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Essays on

Intellectual Property Rights Policy

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For my mother.

Acknowledgements

Declaration

I, Petal Jean Hackett, certify that this thesis has been written by me and that it is my own work except where I indicate otherwise by proper use of quotes and references. I also certify that the work has not been submitted for any other degree or professional qualification.

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Abstract

This dissertation will take a theoretical approach to analyzing certain challenges in the design of intellectual property rights ('IPR') policy. The first essay looks the advisability of introducing IPR into a market which is currently only very lightly protected - the US fashion industry. The proposed Innovative Design Protection and Piracy Prevention Act is intended to introduce EU standards into the US. Using a sequential, 2-firm, vertical differentiation framework, I analyze the effects of protection on investment in innovative designs by high-quality ('designer') and lower-quality ('mass-market') firms when the mass-marketer may opt to imitate, consumers prefer trendsetting designs and firms compete in prices. I show that design protection, by transforming mass-marketers from imitators to innovators, may reduce both designer profits and welfare. The model provides possible explanations for the dearth of EU case law and the increase in designer/mass-marketer collaborations. The second essay contributes to the literature on patent design and fee shifting, contrasting the effects of the American (or 'each party pays') rule and English (or 'losing party pays') rule of legal cost allocation on optimal patent breadth when innovation is sequential and firms are differentiated duopolists. I show that if litigation spending is endogenous, the American rule may induce broader patents and a higher probability of infringement than the English rule if R&D costs are sufficiently low. If, however, R&D costs are moderate, the ranking is reversed and it is the English rule that leads to broader patents. Neither rule supports lower patent breadth than the other over the entire parameter space. As such, any attempts to reform the US patent system by narrowing patents must carefully weigh

the impact on firms' legal spending decisions if policymakers do not wish to adversely affect investment incentives. The third and final essay analyzes the effects of corporate structure on licensing behaviour. Policymakers and legal scholars are concerned about the potential for an Anticommons, an underuse of early stage research tools to produce complex final products, typically arising from either blocking or stacking. I use a simple, one-period differentiated duopoly model to show that if patentees have flexibility in corporate structure, Anticommons problems are greatly reduced. The model suggests that if the patentee owns the single (or single set) of essential IPR and goods are of symmetric quality, Anticommons issues may be entirely eliminated, as the patentee will always license, simply shifting its corporate structure depending on the identity of the downstream competitor. If the rival produces a more valuable good, Anticommons problems are reduced. Further, if the patentee holds 1 of 2 essential patents, the ability to shift its corporate structure may reduce total licensing costs to rival firms. However the analysis offers a cautionary note: while spin-offs by the patentee help to sustain downstream competition, they may restrict market output, and therefore welfare. Thus the inefficiency in the patent system may be in the opposite direction than is currently thought - there may be too much technology transfer, rather than too little.

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1. Introduction

A well-crafted Intellectual Property Rights ('IPR') policy framework is an essential pre-requisite for ongoing innovation. In this regard, policymakers must achieve a fine balance, in that the IPR system must be simultaneously sufficiently robust to incentivize early innovation and sufficiently limited to allow for entry of later generation products. Further, the policies will generally be applicable across the entire economy, so that particular industries may be affected by the IPR system to differing extents. This dissertation will take a theoretical approach to analyzing certain challenges in designing intellectual rights policy in two key areas.

The first area relates to fashion design, a low-IPR, trend-driven industry. In the US, apparel designs (as distinct from logos or trade dress) receive virtually no protection and copying is rampant; in contrast, European fashion designs have been granted strong protection, yet copying is *still* rampant. And in both contexts, design innovation proceeds apace. Which of these systems is better for design innovation? At the current time, there is significant lobbying by high-end labels, via the Council of Fashion Designers of America (CFDA), the major trade association, for protection to be put in place in the US. The latest of repeated attempts at a legislative solution is embodied in the proposed Innovative Design Protection and Piracy Prevention Act ('IDPPPA'), which is intended to bring fashion design IPR in line with the system currently existing in the EU. What can theory say about the advisability of such a policy?

In the first essay, I use a simple, one-period, 2-firm, vertical differentiation framework to analyze the interaction of design imitation, consumer taste for trendsetting apparel

and the potential effects of design protection. The model suggests that in the absence of design protection, a low-quality firm will imitate (or knockoff) a designer firm if the cost savings associated with imitation are sufficiently high and the knockoff is perceived sufficiently well. Imitation has both positive and negative effects: on the one hand, if mass-marketers imitate they do not design novel collections; this leaves the designer as the single novel firm - the trendsetter. On the other hand, imitation allows the mass-marketer to cut into designer profits. The main result is that a design protection system may actually underperform the status quo, leaving both high-end and mass-market firms worse off and welfare lower relative to a no protection regime.

The intuition is that if consumers value both design novelty and quality independently (that is, are willing to pay more for a novel design than for an older one, for any brand) and imitation is suppressed, the mass-market firms face a stark choice: fall behind in trends as well as quality and cede more of the market or spend more to hire in designers and produce novel collections. Under appropriate conditions, this landscape may turn would be imitators into design innovators, stronger competitors to the high-quality, high-cost designers. The model suggests that if the only effect of the design right is to allow for protection from knockoffs, designer firms may do better not to utilize the protection system at all, sanctioning imitation. However, if the design right enhances the popularity of either the brand or the current collection sufficiently, perhaps if it acts as a certification of fashion status, then the design rights system produces a Prisoners' Dilemma in protection: all types of firms will pursue this valuable asset. The result is that firms find themselves locked in a design arms race: each attempts to introduce trendsetting designs, with the result that the competing designs effectively cancel each other out in the market. The model suggests that the welfare enhancing policy is not to allow design protection, as the system may have negative implications for firms and consumers relative to the no protection case. I show that for certain model parameters licensing may provide a means to end the arms race, though even in this outcome designer payoffs may not compare favourably with the no protection regime.

The second area of analysis is highly sequential, IPR active industries, best illustrated by biotechnology. In these industries, research and development ('R&D') inputs, often termed research tools, are virtually impossible to invent around and it is extremely unlikely that any commercial application can be developed without substantial use of the prior inventions. The importance of these research tools means that firms in such sectors tend to patent much more frequently than in other industries. This phenomenon then raises several concerns about the impact of patent assertion and licensing failure on future innovation. High profile court cases have served to reinforce these fears, and has lead to charges by many that US patents are too broad, giving too much power to the early innovators. But attempts to reform the system must consider all the issues that complicate firms' IPR strategies, including R&D spending, licensing and litigation. I focus on two critical factors, the legal cost shifting regime and corporate structuring.

The second essay looks at the effects of legal fee-shifting rules on patent breadth when innovation is sequential, legal costs are endogenous and firms compete in prices. Patent breadth refers to how different a product has to be from the protected one in order to be found infringing. Low breadth (that is, *narrowness*) means that even quite similar products will generally be held not to infringe. Narrow patents therefore leave more space for new products to be developed. Optimal choice of breadth is complicated by the fact that enforcing protection of the patent asset is costly, with costs impacting firm behaviour. Further, the costs of litigating patents are substantial: in the US, direct legal fees alone are estimated at between US$1 and 3 million to each party (American Intellectual Property Law Association 2001 figures) while indirect costs, including business losses due to increased perception of risk, are even higher. This implies that the ability to shift fees is of increasing importance for firms and, by extension, for policy.

However, to date, theoretical models of fee-shifting have tended to assume away policymakers' reactions to legal costs. This paper is an attempt to fill this gap, linking the effects of fee shifting on firms and regulators. Using a simple differentiated duopoly

model based on Singh and Vives (1984), I contrast the American rule (where each party pays its own litigation costs, regardless of judgement) and the English rule (where the losing party pays all litigation costs) on patent breadth. Consistent with much of the literature, I show that the English rule induces more overall spending than the American rule. Interestingly, this is largely due to greater spending by patentee firms when goods are sufficiently similar. But this does not necessarily induce a higher overall probability of receiving a successful judgement. Instead I find that, all else equal, the American rule allows for broader patents than the English rule only if R&D costs are sufficiently low. The intuition is that firms under the English rule must explicitly consider spending by the rival when deciding how much to spend on litigation themselves; this can induce a legal arms race, leading to an explosion in spending costs. The Patent Office therefore sets narrow patents, encouraging the Courts to focus rulings only on the closeness of patented and allegedly infringing goods. If, however, R&D costs are moderate, the ranking is reversed and it is the English rule that leads to broader patents, as the Patent Office prefers to set maximally broad patents under the English rule. The intuition is that because under the American rule firms consider only their own spending, investment incentives remain strong even with high costs, but under the English rule, the patentee will only have an incentive to invest if the rival cannot externalize its litigation costs onto that firm. Neither rule supports lower patent breadth than the other over the entire parameter space. Thus, from first level observation the American system may sometimes appear to be more pro-patentee, but this does not necessarily prejudice later-stage innovation; neither is it necessarily due to any inherent bias or failing at the Patent Office. It may simply reflect the features of the cost allocation system.

The third essay looks at the effect of patentee corporate structure on technology licensing. There is some concern that the numerous extant patents in highly sequential industries could produce what is termed a 'tragedy of the Anticommons': new products may fail to come to market because firms cannot co-ordinate with the multiple owners

of the necessary research tools. This is typically a result of *blocking* problems, *stacking* problems, or both. But the incentive to license - and thus likelihood of any Anticommons - differs substantially if patentees compete in the product markets. And where they do, policymakers must also consider that such companies may elect to spin-off IPR units in an effort to maximize profits. This ability to vertically separate, which allows the patentee to commit to charging downstream entities uniform license royalties, may significantly affect the extent to which later-stage innovators are kept out of the market.

Again using the baseline Singh and Vives (1984) model, I show that if patentees have flexibility in corporate structure, Anticommons problems are greatly reduced. Indeed, the model suggests that if the patentee owns the single (or single set) of essential IPR and products are of symmetric quality, Anticommons issues may be entirely eliminated. The patentee will always license, simply shifting its corporate structure depending on the identity of the downstream competitor. If the rival produces a higher quality good, Anticommons problems may be reduced. And if the patentee holds 1 of 2 essential patents, the ability to shift its corporate structure may reduce total licensing costs to rival firms. Thus if US policymakers are concerned about reducing the likelihood of Anticommons problems, then making spinoffs less costly, by for example increasing the allowed purposes for which such distributions currently receive non-tax status, will go some way to overcoming this problem. However the analysis offers a cautionary note: while spin-offs by the patentee help to sustain downstream competition, they may restrict market output and therefore welfare. Thus the true inefficiency in the patent system may be in the opposite direction than is currently thought - there may be too much technology transfer, rather than too little. And given that such divestitures, unlike mergers, do not normally require permission from competition authorities, such potentially welfare reducing effects may be difficult to avoid.

Taken as a whole, this body of work is intended to illustrate some of the complexities involved in crafting IPR policy. The models are highly stylized and include certain arguably restrictive assumptions, and for these reasons applicability of the results is

limited. I nevertheless feel that the models illustrate some potentially important un-intended consequences of policy actions and therefore provide some useful caveats for policymakers.

2. Cutting Too Close? Design Protection and Innovation in Fashion Goods

Abstract

Lobbying by high-end, American designers for intellectual property-type fashion design protection has culminated in the proposed Innovative Design Protection and Piracy Prevention Act, intended to introduce EU standards. Using a sequential, 2-firm, vertical differentiation framework, I analyze the effects of protection on investment in innovative designs by high-quality ('designer') and lower-quality ('mass-market') firms when the mass-marketer may opt to imitate, consumers prefer trendsetting designs and firms compete in prices. I show that design protection, by transforming mass-marketers from imitators to innovators, may reduce both designer profits and welfare. The model provides possible explanations for the dearth of EU case law and the increase in designer/mass-marketer collaborations.

Keywords: Intellectual Property Rights, Fashion Design Protection, Imitation, Licensing

JEL Classifications: D21, L13, O31, O34

To refrain from imitation is the best revenge.

- *Marcus Aurelius*

2.1. Introduction

It is often argued that a strong intellectual property ('IP') framework is a prerequisite for attracting ongoing investment, as firms only invest where they can be relatively certain of appropriating the returns to such investment. Indeed, this is the argument most often deployed in defense of the high levels of patenting in industries such as biotechnology and software. But this line of reasoning fails to explain the fact that some industries which attract considerable investment do not rely on IP protection to any significant degree. These 'low-IP' industries are perhaps best represented by the US fashion industry, where fashion designs themselves are only very lightly protected and copying is rampant yet economic activity continues apace.

However the Council of Fashion Designers of America (CFDA), the trade association of high-end US designers, has lobbied for legislative attention, claiming that returns to investment are eroded by copying. The latest of the repeated attempts at a legislative solution is embodied in the proposed Innovative Design Protection and Piracy Prevention Act ('IDPPPA'), introduced into the US House of Representatives by Rep. Robert Goodlatte in July 2011.[1] This is intended to bring US fashion design IP into line with the system currently existing in the EU.

In this paper, I use a simple, 2-firm, vertical differentiation framework to analyze the interaction of design imitation, consumer taste for trendsetting apparel and the potential effects of design protection. In the absence of design protection, a low-quality

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[1]Previous versions of similar legislation, collectively termed the Design Piracy Bills, were found in (i) House Bill 5055 of the 109th Congress (failed to advance in December 2006); (ii) House Bill 2033 and its Senate counterpart, Senate Bill 1957, introduced in the 110th Congress in April and August 2007, respectively; and (iii) House Bill 2196 and its Senate counterpart, Senate Bill 3728, introduced in April and August 2010, respectively. The current bill under consideration, House Bill 2511, is unchanged from the Bills introduced into the 111th Congress in 2010. A Preliminary hearing on the proposed Act took place on July 15, 2011 before the US House Subcommittee on Intellectual Property, Competition and the Internet.

mass-market firm will imitate or *knockoff*[2] the designer if the cost savings associated with imitation are sufficiently high and the knockoff is perceived sufficiently well. Imitation has both positive and negative effects: on the one hand, if mass-marketers imitate they do not design novel collections; this leaves the designer as the single novel firm - the trendsetter. On the other hand, imitation allows the mass-marketer to cut into designer profits. The main result of the paper is that a design protection system may underperform the status quo, leaving both high-end and mass-market firms worse off and welfare lower relative to a no protection regime.

The intuition is that if imitation is suppressed, the mass-market firm faces a stark choice: fall behind in trend as well as quality and cede more of the market or spend more to hire in designers and produce novel collections. Under appropriate conditions, this landscape turns would be imitators into design innovators, stronger competitors to the high-quality, high-cost designers. The introduction of design protection may therefore have counter-intuitive effects. The model suggests that if the only effect of the design right is to allow for protection from knockoffs, designer firms may do better not to utilize the protection system at all, effectively sanctioning imitation. However, if the design right enhances the popularity of either the brand or the current collection sufficiently, both firms pursue this valuable asset and find themselves locked in a design arms race: each attempts to introduce trendsetting designs, with the result that the competing designs effectively cancel each other out in the market. I show that for certain model parameters licensing may provide a means to end the arms race, though even in this outcome the designer firm's payoff may not compare favourably with what it would earn if no design protection were available.

The model provides an alternative explanation for observed trends in the fashion industry, namely the lack of case law observed in Europe despite strong protection and the increase in designer/mass-marketer co-branded collections (so-called 'diffusion lines'). The model also suggests that, given that design protection results in a Prisoners'

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[2]I interpret knockoff copying in line with Barnett et al. (2008): " 'mass-market' firms supply close imitations of successful originals to the broad middle of the market demand curve under different brand names and at various quality grades".

Dilemma if the returns to design right ownership are sufficiently high, it may be better for the fashion industry and for consumer welfare if the IDPPPA were *not* adopted.

The rest of the paper is structured as follows: in Section 2.2, I briefly overview the legal framework for design protection in the EU and the proposed US measures. In Section 2.3, I provide a short discussion of the most related work in the economic and legal literature. In Section 2.4, I introduce the model setup. In Section 2.5, I solve the specification with exogenous qualities (reserving the discussion of endogenous quality for Appendix B). Section 2.6 concludes.

2.2. Legal Protection of Fashion Designs

The proposed IDPPPA was crafted after careful consideration of the recently amended European framework for design protection. I thus begin with brief overview of the current protection system in Europe.

2.2.1. Design Protection in Europe

The European Community Design Protection Regulation ('DPR') went into effect in all member states in March 2002. The DPR establishes 2 mechanisms for protection: (i) the unregistered community design ('UCD'), which applies from first disclosure of the design in the Community, including showing at trade fairs or in advertisements, and is valid for 3 years; and (ii) the registered community design ('RCD'), which requires filing of documents with the Office for Harmonization in the Internal Market ('OHIM') and is valid for 5 years. The RCD is renewable up to an additional 4 times, meaning protection is available for a maximum of 25 years. These instruments have simultaneous effect across the 27 EU member countries.

There is no limit to the number of designs per application and there is a 1-year grace period in establishing novelty of the design, so that a designer can 'test the market' for up to a year (with rights under the UCD) before seeking the stronger protection of the RCD. There are 3 requirements for design protection, namely (i) novelty (no identical

design must have been disseminated previously); (ii) individual character (the item's impression on the buying public must be distinct from that made by any previous design); and (iii) inoffensiveness (the design should not constitute an offence against public morality).

Somewhat surprisingly, in spite of the seemingly strong rights granted there has not been much case law relating to designs since the establishment of this framework. Legal scholars have offered various explanations for the lack of judicial decisions relating to the framework, including inter alia, that (a) standards of eligibility are somewhat low (novelty requires only that no *identical* design has been available) so that any attempt at meaningful protection standards may change this outcome; (b) infringement suits are initiated but parties regularly reach confidential settlements before trial, with settlements reported only in the most egregious cases (such as when luxury brand Chloé received around GBP12,000 from Topshop, which was ruled to have plagiarized its dungaree dress[3]); and (c) in general, agents in the EU are somewhat less litigious than in the US, so that cases are less frequent than might be expected under a similar set of rules in the US.

This lack of case law is, however, consistent with the results of this model. I predict that if the only effect of protection is to prevent knockoffs, then designers may do better not to utilize the system at all. The design rights framework would remain under-utilized as fashion leaders choose to let imitation continue, in spite of the fact that such imitation partially erodes any novelty lead. Conversely, if protection carries sufficient additional benefits for firms, I predict that designers will do best not to litigate but to license to would-be infringers. In either case, filings would be minimal.

2.2.2. Current and Proposed Protection in the US

As the current time, fashion design is largely outside of the realm of US IP law, as current IP categories allow for only a small portion of design elements to be protected.

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[3]Emil Dugan, 'Topshop Ordered to Destroy Dresses Copied from Chloé Design', The Independent, July 27, 2007.

Thus, fashion design is often said to fall into IP's 'negative space'[4]: Design Patents only protect "new, original and ornamental design for an article or manufacture"[5], but novelty and non-obviousness criteria are hard to satisfy for apparel and the approval process is lengthy; Copyright covers only "original works of authorship" and does not extend to items which have an "intrinsic utilitarian function"[6]; and Trademark and Trade Dress preserve only distinguishing words and symbols/devices used by an individual or a firm to identify its product but provides no protection to elements of the design itself.

The proposed IDPPPA is intended to fill this gap, suppressing 'knockoff' copying. This protection may be also be deployed between designers, blocking so called 'homage' or inspiration collections. Indeed, while imitation of high-end collections by mass market firms undoubtedly attracts more attention, designer produced homages - effectively high quality knockoffs of past designs by fellow high-end houses - are not insignificant. Notable examples include Ralph Lauren's replication of Yves Saint Laurent's classic black tuxedo dress[7] and the use of Rick Owens designs as 'inspiration' by both Helmut Lang and Alexander Wang.[8]

A Summary of the Proposed Innovative Design Protection and Piracy Prevention Act (IDPPPA)   The proposed Act would extend the existing protection mechanism for vessel hull designs to fashion designs, with a fashion design described as "the appearance as a whole of an article of apparel, including its ornamentation"[9]. Apparel, specifically, is defined as:

"(A) an article of men's, women's, or children's clothing, including undergarments,

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[4]This discussion is based on Spevacek (2009), which provides a more detailed analysis of the challenges for design protection in current IP categories.

[5]35 U.S.C. §171 (2006)

[6]Ibid. §101

[7]The suit over the dress, first created by Mr. Saint Laurent in 1966, was filed in Paris in 1994 by Yves Saint Laurent. The Tribunal de Commerce awarded Yves Saint Laurent USD395,090 for "counterfeiting and disloyal competition". See Amy M. Spindler, 'A Ruling by French Court Finds Copyright in a Design', The New York Times, May 19, 1994.

[8]Ruth La Ferla, 'Imitate that Zipper!', The New York Times, September 02, 2009.

[9]Text of S 3728, 111th Congress (2010), Section 2(a)(7)

outerwear, gloves, footwear, and headgear;

(B) handbags, purses, wallets, duffel bags, suitcases, tote bags and belts; and

(C) eyeglass frames."[10]

Rights would be analogous to those provided under the European UCD, in that they would be valid for up to 3 years with no registration required. Instead, a designer can claim protection of an eligible design simply by marking the apparel as protected (tagging the item with the words 'protected design' or a to-be-approved symbol).[11] However, knowingly marking an ineligible design as protected would also carry penalties.

In theory, eligibility requires "a unique, distinguishable, non-trivial and non-utilitarian variation over prior designs"[12] and designs would be protected only from knockoffs which are "so similar in appearance as to be likely mistaken for the protected design"[13], though there is a real question as to how Courts will go about interpreting the unique and non-trivial criteria. Further, as currently laid out, the Act requires plaintiffs to show that the design meets all the criteria for protection and that it was available for sufficient time and in sufficient locations that the alleged infringer could not reasonably claim to be unaware of its existence.

2.3. Related Literature

The status concerns and psychological motivations surrounding consumption of fashion goods have long been studied in economics, from the seminal works of Veblen (1899) and Leibenstein (1950). However the literature has focused on explaining fashion cycles and on the welfare and public policy impact of the associated consumption externalities, with less attention to the question of imitation. Coelho and McClure (1993) incorporate

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[10]Ibid., Section 2(a)(9)

[11]According to the most recent version of the proposed legislation, if designs are not marked it would be more difficult for a designer to seek relief, as written notice of the design protection would have to be provided to the relevant parties before action could be taken.

[12]Ibid., Section 2(a)(7)

[13]Ibid., Section 2(a)(10)

status effects into the standard monopoly model and show that if consumers consider future as well as current period output by the firm, pricing behavior may be cyclical even with downward sloping demand. Pesendorfer (1995) models demand for fashion goods as driven by the desire to signal status in a matching game. Fashion cycles are driven by the fact that the composition of 'in' and 'out' groups change over time, so that the monopoly designer has the incentive to periodically make new signals. Frijters (1998) takes a similar approach in that fashion goods are used to signal status though here the status associated with the good is the average social standing of those also consuming the good. Again firms have the incentive to periodically create new designs as old ones lose signalling value. Bagwell and Bernheim (1996) and Corneo and Jeanne (1997) also focus on the use of fashion goods as signals of status.

While imitation of fashion designs has to date been less well investigated, three recent works address that question. Caulkins et al. (2007) uses an optimal control model to analyze choices by a fashion leader firm facing multiple imitators in a one-dimensional product space and shows that, depending on the level of design cost, it may be optimal for the leader to never innovate, to innovate once or to constantly innovate, cycling so as to stay ahead of imitators. Jorgensen and Di Liddo (2007) uses a 2 period discrete time model to analyze optimal timing of entry by designers into mid-range markets in response to imitation, modelling the high-end and mid-class segments as separate markets, in which demand depends on brand power. Bekir et al. (2010) looks at the related issue of when luxury designers act to drive counterfeiters out of production, concluding that luxury providers will not act to completely remove counterfeiters as these firms may increase profits to luxury designers if designers are able to appropriate revenues from the infringing counterfeiting and the presence of counterfeiters induces snob effects.

However, without exception these models assume that fashion is driven by designer products and that imitators have no ability to transform themselves into branded competitors who then influence design. Inclusion of both the expanded strategic choice

for mass-marketers and the design protection question distinguishes the current work. We believe the ability of mass-marketers to influence trends is realistic, as the rising influence of street-wear and urban fashion on pop culture has fuelled growth of lower quality, high-volume brand families, certain of which now rival high-end operators in both asset base and supply chain dominance.[14] This is having a knock-on effect on the products of high-end designers themselves, which would suggest that rather than solely making trends designers may also be refining and reflecting them.

This paper is also related to the literature on product differentiation with consumption externalities. Recent papers focus on horizontally related industries with network effects (Ghazzai and Lahmandi-Ayed (2009), Baake and Boom (2001)) and snob effects (Grilo et al. (2001)). Consumption externalities in vertical differentiation has been taken up in Lambertini and Orsini (2002), (2005) which analyze welfare and regulation in monopoly and duopoly cases, respectively. However they analyze the implications of the status effect on firm qualities and profits and on taxation policy, while this paper attempts to analyze the interaction of taste for novelty, imitation and IP policy.

The ongoing legislative attempts at design protection have also inspired a large legal literature on fashion goods and IP policy, with several recent papers focusing squarely on the potential effects of the proposed IDPPPA (Hedrick (2007), Preet (2008), Spevacek (2009), Beltrametti (2010)) though the opposing viewpoints are perhaps best summarized by, on the one hand, the arguments in Hemphill and Suk (2009a), (2009b) that rampant copying is impeding innovation in fashion and that greater IP protection should be applied, and on the other, by the arguments in Raustiala and Sprigman (2006), (2009) that IP protection will harm fashion firms, as imitation boosts profits by establishing anchors (the set of current designs representing what is 'in fashion') and helping to speed up the fashion cycle by diffusing trends.

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[14]One clear example is Swedish retailer H&M Hennes & Mauritz AB; in fiscal 2010, the H&M group earned operating profit of SEK 24.7BN, equivalent to approx USD 3.5BN; this compares well to the operating performance of the entire Fashion and Leather Goods division of LVMH, a stable of 10 luxury brands including Louis Vuitton, Fendi and Marc Jacobs, which earned EUR 2.6BN, equivalent to USD3.4BN.

2.4. Model Setup

I explore a sequential game in which two vertically differentiated, single product apparel firms compete in prices in the market. The vertical differentiation model seems most appropriate for the analysis of fashion firms, as the industry lends itself to broad ordering of preferences on both objective (quality of fabric and ornamentation) and subjective (branding) grounds, with this ordering reinforced by heavy advertising and editorial coverage. The high quality firm (the 'designer' firm, denoted D) faces a lower quality firm (the 'mass marketer', denoted M) which can choose to imitate the design produced by the high-end firm (to *knockoff*), to produce its own mainstream design (I also term this an 'ordinary' design) or to produce its own novel design (to *differentiate*) each season.

I do not focus on explaining the length or persistence of fashion cycles in this effort, simply assuming instead that each firm introduces a new product, which may or may not consist of a novel design, each season.[15] This seems a realistic description, as individual designers do largely conform themselves to the relatively rigid industry calendar in respect of introduction of designs (runway shows) and delivery of new collections into stores, and as not every season is characterized by novelty in fashion designs (with some seasons' designs heavily inspired by the past).

Design protection allows right-holders the legal means to preclude sale of, or to appropriate revenues earned from, any design approximating the protected one. Such rights may also provide additional benefits to the firm over and above the protection of the current season design. Ownership of such assets may positively influence consumer perception of the brand, marking the firm as a true seasonal trendsetter, or of the design itself, certifying the collection as a *focal* collection for the period. In this sense, ownership of the design right makes the product more attractive. Any firm, independent of quality, may thus gain from protecting a novel design. Design rights would reach not simply knockoffs but also potentially any future 'homage' designs and would apply to all

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[15]The single product may also be referred to by the fashion industry term *collection*. I will use the term collection and design interchangeably.

classes of rivals. Protection is costless and any protection decision is observable. Only novel designs may receive protection, implying that novelty is observable to the Courts. This rules out any attempt by a mass-marketer to seek protection for a knockoff.

2.4.1. Firms

I consider a duopoly with the designer offering a quality s_d and the mass-marketer offering quality s_m, with $s_d > s_m > 0$. Each firm seeks to maximize profits, $\pi_i = (p_i - c_i)q_i - F_i$, where p_i refers to the price, q_i to the output and c_i to the marginal cost of firm i.

Marginal cost of production is increasing in quality, taking the form $c_i = \frac{s_i^2}{2}$ to reflect the more luxurious fabric, ornamentation and/or more labour intensive production costs associated with high end apparel.

Firms also face fixed costs of apparel production each season, representing the overheads associated with each collection (inter alia, design and/or sketching time and sample production). Fixed costs are denoted by F_i. Mainstream or ordinary designs, defined as those which rely on past influences and do not themselves constitute an artistic advance in fashion, have no novelty and have $F_i^o = 0$. Novel designs are associated with higher costs, $F_i^n > 0$, as producing a novel collection requires that designers conduct more research to ensure the relevant design elements do indeed comprise a non-trivial design advance. Thus, in selecting a design strategy the firm also selects a fixed cost level.

As the mass-market firm moves second, it faces a novelty cost disadvantage - in producing a novel design it must ensure that it invents around all existing designs, including any new designs presented by the designer firm in the same period. As such, $F_m^n > F_d^n$.

I am interested in exploring the potential effects of design protection on firms' design innovation and as such restrict attention to cases where firms can feasibly opt in or out of producing a novel collection. I therefore consider fixed costs of producing novel

collections which are strictly positive but low enough that the profit earned by the low quality firm is non-negative even if the firm does not maintain a novelty lead.[16]

Assumption 2.1 *Fixed costs are strictly positive but sufficiently low that a mass-market firm may feasibly produce a novel collection even in the absence of a novelty lead:* $0 < F_d^n < F_m^n < \pi_m^{nl}$

where π_m^{nl} refers to M's profit if neither or both firms produce novel, protected collections (and therefore no novelty or protection lead applies).

Imitation by Mass-market Firms

Producing a knockoff allows M to mimic the *look* (but not the branding) of D's collection. If M chooses to knockoff, it is able to avoid some of the season-specific fixed costs associated with producing an original collection (for example, it can save by hiring a smaller or lower-quality design team, or by reducing design time as it simply reverse-engineers D's patterns). This is reflected in $F_m^{im} = \kappa F_m^n$. In what follows, I set $\kappa = 0$, so that producing a knockoff collection incurs the same (zero) fixed cost as producing a mainstream collection.

2.4.2. Consumers

Consumers are heterogeneous in the marginal willingness to pay for quality, θ, distributed uniformly on $[\underline{\theta}, \bar{\theta}]$ where $\underline{\theta} = (\bar{\theta} - 1)$ and $\bar{\theta} > 1$. The mass of consumers is normalized to 1. Each consumer has a unit demand for fashion goods each period and buys from either of the firms. Formally,

Assumption 2.2 *Throughout, $\bar{\theta}$ is restricted such that there is full market coverage.*

This assumption simplifies the exposition.

A *trend* is set if there is a single novel design in the current selling period (season). Consumers have a preference for trendsetting (or novelty-leading) apparel, reflected

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[16]An alternative interpretation would be that I confine attention to large firms, for which the cost of hiring a design team is a small percentage of earnings.

in the increased utility associated with such a product. This is consistent with a Pesendorfer (1995) interpretation that owning a trendsetting design in the relevant period allows a customer to signal higher status (in this case, to signal herself a 'fashionista'). The trendsetting status of a design in a season is judged *relative to* the rival firm: a collection is perceived as novelty-leading if and only if the rival has not also produced a novel collection. If neither firm produces a novel design, the firms compete only on quality, as in the standard vertical differentiation framework. Similarly, if *both* firms produce a novel design, then the entire consumer population has access to new designs; there is no novelty leader which may confer status. In this case, the effective distance between the firms' products is again reduced to the quality differential.

Consumers buying from firm i enjoy a net surplus of $U_i = \theta s_i + n_n + \lambda n_{ipr} - p_i$, where s_i denotes the quality of firm i, alternatively construed as its brand or location in product space; $n_n \in \{0, 1\}$ is an indicator function representing a design novelty lead (or trend lead) over a trailing rival, with $n_n = 0$ if neither (both) firm(s) is (are) novel; and $n_{ipr} \in \{0, 1\}$ is an indicator function representing a protection lead over a trailing rival, with $n_{ipr} = 0$ if neither firm protects or both firms protect a novel design. Thus, if firm i has produced a novel design and firm j has not, consumers buying from firm i enjoy a net surplus equal to U_i and consumers buying from firm j enjoy a net surplus equal to U_j where:

$$U_i = \begin{cases} \theta s_i + 1 + \lambda - p_i & \text{if firm i has protected the novel design,} \\ \theta s_i + 1 - p_i & \text{if firm i has not protected the novel design,} \end{cases}$$

$$U_j = \begin{cases} \theta s_j + (1 - \gamma) - p_j & \text{if firm j knocks off i's novel design,} \\ \theta s_j - p_j & \text{if firm j produces a mainstream design,} \end{cases}$$

The effects of design novelty and protection are additive in the utility function, reflecting the underlying assumption that consumers' enjoyment of novel, protected designs is independent of the firm's quality: whether the brand that produces the

trendy, focal item for the season is a designer such as Gucci or a mass-marketer such as Topshop, its customers' willingness to pay increases.

