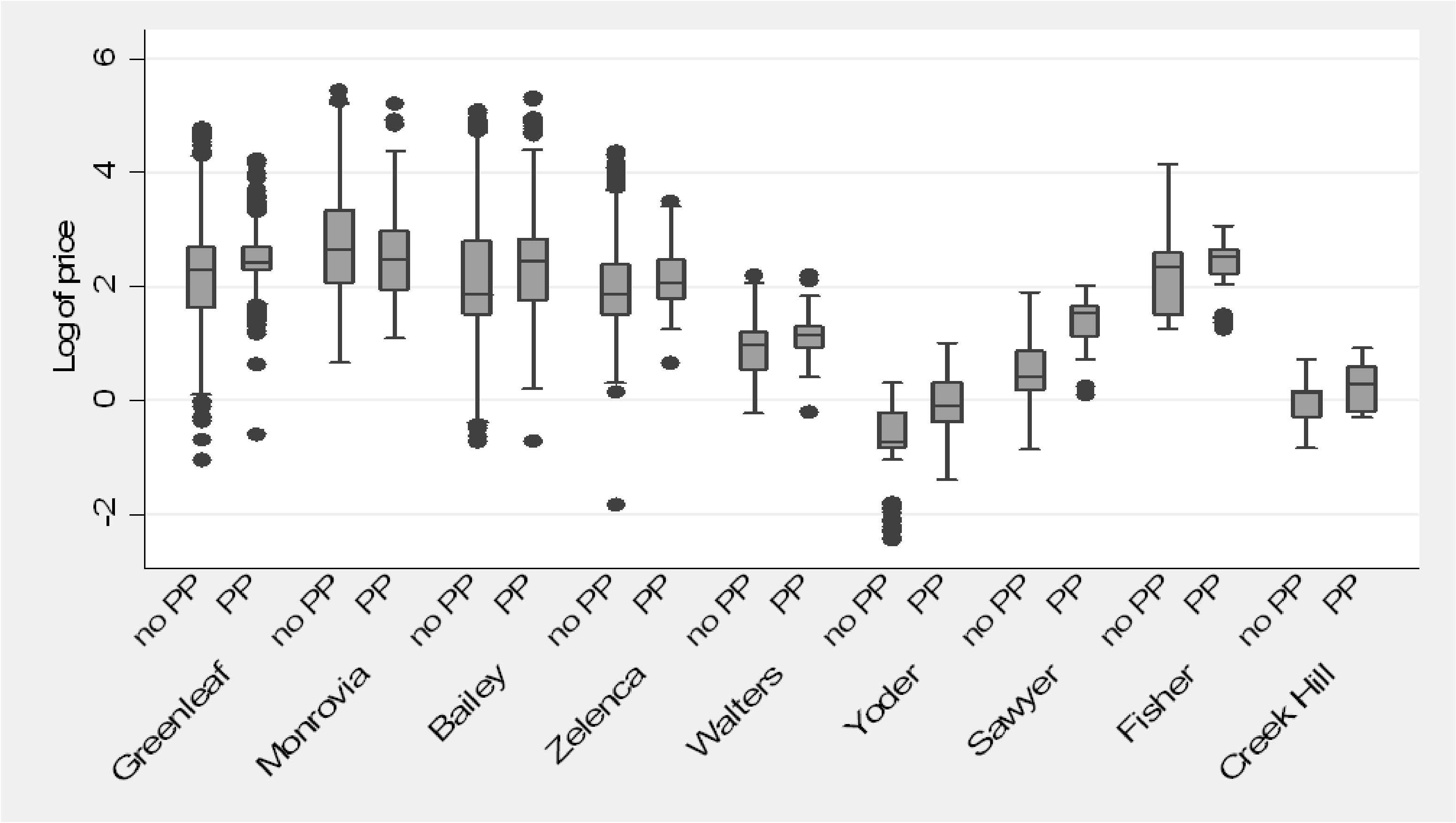
Notes: These variables are firm offering characteristics. The means of each category for each variable is represented by a round node on its respective line. The red line represents the overall mean of price.