Knockoffs allow mass-market consumers to participate in the status-conferring trend by displaying a lesser version of the novel item and, for this reason, provide increased utility relative to a mainstream mass-market design. The parameter $\gamma \in (0, 1)$ reflects the perceived distance between the original design and a knockoff. It is the same for all consumers. If there is imitation, the novelty lead associated with producing an innovative collection reduces to $1 - (1 - \gamma) = \gamma$, which is less than the lead enjoyed by a non-imitated designer (equal to 1). If γ is close to zero, the knockoff is viewed as almost identical to the high quality good in appearance (though there is still an obvious quality difference reflected in s_i) and any novelty advantage held by the designer is almost fully eroded. Conversely, if γ is close to 1, the knockoff is so poor a reproduction of the original design that the designer enjoys almost the full extent of the novelty gap.

The parameter $\lambda \geq 0$ reflects the consumer perception of the ownership of design rights for a trendsetting design. It is the same for all consumers. This is associated with the 'focality' of the design.[17] The design that sparks a trend serves as a focal point for the season, as it will, for example, be heavily publicized as the 'splurge' half of any 'splurge vs. steal' magazine editorials. Ownership of the design right serves to certify the firm's ownership of the focal design and thus increases the desirability of the *brand* that produces such focal designs. This effect is independent of quality. I therefore interpret $\lambda = 0$ to mean that consumers value only novelty; creation of novel designs does not add to the allure of the producer. However if $\lambda > 0$, consumers value novelty and derive increased utility from owning an original from the *it* brand, the producer of the season's focal design.

2.4.3. Welfare

If both firms enjoy positive demand and the marginal consumer (the consumer indifferent between buying the high-end and the mass-market good) has a marginal utility of

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[17]I thank Ed Hopkins for suggesting this interpretation.

quality given by θ^*, consumer surplus ('CS') and welfare ('W'), respectively, are equal to:

$$CS = \int_{\underline{\theta}}^{\theta^*} U_m d\theta + \int_{\theta^*}^{\bar{\theta}} U_d d\theta \qquad (2.1)$$

$$W = CS + \pi_d + \pi_m \qquad (2.2)$$

2.4.4. The Courts and Design Protection

Availability of design protection is announced to the firms at the start of the game. Design protection is perfect and if M imitates, it is required to transfer to the designer all revenue earned from sale of the knockoffs as damages.

2.4.5. Timing

The game proceeds in four steps. Period 0, the pre-season, and period 1, the selling period or *season*, are each divided into 2 sub-periods:

- Period 0.1: the designer chooses quality, decides if to produce a mainstream design or novel design and, if it elects novelty, whether or not to protect the design. At the end of this subperiod, the designer presents its collection (the range of apparel items based on its design) to the public: the real-world analogy is that D puts on a runway show.

- Period 0.2: the mass market firm chooses quality and decides whether to knockoff the designer firm, market its own mainstream design or its own novel design and, if it chooses to be novel, whether or not to protect the design.

- Period 1.1: the firms deliver designs to the market and compete in prices.

- Period 1.2: any cases of infringement are litigated in Court.

This timing captures the reality that while high-end designers show collections months in advance of the relevant season, typically mass market firms do not. These firms instead produce their collections later, and therefore have the opportunity to knockoff
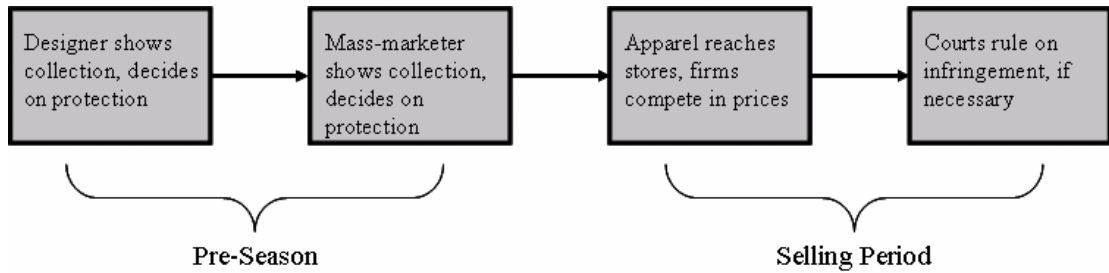
Figure 2.1.: Sequence of the game

designer efforts. As such, knockoffs may reach the market at the same time as originals. The order of moves in the game is illustrated in Figure 2.1.

The structure of the game is common knowledge and there is complete information.

2.5. The Model with Exogenous Quality

I proceed with the additional assumption that firm quality is exogenously given.

This setup of interest for two reasons: firstly, I believe this framework best encapsulates the challenge for existing fashion firms when considering whether to protect designs for a particular selling season. The fashion industry is characterized by heavy investment in establishing and re-enforcing firms' market positions, with the aim of fixing the firm's brand in the minds of consumers. As such, product quality may be viewed as effectively fixed on a *season to season* basis for existing firms.

Secondly, the market sees high-end designers facing competition and threats of imitation from competitors right across the quality spectrum: from the value segment of the market (low end, high volume operators such as Forever 21 and Primark as well as the higher quality fast fashion firms such as Zara and H&M), from the mid-priced segment (including aspirational brands, such as Banana Republic, Ann Taylor and Whistles) and even from the premium segment (other designers, both small, independent design houses as well as respected rival high-end brands) and it is of interest to explore the effects of protection for competition between the designer and various types of mass-marketer.

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I therefore normalize firm qualities s_d and s_m to 1 and β, respectively, with $0 < \beta < 1$.[18]

2.5.1. The no protection regime

First consider the case reflecting the status quo in the US: assume no protection for fashion design is available. At stage 0.2, M must decide if to produce a mainstream collection, knockoff or produce a novel collection. If D has produced a mainstream collection, M may choose to produce a novel collection and take the novelty lead. The effect of such a lead is to make M's product more attractive to consumers. The assumption on fixed costs means that novelty is always feasible, thus if M can take such a lead, it always chooses to do so.

If taking a lead is not possible (that is, if D has produced a novel design) then M must decide between maintaining and closing the novelty gap. If it produces a mainstream collection and trails in design, its product is less attractive to consumers than D's trendsetting offering (trailing is equivalent to increasing γ to 1). The result is that M must lower its price and has lower market share. However, at the same level of fixed cost - zero - M could partially close D's novelty gap by producing a knockoff collection. This allows the firm to adopt some elements of the novel design, free-riding on D's investment. Producing a mainstream collection is therefore always dominated by imitation for the mass marketer.

Optimal prices and payoffs if M imitates are given by:

$$p_d^{im} = \frac{1}{6}\left(2 + \beta^2 + 2\gamma + 2(1-\beta)(1+\bar{\theta})\right) \tag{2.3}$$

$$p_m^{im} = \frac{1}{6}\left(1 + 2\beta^2 - 2\gamma - 2(1-\beta)(-2+\bar{\theta})\right) \tag{2.4}$$

$$\pi_d^{im} = \frac{((1-\beta)(1+\beta-2(1+\bar{\theta}))-2\gamma)^2}{36(1-\beta)} - F_d^n \tag{2.5}$$

$$\pi_m^{im} = \frac{((1-\beta)(1+\beta+2(2-\bar{\theta}))-2\gamma)^2}{36(1-\beta)} \tag{2.6}$$

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[18]Note that this assumption is not crucial for the results, as findings for the specification with endogenous qualities are qualitatively similar. I present the model with endogenous qualities in Appendix B.

The importance of trendsetting status in the market to designers is clear: if M either trails or imitates, D maintains a lead in novelty, which allows the designer firm to set higher prices and earn higher profits than it would absent a novelty lead. Designer prices and profits are increasing in the size of the lead, alternatively interpreted as the perceived imperfection of the knockoff (recall that the larger is γ, the less well-received is the knockoff).

If instead M chooses to produce its own novel collection, the firm can fully extinguish D's novelty lead and eliminate the designer's trendsetting edge (equivalent to reducing γ to 0), though to do so it must incur positive fixed costs. Optimal prices and payoffs if M is novel are given by:

$$p_d^{nov} = \frac{1}{6}\left(2 + \beta^2 + 2(1-\beta)(1+\bar{\theta})\right) \tag{2.7}$$

$$p_m^{nov} = \frac{1}{6}\left(1 + 2\beta^2 - 2(1-\beta)(-2+\bar{\theta})\right) \tag{2.8}$$

$$\pi_d^{nov} = \frac{((1-\beta)(1+\beta-2(1+\bar{\theta})))^2}{36(1-\beta)} - F_d^n \tag{2.9}$$

$$\pi_m^{nov} = \frac{((1-\beta)(1+\beta+2(2-\bar{\theta})))^2}{36(1-\beta)} - F_m^n. \tag{2.10}$$

With no novelty gap, average prices are unchanged though designer prices and payoffs are lower (the firm can no longer attract the trendsetting premium) and mass-market prices and payoffs are higher. At stage 0.2, then, M will compare the payoffs under imitation and under novelty and will imitate only if the increased profit associated with producing a novel collection exceeds the increased fixed cost spend, or if:

$$\frac{\gamma(-5 + \beta(4+\beta) + \gamma + 2\bar{\theta}(1-\beta))}{9(1-\beta)} \geq F_m^n. \tag{2.11}$$

The mass-marketer will knockoff the designer's collection otherwise. The better is the consumer perception of the knockoff (the lower is γ), the more attractive is imitation as a strategy for *any* mass-marketer. The critical value also confirms that different types of mass market firms have different incentives to knockoff: for moderate levels of γ, lower quality M-firms may prefer to knockoff a novel designer while higher quality M-firms may elect to produce novel collections.

I can more formally establish the critical quality levels for the mass marketer's decisions. Defining the following:

$$\beta_1 = -\frac{-9F_m^n + \sqrt{81F_m^n - 4\gamma^2(\gamma - (-3+\bar\theta)^2) + 36F_m^n\gamma(-3+\bar\theta)} - 2\gamma(-2+\bar\theta)}{2\gamma} \quad (2.12)$$

$$\beta_2 = \frac{9F_m^n + \sqrt{81F_m^n - 4\gamma^2(\gamma - (-3+\bar\theta)^2) + 36F_m^n\gamma(-3+\bar\theta)} + 2\gamma(-2+\bar\theta)}{2\gamma} \quad (2.13)$$

$$\beta_3 = -2 + \bar\theta + \sqrt{-2\gamma + (-3+\bar\theta)^2} \quad (2.14)$$

and summarizing, I have the following Lemma:

Lemma 2.1 *If it faces a designer with a novel collection, the mass marketer will imitate iff $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and will produce a novel collection otherwise.*

Proof: See Appendix.

Such a specification is illustrated in Figures 2.2 and 2.3, which are drawn assuming $\bar\theta = 1.4$, $\gamma = 0.21$ and $F_m^n = 0.05$.
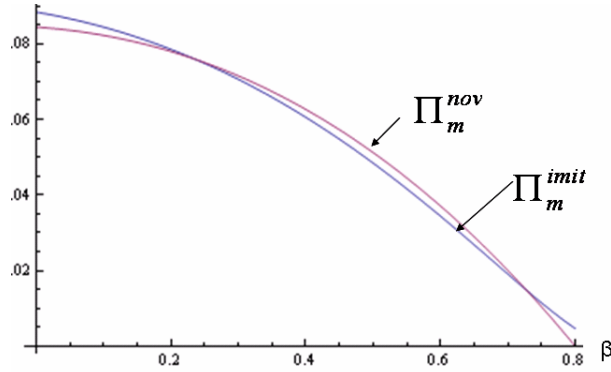
Figure 2.2.: M profit with novel D

The effects of imitation are non-monotonic in mass-market quality, β. The intuition is that for a given quality differential, closing the designer's novelty lead increases profit by allowing M to expand market share while charging a higher price on all units. A low quality M serves only a small share of the market and even with novelty does not extend this very much; further, producing a novel collection would see prices rise only slightly from a low level. As a result, the returns to novelty do not compensate for the increased spend. For a mid-quality M, the ability to expand share and to charge a higher price over

K=Knockoff; N = Novel design
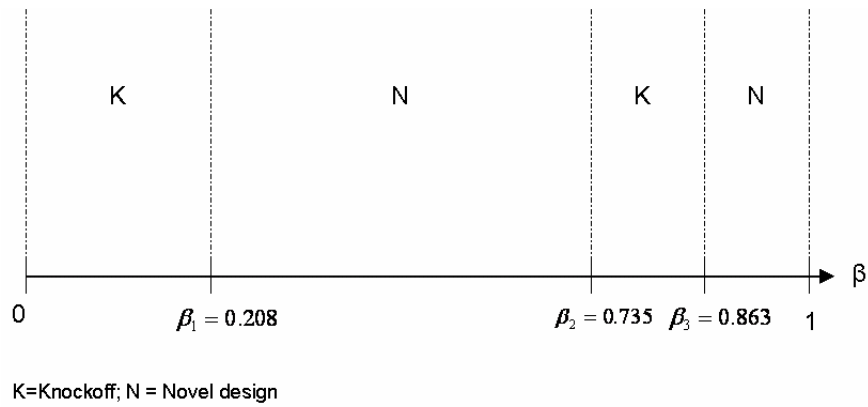
Figure 2.3.: M Choices with novel D

more units increases profit significantly and thus novelty is preferable to an ordinary collection. For moderate-to-high quality M, the quality differential with respect to D is more narrow; even knocking off the designer, M would maintain significant market share. As such, the returns to novelty would not compensate for additional fixed cost spending. For the highest quality competitors, however, the quality differential with respect to D is narrow enough that the firms are approaching horizontal competition. A high quality M would never imitate, as any novelty lead by D would be sufficient to allow D to capture the whole market.

The implications of the model are in line with observed outcomes in the market: given designers producing novel collections, very low quality mass-market brands may prefer to imitate while aspirational brands and close high-end designers produce their own novel collections. However the model illustrates a mechanism somewhat different than is generally assumed: it is not that low quality firms necessarily lack the resources or ability to innovate, but rather they rationally select this action as the extra spending associated with novel collections will not sufficiently increase profit (either prices or market share) to compensate.

Note that for low values of γ, β_2 and β_1 converge and decline toward zero and $\beta_3 \to 1$: the better is consumer perception of a knockoff, the more likely it is that *any* mass-market firm prefers to imitate the designer.

M's strategy may therefore be stated as follows: if D produces an ordinary design, M will produce a novel collection; if instead D produces a novel design, M will either imitate or be novel, but will never choose to produce an ordinary design. The payoff to the designer firm is strictly higher, regardless of M's action, if it produces a novel collection than if it produces a mainstream collection. D thus chooses to invest in novelty.

Summarizing the foregoing and defining:

$$\hat{\theta} = \frac{5 + 2(2 - \beta)\beta - 2\gamma}{2(1 - \beta)} \qquad (2.15)$$

$$\hat{\gamma} = \frac{1}{2}\left(2 + \beta - 2\beta^2 + 2\beta^3\right), \qquad (2.16)$$

Lemma 2.2 *Provided there is full market coverage and both firms operate, (i.e., if $\bar{\theta} < \hat{\theta}$ and $\gamma < \hat{\gamma}$), the designer firm always produces a novel collection. In the absence of design protection, the mass marketer imitates iff $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and produces its own novel collection otherwise.*

Proof: See Appendix.

If D leads in novelty, it can increase prices and profits over an imitating M: the novel designer good is more coveted and the knockoff is relatively less attractive to consumers. Even allowing for the fact that imitation helps trend formation as per Raustiala and Sprigman (2006), the model confirms that, consistent with arguments set forth in Hemphill and Suk (2009a), imitation by M hurts the designer firm, as knockoffs erode the designer's novelty lead.

2.5.2. Design Protection regime with $\lambda = 0$

Now assume that patent-style protection in the vein of the IDPPPA is available for fashion designs, but that $\lambda = 0$. This suggests that consumers are only interested in trendsetting design and that ownership of a design right carries no additional benefits for the firm. The assumption of perfect protection means that if the designer chooses to utilize the design protection system (that is, to claim protection for its design),

imitation is no longer a profitable strategy for the mass market firm: D will win any court action and M will be forced to transfer all profit to the designer as damages; the payoff associated with knockoffs is reduced to zero.

At stage 0.2, if M faces a mainstream collection by D, it does better to present a novel design and open a design lead. If it cannot take a lead, however, (i.e., if D has produced a protected, novel collection) M must now decide only between producing a mainstream collection or producing a novel collection. If it chooses the former, it trails in novelty (equivalent to setting $\gamma = 1$); M will lose market share to the designer and face downward pressure on price, as its product would be less attractive to consumers than D's novel design. If M chooses the latter, it can close the design gap (equivalent to reducing γ to 0), and enjoy both higher market share and price relative to the former case, though it must cover the fixed cost. Given the assumption that novelty is sufficiently cheap, M will do better to invest in novelty.

M's strategy may thus be summarized thusly: If D produces a mainstream collection M will produce a novel design and if D utilizes the design protection system and produces a mainstream collection, M will produce a novel collection. The mass-market firm reacts to a protected design by itself choosing novelty, though as novelty carries no additional benefits it is indifferent between protecting and not protecting its design.

The key question for the designer is therefore: given such reactions by M, is it optimal to utilize the design protection system in the first place? If D does protect, I have shown that M will also invest in novelty; prices and profits will be given by (2.7) through (2.10). If, however, the designer chooses not to protect, there is no impediment to imitation and the situation is equivalent to the no-protection regime. In that case M does better to imitate if $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and equilibrium prices and profits will be given by (2.3) through (2.6). If the designer faces a mass-marketer with quality levels in these ranges, using the protection system leaves D worse off than if no protection were available: (2.5) exceeds (2.9). Use of the system thus either leaves the designer strictly worse off (for relevant β) or indifferent (for all other β) relative to not using the system.

D therefore chooses not to protect any novel design in the current season. I summarize in the following:

Lemma 2.3 *If design protection is available and $\lambda = 0$, the designer firm does not protect its novel design. The mass marketer imitates iff $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and produces its own novel collection otherwise.*

The intuition is that while imitation narrows D's novelty gap, it does not entirely erode it; as such, while the designer would be better off if it could fully suppress imitation *and M continued to trail*, in fact M will never choose to fall behind in novelty if knockoffs are proscribed. If the designer utilizes the protection system, the result is a complete erosion of its novelty lead. Because the designer earns higher profit being imitated than it earns facing a novel mass-marketer collection, the rational response is to not make use of the system.

One result of the model therefore is that if the design right allows for suppression of imitation but the right itself carries no added value for consumers, high-end designers may decline to use the protection system. This provides one possible explanation for the dearth of case law with respect to the DPR in the EU: designers simply do not assert protection against imitators (except in very limited cases).

The implication for US policymakers considering the IDPPPA is that while establishing such a system would not necessarily leave firms any worse off relative to the current no-protection landscape if $\lambda = 0$, the legal framework may remain under-utilized as designers seek to maintain novelty leads. As such, resources invested in establishing the design protection system may not be fully justified.

2.5.3. Design Protection regime with $\lambda > 0$

Assume again that IDPPPA-style protection for fashion design is available, but now consider the case with $\lambda > 0$: the very ownership of a protected design carries benefits for firms in the relevant selling season, as consumers not only enjoy possessing the trendsetting item but, also receive pleasure from/attach significance to knowing that

the fashion company has produced focal designs.

As shown in the preceding sub-section, if M faces a ordinary collection by D it will produce a novel collection, and a mass-marketer facing a novel, protected collection from D finds it preferable to produce a novel collection. With $\lambda > 0$, however, the mass-market firm now also finds it beneficial to protect any novel design. M will thus close any novelty and protection gaps. Optimal prices and profits are again given by (2.7) through (2.10).

But what are M's actions if D chooses not to utilize the protection system? In the foregoing case, the designer could avoid the erosion of its novelty lead simply by not seeking design protection; could a similar strategy be applied here? If the mass-market firm faces a designer which has produced a novel collection but has declined to protect it, there is no impediment to imitation. M could therefore choose to save on fixed costs and knockoff, earning a payoff equal to (2.6); it could invest in novelty without protecting, closing D's novelty gap, earning a payoff equal to (2.10); or it could invest in novelty and protect its design, thereby opening up a protection lead over the designer. In this last case, optimal prices and payoffs are given by:

$$p_d^{im} = \frac{1}{6} \left(2 + \beta^2 - 2\lambda + 2(1-\beta)(1+\bar{\theta}) \right) \tag{2.17}$$

$$p_m^{im} = \frac{1}{6} \left(1 + 2\beta^2 + 2\lambda - 2(1-\beta)(-2+\bar{\theta}) \right) \tag{2.18}$$

$$\pi_d^{im} = \frac{((1-\beta)(1+\beta-2(1+\bar{\theta}))+2\lambda)^2}{36(1-\beta)} - F_d^n \tag{2.19}$$

$$\pi_m^{im} = \frac{((1-\beta)(1+\beta+2(2-\bar{\theta}))+2\lambda)^2}{36(1-\beta)} - F_m^n. \tag{2.20}$$

In this last case, participation by both firms is only guaranteed for sufficiently large quality differential, or for $\beta < \beta_4 = 1 + \bar{\theta} - \sqrt{\bar{\theta}^2 + 2\lambda}$ (see Appendix). If a higher quality mass-marketer opened a protection lead it would capture the whole market. It is straightforward, then, that all such M firms have a clear incentive to seek a protection lead. Within the range of quality differentials in which both firms operate given a protection lead to M (i.e., $\beta \in (0, \beta_4]$), what the firm earns if it takes a lead (2.20) exceeds what it earns by imitating (2.6) only if λ is sufficiently high, specifically

if:

$$\lambda > \hat{\lambda} = \frac{1}{2}(3\beta^2 + 3\sqrt{-4F_m^n(-1 + \beta) + \beta^4} - 2\gamma). \qquad (2.21)$$

If $\lambda > \hat{\lambda}$, *all* mass-marketers would prefer investing in novelty and taking a protection lead over a designer which has a novel, unprotected design. This critical value is decreasing in the fixed cost of novelty, as expected, but interestingly is *increasing* in mass-marketer quality, β. The model suggests it is the lowest quality M firms that are most likely to invest in novelty and protect designs if protection is valuable to consumers and the designer firm does not itself protect. This is because the protection lead, by raising the overall attractiveness of the firm's apparel to consumers, compensates for low quality. This effect is most important for the lowest quality firms.

If $\lambda \in (0, \hat{\lambda}]$, M's strategy is as follows: if D produces a mainstream collection, M will produce a novel collection and protect it; if D produces a novel, protected collection, M will produce a novel, protected collection; and if D produces a novel collection but does not protect it, M will either knockoff or produce a novel, protected collection. Thus ownership of the design protection is not valuable enough to drive mass-marketers with quality in the relevant ranges of β away from a knockoff strategy if imitation is possible. If it competes with such mass-marketers, then, the designer can avoid complete erosion of its design lead if it declines to use the protection system. The situation again parallels the no protection regime; if protection is not utilized, there is no legal impediment to imitation and equilibrium prices and profits are given by (2.3) through (2.6).

If $\lambda > \hat{\lambda}$, however, M's strategy may be laid out as: if D produces a mainstream collection, M will produce a novel collection and protect it; if D produces a novel, protected collection, M will produce a novel, protected collection; and if D produces a novel collection but does not protect it, M will produce a novel, protected collection. Investing in novelty and using the design right system is a dominant strategy for the mass-market firm. The designer, making its choice at stage 0.1, is aware that M will

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produce a novel, protected collection if the benefits associated with protection are sufficiently high; its dominant strategy is to likewise produce a novel, protected collection in such cases. Neither firm maintains a novelty lead or a protection lead and equilibrium prices and profits are described by equations (2.7) through (2.10).

Lemma 2.4 *If design protection is available and $\lambda > \hat{\lambda}$, the designer and the mass marketer both produce novel collections and choose to protect their respective designs.*

The model suggests that if design protection is very valuable to a firm then, unsurprisingly, the system is more likely to be used. But does the design protection system generate the expected benefit to the designer when it is used? Recall that if $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$, the equilibrium outcome in the no protection regime is that the mass-marketer produces a knockoff collection. This leaves the designer with an effective novelty lead, γ, that is less than one but strictly positive. If design rights sufficiently enhance the popularity of a novel collection or the reputation of the design house, I have shown that suppressing imitative activity leads all mass-marketers to become design innovators. The effect is to eliminate any novelty lead and to reduce the competitive landscape to the standard vertical differentiation case. This leaves the designer firm either indifferent or strictly worse off relative to what it would earn if no design protection were available: in both regimes D produces a novel collection, incurring fixed costs of F_d^n; however it is only in the no protection regime that D is able to maintain a small novelty lead.

The key here is that mass-marketers are imitators not by necessity but by choice - they free-ride on the high-end designers' spending on seasonal trends and silhouettes so as to save on collection-related overheads. Should such free-riding be prohibited, however, there is no reason to believe that such firms would be content to fall behind both on quality and on design terms. Indeed, if ownership of a design right sufficiently increases the status (and hence willingness to pay) associated with a fashion firm, the mass-marketer will also have an incentive to secure such a right. For *both* firms, investing in novelty and making use of the protection system is a dominant strategy.

In equilibrium, both firms produce novel collections and there is no single, status-conferring trend in the season.

Proposition 2.1 *If $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and $\lambda > \hat{\lambda}$, the designer firm is unambiguously worse off under design protection relative to the no protection regime.*

The somewhat counter-intuitive outcome is that it is exactly when protection for fashion designs yields valuable advantages that designer firms are worse off if protection is available.

For mass-marketers, model outcomes are more in line with what may be expected: firms that prefer to knockoff in the absence of protection are worse off if the design protection system is used. However it is not because suppressing imitation leaves them at a disadvantage in design. Rather, it is that these firms find themselves driven to invest in novelty - hiring in design teams, for example - though the increased profit associated with producing a competing novel design is low compared to the increased fixed-cost spend. This is nonetheless the best available action, since trailing in both novelty and design protection ownership yields an even smaller payoff.

Proposition 2.2 *If $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and $\lambda > \hat{\lambda}$, the mass-market firm is worse off under design protection relative to the no protection regime.*

How can it be that providing the intellectual property right can leave both firms worse off? The intuition rests on the principle that design novelty is perceived only in relation to the rival firm's offering: consumers like displaying trendsetting apparel and are therefore willing to pay more for such items, but this implies there must be other firms lagging the trend. The design rights system may provide an incentive for mass-marketers to close the trend gap, narrowing the effective degree of product differentiation and making them more dangerous competitors to the higher-cost design firms.

The model therefore provides a cautionary note for IDPPPA proponents: while imitation does reduce the profitability of novel designs - the designer indeed makes lower

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profit if its design is imitated than it would make if it could enjoy the full extent of a novelty lead - the designer will only be better off suppressing knockoffs if the mass-marketer *continues to trail in novelty*. If instead the mass-marketers start to offer competing designs, the effect of protection is to make the industry more competitive.

Results also suggest that the policy would lead to increased design innovation, but that the increase would be driven by mass-marketers rather than designer firms. Indeed, the model implies that high quality firms invest just as much in novel designs if protection is available as they do if it is not. This is because even when imitation is possible, the designer invests in novelty as failing to do so leaves it vulnerable to being overtaken in design.

The overall message is that the proposed design rights system may in fact do designers more harm than good, as fashion firms may find themselves trapped in a trend arms-race: each spends to introduce new, attention-grabbing designs to outdo the rival, but the result is that the competing designs in the marketplace effectively cancel each other out and consumers judge the collections by brand/firm location, just as they would if neither firm invested in novel designs.

Welfare Effects of Design Protection

I have shown that if design protection rights carry sufficient benefits to firms beyond the ability to suppress imitation, certain mass-market firms' equilibrium strategies differ from the no protection regime. What, then, is the welfare impact of the design protection system if the system is utilized (i.e., if $\lambda > \hat{\lambda}$)?

If design protection is not available or not utilized and $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$, M will imitate and D will produce a novel collection. Substituting for prices into (2.1) with $U_d = \theta - p_d + 1$ and $U_m = \theta\beta - p_m + (1 - \gamma)$, I calculate total consumer surplus as:

$$CS^{np} = \frac{1}{72(-1+\beta)} \left[(-13 - \beta^4 + 44\gamma + 4\beta^3(-5+\bar{\theta}) - 28\bar{\theta} - 4(\gamma+\bar{\theta})^2 + \right.$$

$$\left. \beta^2(30 - 4\gamma - 4(-9+\bar{\theta})\bar{\theta}) + 4\beta(1 - 3\bar{\theta} + 2(\gamma(-5+\bar{\theta}) + \bar{\theta}^2))) \right] \qquad (2.22)$$

Total profit to the firms is given by the sum of (2.5) and (2.6).

If instead design protection is available and $\lambda > \hat{\lambda}$, both firms will produce novel collections. Again, I substitute for prices into (2.1), though now with $U_d = \theta - p_d$ and $U_m = \theta\beta - p_d$. Total consumer surplus is now given by:

$$CS^{ipr} = \frac{(-59 - \beta(-9 + \beta(21 + \beta)) + 28\bar{\theta} + 4\beta(10 + \beta)\bar{\theta} - 4(-1 + \beta)\bar{\theta}^2)}{72} \tag{2.23}$$

and total profit to the firms is given by the sum of (2.9) and (2.10).

The increase in welfare under the design rights system relative to the no protection regime may be expressed as:

$$W^{ipr} - W^{np} = \Delta W = \frac{(18 + 5\beta^2\gamma + \gamma(-19 + 5\gamma + 10\bar{\theta}) - 2\beta(9 - 7\gamma + 5\gamma\bar{\theta}))}{18(-1 + \beta)} - F_m^n \tag{2.24}$$

Proposition 2.3 *If $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and $\lambda > \hat{\lambda}$, welfare is unambiguously lower in the design protection regime relative to a no protection regime.*

Proof: See Appendix.

The intuition here is that high-end consumers prefer buying a novel design when others in the market cannot, as the firm is a trendsetter. The presence of knockoffs in the market erodes, but does not completely remove, this effect: designer customers enjoy higher utility - even after considering the higher prices paid for such goods - in the no protection regime. Further, as imitation allows mass-market customers to participate in the status-conferring trend, they are also better off. Consumer surplus is therefore higher without design protection.

Joint firm profit is also higher in the no protection regime: the trend lead means the designer firm's good is more attractive to consumers, allowing D to increase prices and at the same time serve a larger share of the market. The imitating mass-marketer is also better off, as it is able to increase prices and partially close the designer's novelty lead while saving on season fixed costs.

A Prisoners' Dilemma in Design Protection

I have shown above that with introduction of IDPPPA-style protection, only mass-marketers such that $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ will change their strategic choice. In all other cases, introduction of the system leaves firms indifferent relative to the no protection regime. For the remainder of the discussion, I restrict attention to mass-marketers in the aforementioned quality ranges and summarize the effects of introducing a design protection system.

Figure 2.4 lays out the normal form of the game if IDPPPA-style protection is available for fashion designs.

The designer may choose to produce an ordinary design, which is ineligible for protection; to produce a novel design but decline to protect it; or to produce and protect its novel design. The mass-marketer, moving second, has each of these choices as well, plus the option of knocking off the designer's collection. At stage 0.2, M has the benefit of knowing which of the actions D has chosen.

First consider the case if $\lambda \in (0, \hat{\lambda}]$. If the designer has produced a mainstream collection, M's best response is to produce a novel design and protect it: novelty without protection requires the same fixed cost spend but offers a lower lead, and both mainstream and knockoff collections do not allow for any lead at all. If D has produced a novel design and protected it, the best M can do is to take the same action. If instead D has produced a novel design but not protected it, then all mass-marketers with quality in the ranges under consideration do best to imitate. The designer, moving at stage 0.1, can anticipate M's strategic choices; if it produces a mainstream collection it will trail; if it produces a novel collection it will not enjoy any trend or protection lead; and if it produces a novel collection but does not protect, it can maintain a reduced trend lead. Of these possibilities, D does best to choose novelty without protection. The equilibrium with $\lambda \in (0, \hat{\lambda}]$, highlighted in blue in Figure 2.4, replicates the outcome in the no protection regime.