Figure 3: Box plot – price over plant patent, name trademark and plant type



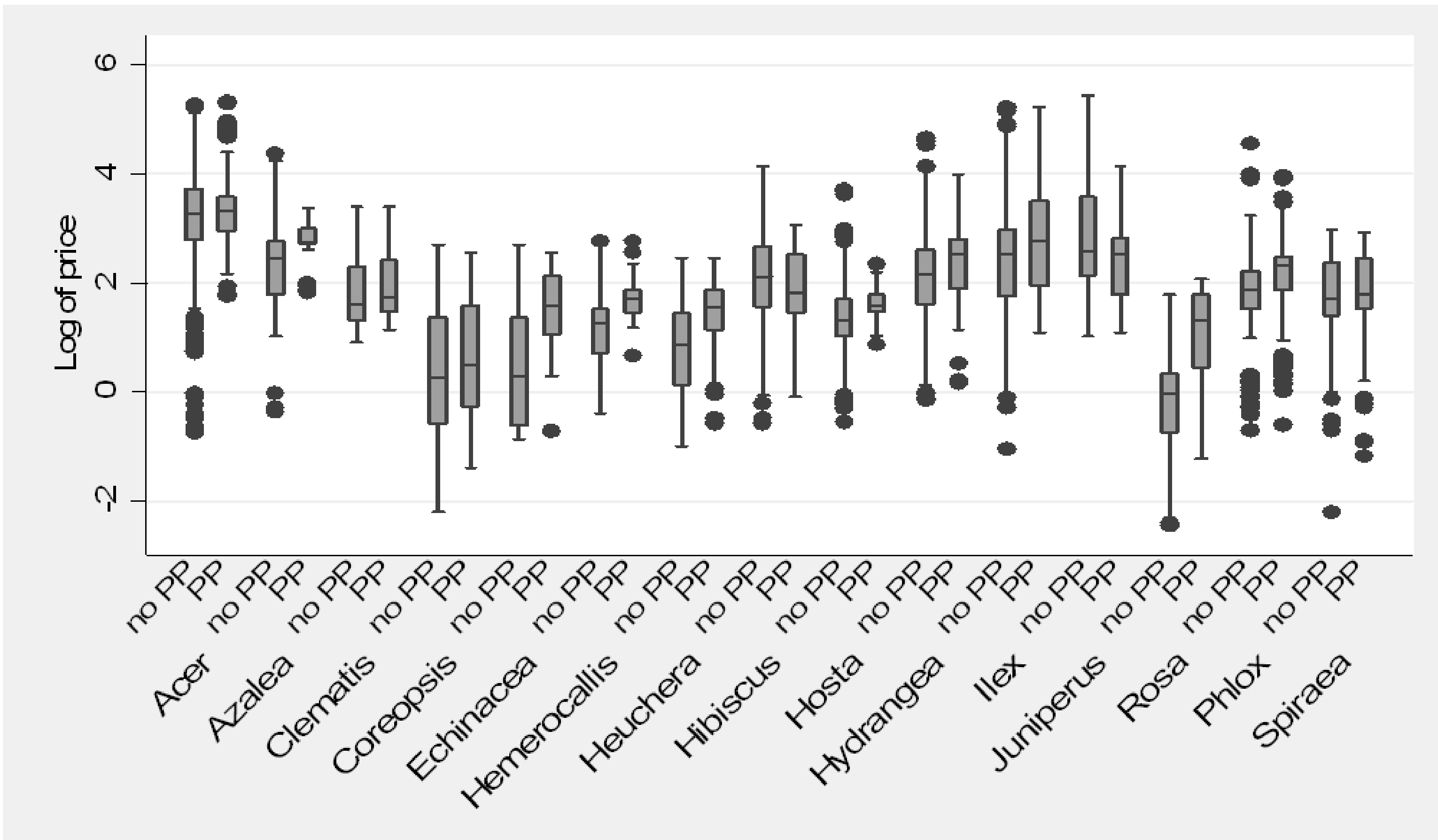
Source: "Ornamental Plant Producer Price Data" compiled and constructed by author for this study.
Notes: These box plots clearly show distributions of price over trademarks are higher for woody and non woody plants patented and nonpatented plants. There is a small median value difference between observations with and without cultivar intellectual property across plant types, and only for observations where there are no trademarks for perennials does the distribution for plant patents appear to be slightly higher in values. This box plot reveals that many of the extreme values are for woody shrubs and trees.

Figure 4: Box plot-price over intellectual property over firm



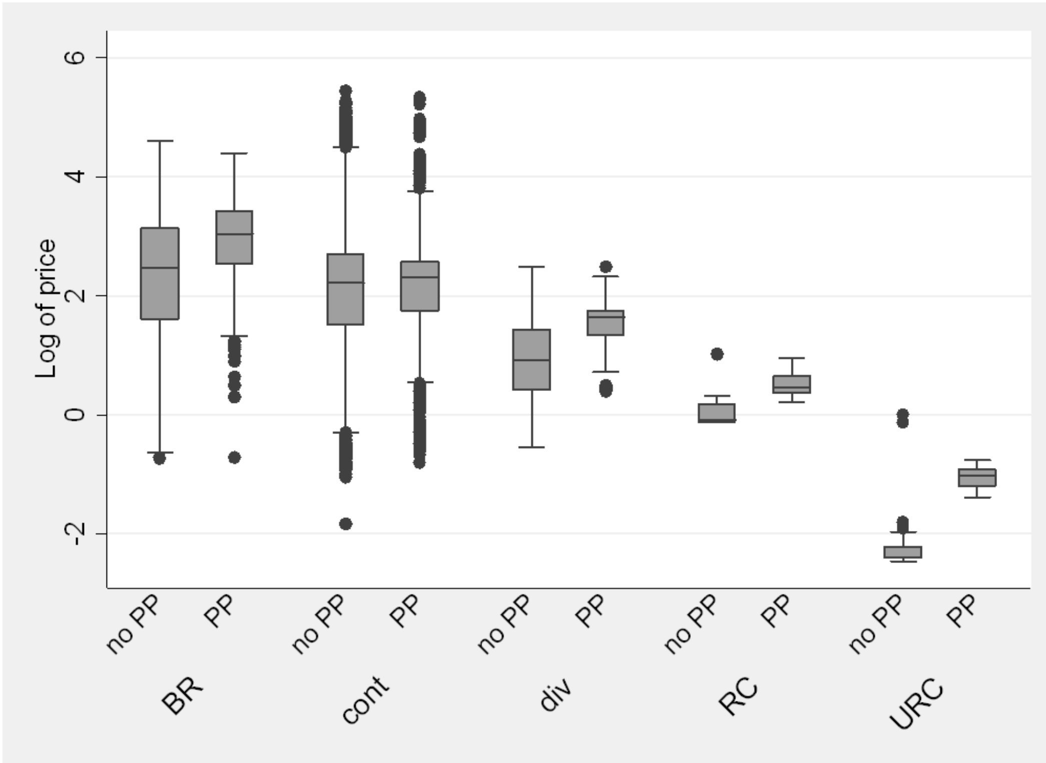
Notes: For all but Monrovia, observations with a plant patent have clearly higher median price. Bailey, Walters, Yoder, Sawyer, and Creek Hill have higher price distributions for the plant patent. Greenleaf, Monrovia, Bailey, Zelenca, and Fisher have a broader and higher range of prices. Prices over firms tend to be more skewed (negatively or positively) for Walters, Yoder, Sawyer, Fisher, and Creek Hill. This plot as well as the other box plots reveals a number of extreme observations.