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D	Novel, Protect	Novel, No Protect	Knockoff	Ordinary
Ordinary	$\pi_d^{-(n+p)}, \pi_m^{n+p} - F_m^n$	$\pi_d^{-n}, \pi_m^n - F_m^n$	π_d^{nl}, π_m^{nl}	π_d^{nl}, π_m^{nl}
Novel, Protect	$\pi_d^{nl} - F_d^n, \pi_m^{nl} - F_m^n$	$\pi_d^p - F_d^n, \pi_m^{-p} - F_m^n$	$\pi^j - F_d^n, 0$	$\pi_d^{n+p} - F_d^n, \pi_m^{-(n+p)}$
Novel, No Protect	$\pi_d^{-p} - F_d^n, \pi_m^p - F_m^n$	$\pi_d^{nl} - F_d^n, \pi_m^{nl} - F_m^n$	$\pi_d^n - F_d^n, \pi_m^{im}$	$\pi_d^n - F_d^n, \pi_m^{-n}$

Superscripts: n=novelty lead; p=protection lead; nl=no lead; im=knockoff; j=joint

Figure 2.4.: A Prisoners' Dilemma in Design Protection

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Now consider the game with $\lambda > \hat{\lambda}$. Whatever the decision of the designer, M's best response is to produce a novel design and protect it: if the designer's collection is ordinary it can take a large lead; if the designer has produced a novel but unprotected collection it can maintain a significant protection lead; and if the designer has similarly produced a novel, protected collection it can close any leads. The designer, moving at stage 0.1, can anticipate that M will play its dominant strategy. But even considering all scenarios available, D does best to also produce and protect its novel collection. The equilibrium with $\lambda > \hat{\lambda}$ is highlighted in orange in Figure 2.4. Note, however, that each firm enjoys higher profit if the designer leads and the mass-marketer imitates; in this way, a trend is formed (increasing willingness to pay of both sets of consumers) and only the designer incurs the fixed cost of novelty. Each firm is worse off playing its dominant strategy of novelty with protection than it would be if the design system were not used. I therefore lay out the main result of the paper:

Proposition 2.4 *If $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$ and $\lambda > \hat{\lambda}$, introduction of the design protection system results in a Prisoners' Dilemma in fashion protection: each firm plays its dominant strategy and produces a novel, protected collection, even though each would enjoy higher profit if the protection system were not used.*

The equilibrium if no protection is available is a trend lead to D with imitation by M. However, if consumers regard trendsetting firms (focal design producers) very highly, introduction of the design system sets up a Prisoners' Dilemma in design protection: M will be unwilling to trail by the full extent of any novelty and protection gaps and will produce and protect a novel design. D - equally unwilling to trail its rival - will do the same. The result is that no trend emerges in the season and consumers judge designs by firm quality, just as they would have done if each firm had produced an ordinary collection.

The policy implication is, therefore, that it is preferable on welfare grounds *not* to allow design protection for fashion goods, as once the option of legal protection is available to the firms, they will either not use the system at all or will react in a manner

that adversely impacts both competitors and consumer welfare. This a strong policy conclusion, which runs counter to the conventional wisdom that increasing the action space of an agent weakly increases welfare.

2.5.4. Licensing

I have shown above that if the design rights system is used, firm profits and welfare may be lower than if no protection were available, but I have not so far allowed for licensing of design rights. Now suppose that if D invests in novelty and protects its design at stage 0.1, it could offer a license to M on entry at stage 0.2. This license constitutes permission to produce an official (lower quality) copy of the novel, protected design under M's brand.

The firms license via Nash bargaining. If they cannot agree a license, the outcome is as has already been shown: if the design system is used, each produces a novel, protected collection. If firms successfully conclude a license, however, then they compete in prices with D having both a protection and a trend lead. Licensing would therefore allow the designer firm to maintain a larger effective lead. But this outcome is only possible if *both* firms would be active in the market given such a combined lead for D. This requires that the quality differential is sufficiently large, or more formally, $\beta \leq \beta_5 = -2 + \bar{\theta} + \sqrt{(-3 + \bar{\theta})^2 - 2(\gamma + \lambda)}$.[19]

The surplus available to be shared in any licensing agreement is given by the difference between joint profit if D has both a protection and a novelty lead and the joint profit firms would make in the absence of licensing. I denote this surplus T, where:

$$T = F_m^n - \frac{2(\gamma + \lambda)\left(-2 + \beta + \beta^2 + \gamma + 2(1 - \beta)\bar{\theta} + \lambda\right)}{9(-1 + \beta)} \tag{2.25}$$

If the firms split the surplus equally[20], the payoffs to the designer and mass-marketer, respectively, under licensing are simply the outside option to each firm (firm payoff if

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[19] If $\beta \in (\beta_5, 1)$, a designer with a combined novelty and protection lead would capture the whole market.

[20] This assumption is somewhat more realistic but is not crucial for the results that follow. I summarize the case if D can appropriate the full surplus in the Appendix. The outcome for D is qualitatively similar to that presented here for low β.

no license is agreed and both offer novel, protected designs) plus $\frac{1}{2}T$, or:

$$\Pi_d^{lic} = \frac{1}{36}\left((-1-\beta)(1+\beta-2(1+\bar{\theta}))^2 - Y\right) - F_d^n; \tag{2.26}$$

$$\Pi_m^{lic} = \frac{1}{36}\left((1-\beta)(5+\beta-2\bar{\theta})^2 - Y\right) - F_m^n; \tag{2.27}$$

$$Y = \frac{2\left(9F_m^n(-1+\beta) - 2(\gamma+\lambda)\left(-2+\beta+\beta^2+\gamma+2\bar{\theta}-2\beta\bar{\theta}+\lambda\right)\right)}{-1+\beta}$$

The designer's payoff under licensing is smaller than its payoff in the no protection regime iff $\lambda \in (0, \lambda^*]$ and $\gamma < \gamma^*$ where

$$\lambda^* = \frac{1}{2}(3 - 3\beta) \tag{2.28}$$

$$\gamma^* = \frac{9F_m^n(-1+\beta) - 2\lambda((-1+\beta)(2+\beta-2\bar{\theta}) + \lambda)}{-6+6\beta+4\lambda}. \tag{2.29}$$

I next define γ_1 as:

$$\gamma_1 = \frac{3}{2}(-1+\beta+\beta^2) + \frac{1}{2}\sqrt{4-4\beta+9\beta^4} \tag{2.30}$$

and have the following proposition:

Proposition 2.5 *If $\lambda > \hat{\lambda}$, $\beta \in (0, \beta_5]$ and firms equally split any surplus associated with licensing, the designer will produce a novel collection and the mass-marketer a licensed, lower quality version of the novel design. The designer is nonetheless worse off under design protection with licensing relative to the no-protection regime if $\beta \in (0, \beta_1]$ or $\beta \in (\beta_2, \beta_3]$, $\hat{\lambda} < \lambda < \lambda^*$ and $\gamma_1 < \gamma < \gamma^*$.*
If $\beta \in (\beta_5, 1)$, no licensing is possible and both firms produce novel, protected designs.
Proof: See Appendix.

Intuitively, licensing would allow the designer to enjoy the benefits associated with leading in both novelty and ownership of the protected design - it markets its product with a larger effective gap than it could in the no protection regime. However, D must transfer half of the joint benefit to the mass-marketer in order to successfully conclude the agreement. The smaller are γ and λ (that is the better is the knockoff and the lower

is consumer regard for ownership of design rights) the smaller is the surplus associated with licensing and the less D is left with after its transfer to M. Thus, even allowing for licensing, the designer firm could be worse off under design protection: the size of the relevant transfer to M may outweigh the benefits of enjoying an expanded gap when selling in the market, meaning that D earns a payoff that is smaller than it would earn in the no protection regime.

Note that the agreement outlined here involves, either explicitly or implicitly, M *receiving* from D a payment on signing the license, as the surplus shared between the firms consists mainly (if not exclusively) of the benefits to D. Such an arrangement may easily be understood as the basis of the diffusion line concepts which are growing in popularity in the fashion industry: licensing with implicit payment to the mass-market firm is consistent with designer firm lending its expertise and brand power to a lower-quality rival via a collection designed by the high-end brand but sold under the lower quality firm's brand. Such undertakings have become increasingly popular in Europe and in the US, with recent examples including: Isaac Mizrahi for Target (2002-2007), Ronson for JC Penney (2009), Jimmy Choo for H&M (2009), Jean Paul Gaultier for Target (2010), Lanvin for H&M (2010), Missoni for Target (2010), Jil Sander's '+J' at Uniqlo (2009-2011) and Versace for H&M (2011).

This model therefore provides an alternative explanation for the proliferation of high-street diffusion lines crafted by designers and would predict an increase in such activity in the US in the wake of the aforementioned legislation.

2.6. Concluding Remarks

The model presented here is very stylized, focussing on a simple, sequential duopoly game with key assumptions of low fixed costs of novelty and full market coverage, and results should be read with the appropriate caution. I nevertheless feel that it succeeds in illustrating a key scenario in which design protection may actually hurt designers, mass-market firms and consumers.

While the claims of designers seeking design rights protection do have some merit - imitation hurts innovative firms relative to the case in which they could enjoy the full extent of any novelty lead - it is by no means certain that such rights will leave them better off. Indeed, in suppressing imitation protection rights may change the behavior of the mass-marketers, inducing these lower quality - and lower cost - competitors to innovate in design. Put more simply, while mass-market firms are happy to free-ride on the innovator and trail slightly, they may not be prepared to fall totally behind in novelty if free-riding is no longer permitted.

If design rights have little or no value in and of themselves, designers can avoid any suboptimal outcome by simply declining to use the system, effectively sanctioning knockoff activity. However if the ownership of design rights has a sufficiently high value to consumers (for example as certification of the originality of the design) firms may find themselves locked in a trend arms race, producing novel designs which simply cancel each other out in the market, so that in the end only quality matters, just as it would without any novelty in design. For certain parameter values licensing provides a way to stave off the arms race, though even in this outcome designers may be worse off relative to the no protection regime.

Fashion design protection policy may therefore have effects which run counter to the expectations of proponents, harming even the firms that seem to most support such legislation. The model also offers alternative explanations for both the lack of case law surrounding the establishment of the European Design Right System and for the uptick in designer-led diffusion lines at mass market stores.

There are several promising areas for extension of the model. These include incorporating a continuous novelty measure (as opposed to the binary choice here), exploring the effects of imperfect design patents and expanding the time horizon of the model to analyze the effect of stacked design rights on firms' future design and protection choices.

A. Appendix 1

A.1. Proof of Lemmata 2.1 & 2.2

Define θ^* as the location of the consumer indifferent between buying from the designer and the mass marketer given that the designer maintains novelty and/or protection leads. Then θ^* is the solution to $U_d = U_m$ (designer and mass-marketer qualities are fixed at 1 and $\beta < 1$, respectively):

$$\theta^* = -\frac{-p_d + p_m + \gamma + \lambda}{1 - \beta}. \tag{2.A.1}$$

θ^* is internal to the support $[(\bar{\theta} - 1), \bar{\theta}]$ iff $(p_d - p_m) \in [((1 - \beta)(-1 + \bar{\theta}) + \gamma + \lambda), ((1 - \beta)\bar{\theta} + \gamma + \lambda)]$.

Profits to the designer and mass-marketer, respectively, are given by:

$$\pi_d = (p_d - \frac{1}{2})(\bar{\theta} - \theta^*); \tag{2.A.2}$$

$$\pi_m = (p_m - \frac{\beta^2}{2})(\theta^* - (\bar{\theta} - 1)). \tag{2.A.3}$$

Substituting for θ^* in the profit functions, the first order conditions w.r.t prices, respectively, are:

$$\frac{\delta \pi_d}{\delta p_d} = \frac{-4p_d + 2p_m + 1^2 + 2\bar{\theta} - 2\beta\bar{\theta} + 2(-1 + \gamma + \lambda)}{2(1 - \beta)} = 0; \tag{2.A.4}$$

$$\frac{\delta \pi_m}{\delta p_m} = \frac{2p_d - 4p_m - 2(-1 + \bar{\theta}) + \beta(-2 + \beta + 2\bar{\theta}) - 2(-1 + \gamma + \lambda)}{2(1 - \beta)} = 0. \tag{2.A.5}$$

If no protection is available, $\lambda = 0$. If there is imitation by M, $\gamma > 0$, so that the simultaneous solution yields the candidate equilibrium prices given in (2.3) and (2.4). If there is novelty by both firms, $\gamma = 0$ and the simultaneous solution yields the candidate prices given in (2.7) and (2.8). These prices satisfy the second order conditions.

These candidate prices are substituted into the profit functions to generate the profit

equations shown in (2.5) and (2.6), and (2.9) and (2.10), respectively.

Full market coverage with both firms active in the market requires that: (i) the price differential is such that θ^* is internal to the support of consumer tastes; (ii) the customer with the lowest marginal utility of quality, $(\bar{\theta} - 1)$, finds it preferable to purchase the product; and (iii) prices are non-negative.

For given trendsetting and protection leads, the marginal θ customer is internal to the support of tastes iff the quality differential is sufficiently large, or if:

$$\beta < \breve{\beta} = -2 + \bar{\theta} + \sqrt{(-3 + \bar{\theta})^2 - 2(\gamma + \lambda)}. \tag{2.A.6}$$

which corresponds to β_3 at (2.14) for $\lambda = 0$. The closer are firms in the quality dimension the closer is the market to horizontal competition and the stronger is the benefit associated with a lead. A leading designer captures the whole market ($\theta^* = (\bar{\theta} - 1)$) if $\beta = \beta_3$ and therefore any M with higher quality will always close any novelty or protection leads.

The utility of the lowest θ customer given the candidate prices is:

$$U_m(\bar{\theta} - 1) = (\bar{\theta} - 1)\beta - p_m + (1 - \gamma) \tag{2.A.7}$$

$$= \frac{1}{6}\left(-5 + 2(1 + 2\beta)\bar{\theta} - 2(-2 + \beta + \beta^2 + 2\gamma)\right). \tag{2.A.8}$$

Solving $U_m(\bar{\theta} - 1) = 0$ for $\bar{\theta}$, I obtain:

$$\bar{\theta}_0 = \frac{-1 + 2\beta(1 + \beta) + 4\gamma - 2\lambda}{2(1 + 2\beta)} \tag{2.A.9}$$

with positive surplus requiring $\bar{\theta} > \bar{\theta}_0$.

Setting the candidate p_m to zero and solving for $\bar{\theta}$ yields:

$$\bar{\theta}_1 = \frac{5 + 2(2 - \beta)\beta - 2\gamma - 2\lambda}{2(1 - \beta)} \tag{2.A.10}$$

with non-negative price requiring $\bar{\theta} < \bar{\theta}_1$. This particular restriction arises because in this setup I abstract from optimizing behaviour in respect of quality. For any higher

value of $\bar{\theta}$, the very lowest quality firms would have to reduce prices to zero and market participation by both firms is not satisfied.

This critical value $\bar{\theta}_1$ is equivalent to $\hat{\theta}$ in (2.14) for $\lambda = 0$. Comparing (2.A.9) and (2.A.10), $\bar{\theta}_1 > \bar{\theta}_0 \, \forall \, \gamma < \hat{\gamma} = \frac{1}{2} \left(2 + \beta - 2\beta^2 + 2\beta^3 - 2\beta\lambda \right)$.

Full market coverage and participation by both firms, given exogenous qualities, thus requires that the market is not too rich and that knockoffs are perceived sufficiently well.

To determine whether M prefers imitation or novelty, I set (2.6)=(2.10) and solve for β. This yields two solutions:

$$\beta_1 = -\frac{-9F_m^n + \sqrt{81F_m^n - 4\gamma^2(\gamma - (-3+\bar{\theta})^2) + 36F_m^n\gamma(-3+\bar{\theta})} - 2\gamma(-2+\bar{\theta})}{2\gamma}$$

$$\beta_2 = \frac{9F_m^n + \sqrt{81F_m^n - 4\gamma^2(\gamma - (-3+\bar{\theta})^2) + 36F_m^n\gamma(-3+\bar{\theta})} + 2\gamma(-2+\bar{\theta})}{2\gamma}$$

Straightforward comparison illustrates that $(2.6) > (2.10) \, \forall \, \beta < \beta_1$ and $\beta > \beta_2$ and $(2.6) < (2.10) \, \forall \, \beta \in (\beta_1, \beta_2)$.

A.2. M choice if D does not protect and $\lambda > 0$

If M opens up a protection lead over D, $U_d = \theta - p_d + 1$ and $U_m = \theta\beta - p_m + 1 + \lambda$. I find the consumer indifferent to buying from the designer and the mass-marketer by setting $U_d = U_m$ and solving for the marginal consumer and proceed with the profit-maximization in a manner analogous to that followed in Appendix A.1. Optimal prices and profits in (2.17) through (2.20).

If facing a novel, unprotected design by D, M has 4 choices: it may produce a mainstream collection and trail the designer firm; it may imitate the designer firm; it may produce a novel design and choose not to protect it; or it may produce a novel design and protect it.

I can rule out the first and third strategies: the first because producing a mainstream collection would mean trailing the designer in novelty and generating a lower total payoff then investing in novelty; and the third because investing in novelty but not protecting

would mean foregoing the costless option of taking a protection lead over the designer. Any investment in novelty is therefore accompanied by utilization of the design right system.

Left to consider are the second and fourth strategies. If the mass market firm imitates, it earns a payoff equal to (2.6). If the mass-market firm is novel and seeks design protection, both firms operate iff $\beta < \beta_4 = 1 + \bar{\theta} - \sqrt{\bar{\theta}^2 + 2\lambda}$. Note also that $\beta_4 > \breve{\beta}$.

Comparing the payoffs, (2.20) exceeds (2.6) iff $\gamma > -\lambda$ and $\bar{\theta} < \bar{\theta}_2$ where

$$\bar{\theta}_2 = \frac{9F_m^n(1-\beta) - 5\gamma + 4\beta\gamma + \beta^2\gamma + \gamma^2 - 5\lambda + 4\beta\lambda + \beta^2\lambda - \lambda^2}{2(-1+\beta)(\gamma+\lambda)}. \tag{2.A.11}$$

I compare this critical value to $\hat{\theta}$ to establish which is larger; if $\bar{\theta}_2 > \hat{\theta}$, then for all relevant model parameters (2.20) exceeds (2.6). Given γ and β, $\bar{\theta}_2 > \hat{\theta}$ if:

$$\lambda > \frac{1}{2}\left(3\beta^2 + 3\sqrt{-4F_m^n(-1+\beta)+\beta^4} - 2\gamma\right). \tag{2.A.12}$$

This critical value is renamed $\hat{\lambda}$ in the text.

A.3. Proof of Proposition 2.3

Total welfare in the no protection regime is given by:

$$W^{np} = \frac{1}{72(-1+\beta)}(-65 - 72F_d^n(-1+\beta) - 5\beta^4 + 76\gamma + 4\bar{\theta} - 20(\gamma+\bar{\theta})^2 + 4\beta^3(-7+5\bar{\theta})+$$

$$\beta^2(6 - 20\gamma + 4(9-5\bar{\theta})\bar{\theta}) + \beta(92 + 20\bar{\theta}(-3+2\bar{\theta}) + 8\gamma(-7+5\bar{\theta})) \tag{2.A.13}$$

while if design protection is available and $\lambda > \hat{\lambda}$, welfare is given by:

$$W^{ipr} =$$

$$\frac{1}{72}\left(-7 - 72F_d^n - 72F_m^n - \beta(27 + \beta(33+5\beta)) - 4\bar{\theta} + 4\beta(14+5\beta)\bar{\theta} - 20(-1+\beta)\bar{\theta}^2\right) \tag{2.A.14}$$

The welfare effect of design protection is therefore given by (2.A.14) minus (2.A.13),

denoted ΔW at (2.24) in the text. The overall sign of the welfare effect of design protection depends on the sign of the numerator of the first term in the ΔW expression as the denominator of the first term is negative. The numerator of the first term is positive, rendering the entire expression negative, iff $\gamma > 0$, $\beta < 1$ and $\bar{\theta} > \theta'$ where

$$\theta' = \frac{(18 - 18\beta - 19\gamma + 14\beta\gamma + 5\beta^2\gamma + 5\gamma^2)}{(-10\gamma + 10\beta\gamma)}. \tag{2.A.15}$$

This term is increasing in gamma and so will be highest if γ is at its maximum, $\hat{\gamma}$. Evaluating this term at the maximum value of γ:

$$\theta' = \frac{1}{20}\left(43 + \frac{15}{(-1+\beta)} + 10\beta(1+\beta) - \frac{7}{2 + \beta(1 + 2(-1+\beta)\beta)}\right) < 0. \tag{2.A.16}$$

As such, even at its highest possible value, this critical value for θ is negative. The numerator of the first term of the expression is therefore positive, and the entire expression for ΔW negative, for all relevant values of $\bar{\theta}$. Welfare is lower under design protection.

A.4. Proof of Proposition 2.5

The benefit to the designer from agreeing a license with M is given by the difference between what the firm would earn if M imitated its protected, novel design under the contract and what it would earn absent licensing (if M also produced a novel, protected design), with the latter given by (2.9). If M imitates with $\lambda > 0$, D earns:

$$\pi_d^{im-p} = \frac{((1-\beta)(4+1+\beta-2\bar{\theta})) - 2(\gamma+\lambda)^2}{36(1-\beta)} - F_d^n. \tag{2.A.17}$$

The designer's benefit is therefore the increase in profit it earns if M chooses to trail in both novelty and design right ownership in the market (which it agrees to do if licensing) versus investing in novelty and removing D's lead. Denote this benefit by H, where:

$$H = -\frac{(\gamma+\lambda)(1 + \beta^2 + \gamma + 2\bar{\theta} - 2\beta(1+\bar{\theta}) + \lambda)}{9(-1+\beta)} \tag{2.A.18}$$

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The benefit to the mass-marketer from entering the license agreement is similarly given by the difference between what it would be able to earn if it produces a licensed copy of the design but incurs a reduced fixed cost spend and what it would earn absent licensing (that is, if it produces a novel, protected collection). If it produces a novel collection, it earns a payoff equal to (2.10) and if it imitates D's protected design it earns:

$$\pi_m^{im-p} = \frac{((1-\beta)(1+\beta+2(2-\bar{\theta})) - 2(\gamma+\lambda)^2}{36(1-\beta)} \qquad (2.A.19)$$

the benefit to M is therefore the cost saving associated with imitation net of any reduction in profit it experiences from trailing in both novelty and design rights ownership. Let the overall benefit to M be denoted by G, where:

$$G = \frac{9F_m^n(-1+\beta) + (\gamma+\lambda)(-5+\beta^2+\gamma - 2\beta(-2+\bar{\theta}) + 2\bar{\theta}+\lambda)}{9(-1+\beta)} \qquad (2.A.20)$$

The surplus available under bargaining is therefore $T = G + H$, defined at (2.25) in the text.

I assume that the firms split the surplus equally; as such, firm payoffs under licensing are simply the firm's outside option (what it earns absent licensing) plus $\frac{1}{2}T$ and are defined in (2.26) and (2.27), respectively, for the designer and the mass-marketer.

In order to establish whether firms are better off under licensing relative to the no protection case, I compare payoffs under licensing to the payoffs under no protection, given at (2.5) and (2.6), respectively.

The designer is worse off under licensing - (2.5) exceeds (2.26) - iff $\beta < 1$, $F_m^n > 0$, $\lambda < \frac{1}{2}(3 - 3\beta)$ and:

$$\gamma < \frac{9F_m^n(-1+\beta) + 4\lambda - 2\beta\lambda - 2\beta^2\lambda - 4\bar{\theta}\lambda + 4\beta\bar{\theta} - 2\lambda^2}{-6 + 6\beta + 4\lambda} \qquad (2.A.21)$$

and these critical values for λ and γ are renamed λ^* and γ^*, respectively, in the text.

It remains to show that such values are possible for the range of parameters in which design protection is utilized. Recall that design protection is used as long as $\lambda > \hat{\lambda}$ and that the maximum novelty lead possible under imitation is given by $\hat{\gamma}$.

This requirement on γ is not restrictive as whether this restriction is larger or smaller

than $\hat{\gamma}$, there is a non empty set of values which satisfy it. I then must compare λ^* and $\hat{\lambda}$. $\lambda^* > \hat{\lambda}$ - so that there is a non-empty set of values for which D will choose to use the design right system but would be worse off under licensing - iff $\beta < -\frac{1}{2} + \frac{\sqrt{15 + 8\gamma}}{2\sqrt{3}}$, $\gamma \leq \frac{3}{2}$ and $F < F^*$ where:

$$F^* = \frac{(-9 + 18\beta + 9\beta^2 - 18\beta^3 - 12\gamma + 12\beta\gamma + 12\beta^2\gamma - 4\gamma^2)}{36(-1 + \beta)}. \qquad (2.A.22)$$

Note that the condition on β is always satisfied (this critical value exceeds β_5), and the condition on F is satisfied iff $\gamma > \gamma_1 = \frac{3}{2}(-1 + \beta + \beta^2) + \frac{1}{2}\sqrt{4 - 4\beta + 9\beta^4}$. I next compare this value to $\hat{\gamma}$. $\hat{\gamma} > \gamma_1$ - so there is a non-empty set of values satisfying all requirement - for moderate to low values of β.

A.5. Licensing outcome for D if it appropriates the full Surplus

Let us now suppose that D is able to extract the full amount of any surplus in a licensing agreement. (Note, however, that with such a division of the surplus licensing may be concluded over a narrower range of low-quality mass-marketers than in the case where the surplus is split). In this situation, M is restricted to its outside option (what it earns absent licensing, its payoff if both firms are novel and protect) given in the text at (2.10), while D earns:

$$\pi_{\bar{d}} \frac{(= 1 + \beta - 2\bar{\theta}) + 8(\gamma + \lambda)(-2 + \beta + \beta^2\gamma + 2\bar{\theta} - 2\beta\bar{\theta} + \lambda)}{36(1 - \beta)}.$$

Comparison of this payoff to D's payoff under the no protection regime show that D is better off with no protection if $\beta < 1$, $F > 0$, and either (i) $\lambda < \lambda^1$ and $\gamma \in (\gamma^1, \gamma^2)$

or (ii) $\lambda > \lambda^2$ and $\gamma \in (\gamma^1, \gamma^2)$, where:

$$\lambda^1 = \frac{1}{4}(6 - 6\beta - \sqrt{2}\sqrt{-J})$$

$$\lambda^2 = \frac{1}{4}(6 - 6\beta + \sqrt{2}\sqrt{-J})$$

$$\gamma^1 = \frac{1}{2}(5 - \beta(4 + \beta - 2\bar{\theta}) - 2\bar{\theta} - 4\lambda - \sqrt{K})$$

$$\gamma^2 = \frac{1}{2}(5 - \beta(4 + \beta - 2\bar{\theta}) - 2\bar{\theta} - 4\lambda + \sqrt{K})$$

where $J = (-1 + \beta)(36F_m^n + (-1 + \beta)(7 + 10\beta + \beta^2 - 4(5 + \beta)\bar{\theta} + 4\bar{\theta}))$

and $K = 36F_m^n(-1 + \beta) + (-1 + \beta)^2(5 + \beta - 2\bar{\theta})^2 + 24(-1 + \beta)\lambda + 8\lambda^2$

Recall that the firm would only make use of the design system if $\lambda > \hat{\lambda}$. There exists a non-empty set of parameter values for which D would use the system but nevertheless be worse off with licensing - even receiving the entire surplus - if either:

- $\lambda \in (\hat{\lambda}, \lambda^1)$ and $\gamma \in (\gamma^1, \gamma^2)$; or

- $\lambda \geq \max\{\hat{\lambda}, \lambda^2\}$ and $\gamma \in (\gamma^1, \gamma^2)$

The former set of requirements is met for low β. Note that in the licensing agreement, M is driven down to its outside option, the payoff it earns if neither firm enjoys a lead. The surplus that is appropriated by D is comprised of the increase in *joint* profit if D can lead by $(\gamma + \lambda)$; as such it takes account of the fact that in such a market outcome, M would be much worse off than D.

B. Appendix 2: The Model with Endogenous Quality

B.1. The no-protection regime

Suppose now that firms are free to select quality as well as novelty when deciding on the season's apparel collection and further that no design protection is available. The designer moves first, acting as a Stackelberg leader in quality selection.

Firm prices and profits at stage 1.1 are given by

$$p_d^e = \frac{1}{6}\left(2s_d^2 + s_m^2 + 2\gamma + 2(s_d - s_m)(1 + \bar{\theta})\right) \tag{2.B.1}$$

$$p_m^e = \frac{1}{6}\left(s_d^2 + 2s_m^2 - 2\gamma - 2(s_d - s_m)(-2 + \underline{\theta})\right) \tag{2.B.2}$$

$$\pi_d^e = \frac{((s_d - s_m)(s_d + s_m - 2(1 + \bar{\theta})) - 2\gamma)^2}{36(s_d - s_m)} - F_d^n \tag{2.B.3}$$

$$\pi_m^e = \frac{((s_d - s_m)(s_d + s_m + 2(2 - \bar{\theta})) - 2\gamma)^2}{36(s_d - s_m)} \tag{2.B.4}$$

which correspond to expressions (2.3) through (2.6) for $s_d = 1$ and $s_m = \beta$.

The first order conditions w.r.t prices, utilizing the most general form of the model are:

$$\frac{\delta\pi_d}{\delta p_d} = \frac{-4p_d + 2p_m + s_d^2 + 2s_d\bar{\theta} - 2s_m\bar{\theta} + 2(\gamma + \lambda)}{2(s_d - s_m)} = 0; \tag{2.B.5}$$

$$\frac{\delta\pi_m}{\delta p_m} = \frac{2p_d - 4p_m - 2s_d(-1 + \bar{\theta}) + s_m(-2 + s_m + 2\bar{\theta}) - 2(\gamma + \lambda)}{2(s_d - s_m)} = 0 \tag{2.B.6}$$

whose simultaneous solution yields the candidate prices:

$$p_d = \frac{1}{6}(2s_d^2 + 2s_d(1 + \bar{\theta}) + s_m(s_m - 2(1 + \bar{\theta})) + 2(\gamma + \lambda)); \tag{2.B.7}$$

$$p_m = \frac{1}{6}(s_d^2 - 2s_d(-2 + \bar{\theta}) + 2s_m(-2 + s_m + \bar{\theta}) - 2(\gamma + \lambda)). \tag{2.B.8}$$

These prices satisfy the second order conditions.

Plugging these expressions into the profit functions, the profits at stage 1.1 are:

$$\pi_d^e = \frac{((s_d - s_m)(s_d + s_m - 2(1 + \bar{\theta})) - 2(\gamma + \lambda))^2}{36(s_d - s_m)} - F_d^n \tag{2.B.9}$$

$$\pi_m^e = \frac{((s_d - s_m)(s_d + s_m + 2(2 - \bar{\theta})) - 2(\gamma + \lambda))^2}{36(s_d - s_m)}. \tag{2.B.10}$$

The designer is a Stackelberg leader, so that its quality is known at stage 0.2. Thus to find the optimal quality choice of the mass-marketer given s_d, I differentiate (2.B.10) and w.r.t s_m and obtain the first order condition:

$$\frac{\delta\pi_m}{\delta s_m} = \frac{((s_d - s_m)(4 + s_d + s_m - 2\bar{\theta}) - 2(\gamma + \lambda))((s_d - s_m)(-4 + s_d - 3s_m + 2\bar{\theta}) - 2(\gamma + \lambda))}{36(s_d - s_m)^2} = 0 \tag{2.B.11}$$

This expression yields four (4) candidate qualities:

$$s_m^1 = -2 + \bar{\theta} - \sqrt{(2 + s_d - \bar{\theta})^2 - 2(\gamma + \lambda)}$$

$$s_m^2 = -2 + \bar{\theta} + \sqrt{(2 + s_d - \bar{\theta})^2 - 2(\gamma + \lambda)}$$

$$s_m^3 = \frac{1}{3}(-2 + 2s_d + \bar{\theta} - \sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)})$$

$$s_m^4 = \frac{1}{3}(-2 + 2s_d + \bar{\theta} + \sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)})$$

I select the quality which results in highest profit and satisfies the second order condition: s_m^3.

At stage 0.1, the designer can predict the mass-marketer's quality choice and substitutes for s_m in its profit function, which then becomes:

$$\pi_d^e = \frac{(s_d^2 - 2s_d(1 + \bar{\theta}) - 2(\gamma + \lambda) + \frac{2}{3}(1 + \bar{\theta})X - \frac{1}{9}(-X)^2)^2}{12(2 + s_d - \bar{\theta} + \sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)})}$$

$$X = (-2 + 2s_d + \bar{\theta} - \sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}).$$

To find the optimal designer quality, I differentiate w.r.t. s_d and obtain the following first order condition:

$$\frac{\delta \pi_d^e}{\delta s_d} = \frac{1}{81}(19 + 4s_d^2 - 24\gamma + 8\bar{\theta} + 4\bar{\theta}^2 - 8s_d(1 + \bar{\theta}) - 24\lambda -$$

$$\frac{18}{\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}} + \frac{27s_d}{\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}} +$$

$$\frac{72\gamma}{\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}} - \frac{27\bar{\theta}}{\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}} +$$

$$\frac{72\lambda}{\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}} - 16\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)} +$$

$$4s_d\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)} - 4\bar{\theta}\sqrt{(2 + s_d - \bar{\theta})^2 + 6(\gamma + \lambda)}) = 0.$$

This expression yields four (4) candidate qualities:

$$s_d^1 = -2 + \bar{\theta} - \frac{1}{2}\sqrt{3}\sqrt{3 - 8(\gamma + \lambda)}; \qquad s_d^2 = -2 + \bar{\theta} + \frac{1}{2}\sqrt{3}\sqrt{3 - 8(\gamma + \lambda)}$$

$$s_d^3 = 1 + \bar{\theta} - \frac{1}{2}\sqrt{9 + 8(\gamma + \lambda)}; \qquad s_d^4 = 1 + \bar{\theta} + \frac{1}{2}\sqrt{9 + 8(\gamma + \lambda)}.$$

The solution which provides highest profits and satisfies the second order condition is s_d^3. I substitute for s_d^3 into s_m^3 to obtain:

$$s_m^* = \bar{\theta} - \frac{1}{3}\sqrt{9 + 8(\gamma + \lambda)} - \frac{1}{6}\sqrt{45 + 32(\gamma + \lambda) - 12\sqrt{9 + 8(\gamma + \lambda)}}.$$

I substitute for s_d and s_m in candidate prices to yield:

$$p_d = \frac{1}{216}(387 + 280\gamma + 280\lambda - 96\sqrt{9 + 8\gamma + 8\lambda} + 12S^e + 4(27\bar{\theta}(2 + \bar{\theta}) -$$

$$27\bar{\theta}\sqrt{9 + 8\gamma + 8\lambda} + \sqrt{9 + 8\gamma + 8\lambda}S^e)); \qquad (2.B.12)$$

$$p_m = \frac{1}{216}(423 + 128\gamma + 108\bar{\theta}^2 + 128\lambda - 84\sqrt{9 + 8\gamma + 8\lambda} + 24S^e +$$

$$8\sqrt{9 + 8\gamma + 8\lambda}S^e - 36\bar{\theta}(2\sqrt{9 + 8\gamma + 8\lambda} + S^e)); \qquad (2.B.13)$$

$$S^e = \sqrt{45 + 32\gamma + 32\lambda - 12\sqrt{9 + 8\gamma + 8\lambda}}.$$

Full market coverage with both firms active in the market requires that (i) the price differential is such that θ^* is internal to the support of consumer tastes; (ii) the customer with the lowest marginal utility of quality, $(\bar{\theta} - 1)$, finds it preferable to purchase the product; and (ii) prices are non-negative.

For given trendsetting and protection leads, the marginal θ customer is internal to the support of consumer tastes iff the combined effective lead of the designer is not too large, specifically if $\lambda \geq 0$ and $\gamma \in (0, \frac{81}{128} - \lambda]$.

The utility of this lowest θ customer given the candidate prices is:

$$U_m(\bar{\theta} - 1) = (\bar{\theta} - 1)s_m - p_m + (1 - \gamma) =$$

$$\frac{1}{216}(-207 + 344\gamma + 108(-2 + \bar{\theta})\bar{\theta} - 128\lambda + 156\sqrt{9 + 8(\gamma + \lambda)} + 12S^e - 8\sqrt{9 + 8(\gamma + \lambda)}S^e);$$

$$S^e = \sqrt{45 + 32\gamma + 32\lambda - 12\sqrt{9 + 8(\gamma + \lambda)}}.$$

Solving $U_m(\bar{\theta} - 1) = 0$ for $\bar{\theta}$, I obtain two possible solutions for $\bar{\theta}$:

$$\bar{\theta}_0^e = 1 \pm \frac{1}{6\sqrt{3}}\left(\sqrt{315 + 344\gamma + 128\lambda - 156\sqrt{9 + 8\gamma + 8\lambda} - 12S^e + 8\sqrt{9 + 8\gamma + 8\lambda}S^e}\right)$$

$$(2.B.14)$$

Only the larger root is acceptable, and positive surplus requires $\bar{\theta} > \bar{\theta}_0^e$.

Setting the candidate price p_m to zero and solving for $\bar{\theta}$ yields two possible solutions for $\bar{\theta}$:

$$\bar{\theta}_1^e = \frac{1}{18}(6\sqrt{9 + 8\gamma + 8\lambda} + 3S^e \pm 2\sqrt{3}\sqrt{-45 + 16\gamma + 16\lambda + 12\sqrt{9 + 8\gamma + 8\lambda} - 6S^e + \sqrt{9 + 8\gamma + 8\lambda}S^e})$$

$$(2.B.15)$$

Only the larger root is acceptable. Strictly non-negative price (and profit) requires $\bar{\theta} > \bar{\theta}_1^e$.

Satisfaction of the requirements for full market coverage and participation by both firms therefore restricts $\bar{\theta} > \max\{\bar{\theta}_0^e, \bar{\theta}_1^e\}$ and $\gamma \in (0, \frac{81}{128} - \lambda]$.

If full market coverage obtains, the optimal prices and qualities in the absence of design protection simplify to ($\lambda = 0$):

$$p_d = \frac{1}{216}(387 + 280\gamma - 96\sqrt{9+8\gamma} + 12S_1^e + 4(27\bar{\theta}(2+\bar{\theta}) - 27\bar{\theta}\sqrt{9+8\gamma} + \sqrt{9+8\gamma}S_1^e));$$

$$p_m = \frac{1}{216}(423 + 128\gamma + 108\bar{\theta}^2 - 84\sqrt{9+8\gamma} + 24S_1^e + 8\sqrt{9+8\gamma}S_1^e - 36\bar{\theta}(2\sqrt{9+8\gamma} + S_1^e);)$$

$$s_d^{np} = \bar{\theta} + 1 - \frac{1}{2}\sqrt{9+8\gamma};$$

$$s_m^{np} = \bar{\theta} - \frac{1}{3}\sqrt{9+8\gamma} - \frac{1}{6}S;$$

$$S_1^e = \sqrt{45 + 32\gamma - 12\sqrt{9+8\gamma}}.$$

The price charged by a leading designer (imitating mass-marketer) is increasing (decreasing) in γ, the size of the novelty lead in the presence of knockoffs.

However optimal qualities are *decreasing* in γ: if it can maintain a novelty lead, as it does if the mass-marketer imitates, the designer will optimally select a lower quality. Because novelty and quality independently enter the consumer's utility function, the firm can view these as substitutes - increasing either will make its product more appealing. Further, both aspects are costly but only quality increases the marginal costs of production; a rational firm finds it profitable to invest in novelty and reduce quality, as this would allow it to take share from the rival and spread the fixed costs over a larger scale.

The mass-marketer optimally responds by locating some distance from the designer in order to minimize price competition; as such, the lower is the optimal quality selected by D, the lower will M's choice be. Indeed, the quality differential between the firms, $s_d^{np} - s_m^{np} = \frac{1}{6}\left(6 - \sqrt{9+8\gamma} + S^e\right)$, is increasing in γ: the greater is the designer's novelty lead, the farther away from the designer the mass-marketer will be forced to locate.

From the foregoing, it is clear that in the absence of design protection, quality and a novelty lead are substitutes for the designer firm - in possession of a design novelty

lead, it reduces the quality offered. The larger is its novelty lead, (the more imperfect the knockoff, or the larger is γ), the larger is the quality differential.

The designer has a clear incentive to invest in novelty; the mass-marketer faces the choice of partially closing the novelty gap and paying lower season fixed costs, or fully closing the novelty gap by itself producing a novel collection. Define $\hat{F}_m^n$ as:

$$\hat{F}_m^n = -\frac{1}{486}\sqrt{729 + 21384\gamma + 165888\gamma^2 + 131072\gamma^3} + \frac{-3 - 64\gamma}{-54} \qquad (2.B.16)$$

The mass-marketer will knockoff the designer if the costs of novelty are sufficiently high, that is, only if $F_m^n > \hat{F}_m^n$, and will produce its own, novel collection otherwise.

If $F_m^n > \hat{F}_m^n$, equilibrium quantities and profits are given by:

$$q_d^{np} = \frac{1}{9}\left(-3 + 2\sqrt{9 + 8\gamma} + S_1^e\right);$$

$$q_m^{np} = \frac{1}{9}\left(12 - 2\sqrt{9 + 8\gamma} - S_1^e\right);$$

$$\pi_d^{np} = -\frac{(16\gamma + (3 + \sqrt{9 + 8\gamma})(3 + S_1^e))^2}{(486(-6 + \sqrt{9 + 8\gamma} - S_1^e))} - F_d^n;$$

$$\pi_m^{np} = -\frac{(-45 + 16\gamma + 12\sqrt{9 + 8\gamma} - 6S_1^e + \sqrt{9 + 8\gamma}S_1^e)^2}{(486(-6 + \sqrt{9 + 8\gamma} - S_1^e))}. \qquad (2.B.17)$$

Market share and profit of the designer (mass-marketer) are increasing (decreasing) in γ, confirming that the payoff to the designer firm is higher the larger is its effective novelty lead. As in the previous section, the designer is harmed by imitation relative to what it would earn if M trailed fully in novelty, but it nevertheless benefits from the reduced novelty lead.

B.2. The effect of Design Protection when $\lambda = 0$

If design protection is available and is utilized, the mass market firm no longer finds it profitable to knockoff: at stage 0.2 it now must decide whether to trail and produce a very low quality or to invest and produce a novel collection of somewhat higher quality. If it chooses to produce a mainstream collection, M will be forced to locate very far away from D in the quality spectrum to relax price competition, as D maintains both a novelty and a quality lead. The low quality attracts low prices and low share. If

instead it chooses to produce a novel collection, M can fully close the novelty gap and return the competitive landscape to the standard vertical differentiation setup. It is not forced as far away from the designer in quality terms and is able to charge higher prices while serving more of the market. M will therefore always choose to produce a novel collection if design protection is utilized.

The designer, aware that its novelty lead will be fully eroded if it protects its design, will invest in novelty but will not protect its design at the previous stage.

The equilibrium - D produces a novel collection but does not protect, and M imitates once fixed costs are sufficiently low - mirrors the outcome in the parallel case with endogenous quality.

B.3. The effect of Design Protection when $\lambda > 0$

If design protection is utilized and novelty carries benefits for the firm over and above the ability to suppress imitation, here as in the parallel case with exogenous costs, M faces slightly different choices. If D declines to protect a novel design, M considers if to trail, imitate, produce a novel design without protecting, or produce a novel design and take the protection lead. I again rule out the first and third strategies and consider only the second and fourth. If it opts for the second, M's payoff is given in (2.B.17). If it chooses the fourth, I solve for optimal prices and payoffs in a manner analogous to that in the previous section given instead a novelty lead by M. Optimal payoffs become:

$$\pi_d^{np} = \frac{(2(3 - 8\lambda + \sqrt{9 + 24\lambda})^2)}{27(3 + \sqrt{9 + 24\lambda})} - F_d^n; \tag{2.B.18}$$

$$\pi_m^{np} = \frac{(3 + 16\lambda + \sqrt{9 + 24\lambda})^2}{54(3 + \sqrt{9 + 24\lambda})} - F_m^n. \tag{2.B.19}$$

Note that the marginal consumer is internal to the support of tastes iff $\lambda < \frac{9}{8}$. M

does better to take a protection lead rather than imitating D iff λ exceeds:

$$
\begin{aligned}
\hat{\lambda}' = & (-9 + (729(1405 + 72F_m^n(13 + 9F_m^n)) + 3888(127 - 144F_m^n)\gamma + 497664\gamma^2 + 131072\gamma^3 - \\
& 341172\sqrt{9+8\gamma} - 227448F_m^n\sqrt{9+8\gamma} - 10368\gamma\sqrt{9+8\gamma} + 124416F_m^n\gamma\sqrt{9+8\gamma} - \\
& 147456\gamma^2\sqrt{9+8\gamma} + 113724S_1^e + 87480F_m^nS_1^e + 10368\gamma S_1^e + 62208F_m^n\gamma S_1^e - 61440\gamma^2 S_1^e - \\
& 37908\sqrt{9+8\gamma}S_1^e - 23328F_m^n\sqrt{9+8\gamma}S_1^e + 10368\gamma\sqrt{9+8\gamma}S_1^e + 8192\gamma^2 \\
& \sqrt{9+8\gamma}S_1^e + Z)^{\frac{1}{3}})^2/(96(729(1405 + 72F_m^n(13 + 9F_m^n)) + 3888(127 - 144F_m^n)\gamma + \\
& 497664\gamma^2 + 131072\gamma^3 - 341172\sqrt{9+8\gamma} - 227448F_m^n\sqrt{9+8\gamma} - 10368\gamma\sqrt{9+8\gamma} + \\
& 124416F_m^n\gamma\sqrt{9+8\gamma} - 147456\gamma^2\sqrt{9+8\gamma} + 113724S_1^e + 87480F_m^nS_1^e + 10368\gamma S_1^e + \\
& 62208F_m^n\gamma S_1^e - 61440\gamma^2 S_1^e - 37908\sqrt{9+8\gamma}S_1^e - 23328F_m^n\sqrt{9+8\gamma}S_1^e + \\
& 10368\gamma\sqrt{9+8\gamma}S_1^e + 8192\gamma^2\sqrt{9+8\gamma}S_1^e + Z)^{\frac{1}{3}})
\end{aligned}
\tag{2.B.20}
$$

where

$$
\begin{aligned}
Z = & (-531441 + (472392(F_m^n)^2 + 131072\gamma^3 + 2048\gamma^2(243 - 72\sqrt{9+8\gamma} - 30S_1^e + \\
& 4\sqrt{9+8\gamma}S_1^e) + 1296\gamma(381 - 8\sqrt{9+8\gamma} + 8S_1^e + 8\sqrt{9+8\gamma}S_1^e) - 729 \\
& (-1405 + 468\sqrt{9+8\gamma} - 156S_1^e + 52\sqrt{9+8\gamma}S_1^e) + 1944F_m^n(351 - 117\sqrt{9+8\gamma} \\
& + 45S_1^e - 12\sqrt{9+8\gamma}S_1^e + 32\gamma(-9 + 2\sqrt{9+8\gamma} + S_1^e)))^2)^{\frac{1}{2}}
\end{aligned}
\tag{2.B.21}
$$

Producing a novel collection and protecting is a dominant strategy for the mass-marketer if $\lambda > \hat{\lambda}'$: it can take a novelty lead and attract customers even while it relaxes the quality offered.

Aware of this, the designer will therefore always itself produce a novel collection and protect the design. Imposition of design protection therefore results in both firms producing novel designs and using the design protection system. Neither firm maintains a protection lead or a novelty lead. Equilibrium prices and qualities are given by:

$$
p_d^{np} = \frac{1}{24}(19 + 12(-1 + \bar{\theta})\bar{\theta}); \qquad p_m^{np} = \frac{1}{24}(35 + 12(-3 + \bar{\theta})\bar{\theta}); \tag{2.B.22}
$$

$$
s_d^{np} = \bar{\theta} - 1/2; \qquad s_m^{np} = \bar{\theta} - 3/2. \tag{2.B.23}
$$

and equilibrium quantities and profits are given by:

$$q_d^{np} = \frac{2}{3}; \qquad q_m^{np} = \frac{1}{3}; \qquad (2.B.24)$$

$$\pi_d^{np} = \frac{4}{9} - F_d^n; \qquad \pi_m^{np} = \frac{1}{9} - F_m^n. \qquad (2.B.25)$$

Welfare Effects of Design Protection

If design protection is not available or not utilized (as is the case if $\lambda < \hat{\lambda}'$) and $F_m^n > \hat{F}_m^n$, M will imitate and D will produce a novel collection. I simply substitute for prices and qualities into (2.2) to give total consumer surplus as:

$$CS_e^{np} = \frac{1}{1944} \big(8\gamma(-387 + 16\sqrt{9 + 8\gamma} + 8S_1^e) - 3(585 - 372\sqrt{9 + 8\gamma} + 6S_1^e + $$
$$20\sqrt{9 + 8\gamma}S_1^e - 324(-1 + \bar{\theta})\bar{\theta}) \big). \qquad (2.B.26)$$

and total profit to the firms is given by the sum of (2.B.19) and (2.B.20). Total welfare in the no protection regime is given by:

$$W^{np-e} = \frac{1}{1944} \big(-1944F_d^n - 84\sqrt{9 + 8\gamma}\sqrt{45 + 32\gamma - 12\sqrt{9 + 8\gamma}} + 8\gamma(-531 + $$
$$80\sqrt{9 + 8\gamma} + 40\sqrt{45 + 32\gamma - 12\sqrt{9 + 8\gamma}}) + 9(-3 + 80\sqrt{9 + 8\gamma} + 26 $$
$$\sqrt{45 + 32\gamma - 12\sqrt{9 + 8\gamma}} + 108(-1 + \bar{\theta})\bar{\theta} - 216F_m^n\kappa)) \qquad (2.B.27)$$

If instead design protection is available and $\lambda > \hat{\lambda}'$, both firms will produce novel collections. Again, I substitute for prices ad qualities into (2.2), and total consumer surplus is now given by:

$$CS_e^p = \frac{1}{72}(-35 + 36\bar{\theta}(-1 + \bar{\theta})) \qquad (2.B.28)$$

and total profit to the firms is given by the terms in (2.B.21) and (2.B.22). Total welfare is given by:

$$W^{ipr-e} = \frac{1}{72}(-11 - 72F_d^n - 72F_m^n - 12\bar{\theta} + 36\bar{\theta}^2) \qquad (2.B.29)$$

If design protection provides sufficient additional benefits to firms, then the increment in welfare if moving from the no protection regime to a design rights regime may be

expressed as:

$$W_e^{ipr} - W_e^{np} = \Delta W_e =$$

$$\frac{1}{972}\left(729 - 630\sqrt{9+8\gamma}S_1^e - 63S_1^e + 6\sqrt{9+8\gamma}S_1^e - 4\gamma(-387 + 80\sqrt{9+8\gamma} + 40S_1^e)\right) - F_m^n. \quad (2.B.30)$$

This expression is negative (that is, welfare is lower with design protection relative to no protection) if $\gamma \geq -\frac{9}{8}$; welfare is therefore unambiguously lower in the design protection regime.

So far, then, all results mirror those in the exogenous quality case. Welfare is lower with design protection, even though such protection forces both firms to provide higher quality goods to the market, as this increase in quality does not increase consumer surplus sufficiently to compensate for the loss of the profit associated with the status-related aspect of design.

Licensing

Now allow for licensing of the design right. Recall that in the no protection regime, M will knockoff iff novelty is sufficiently costly. Given that this condition is satisfied, both firms are worse off under design protection.

The benefit to the designer from licensing is the difference between what it would earn if M produces a sanctioned imitation of its protected, novel design and what it would earn absent licensing (if M also produced a novel, protected design). The latter is given in (2.B.25). If M imitates, D earns:

$$\pi_d^{im-p} = -\frac{(16(\gamma+\lambda) + (3 + \sqrt{9+8\gamma+8\lambda})(3 + \sqrt{45+32\gamma+32\lambda - 12\sqrt{9+8\gamma+8\lambda}}))^2}{486(-6 + \sqrt{9+8\gamma+8\lambda} - \sqrt{45+32\gamma+32\lambda-12\sqrt{9+8\gamma+8\lambda}})} \quad (2.B.31)$$

The benefit to the mass-marketer from entering the license agreement is the difference between what it earns if it produces a licensed copy of the protected design and what it would earn absent licensing (that is, if it also produces a novel, protected collection). If it produces a novel collection, it earns the payoff given in (2.B.28) and if it imitates

D's protected design it earns:

$$\pi_m^{im-p} = -\frac{(-45 + 16(\gamma + \lambda) + 12\sqrt{9 + 8\gamma + 8\lambda} - 6S^e + \sqrt{9 + 8\gamma + 8\lambda}S^e)^2}{(486(-6 + \sqrt{9 + 8\gamma + 8\lambda} - S^e))}, \qquad (2.B.32)$$

$$S^e = \sqrt{45 + 32\gamma + 32\lambda - 12\sqrt{9 + 8\gamma + 8\lambda}}.$$

The bargaining surplus is therefore:

$$T^e = \frac{1}{486}\Big(162 + 486F_m^n - 99\sqrt{9 + 8\gamma + 8\lambda} + 63S^e - 6\sqrt{9 + 8\gamma + 8\lambda}S^e + 32(\gamma + \lambda)$$
$$\Big(-9 + 4\sqrt{9 + 8\gamma + 8\lambda} + 2S^e\Big)\Big); \qquad (2.B.33)$$

$$S^e = \sqrt{45 + 32\gamma + 32\lambda - 12\sqrt{9 + 8\gamma + 8\lambda}}.$$

If firms split the bargaining surplus equally, it is again the case that the designer may still be worse off with design protection relative to no protection. Firm payoffs under licensing are simply the firm's outside option (what it earns absent licensing) plus $\frac{1}{2}T$ and are defined as:

$$\pi_d^{lic} = \frac{1}{972}(594 + 486F_m^n - 99\sqrt{9 + 8\gamma + 8\lambda} + 63S^e - 6\sqrt{9 + 8\gamma + 8\lambda}S^e +$$

$$32\gamma(-9 + 4\sqrt{9 + 8\gamma + 8\lambda} + 2S^e) + 32\lambda(-9 + 4\sqrt{9 + 8\gamma + 8\lambda} + 2S^e)) - F_d^n; \qquad (2.B.34)$$

$$\pi_m^{lic} = \frac{1}{972}(594 + 486F_m^n 99\sqrt{9 + 8\gamma + 8\lambda} + 63S^e - 6\sqrt{9 + 8\gamma + 8\lambda}S^e +$$

$$32\gamma(-9 + 4\sqrt{9 + 8\gamma + 8\lambda} + 2S^e) + 32\lambda(-9 + 4\sqrt{9 + 8\gamma + 8\lambda} + 2S^e) +$$

$$\frac{2(16\gamma + (3 + \sqrt{9 + 8\gamma})(3 + \sqrt{45 + 32\gamma - 12\sqrt{9 + 8\gamma}}))^2}{(-6 + \sqrt{9 + 8\gamma} - \sqrt{45 + 32\gamma - 12\sqrt{9 + 8\gamma}})}. \qquad (2.B.35)$$

In order to establish whether firms are better off under licensing relative to the no protection case, I compare payoffs under licensing to the payoffs under no protection, given at (2.B.17) and (2.B.18)-(2.B.19), respectively.

It is again the case that the designer firm is worse off under licensing relative to the no protection case if λ and γ are sufficiently low. Solutions for the critical values do not admit a neat analytical expression. I therefore rely on a numerical example:

Example Suppose that $\lambda = 0.1$, $\gamma = 0.1$ and $F_m^n = 0.05$. Designer payoff under licensing minus payoff under the no protection framework simplifies to -0.0022961; the

designer firm is (just) worse off under design protection, even with licensing, relative to a no protection case. Suppose instead that $\lambda = 0.15$ with $\gamma = 0.1$ and $F_m^n = 0.05$; this difference becomes 0.0198941; the designer firm is (just) better off with the design protection in place and a licensing agreement signed than it would be if no protection applies.

The model with endogenous quality therefore yields conclusions which are consistent with the ones which may be derived from an examination of the exogenous quality case.

3. Broad (American) Way? Litigation Cost Allocation Rules and Patent Design in Differentiated Duopoly

Abstract

Recent policy debates suggest increasing concern that US patents provide too much power to patentees, a particular worry in highly sequential industries such as biotechnology. This paper contributes to the literature on patent design and legal fee shifting, contrasting the effects of the American ('each party pays') rule and English ('losing party pays') rules on optimal patent breadth when innovation is sequential, litigation spending is endogenous and differentiated duopolists compete in prices. I show that if R&D costs are sufficiently low, the American rule may induce broader patents and a higher probability of infringement than the English rule. This is because in a loser pays system firms must explicitly take account of legal spending by their rivals and this can set off an arms race in legal spending. The Patent Office can suppress this behaviour by making patents narrower, encouraging Courts to focus more on the inherent merits of the case. Broad American patents therefore may not, per se, harm innovation. If, however, R&D costs are moderate, the ranking is reversed and it is the English rule that leads to broader patents. Neither rule supports lower patent breadth over the entire parameter space.

3.1. Introduction

Patent design is especially challenging in the context of sequential innovation, as policy-makers must balance the need to incentivize investment by early innovators against the need to accommodate later stage developers. Recent policy debates in the US suggest increasing concern that the US Patent and Trademark Office has given too much weight to the early innovation aspect and that US patents are too broad, stifling later stage products. The biotechnology and genomic fields provide perhaps the best examples of the sequential innovation motivating this work, as R&D inputs (research tools), which consist largely of genetic and biological material, are virtually impossible to invent around. The importance of key research tools therefore means that firms in this sector tend to patent much more frequently than in other industries, a phenomenon which has led to concern in the legal and economic fields about the impact of patent assertion and licensing failure on future R&D. High profile cases, such as last year's ruling by the US Federal Circuit Court of Appeals that human genetic material can be patented (a reversal of a lower Court's ruling to invalidate the patents held by Myriad Genetics on the BRCA-1 and BRCA-2 genes and tests for hereditary breast and ovarian cancer), have served to reinforce these fears.

Patent policy is further complicated by the fact that enforcing protection of the patent asset is costly. In the US, direct legal fees alone are now estimated at between US$1 and 3 million to each party (American Intellectual Property Law Association 2001 figures, as reported in Bessen and Meurer (2008)) while indirect costs - including business losses due to increased perception of risk - are even higher. These costs are non-trivial and significantly impact firm behaviour.

To date, however, there has been little theoretical work done to link patent design and the litigation cost allocation mechanism. Models of patent policy have tended to overlook legal costs entirely (assuming them, along with all other transactions costs, to be zero) and models of legal cost allocation have simply compared litigants' behaviour across systems for a given patent breadth, ignoring policymakers' potential reactions

to the structure of the cost allocation system. This paper is an attempt to fill this gap. Using a Singh and Vives (1984) differentiated duopoly setting with endogenous legal costs, I contrast the effect of the American rule (where each party pays its own litigation costs, regardless of judgement) with the English rule (where the losing party pays all litigation costs) on the Patent Office's choice of patent breadth.[1] Consistent with earlier results, I show that the English rule induces more overall spending than the American rule. Interestingly, this is in many cases due to greater spending by patentee firms. However this does not necessarily translate into the patentee enjoying a higher probability of prevailing in infringement suits. Instead I find that, all else equal, the American rule induces broader patents and a higher overall probability of infringement than the English rule only if R&D costs are sufficiently low. This is because under the English rule, firms must explicitly take into account the legal spending of their rivals and this can set off an arms race in legal spending. The Patent Office can suppress this behaviour by making patents narrower, encouraging Courts to focus more on the inherent merits of the case. As such, broader American patents do not necessarily harm later-stage innovation and are not, per se, evidence of any inherent bias at the Patent Office, but rather a rational response to the legal cost allocation mechanism. By contrast, if R&D costs are moderately high, the English rule may induce broader patents. Thus neither rule assures narrower patents than the other over the entire parameter space. The implication for policy is that any attempt to change effective patent breadth in the US without considering the effects of the cost allocation regime on firms' optimal legal spending may reduce incentives to innovate.

The next section outlines the related theoretical literature. The model is formulated in section 3.3, which details firm payoffs and feasible patent breadths under each cost

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[1]The American Rule, so called as it is the prevailing regime in the US, prescribes that save in very particular cases- principally fraud, bad faith or willful infringement - a party pays its own litigation costs. By contrast, one of the longest held tenets of the UK civil law framework is that the losing party is called upon to pay the costs incurred by its rival on judgment. In this rule too there are a few exceptional circumstances, such as where a party unreasonably fails to take up a settlement offer or fails to act pursuant to Court arbitration recommendations. This losing party pays rule is not exclusively English, however, as it applies across a wide range of countries. Interestingly, the U.S. state of Alaska also follows this rule.

allocation regime and discusses policy implications. Section 3.4 concludes and offers possible extensions to the current work.

3.2. Previous Work

This work draws on two strands of literature: optimal patent design and legal cost allocation (or fee-shifting).

The analysis of optimal patent design dates back to Nordhaus (1967), with more recent contributions from Gilbert and Shapiro (1990) and Klemperer (1990), before Green and Scotchmer (1995) explicitly explores optimal design in the context of sequential innovation. The main finding of that work is that where the key characteristics of later stage innovations are known, infinitely broad patents are optimal for ensuring entry by the first stage innovator. Chang (1995) builds on Green and Scotchmer (1995) and concludes that very broad protection is best only where social value of first stage innovation is either very high or very low relative to later improvements. The current work follows Chang (1995) in assuming that ex ante licensing does not occur but seeks to explore how optimal patent breadth for a good with given social value changes depending on the legal cost allocation regime. The differentiated duopoly setting provides a good theoretical contrast to the homogenous good and vertical differentiation models used in previous studies. In contrast to Green and Scotchmer (1995), I find that perfectly broad patents are optimal only if R&D costs are sufficiently high.

The analysis of fee-shifting systems stems from seminal papers by Posner (1973) and Shavell (1982) and explores the effect of legal cost allocation on filing, spending and settlement of litigation. Spier (2007) provides a useful survey of the related works, outlining general findings that the English rule encourages higher legal spending, as the private costs are partially externalized, though there are no predictions on how the individual litigants' spending changes across the systems. The effect of the cost allocation rule on settlement is ambiguous: the higher level of legal costs associated with the English rule may increase the incentive to settle as parties will wish to avoid

these costs (Hause (1989)) or may reduce the incentive to settle, as there is greater scope for disagreement (asymmetries now exist not only over who will win, but also who will pay). There also exists a small empirical legal literature focussing on the effect of litigation cost allocation on legal fees. The theoretical literature does not produce a clear prediction on which rule should yield higher *observed* fees, as even if the English rule is predicted to increase legal spending, the indeterminacy of incidence of settlement make prediction unclear: if the English rule decreases the incidence of settlement higher legal spending should be observed, but if it increases the incidence of settlement, then no (higher) fees will be observed. Empirical studies confirm that the English rule is associated with higher spending on litigation but, like theoretical works, have produced unclear results about the overall impact of the rule on total filings (Kritzer (2002) provides a useful survey, Eisenberg and Miller (2010) more recently looks at fee shifting preferences of public companies). Theoretical models of fee shifting do not, however, operationalize the choice of patent breadth, generally adopting a probability of infringement which is either exogenous or which depends exclusively on legal spending. Aoki and Hu (1999), closest to the current work, compares patent litigation and settlement outcomes for homogeneous good duopolists in Nash bargaining under both rules. They find that the English rule is better for innovating firms when the patent-legal system favors patentees. The current paper contributes by explicitly illustrating the link between strategic behavior in respect of litigation spending and policymakers' choice of patent breadth. I find that, if R&D costs are sufficiently low, policymakers may craft a more pro-patentee environment under the American rule without jeopardizing investment or later generation development.

3.3. The Model

3.3.1. Model Setup

Firm 1 ('F1'), the *innovating* firm, may choose to invest an amount C and develop a basic innovation, over which it is awarded a patent. From this basic innovation the

firm develops an *application,* which is defined as a practical use of the basic innovation embodied in a commercial product. In biotechnology terms, for example, a basic innovation would be an isolated or purified human gene, while applications would comprise products derived from that particular gene, such as drug therapies, hormone treatments based on chemicals manufactured by the gene or used to up- or down-regulate the gene and diagnostic tests incorporating comparisons with the chemical composition of the gene.

Conditional on the initial investment and application development by F1, firm 2 ('F2'), the *later entrant* firm, may choose - with or without a license - to produce another application deriving from the basic innovation for the market. The goods are differentiated, with the degree of substitutability given by γ.

Utility   Following Singh and Vives (1984), representative consumer utility is given by

$$U(q_1, q_2) = q_1 + q_2 - \frac{1}{2}(q_1^2 + q_2^2 - 2\gamma q_1 q_2), \tag{3.1}$$

where $0 \leq \gamma \leq 1$. The degree of substitutability, γ, reflects the closeness of the application products: if $\gamma = 0$, the products are independent and the firms are local monopolists; if $\gamma = 1$, the goods are perfect substitutes. The consumer maximizes this utility subject to a budget constraint of the form $R = p_1 q_1 + p_2 q_2$. Inverse demands are given by $p_i = 1 - q_i - \gamma q_j$.

Firms   In the applications market, firms compete in prices to maximize profit given by $\Pi_i = (p_i - c_i)q_i$ where q_i denotes the demand faced by firm i and c_i denotes the marginal cost to firm i, assumed to be zero throughout. The patentee firm may license its patent to the entrant. Licensing is by Nash bargaining. The firms split any surplus available according to the proportions $(\alpha, 1 - \alpha)$, where $\alpha \in [0, 1]$ denotes the portion of the surplus appropriated by the patentee. If $\alpha = 1$, then, the patentee firm has full bargaining power in the licence negotiations. Market payoff to each firm is composed of market profit plus (or minus) licensing revenues (or fees paid).

Firms do not have access to external financing or to reserves and must meet any and all expenses out of market revenues. This assumption, while restrictive, helps to focus the analysis, illustrating how litigation cost allocation regimes combine with patent policy to affect the profitability of R&D investments. It is also arguably relevant to small, startup biotechnology firms, which are often credit-constrained.

The Courts and Litigation   If the entrant firm produces without a license, F1 may sue for infringement, though to do so it must incur a cost $L_1 > 0$ for litigation-related (or, more generally, legal) expenses. The alleged infringer must also incur a cost, denoted $L_2 > 0$, to defend itself. The Courts find in favor of the patentee with probability δ.

Litigation renders the alleged infringer vulnerable to damages[2] claims. I assume that if the entrant firm is found to infringe the patent held by firm 1, the Courts require the former to disgorge all profits earned by use of the protected innovation. This is consistent with the unjust enrichment damages regime, one of the two major liability rules used in the US. In practice, it is used regularly as it is both easier to understand and to calculate than the principal alternative, the 'lost profit' regime, which requires estimation of the effect of entry by the infringer on both prices charged and quantity sold by the first stage firm.

Patents and the Patent Office   I wish to focus on the issue of patent breadth, not strength, and as such abstract from any issue of weak patents. As such, all patents are valid (that is, all patents granted satisfy the requirements in respect of novelty, non-obviousness and/or usefulness).