Figure 5: Box plot – price over the plant patent (plant patent or plant patent applied for) and crop.



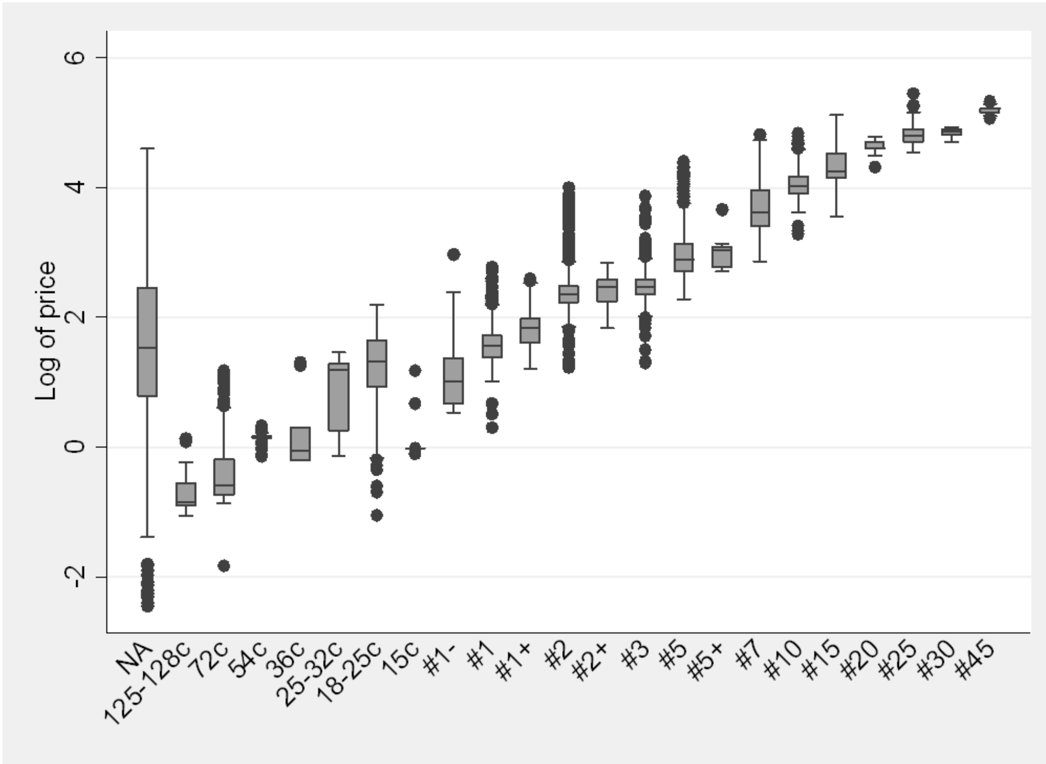
Notes: The box plot reveals, for most crops, except Acer, Juniperus and Hibiscus, the price over the plant patent appears to have higher medians and/or distributions.