Patent breadth refers to how different a product has to be from the protected one in order to be found infringing. This is determined primarily through the language used in the claims of the patent document, which describe the form and use of the subject matter being protected. In general, then, narrow patents will have claims which are

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[2]Damages are defined as monetary compensation awarded to a wronged party. If F2 is found to infringe the patent held by F1, any sum it is forced to transfer to the patentee may be interpreted as damages.

more explicit than those in broad patents. The Patent Office controls breadth as it determines what language is acceptable in the patent filing.

The patentee's probability of prevailing is determined by both the inherent merits of the case and its strategic choice of litigation spending. Specifically, the probability of infringement, δ, is given by:

$$\delta = \gamma + (1 - \gamma)\lambda \left(\frac{L_1}{L_1 + L_2} \right). \tag{3.2}$$

The first term may be interpreted as the inherent merit of the case for infringement: this depends only the closeness of the products and cannot be influenced by spending on legal services. The second term denotes the portion of the patentee's likelihood of prevailing that is sensitive to legal spending.

The policy parameter $\lambda \in [0, \Lambda]$ reflects the *breadth* of the patent. If $\lambda > 0$, the patent claims are equivocal and may be interpreted as extending beyond inherently similar goods. Thus, by spending more on legal services (increasing L_1), the innovator may present a compelling case to the Courts for why a broad substitute may infringe its patent. Note that in the extreme case of local monopolies, there is no inherent merit to the case, though with positive patent breadth the patentee may still prevail if it spends enough on legal services. On the other hand, if the goods are perfect substitutes then the patentee will win solely on the merits, even with minimal spending.

If the applications are imperfect substitutes, or if $\gamma \in (0, 1)$, low λ implies that F1's probability of winning is more dependent on the nature of the goods (patents are narrow). In the extreme case, $\lambda = 0$ would imply that the patent is as narrowly crafted as possible, so that only a perfect substitute is found to infringe with certainty. I term such patents *perfectly narrow* patents. Conversely, a higher value of λ means that the patentee's overall probability of prevailing depends more heavily on how much the patentee commits to spending: if F1 spends enough, even a good with low substitutability may be found to infringe with high probability (patents are broad). At the extreme, if $\lambda = \Lambda = \frac{L_1 + L_2}{L_1}$, any potential substitute will be found to infringe. I term

such a patent *perfectly broad.* The effects of λ on the probability of infringement are shown in Figure 1. This specification for the legal technology is similar to that Plott
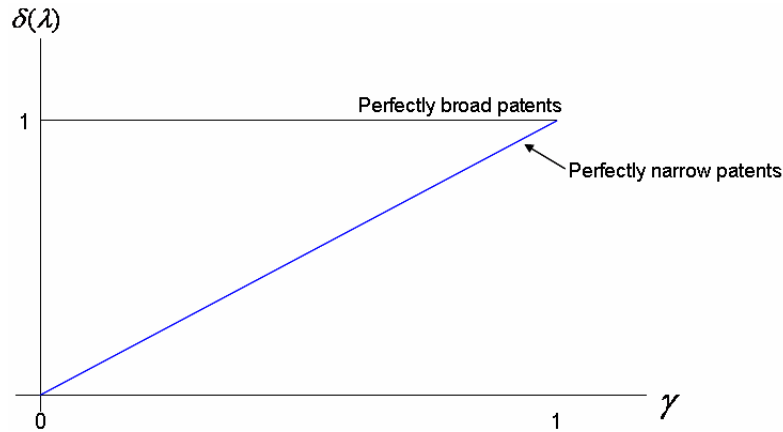

Figure 3.1.: Patent breadth and the Probability of Infringement

$(1987)^3$ and is realistic in that if the patent is granted with sufficiently broad scope that the Courts must apply discretion (that is, if claims are equivocal or patents have positive breadth) then increased input of legal services may positively influence the Court's decision (larger legal team, greater detail in discovery, etc. allow a patentee to craft a more comprehensive or more convincing complaint). This specification further implies that increased spending is less useful the more substitutable are the goods: close substitutes are inherently more likely to be found to infringe with a relatively high probability, even if the firm did not spend anything on legal services. A patentee with an inherently 'good' case thus does not have to spend heavily. By contrast, spending on legal services is more useful if the patentee faces a more dissimilar application (that is, the patentee has a relatively 'weak' case) as increased (or increased quality) legal services may significantly increase the chance of a positive judgement.

The Patent Office ('PO') wishes to maximize social welfare, measured by total utility (or total potential surplus): $SW = U(q_1, q_2)$. But accomplishing this goal requires

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[3]This specification used in Plott (1987) also includes a ratio of patentee spending to total legal spending, but in the current model the inherent merits depend on closeness of the good. This model is therefore able to provide additional insight into how the identity of a rival impacts a firm's incentive to spend on legal services. Another innovation of this model's specification is that legal spending only matters to the extent that patent breadth is positive.

considering two often competing issues. Firstly, the PO must maximize the incentives for investment in basic innovations, since without this first step no applications can be brought to market. Secondly, though, the PO must also provide incentives for later stage entrant firms to invest, as social welfare is increasing in the output of *both* applications. In setting patent breadth, the PO will attempt to find the maximum patent breadth that would allow for investment and production by F1 while also allowing for production by F2. This will maximize social welfare. However if no such patent breadth exists, the best the PO can do is to maximize the innovator's incentives to invest by setting patent breadths to the highest possible level.

Timing The sequence of the game is presented in Figure 2. In the first stage, the Patent Office decides on the patent breadth. In the second stage, F1 must decide, given λ, whether to invest a sunk amount C to develop its idea into a patentable product. If it invests, F1 is awarded a patent on the basic innovation and the claimed application. If F1 does not invest, no innovation is possible and the game ends. Conditional on investment by F1, in the third stage F2 costlessly develops a separate application deriving from F1's basic innovation. F1 decides if to offer a license and F2 decides whether to produce without a licence from F1. If F2 does not produce without a licence, F1 operates as a monopolist in the applications market. If the firms fail to successfully conclude an agreement but F2 offers its product without a license, then in the fourth stage F1 may file suit for infringement, at which time firms simultaneously choose litigation spending levels, $L_1 > 0$ and $L_2 > 0$, respectively. In the fifth stage, the Courts rule. F1 prevails with probability δ and on judgement F2 is called upon to transfer all of its market profits to F1.

There is complete information. Given this sequence of events, F2 must either face the patentee in licensing or in litigation. Expected payoffs with litigation determine the outside options in the bargain over a license, so that F1 can use the threat of litigation to influence the rival's decisions.
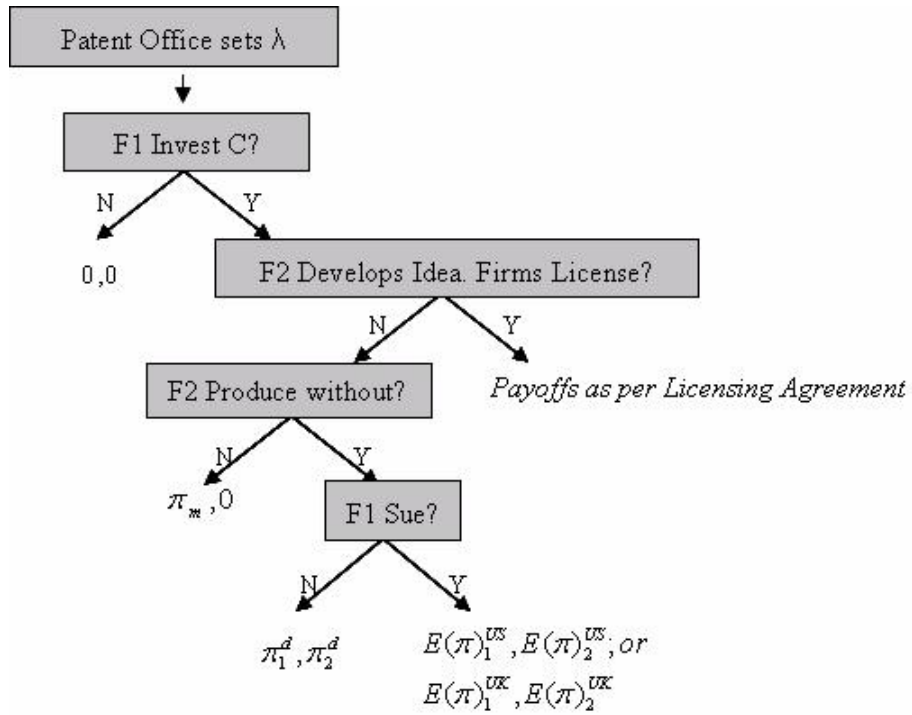
Figure 3.2.: Sequence of the game

3.4. Solving the Model

3.4.1. Firms' decisions

At the final stage[4] if no license has been agreed it falls to the Courts to adjudicate between the parties. Courts rule in favor of F1 with probability δ. In the penultimate stage, then, firms may perfectly anticipate their payoffs. If firms compete in prices in the applications market, each makes profits equal to:

$$\pi_d = \pi_1 = \pi_2 = \frac{1-\gamma}{(-2+\gamma)^2(1+\gamma)}. \tag{3.3}$$

Expected payoffs are given by each firm's market profit adjusted for expected damages received or paid, as relevant, net of litigation spending. Both the probability of infringement and the chosen litigation spend depend on the cost allocation regime, so

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[4]If firms agree a license then each receives payoffs as per that agreement. However I begin with an explanation of the no licensing outcome as this sets the disagreement point for any licensing bargain.

that expected payoffs for the firms under each rule are:

$$\text{American Rule} = \begin{cases} E(\Pi_1^{US}) = & (1 + \gamma + \lambda(1-\gamma)\frac{L_1}{L_1+L_2})\pi_d - L_1, \\ E(\Pi_2^{US}) = & (1 - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1+L_2})\pi_d - L_2 \end{cases}$$

and

$$\text{English Rule} = \begin{cases} E(\Pi_1^{UK}) = & (1 + \gamma + \lambda(1-\gamma)\frac{L_1}{L_1+L_2})\pi_d - (1 - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1+L_2})(L_1+L_2), \\ E(\Pi_2^{UK}) = & (1 - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1+L_2})\pi_d - (\gamma + \lambda(1-\gamma)\frac{L_1}{L_1+L_2})(L_1+L_2) \end{cases}$$

In the prior stage, firms consider licensing. If F2 would not enter without a license, F1 could refuse to offer one and produce as a monopolist. In this case, the surplus available in bargaining is the increase in joint profit from expansion in the market: $S_1 = \Pi_j - \Pi_m$. F1 must weigh the benefit from licensing (the portion of the surplus it is able to appropriate, αS_1) against the cost (allowing competition into the applications market). In fact, F1 only ever finds it preferable to offer a license if production by the entrant firm expands the applications market and it can appropriate a sufficiently large share of any surplus generated. In the best case scenario for the patentee (when $\alpha = 1$) joint duopoly profit exceeds monopoly profit only if $\gamma < 0.6117$. Thus, if F2 would not enter without a license, then even with full bargaining power the patentee will never offer a license if $\gamma \geq 0.6117$.

If F2 would produce without a license, then F1 could never prevent its entry into the applications market by simply refusing to license. Even absent agreement between the firms, the market would be a duopoly. However licensing would allow firms to avoid costly litigation. The surplus available in bargaining then reflects the legal cost savings: $S_2 = L_1 + L_2$. The patentee would therefore be prepared to offer a license regardless of the closeness of the rival's good, meaning that licenses may be concluded over the full range of γ.

If F2 would enter without a license, its expected licensing payoff under American

and English rules, respectively, is:

$$E(\Pi_{2l}{}^{US}) = \left(1 - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1 + L_2}\right)\pi_d + (1-\alpha)L_1 - \alpha L_2 \qquad (3.4)$$

$$E(\Pi_{2l}{}^{UK}) = \left(1 - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1 + L_2}\right)\pi_d + \left(1 - \alpha - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1 + L_2}\right)(L_1 + L_2) \qquad (3.5)$$

The firm will produce as long as this expected licensing payoff is positive. By analogous reasoning the patentee foresees expected licensing payoffs (under the respective rules) of:

$$E(\Pi_{1l}{}^{US}) = \left(1 + \gamma + \lambda(1-\gamma)\frac{L_1}{L_1 + L_2}\right)\pi_d - (1-\alpha)L_1 + \alpha L_2$$

$$(3.6)$$

$$E(\Pi_{1l}{}^{UK}) = \left(1 + \gamma + \lambda(1-\gamma)\frac{L_1}{L_1 + L_2}\right)\pi_d - \left(1 - \alpha - \gamma - \lambda(1-\gamma)\frac{L_1}{L_1 + L_2}\right)(L_1 + L_2)(L_1 + L_2)$$

$$(3.7)$$

and will invest if and only if the expected licensing payoff is greater than or equal to its fixed R&D cost, C. If F2 produces without a license, both do better to license.

3.4.2. The Patent Office's decision

At the first stage, the PO chooses patent breadth, λ. I confirm that the PO strictly prefers downstream duopoly: if the patentee firm produces as a monopolist, social welfare reduces to

$$SW_m = \frac{3}{8}, \qquad (3.8)$$

while if both firms operate, each produces $q_1 = q_2 = \frac{1}{(2-\gamma)(1+\gamma)}$ and social welfare is

$$SW_d = \frac{3 - 2\gamma}{(-2+\gamma)^2(1+\gamma)}. \qquad (3.9)$$

Welfare is unambiguously higher with a downstream duopoly. The PO is aware that if patents are sufficiently broad that F2 would not enter without a license, such an agreement is concluded - and duopoly in the market results - if and only if the entrant's good is sufficiently dissimilar.

On the other hand, if patents are sufficiently narrow that F2 would enter without

a license, F1 would be willing to offer a license to entrants over a broader range of γ. Thus, if the PO wishes to allow maximum incentives for investment and duopoly in the applications market it should to select λ such that both firms would be active in the no licensing outcome. This will encourage firms to bargain, avoiding costly litigation, over the largest possible range of γ. Because patent breadth affects the firms in opposing ways - the patentee's payoff is increasing in λ while the entrant's payoff is decreasing in λ - then patent breadths that allow for non-negative outside options for both firms must be simultaneously large enough to make investment by F1 worthwhile and small enough to make later entry profitable. I refer to this as the *feasible* range. The minimum of the feasible range is the lowest patent breadth necessary for investment by the patentee if no license is agreed; the maximum is the largest patent breadth that will allow the entrant firm to earn a non-negative expected payoff in the absence of a license. Inasmuch as the PO wishes to provide maximum incentives for investment, I posit that its *preferred* patent breadth will be the maximum of this well-defined range.

If the feasible range is empty, meaning that there is no conceivable way to ensure both investment by F1 and production by F2 without a license, the PO will do best to allow for perfectly broad patents. This will maximize the probability of investment by F1, the crucial step without which no product will reach the market. Further, it will allow for some licensing: as I show in the section above, the patentee will license to the entrant if such entry sufficiently enlarges the joint profit.

I next turn to comparing the outcomes under the different cost sharing rules.

3.4.3. The American or 'Each Party Pays' Rule

Under the American rule, each party pays its own legal costs, regardless of the Court's decision. In the no licensing case the firms simultaneously choose litigation levels to maximize individual expected payoffs, taking spending by the other as given. Each firm in fact selects:

$$L_1^{US} = L_2^{US} = -\frac{(-1+\gamma)^2 \lambda}{4(-2+\gamma)^2(1+\gamma)} \tag{3.10}$$

(see Appendix). As may be expected, if each enjoys the same market profit and chooses its litigation spending independently of the rival, the firms choose the same level of spending. Given such values, the expression for the probability of infringement simplifies to:

$$\delta^{US} = \gamma - \frac{1}{2}(-1 + \gamma)\lambda. \tag{3.11}$$

Substituting these expressions for litigation spend and infringement probability into the expressions for firms' expected payoffs assuming no licensing yields:

$$E(\Pi_1^{US}) = \frac{(-1 + \gamma)(-4 + \gamma(-4 + \lambda) - \lambda)}{4(-2 + \gamma)^2(1 + \gamma)}$$

$$E(\Pi_2^{US}) = -\frac{(-1 + \gamma)^2(-4 + 3\lambda)}{4(-2 + \gamma)^2(1 + \gamma)}. \tag{3.12}$$

As is explained above, the PO prefers to set patent breadth at the maximum of the feasible range. I define $\underline{\lambda}^{US}$ and $\overline{\lambda}^{US}$ as the required minimum and maximum patent breadths, respectively, bounding the feasible range. These threshold values are computed by setting the relevant firm's no licensing payoff equal to its investment cost and solving for λ, which yields the following:

Remark 3.1 *If there is no licensing agreement, then under the American rule, the minimum patent breadth required for investment by the patentee, $\underline{\lambda}^{US}$, is:*

$$
\begin{array}{ll}
0 & if \quad 0 < C \leq 0.25 \ and \ \gamma \in [0, \ \gamma_1); \\[2ex]
\frac{4(1 + \gamma)(-1 + C(-2 + \gamma)^2 + \gamma)}{(-1 + \gamma)^2} & if \left\{
\begin{array}{l}
0 < C \leq 0.03303 \ and \ \gamma \in (\gamma_1, \ \bar{\gamma}_2) \\[1ex]
0.03303 < C \leq 0.25 \ and \ \gamma \in (\gamma_1, \ \bar{\gamma}_3) \\[1ex]
0.25 < C \leq 0.3125 \ and \ 0 \leq \gamma \leq \bar{\gamma}_3
\end{array}
\right.
\end{array}
$$

where $\gamma_1 = \frac{1}{2}\sqrt{\frac{1 - 4C}{C^2}} + \frac{-1 + 4C}{2C}$ and $\bar{\gamma}_2$ and $\bar{\gamma}_3$ are the third and first roots, respectively, of the expression $(-3 + 8C + 2\gamma + (1 - 6C)\gamma^2 + 2C\gamma^3)$.

The maximum patent breadth that allows a later entrant to operate is $\overline{\lambda}^{US} = \frac{4}{3}$.

I next consider whether the feasible range is non-empty. The maximum patent breadth for which F2 will enter without a license, $\overline{\lambda}^{US}$, is constant, reflecting the fact that its choice of legal spending is independent of the patentee's spending.

The minimum patent breadth required for investment by F1 is increasing in C, as may be expected. Interestingly, it is non-monotonic in γ, first falling and then rising, for low R&D costs. The intuition is that if R&D costs are low, then the patentee will operate with perfectly narrow patents if the entrant's product is either very dissimilar or highly substitutable. In the former case, the entrant expands the market and price competition is very weak. In the latter case, the applications are so similar that the patentee would prevail in Court with very high probability even with $\lambda = 0$. For a range of moderately substitutable goods, positive patent protection is required. This is because goods are close enough that competition compresses prices, but not close enough that expected damages compensate for the reduction in profit.

For moderate to high R&D costs, however, the closeness of the entrant's product becomes more important. The range of substitutes that the patentee is able to tolerate[5] with perfectly narrow patents is lower. For high costs, the patentee will always require a strictly positive patent breadth and will only operate if the rival's good is sufficiently dissimilar.

The maximum feasible patent breadth, $\overline{\lambda}^{US}$ is independent of γ, while the minimum feasible patent breadth, $\underline{\lambda}^{US}$, is increasing in the degree of closeness between the applications as R&D costs increase; thus the range of γ over which the feasible range of patent breadths is non-empty narrows as R&D costs increase. Recalling that with maximum patent breadths the best case scenario (if F1 has full bargaining power) assures licensing only if $\gamma < 0.6117$, when does the PO do better to select $\overline{\lambda}^{US}$ rather than Λ? Comparing the outcomes under each:

Remark 3.2 *Under the American rule, the Patent Office ensures investment by F1 and duopoly production over a greater range of entrant applications by setting $\lambda = \overline{\lambda}^{US}$ than by setting perfectly broad patents if and only if $C \leq 0.218$.*

Proof: See Appendix.

---

[5] 'Tolerance' here describes whether or not the firm is able to enjoy non-negative expected payoff if its rival is active in the market.

The PO's feasible range is large if R&D costs are low, as the patentee finds it profitable to invest even with very limited patent protection. If F1 faces higher R&D costs, however, the firm is less able to tolerate close competitors and will require more protection. For sufficiently high investment costs, the feasible range is empty and the PO will do better to set patent breadth to its maximal level: in this way, the patentee has an incentive to offer a license whenever the entrant's application sufficiently expands the overall market. Thus the model implies that for low to moderate R&D costs, imperfect patents are preferable. Only for sufficiently high investment costs are results consistent with Green and Scotchmer (1995) in recommending perfectly broad patents.

3.4.4. The English or 'Losing Party Pays' Rule

Under the English Rule, the losing party pays all litigation costs; a firm's spending thus depends on patent breadth and on the spending of its rival. If firm 1 sues for infringement, simultaneous choice of litigation spending to maximize expected payoffs yields:

$$
L_1^{UK} = \frac{(-1+\gamma)^2\gamma\lambda}{(-2+\gamma)^2(1+\gamma)(1+(-1+\gamma)\lambda)^2}
$$
$$
L_2^{UK} = \frac{(-1+\gamma)^3(-1+\lambda)\lambda}{(-2+\gamma)^2(1+\gamma)(1+(-1+\gamma)\lambda)^2} \tag{3.13}
$$

(see Appendix). Consistent with much of the literature, then, the English rule here leads to greater total litigation spending than the American rule for a given patent breadth. In this setup, I can also analyze more closely the spending incentives of each firm. The English rule suggests that for a given strictly positive patent breadth, the patentee spends considerably more (less) on litigation than the entrant firm if the goods are close (far) substitutes. This is because the the extent to which one unit of spending on legal services by F1 increases the probability of infringement (the marginal benefit of litigation spending to the patentee) is greater than the extent to which one unit of spending by F2 reduces the probability of infringement (the marginal benefit to the entrant) for close substitutes: if F1 has a good case, spending a bit more on legal

services helps to support it; at the same time, F2 knows its own case is weak and spending a bit more in defense does not enhance it very much. These incentives are of course reversed for low substitutability

The probability of infringement is given by:

$$\delta^{UK} = \frac{\gamma}{1 + (-1 + \gamma)\lambda} \tag{3.14}$$

Substituting for litigation spending levels and probability of infringement in the expressions for expected payoffs yields:

$$E(\Pi_1^{UK}) = -\frac{-1 + \gamma^2 + 3(-1 + \gamma)^2\lambda + 2(-1 + \gamma)^3\lambda^2}{(-2 + \gamma)^2(1 + \gamma)(1 + (-1 + \gamma)\lambda)^2}$$

$$E(\Pi_2^{UK}) = -\frac{(-1 + \gamma)^2(-1 + \lambda(2 + (-1 + \gamma)\lambda))}{(-2 + \gamma)^2(1 + \gamma)(1 + (-1 + \gamma)\lambda)^2}. \tag{3.15}$$

Denote by $\underline{\lambda}^{UK}$ and $\overline{\lambda}^{UK}$ the required minimum and maximum patent breadths, respectively, of the feasible range under the English rule:

Remark 3.3 *If there is no licensing agreement, then the minimum patent breadth required for investment by the patentee under the English rule, $\underline{\lambda}^{UK}$, is given by:*

$$
\begin{cases}
0 & if \quad 0 < C \le 0.25 \ and \ \gamma \in [0, \gamma_1); \\
\frac{1}{2}\left(-\frac{2}{-1+\gamma} + \frac{1}{A} + \sqrt{\frac{-1 + \gamma(9 - 8\gamma - 4C(-2 + \gamma)^2(1 + \gamma))}{(-1 + \gamma)A^2}}\right) & if \begin{cases} 0 < C \le 0.25 \ and \ \gamma \in (\gamma_1, \tilde{\gamma}_2) \\ 0.25 < C \le 0.3125 \ and \ 0 \le \gamma \le \tilde{\gamma}_2 \end{cases}
\end{cases}
$$

where $A = 2(-1 + \gamma) + C(-2 + \gamma)^2(1 + \gamma)$ and $\tilde{\gamma}_2$ is the first root of the expression $(-2 + 4C + 2\gamma - 3C\gamma^2 + C\gamma^3)$.

The maximum patent breadth that allows a later entrant to operate is given by $\overline{\lambda}^{UK} = \frac{1}{2}$ if $\gamma \in [0, \frac{1}{2}(3 - \sqrt{5}))$; $\frac{1}{(1+\sqrt{\gamma})}$ if $\gamma \in [\frac{1}{2}(3 - \sqrt{5}), 1]$.

Unlike under the American rule, the maximum patent breadth that allows F2 to operate now depends on the degree of substitutability between the goods. This is because firms operating under a 'loser pays' principle partially externalize their legal spending. And since legal spending is driven to a great degree by the closeness of the rival's product, each firm is affected more intensely by the identity of its rival, reflected in γ. Indeed,

if goods are moderately close ($\gamma < \frac{1}{2}(3 - \sqrt{5})$), firms are sufficiently aggressive in their legal spending that the PO moves to cap patent breadth. It is clear that $\overline{\lambda}^{UK}$ is decreasing in the closeness of the goods, meaning that the rival is able to operate profitably with stronger patents only if it produces a more dissimilar good.

Under the English rule, then, $\underline{\lambda}^{UK}$ is non-decreasing in γ (strictly increasing for $\gamma \in [\frac{1}{2}(3 - \sqrt{5}), 1]$) and $\overline{\lambda}^{UK}$ is decreasing in γ as R&D costs rise: thus here again the feasible range narrows as C increases. Comparing the range of γ for which the feasible range of patent breadths is non-empty if the PO selects $\overline{\lambda}^{UK}$ rather than Λ:

Remark 3.4 *Under the English rule, the Patent Office ensures investment by F1 and duopoly over a greater range of entrant applications by setting $\lambda = \underline{\lambda}^{UK}$ rather than by setting perfectly broad patents if and only if $C \leq 0.215$.*

Proof: See Appendix.

The recommendation here mirrors that under the American rule: the PO does better to set moderately broad rather than perfectly broad patents if R&D costs are low to moderate. By doing so, they ensure that the welfare-superior licensing outcome is realized for a wider range of entrant firms. If R&D costs are high, however, then the best way to maximize the probability of investment by early innovating firms is to set perfectly broad patents.

3.4.5. Comparison of Patent Breadths under the American and English Rules when $C \leq 0.215$

I have so far shown the boundary values for the feasible range under each rule, along with setting out the R&D cost requirements for the relevant feasible ranges to be non-empty. If such costs are sufficiently high, then the PO will set perfectly broad patents regardless of the cost allocation rule in force. If $C \leq 0.215$, however, the PO's preferred patent breadths under the respective cost allocation rules are $\overline{\lambda}^{US}$ and $\overline{\lambda}^{UK}$. In this sub-section, I examine the implications of the cost allocation rule for policy, and so fix R&D costs at a level which would lead to rule-specific patent breadths. I examine the

impact of the specific rule on (i) patent breadth, (ii) legal spending by firms and (iii) the overall probability of infringement.

First, compare the relative patent breadths. Given the PO's choice of $\overline{\lambda}^{US}$ and $\overline{\lambda}^{UK}$ under respective rules, it follows that:

Proposition 3.1 *If $C \leq 0.215$, the Patent Office's preferred patent breadth is lower (that is, patents are narrower) under the English rule.*

The PO selects the highest possible patent breadth which allows later stage firms to enter the market. The American rule allows for broader patents because firms consider only their own costs when deciding how much to spend. Under the English rule, however, firms must consider the rival's spending as well as its own. As a result, each firm's incentive to spend increases with patent breadth. If the PO were to set λ at a high level, this would set off an arms race in legal spending - F1 would increase its spending to increase the overall probability of infringement, while F2 in turn would raise its spending to counteract the patentee's efforts. The negative externalities firms impose on each other via legal spending are strong enough to lead to an explosion in spending. This is consistent with the discussion in Plott (1987) about the instability of the English rule, though in the current specification this occurs only if patents are sufficiently broad.

The model suggests that, all else equal, if R&D costs are sufficiently low, policymakers operating with the American rule will maintain broader patents than those under the English rule, even while the different systems result in equal levels of innovation and activity by later stage entrants. Broader American patents therefore do not necessarily prejudice innovation and neither are they per se symptoms of a pro-patentee Patent Office; rather, they reflect the effects of the legal cost allocation mechanism. A corollary of this policy implication would be that any attempt to narrow patents without expressly addressing the effects of the fee-shifting regime - in the manner of the recent Leahy-Smith America Invests Act - may have adverse effects on investment and innovation.

Now turn to the legal spending under the respective rules. Substituting $\overline{\lambda}^{US}$ for patent breadth in the expressions for legal spending under the American rule yields:

$$L_1^{US} = L_2^{US} = \frac{(-1+\gamma)^2}{3(-2+\gamma)^2(1+\gamma)} \tag{3.16}$$

and substituting for $\overline{\lambda}^{UK}$ in the corresponding expressions for the English rule, they become:

$$
\begin{aligned}
L_1^{UK} &= \frac{2(-1+\gamma)^2\gamma}{(-2+\gamma)^2(1+\gamma)^3} \text{ if } \gamma \in [0, \tfrac{1}{2}(3-\sqrt{5})) \\
&\quad \frac{(-1+\sqrt{\gamma})^2(1+\sqrt{\gamma})}{(-2+\gamma)^2(1+\gamma)} \text{ if } \gamma \in [\tfrac{1}{2}(3-\sqrt{5}), 1]; \\
L_2^{UK} &= -\frac{(-1+\gamma)^3}{(-2+\gamma)^2(1+\gamma)^3} \text{ if } \gamma \in [0, \tfrac{1}{2}(3-\sqrt{5})) \\
&\quad -\frac{2-\frac{1}{\sqrt{\gamma}}-2\gamma+\gamma^{\frac{3}{2}}}{(-2+\gamma)^2(1+\gamma)} \text{ if } \gamma \in [\tfrac{1}{2}(3-\sqrt{5}), 1]
\end{aligned}
\tag{3.17}
$$

Comparing the foregoing:

Proposition 3.2 *If $C \leq 0.215$ and the Patent Office sets patent breadth at its rule-specific preferred level, patentee firms spend more under the English rule than under the American rule if goods are sufficiently similar, while entrant firms always spend more under the English rule relative to the American rule. Total litigation spending is always higher under the English rule than under the American rule.*

Given the PO's preferred patent breadths, the English rule leads to greater total litigation spending. Firm spending is shown in Figure 3.3. The patentee will spend more on legal services if operating under the English rule than it will under the American rule only if the degree of substitutability between the applications is sufficiently high, though its spending decreases as good become more similar and its case is inherently stronger. Note that the entrant firm always spends more on litigation under the English rule relative to the American rule, but for low substitutability the entrant spends considerably more than the patentee, bolstering its already strong defense. The entrant firm will spend less on legal services than the patentee if it produces a sufficiently close
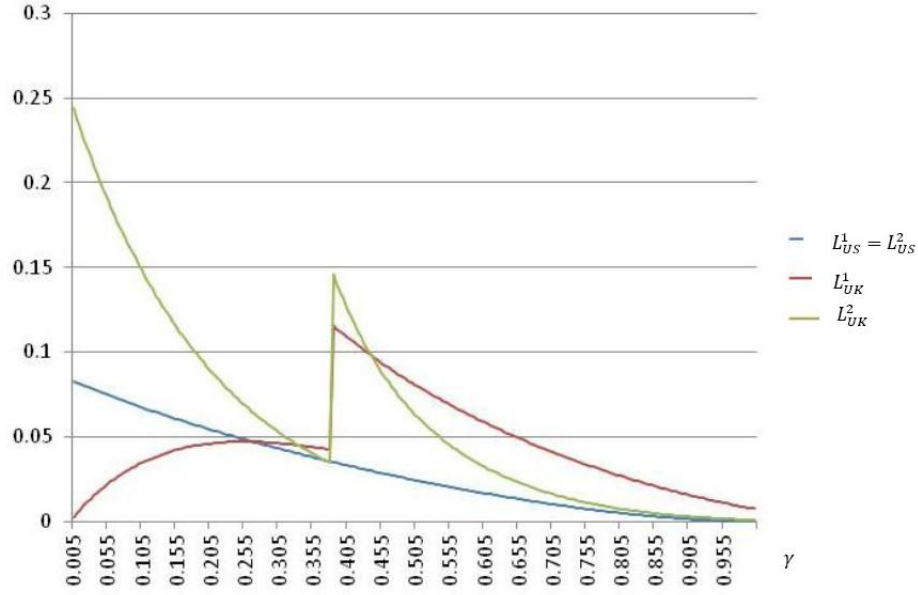
Figure 3.3.: Comparison: Legal Spending if $C \leq 0.215$

substitute, both because pricing pressure is higher (it has less to spend) and because the marginal benefit of spending on an inherently weaker case is low.

I have shown that the American rule results in stronger patents, but that the English rule induces more legal spending. What, then, is the effect on the overall probability of infringement? Substituting for legal spending and preferred patent breadths under each system, the probability of infringement under the respective rules simplifies to:

$$\delta^{US} = \frac{2+\gamma}{3};$$
(3.18)

$$\delta^{UK} = \frac{2\gamma}{1+\gamma} \ \text{ if } \ \gamma \in [0, \frac{1}{2}(3-\sqrt{5}))$$

$$\sqrt{\gamma} \quad \text{if } \ \gamma \in [\frac{1}{2}(3-\sqrt{5}), 1].$$
(3.19)

In spite of the fact that the English rule induces higher legal spending by both firms, it is the American system that results in the larger overall probability of infringement.

Proposition 3.3 *If $C \leq 0.215$ and the Patent Office sets patent breadth at its rule-specific preferred level, the overall probability of infringement is higher under the American rule than under the English rule.*
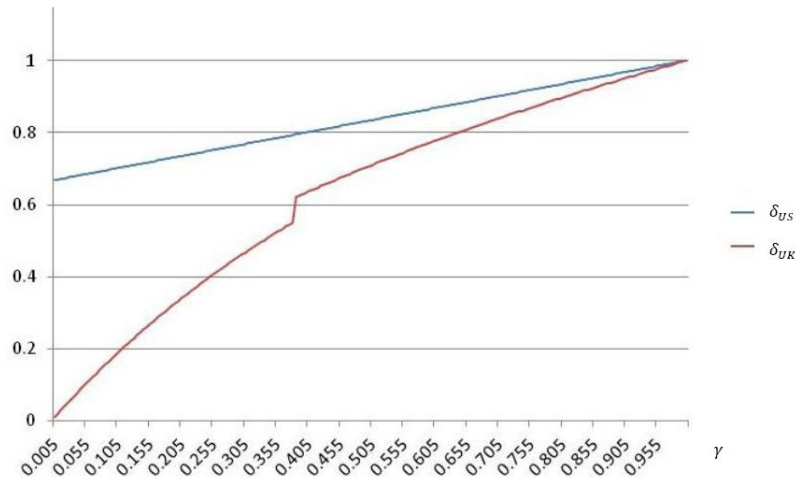
83

Figure 3.4.: Comparison: Probability of Infringement if $C \leq 0.215$

The intuition is that under the English rule, the PO will set narrower patents. If patents are narrow, it is the intrinsic differences between the applications that more heavily affect the Court's decision; thus even with high levels of legal spending (better lawyers, more detailed discovery, etc), the patentee's chance of a favorable judgement is not markedly enhanced. The probability of infringement under the respective rules is illustrated in Figure 3.4. This overall result implies that for given R&D cost levels and closeness of application products, it is the American rule of legal cost allocation that is better for the patentee. Importantly, however, the system is more pro-patentee not because of any inherent bias in the Patent Office, but as an intrinsic feature of the legal cost allocation. The firms are able to de-couple their legal spending decisions, which allows the PO to set broader patents. The English system, in forcing the firms to think about the rival's spending, sets the scene for an arms race in legal spending. This leads the PO to set low patent breadths.

3.4.6. Comparison of Patent Breadths under the American and English Rules when $C > 0.215$

I now turn to analysis of the implications of the cost rules for patent policy if $C > 0.215$. I have shown above that the PO does better to set patent breadth at the rule-specific level if $C \leq 0.218$ under the American rule, while the same is only true under the English rule if $C \leq 0.215$. Thus, for R&D costs in the range $0.215 < C \leq 0.218$, a PO operating in a system with the English rule of legal cost allocation will set perfectly broad patents while a PO operating with the American rule will do better to set patent breadth at $\overline{\lambda}^{US}$.

Comparing the overall probability of infringement under the respective rules for such cost levels:

Proposition 3.4 *If $0.215 < C \leq 0.218$, the Patent Office's preferred patent breadth is lower (that is, patents are narrower) under the American rule.*

This is illustrated in Figure 3.5. For R&D costs in this range, investment by the patentee requires that either the rival sells a sufficiently dissimilar good or that expected damages are sufficiently high. Under the English rule, however, high patent breadth drives both firms to spend heavily. This in turn means duopoly cannot be sustained if goods are close substitutes (pricing competition is high and firms are driven to spend more on legal services; both of these factors mean that expected payoffs decline). A PO operating under the English rule may therefore do better to set perfectly broad patent breadths, as this encourages investment while still providing for at least some licensing.

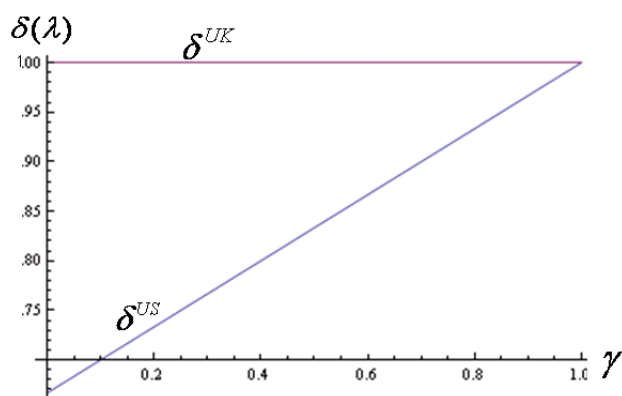If $C > 0.218$, the PO will find it preferable to set perfectly broad patents under either rule.

Figure 3.5.: Comparison: Probability of Infringement if $0.215 < C \leq 0.218$

3.5. Concluding Remarks

Patent design in the context of sequential innovation is a balancing act between ensuring that patentee rights are strong enough to enable R&D investment yet weak enough that future development is not impeded. Licensing and investment behaviour are also impacted by the method used to allocate legal costs. Thus, effective patent policy must consider not only patent breadth and the level of litigation cost but also how these costs are split across firms. This paper has compared R&D investment and patent licensing outcomes for the American and English rules of legal cost allocation in a highly stylized setting, assuming complete information, one-period duopoly and licensing by Nash bargaining. Caution is therefore advised in any interpretation of results.

Nevertheless, it provides interesting insight into the relationship between the nature of the fee-shifting regime and licensing incentives. I have shown that, all else equal, if R&D costs are sufficiently low, American policymakers may maintain a greater degree of patent breadth and allow a higher probability of infringement of patents than would be the case under the English rule. As such, the US patent system may indeed appear to be more patentee-friendly than systems elsewhere. However this does not necessarily prejudice later entrants and is due to the fee-shifting system itself, not any inherent pro-patentee bias at the Patent Office. However if R&D costs are moderate, it is

the English rule which may induce broader patents. An important corollary of model results is that any attempt to narrow patents without expressly addressing R&D costs and the fee-shifting regime may mean that patentees may no longer find it profitable to invest. Results further suggest that if R&D is sufficiently expensive, then perfectly broad patents should be adopted regardless of the cost allocation rule.

There are several interesting avenues for further research, including expanding competition to a greater number of applications and exploring the effects of the rule on optimal patent breadth if both insider- and outsider-patented inputs are essential for production.

A. Appendix

A.1. American rule: Choice of Litigation Spending

If both firms operate in the applications market and F2 does not license, payoffs to F1 and F2, respectively, are given by:

$$
E(\Pi_1) = \left(1 + (\gamma + \lambda(1-\gamma)\frac{L_1}{L_1+L_2})\right)\left(\frac{1-\gamma}{(-2+\gamma)^2(1+\gamma)}\right) - L_1
$$
$$
E(\Pi_2) = \left(1 - (\gamma + \lambda(1-\gamma)\frac{L_1}{L1+L_2})\right)\left(\frac{1-\gamma}{(-2+\gamma)^2(1+\gamma)}\right) - L_2 \tag{3.A.1}
$$

Each firm will simultaneously choose its legal spending to maximize its payoff. This yields 2 possible solutions for L_1, given by:

$$
L_{11} = -\frac{L_2(-2+\gamma)^2(1+\gamma) + \sqrt{L_2(1+\gamma)(2+(-3+\gamma)\gamma)^2\lambda}}{(-2+\gamma)^2(1+\gamma)}
$$
$$
L_{12} = \frac{-L_2(-2+\gamma)^2(1+\gamma) + \sqrt{L_2(1+\gamma)(2+(-3+\gamma)\gamma)^2\lambda}}{(-2+\gamma)^2(1+\gamma)} \tag{3.A.2}
$$

and 2 possible solutions for L_2:

$$
L_{21} = -\frac{L_1(-2+\gamma)^2(1+\gamma) + \sqrt{L_1(1+\gamma)(2+(-3+\gamma)\gamma)^2\lambda}}{(-2+\gamma)^2(1+\gamma)}
$$
$$
L_{22} = \frac{-L_1(-2+\gamma)^2(1+\gamma) + \sqrt{L_1(1+\gamma)(2+(-3+\gamma)\gamma)^2\lambda}}{(-2+\gamma)^2(1+\gamma)} \tag{3.A.3}
$$

Simultaneous solution yields four pairs of expressions, but the only pair that yields

non-negative expressions for both are given in the text at (3.10). Total litigation costs are:

$$\frac{(-1+\gamma)^2 \lambda}{2(-2+\gamma)^2(1+\gamma)} \tag{3.A.4}$$

A.2. American rule: Feasible Range of Patent Breadths

To find the feasible range, I look for the range of parameters for which $\underline{\lambda}^{US} \leq \overline{\lambda}^{US}$. This is the case if and only if:

- $0 < C \leq 0.0330309$ and $\gamma < \hat{\gamma}_2$

- $0.0330309 < C \leq 0.0620499$ and $\gamma < \hat{\gamma}_2$

- $0.0620499 < C < 0.25$ and $\gamma < \hat{\gamma}_3$

where $\hat{\gamma}_2$ and $\hat{\gamma}_3$ are the third and first roots of the expression $(-4 + 12C + 2\gamma + (2 - 9C)\gamma^2 + 3C\gamma^3)$. Note that $\bar{\gamma}_2 > \hat{\gamma}_2$ and $\bar{\gamma}_3 > \hat{\gamma}_3$ for all relevant values of C.

In order to evaluate when the PO does better to choose $\overline{\lambda}^{US}$ or maximal patent breadth, I consider the range of substitutes that will be granted a license. With perfectly broad patents, if it has full bargaining power - and is therefore most likely to license - the patentee will grant a license only if $\gamma < 0.611709$. Note that $\hat{\gamma}_2 > 0.611709 \; \forall \; 0 < C \leq 0.0620499$; if R&D costs are low, the PO does better to set patent breadths according to $\overline{\lambda}^{US}$. I next note that $\hat{\gamma}_3 > 0.611709$ only if $C \leq 0.217642$; only if R&D is very costly is it better for the PO to set perfectly broad patents.

A.3. English rule: Choice of Litigation Spending

If both firms operate in the applications market, payoffs to F1 and F2, respectively, are given by:

$$E(\Pi_1) = \left(1 + (\gamma + \lambda(1-\gamma)\frac{L_1}{L_1 + L_2})\right)\left(\frac{1-\gamma}{(-2+\gamma)^2(1+\gamma)}\right) - \left(1 + (\gamma + \lambda(1-\gamma)\frac{L}{L1+L2})\right)(L_1 + L_2)$$

$$E(\Pi_2) = \left(1 - (\gamma + \lambda(1-\gamma)\frac{L_1}{L_1 + L_2})\right)\left(\frac{1-\gamma}{(-2+\gamma)^2(1+\gamma)}\right) - (L_1 + L_2)$$

(3.A.5)

if F1 files suit, each firm will simultaneously choose its legal spending to maximize its payoff. This yields 2 possible solutions for L_1, given by:

$$L_{11} = -\frac{L_2(-2+\gamma)^2(1+\gamma)(-1+\lambda) + \sqrt{L_2(-2+\gamma)^2(-1+\gamma^2)(-1+\lambda)\lambda}}{(-2+\gamma)^2(1+\gamma)(-1+\lambda)}$$

$$L_{12} = \frac{-L_2(-2+\gamma)^2(1+\gamma)(-1+\lambda) + \sqrt{L_2(-2+\gamma)^2(-1+\gamma^2)(-1+\lambda)\lambda}}{(-2+\gamma)^2(1+\gamma)(-1+\lambda)}$$

(3.A.6)

and 2 possible solutions for L_2:

$$L_{21} = -\frac{L_1(-2+\gamma)^2\gamma(1+\gamma) + \sqrt{L_1\gamma(1+\gamma)(2+(-3+\gamma)\gamma)^2\lambda}}{(-2+\gamma)^2\gamma(1+\gamma)}$$

$$L_{22} = \frac{-L_1(-2+\gamma)^2\gamma(1+\gamma) + \sqrt{L_1\gamma(1+\gamma)(2+(-3+\gamma)\gamma)^2\lambda}}{(-2+\gamma)^2\gamma(1+\gamma)}$$

(3.A.7)

Simultaneous solution yields four pairs of expressions, but the only pair that yields non-negative expressions for both are given in the text at (3.13). Total litigation costs are:

$$\frac{(-1+\gamma)^2\lambda}{(-2+\gamma)^2(1+\gamma+(-1+\gamma^2)\lambda)},$$

(3.A.8)

which is greater than spending under the American Rule, given at (3.A.4), $\forall \lambda > 0$.

A.4. English rule: Feasible Range of Patent Breadths

I wish to find the range of parameters for which the feasible range is non-empty, or $\underline{\lambda}^{UK} \leq \overline{\lambda}^{UK}$, under the English rule. This is the case if and only if:

- $0 < C \leq 0.236068$ and $\gamma_1 < \gamma < \hat{\hat{\gamma}}_2$

- $0.236068 < C \leq 0.238534$ and $\hat{\hat{\gamma}}_1 < \gamma < \hat{\hat{\gamma}}_2$

where $\hat{\hat{\gamma}}_1$ and $\hat{\hat{\gamma}}_2$ are the first and second roots respectively, of the expression $(-1+(11-24C+16C^2)\gamma + (-19+24C)\gamma^2 + (9+18C-24C^2)\gamma^3 + (-24C+8C^2)\gamma^4 + (6C+9C^2)\gamma^5 - 6C^2\gamma^6 + C^2\gamma^7)$. Note that $\hat{\hat{\gamma}}_1 \geq \gamma_1$ and $\hat{\hat{\gamma}}_2 < \tilde{\gamma}_2$ and for all relevant values of C.

In order to evaluate when the PO does better to choose $\overline{\lambda}^{UK}$ or maximal patent breadth, I consider the range of substitutes that will be granted a license. Recall that with perfectly broad patents, the patentee will grant a license to all $\gamma > 0.611709$. Note that $\hat{\hat{\gamma}}_2 > 0.611709 \ \forall \ 0 < C \leq 0.215177$. Thus for all R&D costs below this level, the PO can ensure licensing over a larger range of substitute applications if it sets patent breadth at $\overline{\lambda}^{UK}$ rather than allowing for perfectly broad patents. The PO switches to perfectly broad patents at a lower investment cost level under the English rule than under the American rule.

4. Spinning out of an Anticommons: Licensing and Vertical Separation in Differentiated Duopoly

Abstract

The potential for an Anticommons, an underuse of early stage research tools to produce valuable, complex final products, is a source of much concern among policymakers and legal scholars, especially in the US. In spite of the mixed empirical evidence, policymakers have recently legislated to weaken patents in an effort to ensure that later-stage development is not impeded. I use a simple, one-period differentiated duopoly model to show that if the holder of the single essential patent has flexibility in corporate structure and if products are of equal quality, Anticommons problems are eliminated, while if later-stage products are of higher quality, the likelihood of such problems is reduced. If the patentee holds 1 of 2 essential patents, the ability to shift its corporate structure may reduce total licensing costs to rival firms. However while vertical separation by the patentee may help to sustain downstream competition, it may reduce welfare. Thus the inefficiency may be in the opposite direction to the one currently thought - there may be too much technology transfer, rather than too little.

4.1. Introduction

In highly sequential industries such as biotechnology and genomics, R&D inputs (previous generation products and research tools) are virtually impossible to invent around, leading firms to seek intellectual property right ('IPR') protection and to defend IPRs at above-average levels. Fears about the power of patentees over the direction and speed of potentially much more valuable later stage innovation has led many in the US to argue that patent rights are too strong (Jaffe and Lerner (2004)). Policymakers are moving to respond to these concerns with increased legislation, the latest of which is the Leahy-Smith America Invents Act, signed into law on September 16, 2011.[1] This law includes, inter alia, a broader scope for prior art, additional support to defendants in infringement claims and revised post-examination processes, all in an attempt to dilute protection to patentees.

However, much of the theoretical work on which concerns about the adverse effects of patentee power are based assumes that the industrial relationship of patent owners and licensees is fixed; that is, most models assume the patentee is either a co-competitor in the final goods market (an *insider*) or an input provider which does not produce (an *outsider*). In reality, patentees may change corporate structure, transforming themselves from outsiders to insiders or vice versa. Such changes in corporate structure have direct implications for patentees' incentives to license to non-patentholding competitors and, as such, for the likelihood that later stage innovators will be kept out of the market.

Using a simple differentiated duopoly model based on Singh and Vives (1984), I examine the potential for an Anticommons, defined as failure of a firm to secure all licenses necessary for production where such production is welfare enhancing (typically deriving from either *blocking* or *stacking* problems), if vertically integrated patentees are able to dis-integrate. Such vertical separation allows the patentee to commit to charging downstream entities uniform license royalties. I show that in this model, where production

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[1] This law was the outcome of repeated attempts at patent reform and follows on from similar proposals in 2005, 2007 and 2009, when Bills failed to make it to floor vote.

by a second downstream firm is always welfare-enhancing, Anticommons problems will not occur if the products are of equal quality and the patentee holds the only patent essential for production, as that firm will always license to its downstream rival, simply shifting its corporate structure depending on the identity of the competitor. If the rival offers higher quality, Anticommons problems occur only if goods are sufficiently close substitutes. If the patentee owns only 1 of 2 essential inputs, vertical separation may reduce total royalty payments for rival firms. Results therefore suggest that, rather than seeking to foreclose rivals in the downstream market, early stage patentees may instead choose vertical structures which preserve downstream competition. The model thus suggests that concerns about the strength of upstream patents may be somewhat exaggerated, as potential Anticommons may be greatly reduced provided that patent owners have flexibility in corporate structuring.

However I find that this preservation of downstream competition may be at the expense of welfare. Indeed, for certain parameter ranges there may be too much technology transfer rather than too little. If the patentee controls the single essential patent, vertical separation is welfare reducing if the rival does not offer a significantly higher quality. If the patentee controls only 1 of 2 essential patents, with the second owned by an outsider, whenever vertical separation is employed it is welfare reducing. Thus, an Anticommons result may be welfare-superior to downstream duopoly. Consequently, the more serious issue for policymakers, given that such divestitures do not normally require permission from competition authorities, is that welfare reducing vertical separation may be observed.

I focus on the case of a vertically integrated patentee which has the option to vertically separate, or to *spinoff* its research/IPR unit as this setup seems to more closely mirror the concerns of legal and policy scholars that powerful insider firms can use intellectual property rights to foreclose rivals and retard later-generation products. Further, spinoffs are a major feature of the biotechnology landscape: parent companies often spin off specific IP assets into separate companies to allow management to focus on core assets

or facilitate external financing. In the vein of Adams and Mukherji (1999), I define a spinoff as a transfer by a 'parent' company of some specific portion of its assets, technology, property and/or personnel into a separate legal entity, the shares of which are distributed to the owners of the parent company by means of a dividend. The owners of the parent company are not required to relinquish any of their existing holdings in exchange for this dividend, meaning that after the spinoff they hold shares in the two distinct companies.

Such a change in corporate structure may be costly, especially in respect of taxes, as distributions to shareholders in the form of a dividend typically attract capital gains taxes. The US Internal Revenue Service permits tax-free treatment of spinoff share distributions only if the transaction meets certain standards, the most stringent of which is the independent business purpose test.[2] At the current time, spinoffs which simply maximize shareholder value (along the lines of the spinoffs in this model) do not meet the test. The model therefore suggests that if policymakers prioritize downstream licensing over static welfare, this type of tax-free treatment should be extended to spinoffs which result in higher levels of technology licensing.

4.2. Related Literature

This paper is related to two strands of literature: (i) complementary monopoly and the tragedy of the anticommons; and (ii) vertical separation theory.

Complementary monopoly refers to a case where participation by multiple rights-holders is required for production of a final good to take place. If participation is not secured, there is a social loss as valuable final goods are not produced, an outcome which is termed the 'tragedy of the anticommons'. This could occur because final stage firms control none of the rights essential to production of a good, needing to in-license from other firms which cannot co-ordinate pricing (fragmentation in upstream property rights or stacking) or because a firm faces controls only some, but not all of the

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[2]These standards are laid out in the Internal Revenue Code §355. Adams and Mukherji (1999) provides an in-depth discussion.

essential rights (it faces blocking patents). A relatively recent anticommons literature has emerged since the term was coined in Heller and Eisenberg (1998). Llanes and Trento (2009) looks at probability of innovation (market entry) where a firm faces multiple patentee input suppliers, finding that innovation cost increases (decreases) as products become more complex if inputs are complements (substitutes). Anticommons effects therefore may be realized where products are complex and inputs are essential or difficult to substitute. However Cheng and Nahm (2007), (2010) show that such effects are more likely to arise only if individual components have no/ little value relative to the value of the final good. Though some scholars simply posit that competition in components will solve this problem (Dari-Mattiacci and Parisi (2006)), further work has shown that this may not be sufficient if all sectors are not competitive (Casadesus-Masanell et al. (2009), Alvisi and Carbonara (2010)).

The continued debate over the ability of first generation patentees to block rivals and create anticommons-type problems has led to calls from the legal academe (Mireles (2004), Barnett (2000)) for some combination of (i) weakening patent rights; (ii) adoption of relaxed antitrust supervision of research joint ventures and patent pools; and/or (iii) more aggressive antitrust policy outside of such collective arrangements (with merger control more driven by concerns about innovation markets, to keep patents rights relatively diffused), a discussion which has doubtless influenced the recent America Invents Act. However there have also been counter-arguments, principally Lichtman (2006) which suggests that if downstream revenue does not depend on the number of individual components to be assembled and component owners know the overall number of components required, then each should be more willing to settle as the number of components increases.

This lack of theoretical consensus is matched by mixed results in US industry studies on the question of a biotechnology anticommons. Walsh et al. (2003) finds that while there has been increased patenting activity on research tools in the biomedical sector, there is only limited evidence that drug discovery has been 'substantially impeded'.

But Merz et al. (2002), Cho et al. (2003) and Gaisser and Hopkins (2009) contradict these findings, reporting anticommons-type effects in the diagnostic testing market as surveys of clinical geneticists indicate that they are dissuaded from developing or offering diagnostic tests where underlying patents are in force. Recent empirical papers also seem to support the presence of a 'scientific' anticommons: Murray and Stern (2007) compares biotechnology patent-paper pairs and finds that the flow of knowledge (as captured by citations) drops 10 - 20% after a patent is granted, with the effect greater over time and for public researcher papers. A similar work, Huang and Murray (2008) finds that flow of knowledge (again captured by follow-on publications) relating to human gene-based patent-paper pairs declines significantly after grant of the patent, with this decline increased for, inter alia, private-sector ownership, broad scope and commercial importance of the gene.

The question of vertical separation and market foreclosure has also been well explored. Notable works include Bonanno and Vickers (1988), which shows that vertical separation is better for firms if they can use franchise fees to extract profit from downstream and Cyrenne (1994), which shows that firms will separate upstream and downstream functions under Bertrand competition if the downstream goods are sufficiently close substitutes and downstream firms pay a per unit fee. Rey and Tirole (2007) provides a useful survey or work in this area and sets out conditions under which an integrated entity would prefer to divest its downstream operation. In their model, the entity faces 1 upstream rival and a downstream rival, with downstream firms making an irreversible choice of upstream supplier. They show that if downstream goods are sufficiently close substitutes, the pure downstream rival is more concerned about foreclosure and has an incentive to choose the alternate upstream supplier. The integrated entity may therefore choose to divest its downstream operation so as to avoid loss of a downstream customer. Reisinger and Tarantino (2011) looks at complementary input producers each facing competition from less efficient sources and facing homogeneous downstream duopoly, and concludes that vertical integration may lead to lower in-

put prices as the integrated entity reduces input prices when its corporate structure changes.

This paper draws on each of the aforementioned streams and contributes to a smaller literature on the competitive and welfare effects of strategic choice of vertical structure with patent ownership. Matsushima and Mizuno (2009) and Laussel and VanLong (2011) look at, respectively, static and dynamic choices of vertical separation by a downstream monopolist if multiple inputs are required for production, concluding that separation may lower input prices to the monopolist. This paper contributes by extending the question to downstream duopoly where the firm also licenses to its rival. This setup allows us to explore a tradeoff that is not present in the monopoly setup: integration allows the firm to use the per-unit license to benefit its own competitive potion, but separation forces the outsider patentee to offer a lower royalty.

Fauli-Oller and Sandonis (2002) examines a patentee's incentives to license a cost-reducing innovation to a differentiated rival and concludes that licensing by royalty is welfare reducing only if firms compete in prices, the goods are close substitutes and the innovation is large but not drastic. I look at the case of a product innovation, which is qualitatively similar to a drastic cost innovation, and so extend this result.

Sandonis and Fauli-Oller (2006), the paper closest to this work, explores choices facing an upstream patentee research laboratory which supplies its cost-reducing technology to downstream duopolist manufacturers and shows that when upstream patentees choose two-part tariff licensing, they merge with one of the downstream firms if products are sufficiently close substitutes. Such mergers are both profitable and welfare enhancing if the innovation is small. This paper looks at a related but distinct question: the optimal corporate structure and licensing strategy for an initially vertically integrated patentee facing differentiated competition in the downstream market and licensing by per-unit royalty. This setup allows us to analyze the potential for powerful insiders to foreclose rivals and retard later-generation products. It is also a distinct policy question from the case of an upstream research laboratory since in the latter

case, any welfare reducing merger could simply be blocked by competition authorities whereas spin-offs require no such permission. As a result, any welfare reducing outcomes cannot be prevented. The current model contributes in two further ways. Firstly, I examine this question both when the patented input is the only essential input and when it is only 1 of 2 essential inputs, allowing for an analysis of stacking. Second, I allow for demand asymmetry in the downstream products, so that I can address the impact of early IPR on relatively more valuable later stage innovation. I find that if only 1 patent is required, the Sandonis and Fauli-Oller (2006) policy recommendation to block any profitable merger is appropriate only if the rival does not offer significantly higher quality, as vertical integration (effectively, a merger) is both profitable and welfare enhancing if the quality differential is sufficiently large.

4.3. Model Setup

Firm 1 (the *patentee* firm) is an integrated firm consisting of an upstream research division and a downstream manufacturing division. Via its upstream unit, firm 1 holds the patent on an input, component A, which is essential for downstream production. The patent granted on the input is perfect. Firm 1 may, at no cost, vertically separate. Under separation, the spun-off research entity would deal with the downstream production unit on an arms length basis, although both would remain part of the same business group or *consortium*. Firm 1's downstream division faces competition from Firm 2 (the *entrant* firm) which operates downstream only, having no research capacity. Firm 2 makes use of the patented Component A to produce a differentiated final good.

Consumers A continuum of consumers with mass equal to 1 have utility given by

$$U(q_1, q_2) = q_1 + aq_2 - \frac{1}{2}(q_1^2 + q_2^2 + 2\gamma q_1 q_2), \qquad (4.1)$$

where $\gamma \in [-1,1]$ and $a \geq 1$.[3] Consumers maximize this utility subject to a budget constraint of the form $R = p_1 q_1 + p_2 q_2$. Social welfare is measured by total utility (or total potential surplus): $SW = U(q_1, q_2)$.

Firms The producers compete in prices, with firm 1's downstream unit and firm 2 facing inverse demands given by $p_1 = 1 - q_1 - \gamma q_2$ and $p_2 = a - q_2 - \gamma q_1$, respectively. The parameter a reflects the asymmetry in the quality or social value of the goods: if $a = 1$ ($a > 1$), the quality of good 1 is equal to (lower than) that of good 2. The degree of product differentiation is given by γ: if $\gamma > 0$, the goods are substitutes; the closer is γ to 1, the more substitutable the goods. If $\gamma = 0$, the goods are independent and each firm is a local monopolist. If on the other hand $\gamma < 0$, the goods are complements. In what follows, I consider only independent and substitute goods, and therefore restrict that $\gamma \in [0,1]$.

Each downstream firm requires access to all essential research tools if it is to be active in the market. If a producer is unable to conclude a successful licensing agreement with any of the patentees, it is unable to produce and its rival may be left as a monopolist in the downstream market. Such a failure to agree has a negative effect on social welfare, which is increasing in the production of both goods. I formally define an *Anticommons* (or an *Anticommons problem*) as the failure by either downstream firm to secure the essential patents for production when such production is welfare enhancing. Anticommons problems may arise either because the patentees are not willing to license (this may be termed the *blocking* effect: patentees may assert the patents to successfully block production by rivals and secure their own competitive positions) or because parties are unable to come to terms (typically due to the *stacking* effect: patentees negotiate with producers individually and the sum of the individual license fees makes production unprofitable).

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[3]This corresponds to the Singh and Vives (1984) model with $\alpha_1 = \beta = 1$ and $\alpha_2 = a \times \alpha_1$.
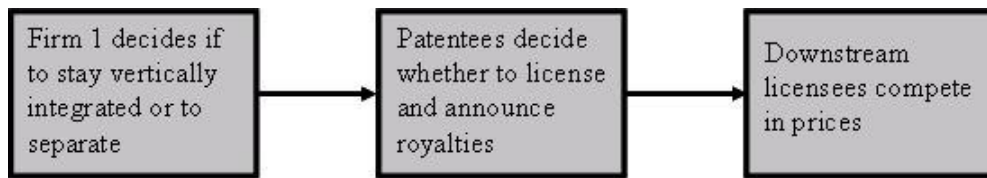
Figure 4.1.: Timing of the game

Timing   The timing of the game, summarized in Figure 4.1, is as follows: in the first stage, firm 1 decides whether to remain vertically integrated or to spin off its upstream R&D unit. In the second stage, patentee firms decide whether to offer a license to the downstream firms and if so, announce the royalty(ies), simultaneously where applicable, on a take-it-or-leave-it basis. In the third stage, all downstream licensees compete in prices in the downstream market.

4.4. The Model with One Essential Input

First suppose that component A is the only input required for production of the final (downstream) good. Production technology is such that 1 unit of component A is needed to manufacture 1 unit of the final good. The industry structure is illustrated by Figure 4.2. A vertically integrated firm 1 provides the input to its downstream
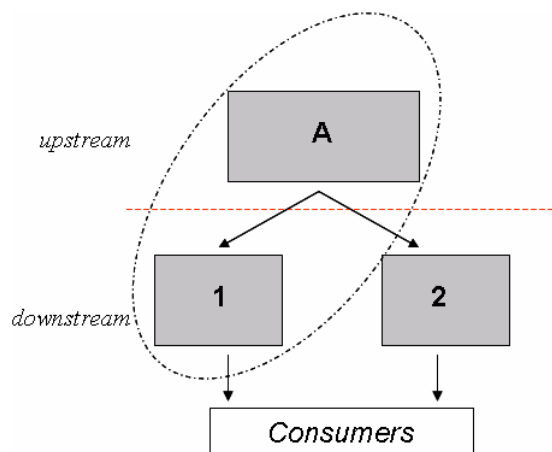

Figure 4.2.: The model with 1 essential input

division and decides whether to license to the rival or to operate as a downstream

monopolist. The upstream unit of a vertically separated firm 1 could license to one or to both downstream operators, though consortium profits would equal the sum of firm 1's upstream and downstream profits. A license is characterized by a non-negative per-unit royalty payment, r_A. In this case, only 1 input is required so the stacking issue does not apply. My analysis of the likelihood of an Anticommons therefore focusses on potential blocking by the patentee.

A fully vertically integrated firm 1 could in theory offer component A to its downstream arm at a transfer price anywhere between cost and the price at which it licenses to firm 2. Unless the firm's transfer price announcement is enforceable, however, it faces a commitment problem if it announces any price other than the cost price, zero.[4] I proceed assuming that such announcements are not enforceable, so that vertical integration implies that firm 1's downstream unit accesses component A without cost.[5]

4.4.1. Vertical Integration

At the final stage, if firm 1 is a downstream monopolist, it earns a profit of $\pi_{1,m} = \frac{1}{4}$. If instead firm 2 operates as a downstream monopolist, it must in-license component A. In that scenario, firm 1, the patentee, enjoys licensing revenue of $\pi_{1,m} = \frac{a^2}{8}$ and the downstream monopolist makes a profit, net of licensing costs, of $\pi_{2,m} = \frac{a^2}{16}$. If, however, there is a downstream duopoly, firm 1 has marginal cost of zero (it owns the required patent) while firm 2 has a per unit input cost equal to r_A, the per unit royalty charged by firm 1 for component A. Optimal prices and quantities are given by:

$$p_1 = 1 + \frac{-8 + 5\gamma^2 + a\gamma(-2 + \gamma^2)}{2(8 - 7\gamma^2 + \gamma^4)}; \; p_2 = a + \frac{(a + \gamma)(-2 + \gamma^2)}{2(8 - 7\gamma^2 + \gamma^4)}$$

$$\pi_1 = \frac{-8 + 11\gamma^2 - 4\gamma^4 - a^2(-2 + \gamma^2)^2 + a(8\gamma - 6\gamma^3)}{4(-1 + \gamma^2)(8 - 7\gamma^2 + \gamma^4)}; \; \pi_2 = -\frac{(-4\gamma + 3\gamma^3 + a(-2 + \gamma^2)^2)^2}{4(-1 + \gamma^2)(8 - 7\gamma^2 + \gamma^4)}$$

$$(4.2)$$

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[4]If the rival were to price assuming per-unit costs to firm 1 equal to the announced transfer price, then the integrated firm has an incentive to lower the actual transfer price below this level and partially foreclose its rival.