Figure 6: Box Plot-price over offering form



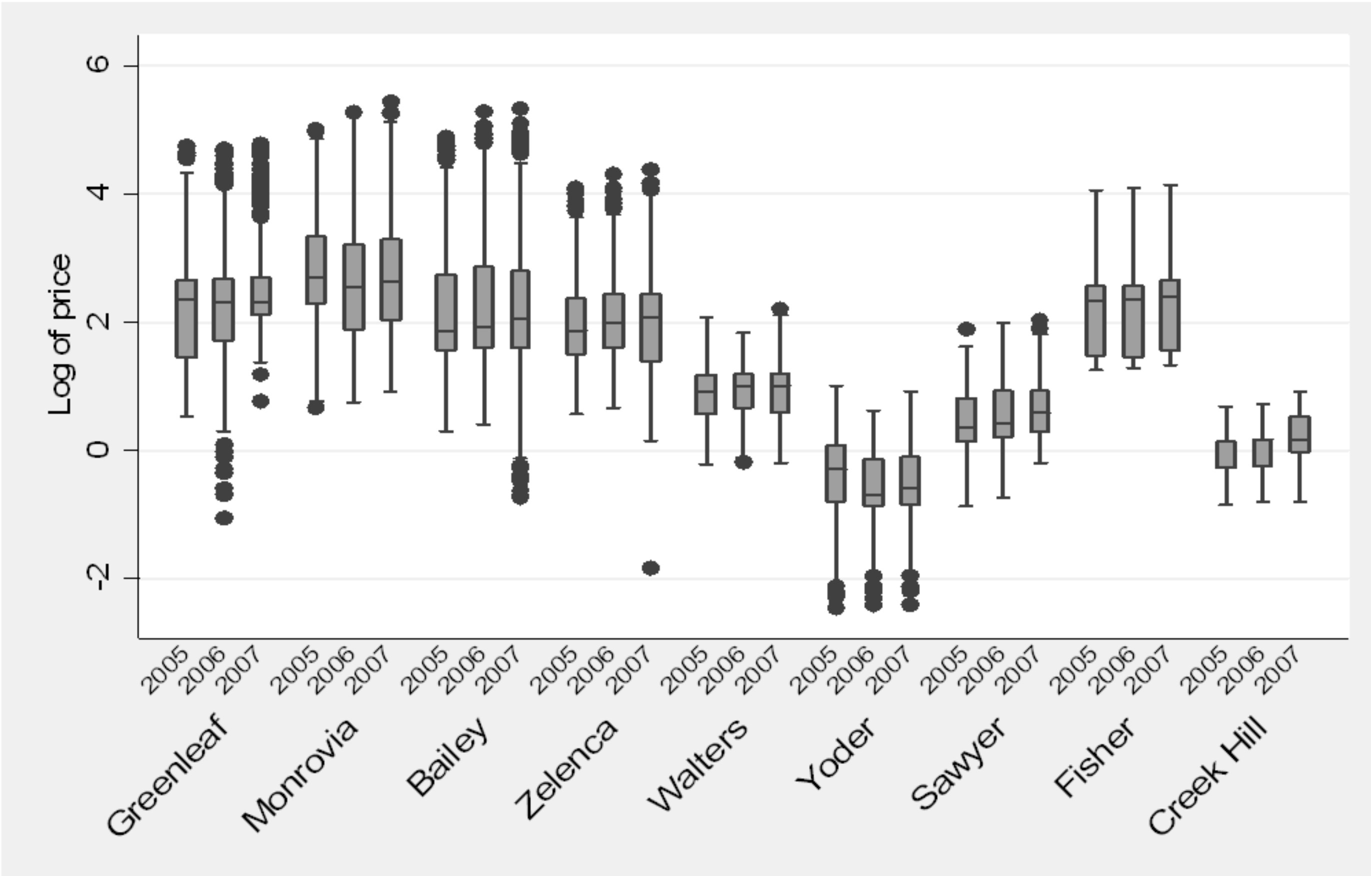
Notes: The median difference between observations with and without cultivar intellectual property across plant offering types is large for all categories except container plant offerings. (This group contains 80 percent of all observations.) BR denotes bare root nursery stock, cont denotes plants offered in containers (these include plants offered in celled flats, small and large pots), div denotes plants offered as divisions, RC denotes rooted cuttings, and URC denotes unrooted cuttings.

Figure 7: Box plot-price over container size



Notes: Containers are from smallest (left) to largest (right). NA denotes other forms that are not containers.

Figure 8: Box plot-price over year over firm.



Notes: It appears that for most firms (Bailey, Zelenca, Walters, Sawyer, Fisher and Creek Hill) the median price and the price distribution have increased over the period of observations.