[5]Relaxing this assumption would simply change the interpretation of model results. If announced transfer prices were enforceable, what I term 'vertical integration' would translate to firm 1 setting a transfer price equal to upstream marginal cost and what I term 'vertical separation' would translate to firm 1 setting a uniform downstream royalty. The model would therefore lay out the effect of the firms's transfer pricing strategy on the possibility of an Anticommons.

and the per-unit royalty charged by firm 1 is:

$$r_A = \frac{-\gamma^3 + a(8 - 8\gamma^2 + \gamma^4)}{2(8 - 7\gamma^2 + \gamma^4)} \tag{4.3}$$

(see Appendix). The royalty is decreasing in the degree of substitutability, γ, and increasing in the social value of firm 2's product, a. Note that if the entrant firm produces a more valuable product, duopoly is only possible if the degree of substitutability between the products is sufficiently low; if the degree of substitutability exceeds the critical threshold, goods are almost homogenous and consumers prefer the rival's higher quality good. The patentee is unable to attract positive demand and will therefore only earn licensing revenue.

By comparison of the patentee's potential earnings across the different scenarios, I establish the patentee's licensing behaviour. In deciding whether to offer a license to firm 2, firm 1 must weigh the licensing revenue it can receive against the increased competitive pressure it will face. Summarizing:

Remark 4.1 *If a vertically integrated firm 1 owns the only essential patent reading on downstream production and licenses via a per-unit royalty, then the patentee will refuse a license (an Anticommons result) if and only if (a) $1 \leq a \leq 1.01975$ and either (i) $\gamma \in (\gamma^1, \gamma^2)$ or (ii) $\gamma > \tilde{\gamma}_1$ or (b) $1.01975 < a \leq \sqrt{2}$ and either (i) $\gamma \in (\gamma^1, \gamma^2)$ or (ii) $\gamma > \tilde{\gamma}_2$, where:*
γ^1 and γ^2 are the third and fourth roots, respectively, of the expression
$\left(4a^2 - 8a\gamma + (4 - 4a^2)\gamma^2 + 6a\gamma^3 + (-4 + a^2)\gamma^4 + \gamma^6\right)$; $\tilde{\gamma}_1$ is the third root of the expression
$\left(4a - 4\gamma - 4a\gamma^2 + 3\gamma^3 + a\gamma^4\right)$; and $\tilde{\gamma}_2$ is the third root of the expression
$\left(8 - 2a\gamma - 9\gamma^2 + a\gamma^3 + 2\gamma^4\right)$.
No Anticommons occurs if $a > \sqrt{2}$.

Proof: See Appendix.

The intuition is the following: for low enough demand asymmetry (that is, if $1 \leq a \leq \sqrt{2}$), the patentee firm compares the profit from operating as a downstream monopolist to that earned from licensing and competing in downstream duopoly. If the

goods are sufficiently different, competitive pressure is weak and joint profit high so that licensing revenue exceeds any losses from increased competition. If goods are moderately substitutable, however, competitive pressure is strong enough to compress firm 1's downstream earnings and the level of the per unit license, but not strong enough that the rival can take advantage of the higher value attached to its product. Licensing is therefore not a profitable choice and the patentee will assert its patent to block production by firm 2: Anticommons problems thus result for this range of γ. If goods are moderate-to-high substitutes, the entrant firm, by dint of its higher quality, is able to capture more of the market and licensing is again preferable for firm 1 as in this way it can appropriate some portion of firm 2's profit. For the closest substitutes, as is explained above, the patentee will not attract positive demand. It does better to block the entrant and produce as a downstream monopolist; Anticommons problems occur.

However, if the entrant's quality is sufficiently high, that is, if $a > \sqrt{2}$, the patentee will always license to the rival firm 2; no Anticommons will result. The patentee rather decides whether it should maintain its downstream operation or allow the licensee firm 2 to operate as a monopolist, and operates downstream only if it can generate sufficiently high market revenues.

4.4.2. Vertical Separation

Let us now suppose that at stage 1, firm 1 spins off its (upstream) research unit. Recall that under vertical separation, the upstream entity offers arms-length, per-unit royalty contracts to either one or both downstream operators. If it contracts with both downstream firms, then, they access component A at the same per-unit cost, r_A.

If the upstream entity sells only to the consortium's downstream operation, then upstream unit sets a per-unit royalty of $r_{A_u} = \frac{1}{2}$ and makes licensing revenue of $\pi_{u,m} = \frac{1}{8}$. Downstream profit, net of licensing costs, is $\pi_{d,m} = \frac{1}{16}$ and consortium profit is $\pi_{c,m} = \frac{3}{16}$. If instead the consortium's patent-holding upstream unit offers a license only to firm 2, the outcome will be as in the comparable case under vertical integration: firm 2 earns a profit, net of licensing costs, of $\pi_{2,m} = \frac{a^2}{16}$. The patentee makes licensing

revenue of $\pi_u = \frac{a^2}{8}$. If the research unit sells to both downstream producers, optimal downstream prices and profits are given by:

$$p_{1,vs} = \frac{-2 - \frac{1}{4}(1+a)(2+\gamma) + \gamma(a+\gamma)}{(-4+\gamma^2)}; \; p_{2,vs} = \frac{\gamma - \frac{1}{4}(1+a)(2+\gamma) + a(-2+\gamma^2)}{(-4+\gamma^2)}$$

$$\pi_{1,vs} = -\frac{(6+\gamma-3\gamma^2+a(-2+(-3+\gamma)\gamma))^2}{16(-4+\gamma^2)^2(-1+\gamma^2)}; \; \pi_{2,vs} = -\frac{(-2+(-3+\gamma)\gamma+a(6+\gamma-3\gamma^2))^2}{16(-4+\gamma^2)^2(-1+\gamma^2)}$$

$$(4.4)$$

and the per unit royalty and upstream profits are given by:

$$r_{A_{vs}} = \frac{1+a}{4}; \; \pi_u = -\frac{(1+a)^2}{8(-2+\gamma)(1+\gamma)}. \tag{4.5}$$

(see Appendix). The royalty is increasing in the entrant's quality, a, but is independent of the degree of substitutability, γ. Note that duopoly is only possible if the quality differential is not too large and the degree of substitutability between the products is sufficiently low.

The upstream unit always does better to offer a license to the entrant firm. Thus, if firm 1 opts for vertical separation, blocking does not arise: no Anticommons exists. But the firm will only make such a choice if consortium payoffs under vertical separation exceed payoffs under vertical integration. I next examine when the firm will opt to spin off its research unit, comparing vertically integrated profit to consortium profit under vertical separation:

Proposition 4.1 *If firm 1 owns the single essential patent reading on downstream production and licenses via per-unit royalty, then if vertical separation is possible,*

- *if $a = 1$, the patentee will always always provide a license to the entrant and no Anticommons occurs;*

- *if $1 < a < 1.30395$, the patentee will provide licenses to rivals over a larger range of γ than is possible if it could not dis-integrate; the option to separate therefore means Anticommons outcomes are less likely; and*

- *if $a > 1.30395$, the patentee's licensing behaviour does not change.*

Proof: See Appendix.

Thus the option of vertical separation helps to reduce the blocking effect for some parameter values. The intuition here is that with the elimination of double marginalization under vertical integration, the downstream unit of firm 1 faces a marginal cost of zero and the rival firm, taking this into account, prices more aggressively. By spinning off the research unit, the conglomerate can credibly raise the marginal cost facing its downstream unit, raising the price charged by the rival firm as well. The benefit associated with this less aggressive pricing is more important the stronger is the pricing pressure - that is, the lower is the quality differential and the more substitutable are the goods.

In the special case of symmetric quality, consortium profit exceeds vertically integrated profit if $\gamma > 0.629$ and $\tilde{\gamma}_3 = 1$. Firm 1 will remain integrated and license to the rival if γ is low and will spin off the upstream research unit and license to *both* downstream producers if γ is high. The model suggests that as the degree of substitutability increases, firm 1 will switch from a regime where it is vertically integrated and licensing to its rival, to vertical separation where it licenses to both downstream units. The option of vertical separation therefore preserves downstream competition over the entire range of γ. For any degree of substitutability, then, the patentee will never block entry. No Anticommons exists.

For larger values of a, however, the entrant firm is able to capture more of the market; the patentee thus has more to lose from downstream competition and licensing becomes a less attractive strategy. This means there will be some blocking, though the ability to spin off upstream units makes this outcome less likely.

The change in firm 1's licensing behaviour resulting when it has the option to vertically separate is shown in the figures below. Figures 4.3 and 4.4 are drawn assuming $a = 1$, while Figures 4.5 and 4.6 are drawn assuming $a = 1.25$. While there is no stacking issue per se - only 1 input is required for consumption - it is interesting to explore what effect this switch in corporate structure may have on the licensing cost to
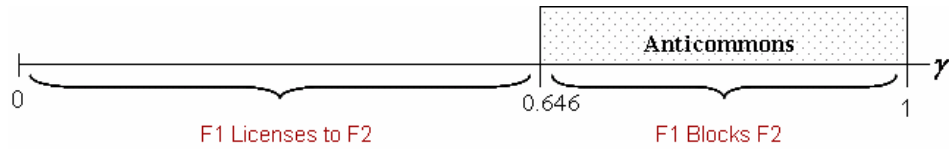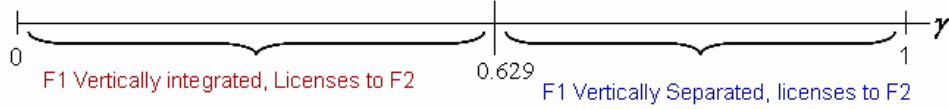
Figure 4.3.: No Vertical Separation, a=1

Figure 4.4.: With Vertical Separation, a=1

entrants. Comparing the per unit royalty charged under integration with that under separation:

Proposition 4.2 *If firm 1 owns the single essential patent reading on downstream production and licenses via a per-unit royalty, then vertical separation by firm 1 results in a lower royalty to the downstream rival if and only if* $1.33079 < a < 1.4439$.

Proof: The patentee switches from remaining vertically integrated and licensing to its rival at a per-unit royalty r_A to vertically separating and licensing to both downstream operators at a per unit royalty $r_{A_{vs}}$ only if (i) $1 \leq a \leq 1.42933$ and $\gamma \in [\check{\gamma}_1, \tilde{\gamma}_3]$ or (ii) $1.42933 < a < 1.91809$ and $\gamma \in [\check{\gamma}_3, \tilde{\gamma}_3]$. For each specific range of γ, I check the relative size of the per-unit royalties. For a as per (i) $r_A > r_{A_{vs}}$ only if $a \in (1.33079, 1.42933]$. For a as in (ii), $r_A > r_{A_{vs}}$ only if $a \in (1.42933, 1.4439)$. □
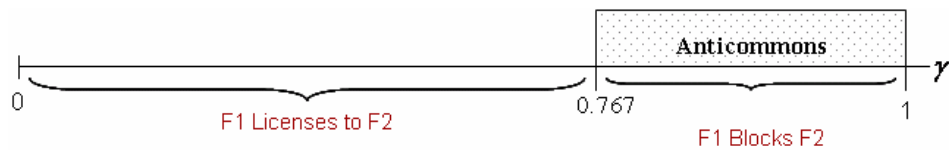

Figure 4.5.: No Vertical Separation, a=1.25

The standard result is that if products are symmetric in quality, vertical integration by a patentee and a downstream supplier raises rivals' costs; as such, vertical separation
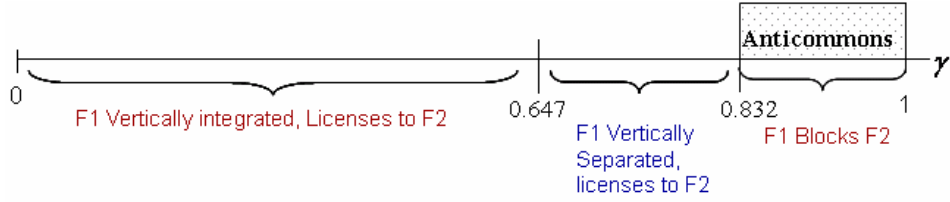
Figure 4.6.: With Vertical Separation, a=1.25

may be expected to lower rivals' costs. However results here suggest that the rival firm will benefit from a decrease in royalties only if the quality asymmetry lies in a moderate range. The intuition is that while the royalty set by an outsider increases in a and is independent of γ, the royalty charged by an insider patentee increases in a to a larger extent, and decreases in γ. For low quality differentials, the latter effect is more important: because the royalty set by a competitor-patentee is decreasing in the closeness of the goods, a patentee with flexible corporate structure will rationally dis-integrate only if it can charge more per unit (i.e., if the rival is sufficiently close). Thus, separation always raises the rival's cost. For moderate quality differentials, the effect of a on the royalties is more pronounced; any separation will lower rivals' costs. For large quality differentials, the patentee will move to shut its downstream operations entirely, so that its corporate structure has no bearing on royalty levels.

4.4.3. Welfare

Let us now consider the welfare implications of firm 1's corporate structure. First, assume that the firm remains vertically integrated. If firm 1 operates as a monopolist, welfare is equal to U_m where:

$$U_{1,m} = q_{1,m} - \frac{1}{2}\left(q_{1,m}^2\right) = \frac{1}{2} - \frac{1}{2}\left(\frac{1}{2}\right)^2 = \frac{3}{8}. \tag{4.6}$$

If instead firm 2 operates as a monopolist, welfare becomes:

$$U_{2,m} = aq^r_{2,m} - \frac{1}{2}\left(q_{2,m}^2\right) = a\left(\frac{a}{4}\right) - \frac{1}{2}\left(\frac{a}{4}\right)^2 = \frac{7a^2}{32}. \tag{4.7}$$

In contrast, welfare with a downstream duopoly is given by:

$$U_d = \frac{1}{8(-1+\gamma^2)(8-7\gamma^2+\gamma^4)^2}\big[192 - 384\gamma^2 + 267\gamma^4 - 76\gamma^6 + 8\gamma^8 + a^2(-2+\gamma^2)^2$$

$$(28 - 25\gamma^2 + 4\gamma^4) + 2a\gamma(-3+2\gamma^2)(32+5\gamma^2(-6+\gamma^2))\big] \qquad (4.8)$$

and by straightforward comparison of this and the foregoing utility expressions, I note that U_d exceeds utility under either form of monopoly for all permitted values of γ. As such, any refusal to license is welfare reducing.

Now suppose that firm 1 is vertically separated. Total utility with a separated firm 1 and downstream duopoly is given by:

$$U_{d,vs} = \frac{1}{16(-4+\gamma^2)^2(-1+\gamma^2)}\big[-76 + \gamma(-16+\gamma(57+(7-12\gamma)\gamma)) + a(40+2\gamma(48+$$

$$(-5+\gamma)\gamma(3+4\gamma))) + a^2(-76+\gamma(-16+\gamma(57+(7-12\gamma)\gamma)))\big] \qquad (4.9)$$

By comparison of this expression to U_d, it is straightforward that welfare is unambiguously improved with a vertically separated patentee only if the quality associated with the entrant's product is sufficiently high, specifically:

Proposition 4.3 *If firm 1 owns the single essential patent reading on downstream production and licenses via a per-unit royalty, vertical separation is welfare enhancing if and only if $1.549 < a < 3$ and $\gamma \leq \tilde{\gamma}_3$.*

Proof: See Appendix.

If the quality differential is smaller than this, whenever the firm chooses to spin off the upstream unit, welfare is reduced. This is because the patentee is able to use royalty licensing to soften downstream competition; the effect is to restrict downstream output. Even though the ability to vertically separate and use royalty licensing preserves downstream *competition*, such a strategy lowers welfare. To the extent that the rival product has a sufficiently higher quality, however, preservation of downstream competition enhances welfare, as production of the high quality good compensates for the increased input prices.

This result is consistent with Fauli-Oller and Sandonis (2002), but the current model

contributes by showing that (i) the intuition holds for the case of a product innovation, which is conceptually similar to a *drastic* cost innovation and therefore that an integrated firm may opt to divest its downstream arm and license to both manufacturers even when it could *fully* foreclose and (ii) vertical separation may be welfare enhancing even with partial foreclosure if the rival firm produces a differentiated good with sufficiently higher quality.

4.5. The Model with Two Essential Inputs

As the number of essential inputs required for a given final good increases, producers face both the blocking and stacking problems. This is especially true of the biotechnology sector, where fragmented ownership of genetic material means that a producer often has to assemble an array of research tools if it is to operate. In order to analyze the effect of choice of corporate structure on downstream production when there exists a stacking issue in research tools, I now vary the setup slightly and consider the model with two essential inputs and three firms. Firm 1 is (again) an integrated firm consisting of an upstream research division and a downstream manufacturing division. Via its upstream unit, the firm holds the patent on an input, component A, which is one of two inputs essential for downstream production. Firm B is an independent upstream firm producing component B, the second input required for production. It has no downstream capability. Production technology is such that 1 unit each of components A and B are required for production of 1 unit of the downstream good. There are no marginal costs of production in the upstream units and the patents granted on the inputs are again assumed to be perfect.

Downstream, firm 1 faces competition from firm 2, which produces a differentiated substitute. The downstream firms compete in prices to maximize profit. The industry structure is summarized in Figure 4.7. The timing mirrors that described in the model with 1 essential patent: in the first stage, firm 1 decides whether to remain vertically integrated or to spin off its upstream R&D unit. In the second stage, patentee firms
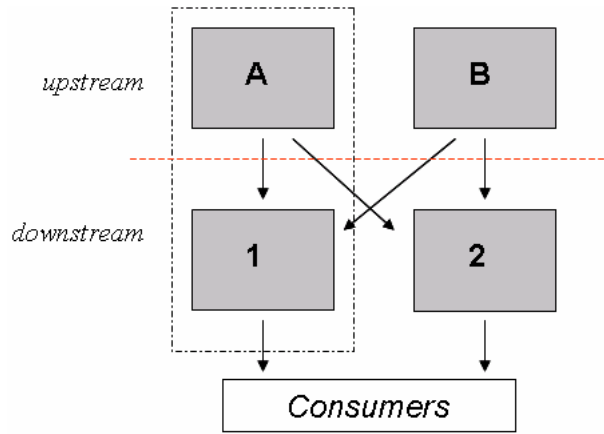
Figure 4.7.: The model with 2 essential inputs

decide whether to offer a license to the downstream firms and if so, announce licensing fees simultaneously, with licenses offered on a take-it-or-leave-it basis. In the third stage, all downstream licensees compete in prices in the downstream market. As in the section above, I first consider the scenario in which firm 1 remains vertically integrated, and then turn to the outcomes under vertical separation.

4.5.1. Vertical Integration

Under vertical integration, firm 1's downstream unit accesses component A at no cost.

At the final stage, if firm 1 operates as a monopolist, in-licensing only component B, it will pay a license fee equal to $r_{B1,m} = \frac{1}{2}$ and make a profit (net of royalties) of $q_{1,m} = \frac{1}{16}$. Firm B makes a profit of $\pi_{B1,m} = \frac{1}{8}$. If instead firm 2 is a monopolist, it must in-license both components. The patentees, setting royalties simultaneously, will charge $r_{A2,m} = r_{B2,m} = \frac{a}{3}$. Firm 2 will produce $q_{2,m} = \frac{a}{6}$ and make a profit (net of royalties) of $\pi_{2m} = \frac{a^2}{36}$. The patentees each make licensing revenue equal to $\pi_{A2,m} = \pi_{B2,m} = \frac{a^2}{18}$. Firm 1 therefore prefers to sell to a monopolist firm 2 (rather than operate as a monopolist itself) if $a \geq a^* = \frac{3}{2\sqrt{2}} \approx 1.06$.

If instead both producers successfully agree licenses for the required inputs, firms choose prices to maximize market profits. In the previous stage, the integrated firm 1 chooses r_A to maximize its total payoff, composed of licensing revenue *and* downstream
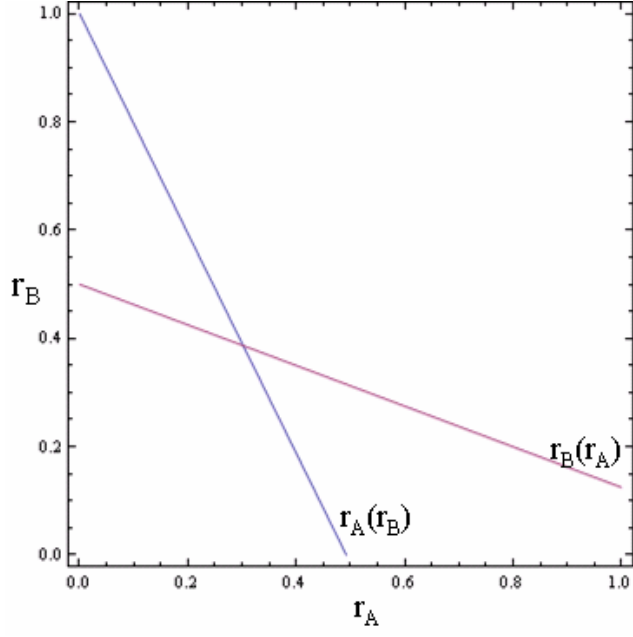
110

Figure 4.8.: Reaction Functions with Vertically Integrated Firm 1

profits, while firm B chooses r_B to maximize licensing revenue. The firms set royalties according to (see Appendix):

$$r_A = \frac{8a + \gamma^3 - r_B(8 + \gamma^3)}{2(8 + \gamma^2)}; \ r_B = \frac{1 + a - r_A - r_A\gamma}{4} \tag{4.10}$$

Each upstream firm's royalty is *decreasing* in its rival's, as the individual royalties are strategic substitutes. The per-unit royalty charged by the insider firm is increasing in γ, the degree of substitutability, consistent with the previous literature. For relatively close substitutes, the insider attempts to use the royalty as a collusive device to ease price competition. However the royalty charged by the outsider is decreasing in the degree of substitutability, as the outsider must react to the increased pricing pressure downstream. The firms' reaction functions are shown in Figure 4.8, which is drawn assuming $\gamma = 0.5$.

Substituting and solving for the per-unit royalties in terms of model parameters:

$$r_A = \frac{8 - 3\gamma^3 + a(-24 + \gamma^3)}{-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2))}; \ r_B = \frac{-16 - 2a(-2 + \gamma)^2 + \gamma^2(-2 + \gamma + \gamma^2)}{-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2))} \tag{4.11}$$

If the entrant offers the same quality ($a = 1$), the per-unit royalty charged by the insider firm is *lower* than that charged by the outsider over the relevant ranges of γ. This is because, notwithstanding the fact that royalties are increasing in substitutability of the goods, the insider internalizes the effect of royalties on downstream profits. The outsider is able to leverage on the insider's greater sensitivity to downstream market conditions to charge a higher royalty. In the case of asymmetric quality, the per-unit royalty charged by the insider (outsider) is increasing (decreasing) in a. Where products are highly quality-asymmetric, then, the insider patentee sets a per-unit royalty rate higher than that of the outsider.

The optimal prices and profits are given as:

$$p_1 = \frac{-36 + 6\gamma + \gamma^4 + a(-4 + \gamma(-2 + (-2 + \gamma)\gamma))}{-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2))}$$

$$p_2 = \frac{-4 + \gamma(10 + \gamma(-2 + 3\gamma)) + a(-44 + \gamma(6 - 6\gamma + \gamma^3))}{-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2))}$$

$$\pi_2 = \frac{(2 + \gamma^2)^2(-2 + (-5 + \gamma)\gamma + a(6 + \gamma - \gamma^2))^2}{(-1 + \gamma^2)(-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2)))^2}$$

$$\pi_B = -\frac{2(-2 + \gamma)(8 - 2a(-2 + \gamma) + \gamma(4 + \gamma(3 + \gamma)))^2}{(1 + \gamma)(-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2)))^2}$$

$$\pi_{1,d} = \frac{1}{(-1 + \gamma^2)(-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2)))^2}\left[(-20 + \gamma(6 - (-2 + \gamma)\gamma)+\right.$$

$$\left. a(4 - 10\gamma + \gamma^3))(20 + a(-4 - 14\gamma - \gamma^3 + \gamma^4) + \gamma(2 + \gamma(-2 + \gamma - 3\gamma^2)))\right] \qquad (4.12)$$

(see Appendix). The total payoff to firm 1 is given by $\pi_C = \pi_{1,d} + r_A q_2$.

By comparing firm 1's payoffs under each of the three scenarios, I establish its licensing behaviour[6]:

Remark 4.2 *If firm 1 owns 1 of 2 essential patents (or sets of essential patents) that read on downstream production and patentees license via a per-unit royalty, then the firm will never refuse a license if $a = 1$. If $1 < a < a^*$, firm 1 will refuse to license to the entrant (an Anticommons result) if and only if $\gamma > \hat{\gamma}_1$. If $a > a^*$, firm 1 will never refuse a license.*

Proof: See Appendix.

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[6]It is straightforward that firm B, the outsider patentee, always prefers to offer licenses as this is its only source of revenue. For analysis of the blocking issue, then, it suffices to examine firm 1's licensing behaviour.

The intuition is that licensing is more profitable to the innovating firm 1 the larger is the market-expanding effect of the rival's good (that is, the lower is γ) and its downstream operation is able to enjoy a higher market share the smaller is the quality differential (that is, the lower is a). There thus exists only a small range of substitutability over which the patentee firm would block production by a rival.

4.5.2. Vertical Separation

Let us now suppose that at stage 1 firm 1 spins off its upstream research unit into a separate entity. As in the model with 1 essential input, the newly independent research unit deals with the downstream production unit on an arms length basis, providing component A to both downstream producers at a per-unit royalty r_A, though it remains part of the same consortium. The upstream unit is now an outsider patentee and will therefore operate like firm B, the formal outsider.

At the final stage, both producers must now in-license both components. A downstream monopolist maximizes $\pi_m = (p_m(r_A, r_B) - r_A - r_B) \times q_m(r_A, r_B)$. If firm 1's downstream unit operates as a monopoly, consortium profit is given by $\pi_{C,m} = \frac{1}{18} + \frac{1}{36} = \frac{1}{12}$. If instead firm 1 offers a license only to firm 2, the outcome mirrors that with a firm 2 monopoly in subsection 5.1: each patentee charges $r_{Am} = r_{Bm} = \frac{a}{3}$; the firm 2 produces $q_m = \frac{a}{6}$ and makes a profit (net of royalties) of $\pi_m = \frac{a^2}{36}$. The patentees each make a profit of $\pi_{um} = \pi_{Bm} = \frac{a^2}{18}$ from licensing. The consortium would prefer to sell exclusively to its downstream arm rather than selling exclusively to the rival downstream producer if $a < a_2^* = \frac{\sqrt{3}}{\sqrt{2}} \approx 1.225$.

If instead firm 1 offers licenses to both firms, the downstream duopolists maximize $\pi_i = (p_i(r_A, r_B, p_j) - r_A - r_B) \times q_i(r_A, r_B, q_j)$ $(i \neq j)$. At the previous stage, patentees simultaneously announce royalties, setting the per-unit charges at:

$$r_{Avs} = \frac{1 + a - 2r_{Bvs}}{4}; \ r_{Bvs} = \frac{1 + a - 2r_{Avs}}{4}. \tag{4.13}$$

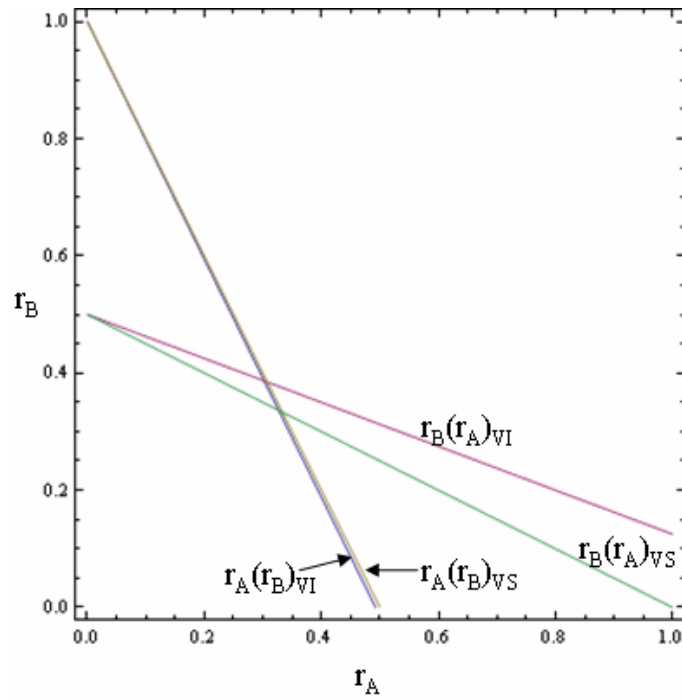These reaction functions are compared with the reaction functions with vertical inte-

Figure 4.9.: Comparison of Reaction Functions: Vertically Integrated vs. Separated Firm 1

gration in Figure 4.9 (again drawn assuming $\gamma = 0.5$).

The reaction function of firm 1 is only slightly displaced if it chooses to vertically separate. Indeed, the major difference in royalties is observed because the *outsider* patentee, firm B, changes its behaviour markedly if it faces another outsider patentee: royalties are strategic substitutes, and with vertical separation firm 1 must now pay a non-zero price for use of component A. As a result, firm B moderates its royalty. This is shown by a downward rotation in the reaction function.

Solving for the royalties in terms of model parameters, I confirm that in vertical separation, the patentees charge symmetric royalties:

$$r_{Avs} = r_{Bvs} = \frac{1+a}{6}. \tag{4.14}$$

Optimal prices and profits are given by:

$$p_{1VS} = \frac{8 + 2a + \gamma - 2a\gamma - 3\gamma^2}{12 - 3\gamma^2}; \ p_{2VS} = -\frac{2 - 2\gamma + a(8 + \gamma - 3\gamma^2)}{3(-4 + \gamma^2)}$$

$$\pi_{BVS} = \frac{(1+a)^2}{18(2-\gamma)(1+\gamma)}; \ \pi_{2VS} = -\frac{(-2 + (-2+\gamma)\gamma + a(4 + \gamma - 2\gamma^2))^2}{9(-4+\gamma^2)^2(-1+\gamma^2)}$$

$$\pi_{cVS} = \frac{(4 + \gamma - 2\gamma^2 + a(-2 + (-2+\gamma)\gamma))^2}{9(-4+\gamma^2)^2(1-\gamma^2)} + \frac{(1+a)^2}{18(2-\gamma)(1+\gamma)}. \qquad (4.15)$$

Downstream duopoly is only feasible if the markets sizes are sufficiently close and the degree of substitutability is sufficiently low, or specifically, if $1 \leq a \leq 2$ and $\gamma \leq \hat{\gamma}_3$, where

$$\hat{\gamma}_3 = \frac{-1 + 2a}{2(-2+a)} + \frac{1}{2}\sqrt{3}\sqrt{\frac{11 - 12a + 4a^2}{(-2+a)^2}}. \qquad (4.16)$$

For (i) $1 < a < 2$ and $\gamma > \hat{\gamma}_3$ or (ii) $a > 2$, the consortium's downstream unit would not be able to sustain positive output. For such parameter values, then, firm 2 would function as a downstream monopoly.

I now turn to the question of firm 1's choice of corporate structure. Note that the upstream unit always prefers to sell to both downstream producers, so there is no blocking. But $\hat{\gamma}_1 > \hat{\gamma}_3$ for the relevant range of a, meaning that the vertically separated structure supports licensing over a narrower range of downstream substitutability than vertical integration. Thus the option of vertical separation does not change the potential for blocking of the rival.

I next investigate if vertical separation has any influence on the stacking effect. If vertical separation is possible, firm 1 will opt to spin off the upstream unit only if the goods are sufficiently dissimilar and the quality differential is sufficiently low. More precisely:

Proposition 4.4 *If firm 1 owns 1 of the 2 essential patents (or sets of essential patents) that read on downstream production and licensing is by per-unit royalty, then if vertical separation is possible, firm 1 will spin off its upstream unit and license to both downstream producers if and only if $1 \leq a \leq \frac{1}{73}(50 + 21\sqrt{6})$ and $0 \leq \gamma \leq \tilde{\gamma}_4$. Such*

vertical separation has no effect on blocking but does reduce total royalty payments to firm 2 (stacking).

Proof: See Appendix.

This result is the key contribution of this section. The patentee will only opt for vertical separation if both a and γ are sufficiently low, so unlike in the model with one essential input, the ability to shift its corporate structure does not reduce the likelihood that firm 1 will act to block its rival. However whenever firm 1 does spin off its upstream unit, separation means reduced total royalty for its downstream rival: it reduces the stacking effect. This increases the profit to the entrant, making an Anticommons problem less likely.

The intuition is that because insider patentees are more sensitive to downstream pricing than outsider patentees, vertical separation - which converts firm 1's upstream unit from an insider into an outsider - increases competition upstream. This is consistent with Laussel (2008), Laussel and VanLong (2011) and Matsushima and Mizuno (2009) though it extends those results to a setting with downstream duopoly. Separation by firm 1 forces the outsider patentee to price less aggressively; for the rival firm, this input cost reduction is substantial enough to compensate for the increased cost of the input sold by the spin-off unit. The illustrated in Figures 4.10 and 4.11:
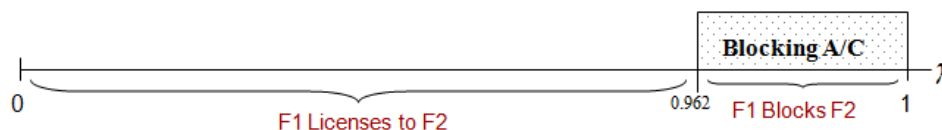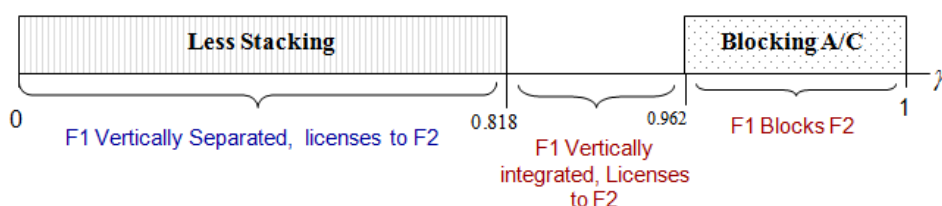

Figure 4.10.: No Vertical Separation, a=1.05

Figure 4.11.: With Vertical Separation, a=1.05

Separation improves payoff to the consortium as even though the downstream operation faces higher costs relative to the integrated case (it must now pay to access component A), the upstream unit benefits from increased licensing revenue from the rival firm (which produces more as its total royalty payments have declined). Separation here increases total profit to the consortium and entrant firms not because of any collusive effect in the downstream market (firm 2 actually *lowers* its downstream price) but because it inhibits expropriation by the outsider patentee.

4.5.3. Welfare

Welfare is unambiguously higher under downstream duopoly. However note that when vertical separation does occur it is not welfare enhancing: welfare with a vertically integrated patentee licensing to its rival is given by:

$$U_{d,vi} = \frac{1}{(-1+\gamma^2)(-56+\gamma(8+\gamma(-8+\gamma+\gamma^2)))^2}\Big[-912+\gamma(48+\gamma(-20+\gamma$$

$$(-44+\gamma(132+\gamma(-14+\gamma(2+\gamma-3\gamma^2))))))+a^2(-592+\gamma(16+\gamma(-252+\gamma(-16+\gamma(34-(-1+\gamma)$$

$$\gamma(-10+\gamma^2))))))+2a(160+\gamma(560+\gamma(-76+\gamma(230+\gamma(-72+\gamma(15+\gamma(-4+(-4+\gamma)\gamma)))))))\Big]$$

(4.17)

while welfare with vertical separation is given by:

$$U_{d,vs} = \frac{1}{18(-4+\gamma^2)^2(-1+\gamma^2)}\Big[-76+64a-76a^2-24(1+(-4+a)a)\gamma+3(19+$$

$$a(-16+19a))\gamma^2+2(5+a(-17+5a))\gamma^3-12(1+(-1+a)a)\gamma^4\Big] \qquad (4.18)$$

Straightforward comparison of (4.17) and (4.18) illustrates that in the relevant ranges of a and γ, the increased output from firm 2 (resulting from the reduced input cost) is insufficient to compensate for the reduction in output from the downstream unit of the consortium (due to its increased input costs). The result is that vertical separation reduces welfare.

4.6. Conclusion

The potential for an Anticommons, an underuse of early stage research tools and other IPR to produce complex, valuable products, is a source of much concern among policymakers and legal scholars. It arises when downstream firms are unable to secure access to vital inputs, typically due to either blocking or stacking problems. In spite of mixed empirical evidence about the extent to which Anticommons problems are observed in reality, US policymakers have recently moved, via the Leahy-Smith America Invents Act, to weaken patents in an effort to ensure that later-stage development is not impeded by upstream rights-holders. I use a simple, one-period differentiated duopoly model to show that if patentees have flexibility in corporate structure, Anticommons problems are greatly reduced. Indeed, the model suggests that if the patentee and entrant firms offer symmetric qualities and the patentee holds rights to the single essential input, Anticommons issues can be entirely eliminated. If instead the patentee owns one of 2 essential IPR, vertical separation does not affect blocking but does reduce the stacking problem to entrants. But while vertical separation by the patentee helps to sustain downstream competition, it may reduce welfare. Thus, while policymakers are concerned about inefficiencies associated with underuse of upstream research tools, the true inefficiency may be in the opposite direction - there may be too much technology transfer, rather than too little.

I recognize that given the assumptions embedded in the current specification, namely complete information, absence of ex ante licensing and costless re-structuring, the results should be interpreted with a great deal of caution. However the model succeeds in illustrating a case where policymakers' worry of too little development may not just be exaggerated but misguided as increasing downstream competition may harm welfare.

A. Appendix 1: The Model with One Essential Patent

A.1. Vertical Integration - Optimal prices and profits

If firm 1 is a downstream monopolist, it faces an inverse demand of $p_{1,m} = 1 - q_{1,m}$. Since it holds the patent on component A, marginal costs downstream are zero. The firm maximizes profit $\pi_{1,m} = p_{1,m}q_{1,m}$ by setting price equal to $p_{1,m} = \frac{1}{2}$ and produces $q_{1,m} = \frac{1}{2}$. Profit is thus $\pi_{1,m} = \frac{1}{4}$.

If firm 2 operates as a downstream monopolist, it faces inverse demand of $p_{2,m} = a - q_{2,m}$ and must choose price to maximize profit of $\pi_{2,m} = (p_{2,m} - r_A) q_{2,m}$. It will produce $q_{2,m} = \frac{a - r_A}{2}$. At the previous stage, the patentee firm chooses r_A to maximize its licensing profit, $\pi_{A,m} = r_A \times q_{2,m}$, and thus sets a per-unit royalty of $r_{A2,m} = \frac{a}{2}$. Substituting for r_A in firm 2's choices, firm 2 produces $q_{2,m} = \frac{a}{4}$ and earns a profit, net of licensing costs, of $\pi_{2,m} = \frac{a^2}{16}$. The patentee enjoys licensing revenue of $\pi_1 = \frac{a^2}{8}$.

Comparing its profits in the alternate monopoly scenarios, it is clear that firm 1 therefore would prefer to license component A to a monopolist firm 2, rather than operate as a monopolist itself, only if $a > \sqrt{2}$.

If instead there is a downstream duopoly at the final stage, firms face inverse demand of the form $p_1 = 1 - q_1 - \gamma q_2$ and $p_2 = a - q_2 - \gamma q_1$, respectively. Further, firm 1 has a marginal cost of zero (it owns the required patent) while firm 2 has a marginal cost equal to r_A, the per unit royalty charged by firm 1 for component A. Optimal prices and quantities with per unit licensing in terms of r_A are given by:

$$p_1 = \frac{-2 + \gamma(a - r_A + \gamma)}{-4 + \gamma^2}; \; p_2 = \frac{-2(a + r_A) + \gamma + a\gamma}{-4 + \gamma^2}$$

$$q_1 = \frac{2 - \gamma(a - r_A + \gamma)}{(4 - \gamma^2)(1 - \gamma^2)}; \; q_2 = -\frac{-2a + 2r_A + \gamma + (a - r_A)\gamma^2}{(4 - \gamma^2)(1 - \gamma^2)} \qquad (4.A.1)$$

At the previous stage, firm 1 must choose r_A considering both the effect on its *own* as well as the rival's downstream profits. It chooses the royalty to maximize $\pi_1 = $

$p_1(r_A) \times q_1(r_A) + r_A \times q_2(r_A)$, and sets the per-unit royalty at

$$r_A = \frac{-\gamma^3 + a(8 - 8\gamma^2 + \gamma^4)}{2(8 - 7\gamma^2 + \gamma^4)}. \qquad (4.A.2)$$

Substituting for r_A into the final stage expressions, optimal downstream prices and total firm profits may be expressed as:

$$p_1 = 1 + \frac{-8 + 5\gamma^2 + a\gamma(-2 + \gamma^2)}{2(8 - 7\gamma^2 + \gamma^4)}; \; p_2 = a + \frac{(a + \gamma)(-2 + \gamma^2)}{2(8 - 7\gamma^2 + \gamma^4)}$$

$$\pi_1 = \frac{-8 + 11\gamma^2 - 4\gamma^4 - a^2(-2 + \gamma^2)^2 + a(8\gamma - 6\gamma^3)}{4(-1 + \gamma^2)(8 - 7\gamma^2 + \gamma^4)}; \; \pi_2 = -\frac{(-4\gamma + 3\gamma^3 + a(-2 + \gamma^2)^2)^2}{4(-1 + \gamma^2)(8 - 7\gamma^2 + \gamma^4)} \quad (4.A.3)$$

Note that such an outcome is not always feasible. More precisely, firm 1 prices and output are only positive if the degree of substitutability between the downstream products is sufficiently low, or if $\gamma < \tilde{\gamma}_2$, where $\tilde{\gamma}_2$ is the third root of the expression $(8 - 2a\gamma - 9\gamma^2 + a\gamma^3 + 2\gamma^4)$. Additionally, firm 2 prices and profits are only positive if either (i) $a \in [1, 1.01975]$ and $\gamma < \tilde{\gamma}_1$, where $\tilde{\gamma}_1$ is the third root of the expression $(4a - 4\gamma - 4a\gamma^2 + 3\gamma^3 + a\gamma^4)$; or (ii) $a > 1.01975$. Note that $\tilde{\gamma}_1 < \tilde{\gamma}_2 \; \forall a \in [1, 1.01975]$. Taking both sets of restrictions into account, then, duopoly is possible if (i) $a \in [1, 1.01975]$, $\gamma \leq \tilde{\gamma}_1$ or (ii) $a > 1.01975$ and $\gamma < \tilde{\gamma}_2$.

A.2. Proof of Remark 4.1

If $1 \leq a \leq \sqrt{2}$, the patentee must decide between operating as a downstream monopolist (refusing a license) and operating in downstream duopoly (licensing to the entrant). It therefore compares monopoly profits of $\pi_{1,m} = \frac{1}{4}$ with duopoly payoff (market profits plus licensing revenue). The latter is larger (so the patentee will license) if and only if:

- $a \in [1, 1.01975]$ and either $\gamma \leq \gamma^1$ or $\gamma \in [\gamma^2, \tilde{\gamma}_1)$, where γ^1 and γ^2 are the third and fourth roots, respectively, of the expression
  $(4a^2 - 8a\gamma + (4 - 4a^2)\gamma^2 + 6a\gamma^3 + (-4 + a^2)\gamma^4 + \gamma^6)$ and $\tilde{\gamma}_1$ is as in the previous subsection;

- $a \in (1.01975, \sqrt{2}]$ and either $\gamma \leq \gamma^1$ or $\gamma \in [\gamma^2, \tilde{\gamma}_2)$, where $\tilde{\gamma}_2$ is as in the previous subsection.

If $a > \sqrt{2}$, the patentee always prefers selling to a monopolist entrant rather than operating as a monopolist itself. Therefore whether or not there is duopoly downstream, firm 1 will always license: no Anticommons occurs. The patentee compares its licensing revenue if selling to a monopolist, $\pi_1 = \frac{a^2}{8}$ to its earnings (including licensing revenue) from duopoly. The patentee will operate downstream only if (i) $a \in [\sqrt{2}, 1.45514]$ and $\gamma < \gamma^3$ or $\gamma \in [\gamma^4, \tilde{\gamma}_2]$; or if (ii) $a > 1.45514$ and $\gamma < \tilde{\gamma}_2$, where γ^3 and γ^4 are the third and fourth roots, respectively, of the expression $\left(16 - 16a\gamma + (-22 + 7a^2)\gamma^2 + 12a\gamma^3 + (8 - 6a^2)\gamma^4 + a^2\gamma^6\right)$.

A.3. Vertical Separation - Optimal prices and profits

Let us now consider the case if at stage 1 firm 1 elected to spin off its upstream research unit. Under vertical separation, the upstream entity will offer arms-length, per-unit royalty contracts to either 1 or to both downstream operators.

If the upstream entity elects to sell to only 1 downstream firm, it may offer a license to the consortium's downstream operation or to firm 2. If it offers a license to the related producer, that firm maximizes profit $\pi_{d,m} = (p_{d,m} - r_A)q_{d,m}$ and will produce $q_{d,m} = \frac{1-r_A}{2}$, where the subscript d denotes that it is the downstream unit of the consortium. At the previous stage, the upstream patentee unit chooses r_A to maximize its licensing profit, $\pi_u = Aq_{d,m}$, and thus sets a per-unit royalty of $r_{Ad,m} = \frac{1}{2}$. Substituting for r_A in the downstream firm's choices, output becomes $q_{d,m} = \frac{1}{4}$ and downstream profit, net of licensing costs, becomes $\pi_{d,m} = \frac{1}{16}$. The patentee enjoys licensing revenue of $\pi_u = \frac{1}{8}$. Consortium profit is $\pi_{d,m} + \pi_u = \frac{3}{16}$.

If the patentee unit offer a license instead only to firm 2, the outcome will be as in the comparable case under vertical integration: firm 2 produces $q_{2,m} = \frac{a}{4}$ and earns a profit, net of licensing costs, of $\pi_{2,m} = \frac{a^2}{16}$. The patentee enjoys licensing revenue of $\pi_{2,m} = \frac{a^2}{8}$. Thus, if the patentee wishes to offer only 1 license, it does better to license to the rival firm 2 $\forall \, a > 1.22$.

The upstream entity may of course offer two licenses, one to each downstream operator. In this case, each of those firms faces a per unit input cost of r_A^D (where the

superscript 'D' denotes that the upstream firm licenses to both operators and yields downstream duopoly). Optimal prices and quantities are given by:

$$p_{1,vs} = \frac{-2 - r_A^D(2+\gamma) + \gamma(r_A^D+\gamma)}{4+\gamma^2}; \quad p_{2,vs} = \frac{\gamma - r_A^D(2+\gamma) + a(-2+\gamma^2)}{(-4+\gamma^2)};$$

$$q_{1,vs} = \frac{2 - \gamma(a+\gamma) + r_A^D(-2+\gamma+\gamma^2)}{(4-\gamma^2)(1-\gamma^2)}; \quad q_{2,vs} = \frac{\gamma + a(-2+\gamma^2) - r_A^D(-2+\gamma+\gamma^2)}{(4-\gamma^2)(1-\gamma^2)} \quad (4.A.4)$$

At the second stage, the upstream unit chooses r_A^D to maximize its own profit, π_u, where

$$\pi_u = r_A^D(q_1 + q_2) = r_A^D\left(\frac{1 + a - 2r_A^D}{(2-\gamma)(1+\gamma)}\right). \quad (4.A.5)$$

It will therefore set the royalty rate, r_A^D, at

$$r_A^D = \frac{1+a}{4} \quad (4.A.6)$$

and will make a profit equal to:

$$\pi_u = -\frac{(1+a)^2}{8(-2+\gamma)(1+\gamma)}. \quad (4.A.7)$$

Substituting for r_A^D in the stage 3 expressions, optimal downstream prices and profits are given by:

$$p_{1,vs} = \frac{-2 - \frac{1}{4}(1+a)(2+\gamma) + \gamma(a+\gamma)}{(-4+\gamma^2)}; \quad p_{2,vs} = \frac{\gamma - \frac{1}{4}(1+a)(2+\gamma) + a(-2+\gamma^2)}{(-4+\gamma^2)}$$

$$\pi_{1,vs} = -\frac{(6+\gamma-3\gamma^2 + a(-2+(-3+\gamma)\gamma))^2}{16(-4+\gamma^2)^2(-1+\gamma^2)}; \quad \pi_{2,vs} = -\frac{(-2+(-3+\gamma)\gamma + a(6+\gamma-3\gamma^2))^2}{16(-4+\gamma^2)^2(-1+\gamma^2)}$$

$$(4.A.8)$$

and consortium profit to the entity comprising the upstream patentee and the downstream firm 1 is:

$$\pi_{c,vs} = \left(\frac{(1+a)^2}{8(2-\gamma)(1+\gamma)} + \frac{(6+\gamma-3\gamma^2 + a(-2+(-3+\gamma)\gamma))^2}{16(-4+\gamma^2)^2(1-\gamma^2)}\right) \quad (4.A.9)$$

Here, as in the previous subsection, duopoly is not always feasible. More precisely, firm 1 prices and output are only positive if the values of the goods are not too different and the degree of substitutability between the downstream products is sufficiently low. More precisely, firm 1 profits are positive only if $1 \leq a < 3$ and $\gamma \leq \tilde{\gamma}_3 = \frac{1}{2}\left(3 + \frac{8}{-3+a} + \sqrt{\frac{73+a(-54+17a)}{(-3+a)^2}}\right)$. If either of these conditions does not hold, firm 1 will shut its downstream unit and firm 2 operates as a monopolist.

The upstream unit will always offer a license to the entrant: no Anticommons arises. But how does the consortium fare? If $1 \leq a \leq 2$, the consortium does best if the upstream unit sells to both downstream producers. If, however, $a > 2$, the consortium does better to shut its downstream production unit and simply license to firm 2.

A.4. Proof of Proposition 4.1

If the firm is vertically integrated, I have shown above that if (i) $1 \leq a \leq 1.01975$, firm 1 will refuse a license only if $\gamma \in [\gamma^1, \gamma^2]$ or $\gamma > \tilde{\gamma}_1$; or (ii) if $1.01975 < a \leq \sqrt{2}$, only if $\gamma \in [\gamma^1, \gamma^2]$ or $\gamma > \tilde{\gamma}_2$. If $a > \sqrt{2}$, the vertically integrated patentee will always license, so no Anticommons results. But the firm will only operate downstream if (i) $a \in (\sqrt{2}, 1.45514]$, $\gamma \notin [\gamma^3, \gamma^4]$ and $\gamma < \tilde{\gamma}_2$ or if (ii) $a > 1.45514$ and $\gamma < \tilde{\gamma}_2$. If $\gamma \geq \tilde{\gamma}_2$, a vertically integrated patentee will refuse to license and operate as a downstream monopolist.

Consortium profit always exceeds $\pi_{1,m}$ but only exceeds vertically integrated payoff when licensing (π_1) if (i) $1 \leq a \leq 1.42933$ *or* $a \geq 1.91809$ and $\gamma \in (\breve{\gamma}_1, \breve{\gamma}_2)$; or (ii) $1.42933 < a < 1.91809$ and $\gamma \in (\breve{\gamma}_3, \breve{\gamma}_4)$ where the critical values $\breve{\gamma}_1$, $\breve{\gamma}_2$, $\breve{\gamma}_3$, and $\breve{\gamma}_4$ are the third, fourth, first and second roots, respectively, of the expression:

$$
96 - 64a + 96a^2 + (-32 - 64a - 32a^2)\gamma + (-220 + 104a - 188a^2)\gamma^2 +
$$
$$
(60 + 56a + 60a^2)\gamma^3 + (171 - 34a + 115a^2)\gamma^4 + (-32 - 32a^2)\gamma^5 +
$$
$$
(-48 - 8a - 20a^2)\gamma^6 + (4 + 4a^2)\gamma^7 + (5 + 2a + a^2)\gamma^8 \qquad (4.A.10)
$$

The firm's choice of corporate structure, and its licensing behaviour, for the permitted range of γ therefore depends on the relative sizes of the key critical values γ^1, γ^2, $\breve{\gamma}_1$,

$\check{\gamma}_2$, $\tilde{\gamma}_1$, $\tilde{\gamma}_2$ and $\tilde{\gamma}_3$:

- if $a = 1$, $0 < \check{\gamma}_1 \approx 0.629 < \tilde{\gamma}_1 < 1 = \check{\gamma}_2 = \tilde{\gamma}_2 = \tilde{\gamma}_3$; the firm will remain vertically integrated and license to the rival if $\gamma \leq \check{\gamma}_1$ and will vertically separate and sell to both downstream producers if if $0.629 \leq \gamma < 1$;

- if $a \in (1, 1.01975)$, $0 < \check{\gamma}_1 < \tilde{\gamma}_1 < \tilde{\gamma}_3 < \check{\gamma}_2 < 1$; the firm will remain vertically integrated and license to the rival if $\gamma \leq \check{\gamma}_1$; it will vertically separate with the upstream unit selling to both downstream producers if $\check{\gamma}_1 < \gamma \leq \tilde{\gamma}_3$; and it will remain vertically integrated but block the rival if $\tilde{\gamma}_3 < \gamma < 1$

- if $a \in [1.01975, 1.30395)$, $0 < \check{\gamma}_1 < \gamma^1 < \tilde{\gamma}_3 < \gamma^2 < \tilde{\gamma}_2 < \check{\gamma}_2 < 1$; the firm will remain vertically integrated and license to the rival if $\gamma \leq \check{\gamma}_1$; it will vertically separate with the upstream unit selling to both downstream producers if $\check{\gamma}_1 < \gamma \leq \tilde{\gamma}_3$; it will remain vertically integrated but block the rival if $\tilde{\gamma}_3 < \gamma \leq \gamma^2$; it will remain vertically integrated and license to the rival if $\gamma^2 < \gamma < \tilde{\gamma}_2$; and will remain vertically integrated but block the rival if $\tilde{\gamma}_2 < \gamma < 1$

- if $a \in [1.30395, \sqrt{2}]$, $0 < \check{\gamma}_1 < \tilde{\gamma}_3 < \gamma^1 < \tilde{\gamma}_2 < \gamma^2 < \check{\gamma}_2 < 1$; the firm will remain vertically integrated and license to the rival if $\gamma \leq \check{\gamma}_1$; it will vertically separate with the upstream unit selling to both downstream producers if $\check{\gamma}_1 < \gamma \leq \tilde{\gamma}_3$; it will remain vertically integrated and license to the rival if $\tilde{\gamma}_3 < \gamma \leq \gamma^1$; it will remain vertically integrated but block the rival if $\gamma^1 < \gamma \leq \gamma^2$; it will remain vertically integrated and license to the rival if $\gamma^2 < \gamma < \tilde{\gamma}_2$; and will remain vertically integrated but block the rival if $\tilde{\gamma}_2 < \gamma < 1$

To summarize, if the patentee can vertically separate, then

- if $a = 1$ it will never block the rival; Anticommons problems are eliminated.

- if $a \in (1, 1.01975)$, the range over which the patentee will block is reduced from $[\gamma^1, \gamma^2]$ and $\tilde{\gamma}_1 < \gamma < 1$ to only $\tilde{\gamma}_3 < \gamma < 1$; Anticommons problems are less likely.

- if $a \in [1.01975, 1.30395)$, the first range over which the patentee will block is reduced from $[\gamma^1, \gamma^2]$ to only $[\tilde{\gamma_3}, \gamma^2]$ (in this range, $\gamma^1 < \tilde{\gamma_3}$). The second range over which the patentee will block the rival, $\tilde{\gamma_2} < \gamma < 1$, is not affected. Anticommons problems are less likely.

- if $a \geq 1.30395$, the patentee's licensing behaviour does not change.

If $a > \sqrt{2}$, the firm will always license to the rival. In this range of parameters, $\tilde{\gamma_3} < \gamma^3$ meaning that the firm will vertically separate and license to the rival if γ is low; it will remain vertically integrated and licenses to the rival if $\gamma \leq \tilde{\gamma_1}$ and will vertically separate otherwise, with licensing behaviour as described in Appendix 4.A.1 above. in this case, the option of vertical separation does not change the patentee's licensing behaviour.

A.5. Proof of Proposition 4.3

In order to comment on the welfare effects of firm 1's change in corporate structure, I compare welfare with vertical integration to that with vertical separation, assuming in each case that there is duopoly in the market. This yields the following:

- if $1 < a < 1.32323$, welfare is higher under vertical separation only if $\gamma > \dot{\gamma_1}$

- if $1.32323 \leq a \leq 2$, welfare is higher under vertical separation - that is (4.9) > (4.8) - only if $\gamma > \dot{\gamma_2}$

where $\dot{\gamma_1}$ is the fifth root of the expression

$$(-1280 - 2560a + 1280a^2 + (1024 + 1024a^2)\gamma + (3200 + 6400a - 3584a^2)\gamma^2 + (-2240 - 2240a^2)\gamma^3 +$$
$$(-2980 - 6472a + 3868a^2)\gamma^4 + (1824 + 64a + 1824a^2)\gamma^5 + (1359 + 3406a - 2073a^2)\gamma^6 +$$
$$(-679 - 102a - 679a^2)\gamma^7 + (-352 - 980a + 582a^2)\gamma^8 + (114 + 48a + 114a^2)\gamma^9 + (55 + 142a$$
$$-79a^2)\gamma^{10} + (-7 - 6a - 7a^2)\gamma^{11} + (-4 - 8a + 4a^2)\gamma^{12}$$

$$(4.A.11)$$

and $\dot{\gamma_2}$ is the seventh root of the expression given at (4.A.11).

I then compare these critical substitutability thresholds to the threshold at which the patentee firm elects to vertically separate. If the critical value at which firm 1 separates is larger, then the change in corporate structure is welfare enhancing. Comparing, $\breve{\gamma}_1 < \dot{\gamma}_1 \forall a \in (1, 1.32323)$; but $\breve{\gamma}_2 > \dot{\gamma}_2 \forall a \in (1.54874, 1.91809)$ and $\breve{\gamma}_1 > \dot{\gamma}_2 \forall a \in (1.91809, 3)$. Thus whenever the patentee chooses vertical separation, this choice is welfare enhancing if $1.54874 < a < 3$.

B. Appendix 2: The Model with Two Essential Patents

B.1. Proof of Remark 4.2

At stage 3, if there is downstream duopoly, the firms maximize $\pi_1 = (p_1 - r_B)q_1(p_1, p_2, \gamma)$ and $\pi_2 = (p_2 - r_A - r_B)q_2(p_1, p_2, \gamma)$, respectively. Optimal prices and quantities are given by

$$p_1 = \frac{-2 - r_B(2 + \gamma) + \gamma(a - 3r_A + \gamma)}{-4 + \gamma^2}$$

$$p_2 = \frac{-2(a + r_A + r_B) + \gamma - r_B\gamma + (a - r_A)\gamma^2}{-4 + \gamma^2} \quad (4.B.1)$$

$$q_1 = \frac{2 + r_B(-2 + \gamma + \gamma^2) - \gamma(a + r_A + \gamma - r_A\gamma^2)}{(4 - \gamma^2)(1 - \gamma^2)}$$

$$q_2 = \frac{2a - 2(r_A + r_B) + (-1 + r_B)\gamma + (-a + 2r_A + r_B)\gamma^2}{(4 - \gamma^2)(1 - \gamma^2)}. \quad (4.B.2)$$

At stage 2, each patentee chooses its per-unit royalty taking its rival's choice as given. Firm 1, the insider, chooses A to maximize licensing revenue and downstream profits. The firm's total payoff max be expressed as:

$$r_A q_2 + (p_1 - r_B)q_1 =$$

$$r_A \left(\frac{(2a - 2(r_A + r_B) + (-1 + r_B)\gamma + (-a + 2r_A + r_B)\gamma^2)}{(4 - 5\gamma^2 + \gamma^4)} \right) +$$

$$\left((\frac{-2 - r_B(2 + \gamma) + \gamma(a - 3r_A + \gamma)}{-4 + \gamma^2} - r_B)(\frac{2 + r_B(-2 + \gamma + \gamma^2) - \gamma(a + r_A + \gamma - r_A\gamma^2)}{4 - 5\gamma^2 + \gamma^4}) \right) \quad (4.B.3)$$

while firm B chooses B to maximize licensing revenue, given by:

$$r_B(q_2 + q_1) = r_B((\frac{2 + r_B(-2 + \gamma + \gamma^2) - \gamma(a + r_A + \gamma - r_A\gamma^2)}{4 - 5\gamma^2 + \gamma^4}) +$$

$$(\frac{2a - 2(r_A + r_B) + (-1 + r_B)\gamma + (-a + 2r_A + r_B)\gamma^2}{4 - 5\gamma^2 + \gamma^4})) \quad (4.B.4)$$

The above yield the reaction functions, as follows:

$$r_A = \frac{8a + \gamma^3 - B(8 + \gamma^3)}{2(8 + \gamma^2)}; \quad r_B = \frac{1 + a - A - A\gamma}{4}. \tag{4.B.5}$$

Simultaneous solution of the foregoing yield expressions for the royalties in terms of model parameters, given in (4.10). Given these royalties, downstream production is:

$$q_1 = \frac{20 + a(-4 - 14\gamma - \gamma^3 + \gamma^4) + \gamma(2 + \gamma(-2 + \gamma - 3\gamma^2))}{(-1 + \gamma^2)(-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2)))} \tag{4.B.6}$$

$$q_2 = \frac{(2 + \gamma^2)(2 - (-5 + \gamma)\gamma + a(-3 + \gamma)(2 + \gamma))}{(1 - \gamma)(1 + \gamma)(-56 + \gamma(8 + \gamma(-8 + \gamma + \gamma^2)))} \tag{4.B.7}$$

Note that duopoly is only feasible if the downstream products are sufficiently different and the market sizes are sufficiently close. Specifically, if (i) $1 \le a < 3$ and $\gamma \le \hat{\gamma}_1$, where $\hat{\gamma}_1$ corresponds to the second root of the expression

$\left(20 - 4a + (2 - 14a)\gamma - 2\gamma^2 + (1 - a)\gamma^3 + (-3 + a)\gamma^4\right)$; or if (ii) $a \ge 3$ and $\gamma \le \hat{\gamma}_2$, where $\hat{\gamma}_2$ is the first root of the expression $\left(20 - 4a + (2 - 14a)\gamma - 2\gamma^2 + (1 - a)\gamma^3 + (-3 + a)\gamma^4\right)$.

I next compare firm 1 profit under duopoly with that under monopoly. If $1 \le a < a^*$, the firm must decide if to refuse a license to firm 2 and operate as a monopolist, or offer a license. It will always prefer to license to the rival if possible. If $a \ge a^*$, firm 1 will always license, but must decide whether to operate downstream. Again here it prefers to operate so long as duopoly is feasible. Combining the foregoing, then, I conclude that if $1 \le a < a^*$, firm 1 will license if $\gamma \le \hat{\gamma}_1$ and refuse to license if $\gamma > \hat{\gamma}_1$; and if $a \ge a^*$, firm 1 will always license but will only operate downstream if $\gamma \le \min\{\hat{\gamma}_1, \hat{\gamma}_2\}$.

B.2. Proof of Proposition 4.4

Given a, the patentee selects the profit maximizing corporate structure for the relevant ranges: $0 \le \gamma < \hat{\gamma}_3$, when it would license under both structures; for $\hat{\gamma}_3 \le \gamma < \hat{\gamma}_1$ when it would license if integrated but license to a downstream monopolist if separated; and for $\hat{\gamma}_1 \le \gamma < 1$ when would operate as a downstream monopolist if integrated but license to a downstream monopolist if separated. Comparing its profit under the respective corporate structures:

- if $a \in [1, a_2^*)$, the firm will vertically separate and license to downstream duopolists if $\gamma \leq \tilde{\gamma}_4$; remain vertically integrated and license to the rival if $\tilde{\gamma}_4 < \gamma \leq \gamma_2^*$ and will vertically separate operate as a downstream monopolist if $\gamma_2^* < \gamma \leq 1$

- if $a \in [a_2^*, \frac{1}{73}(50 + 21\sqrt{6}))$, the firm will vertically separate and license to downstream duopolists if $\gamma \leq \tilde{\gamma}_4$; remain vertically integrated and license to the rival if $\tilde{\gamma}_4 < \gamma \leq \gamma_2^*$ and will shut its downstream production, licensing only to the downstream rival if $\gamma_2^* < \gamma \leq 1$ where $\tilde{\gamma}_4$ is the first root of J;

- if $a \in [\frac{1}{73}(50 + 21\sqrt{6}), 3)$, the firm will remain vertically integrated and license to the rival if $\gamma \leq \gamma_2^*$ and will shut its downstream production, licensing only to the downstream rival if $\gamma_2^* < \gamma \leq 1$;

- if $a \geq 3$, the firm will shut its downstream operation and license to firm 2 for all $0 \leq \gamma \leq 1$.

where $\tilde{\gamma}_4$ is the first root the following expression:

$$-1024 - 51200a + 37376a^2 + (-2816 - 7168a + 32512a^2)\gamma + (-6272 + 3584a - 9728a^2)\gamma^2 + (3392 - 3200a$$
$$-4288a^2)\gamma^3 + (416 + 15808a - 6496a^2)\gamma^4 + (32 - 2432a + 1856a^2)\gamma^5 + (-688 - 32a + 296a^2)\gamma^6$$
$$+(700 - 880a + 436a^2)\gamma^7 + (-228 + 84a - 66a^2)\gamma^8 + (-21 + 78a - 63a^2)\gamma^9 + (20 + 4a + 2a^2)$$
$$\gamma^{10} + (9 - 6a + 3a^2)\gamma^{11}.$$

$$(4.B.8)$$

Note that when the patentee shuts downstream production and simply licenses to the rival, it is indifferent to the corporate structure.

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