International Diffusion and Intellectual Property Rights: An Empirical Analysis

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Abstract

Traditional thinking about intellectual property rights (IPR) suggests a monotonically increasing relationship between property rights and the speed of diffusion of new products and technology. Our analysis of data on the international release pattern of Hollywood movies suggests a more complex story: although moderate standards of IPR encourage the spread of movies, either weaker or stronger property rights tend to decrease the speed with which American movies are released abroad. This empirical finding is consistent with a variety of specifications, including controlling for countries' self-selection of IPR standards. Overall, it appears that while some IPR recognition may encourage diffusion, very strong IPR may actually retard the speed of diffusion.

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In the past two decades the protection of intellectual property has become one of the most important concerns of international economic diplomacy. As goods and services have become increasingly dependent on copyrights, trademarks and patents to protect competitiveness in world markets, diplomatic efforts have sought to strengthen the protection available through a range of bi-lateral, regional and multi-lateral initiatives. These efforts to reform the global system of intellectual property rights (IPR) have typically seen countries embroiled in heated debates over almost every aspect of intellectual property rights.

The complexity of IPR along with the redistributive implications of reform means that there is no clear-cut first best solution that countries can work towards.[1] Instead reform is implemented after negotiations, resulting in outcomes that seem to be mainly a reflection of bargaining power. This situation is due in part to a lack of studies of the outcomes associated with various systems of IPR. This paper aims to contribute to our understanding of the implications of intellectual property rights by examining the role of IPR in the process of diffusion of new goods and services. This focus allows one dimension of the debate to be brought into sharp relief. In particular it is often claimed that weak institutions of a country are an impediment to the diffusion of new goods and services (UNDP, 2001). Broadly, the argument is made that since the introduction of an innovation is associated with a fixed cost (conversion to a new technology or the expenditures involved in the promotion and marketing of a new product) the increment in the revenue stream needs to be sufficiently large to justify its introduction. This revenue stream is critically affected by the standards of IPR. Therefore, it has been argued that the greater the security of intellectual property rights, the faster a new good or service is likely to diffuse.[2]

However, a contrary view also exists that suggests other forces may counteract those that tend to accelerate the speed of diffusion when market power is increased. In particular it is has been argued that an increase in market power (such as that associated with a strengthening of IPR) may reduce the speed of diffusion due to concerns over the cannibalization of revenue from existing products and technology (see Quirmbach 1986). This suggests that ultimately the speed of diffusion will be determined by the net effect of these two forces.

In order to gain insight into the relationship between IPR and diffusion this paper studies the behavior of the major Hollywood studios and examines how they exploit their IPR in a global

[1] For an indication of the redistributive implications see McCalman (2001).
[2] A theoretical model which is consistent with this claim is Reinganum (1981).

setting. The global motion picture industry and the role of the Hollywood studios is particularly interesting to study for a number of reasons. One reason is purely pragmatic, there exists a large amount of data on the film industry. In particular, the international pattern of release of feature films is available. This allows an extensive dataset of speeds of diffusion to be constructed. In addition, feature films also serve as an interesting technological benchmark. One especially attractive aspect is that it is technologically possible to have a movie released simultaneously around the world. Since this never happens, it is interesting to study why this is the case and try to isolate the role, if any, of IPR in Hollywood's decision making process.

While the availability of data is an important issue, this industry also has a number of other characteristics which identify it as an important industry to study. Not the least of these is that the audio-visual industry ranks as the number two export industry of the US, and the output of Hollywood plays an important part in this outcome.[3] The global success that Hollywood has enjoyed also means that it is often cast in the role of villain in debates over IPR standards. The position it finds itself in is that of a dominant firm seeking to further drive home its advantage by requesting that countries raise their standards of protection. Since this tension is central to negotiations over IPR more generally, it is important to study the possible implications of reform in order to assess both the positive and negative claims that have been made.

The variation in the standards of IPR around the world offers one potential way of studying the implications of reform for the speed of diffusion. To exploit this potential, I begin by applying the techniques used to study diffusion in a single country context to a multi-country setting. The empirical results of this approach reveal a non-monotonic relationship between the speed of diffusion and the standards of IPR. In particular, reforming IPR standards from a relatively low level to an intermediate level is estimated to increase the speed of diffusion. However, increasing IPR standards from an intermediate level to a high level is predicted to decrease the speed of diffusion. This non-monotonic relationship has important implications for the size of reforms a country maybe willing to undertake in relation to its IPR regime, especially since one suggested benefit of IPR reform is that it may contribute to a faster diffusion of new products and technologies. The results of the estimates derived below suggest that such conjectures should not be accepted unquestioningly, and in fact may need to be heavily qualified.

[3] This is a claim that is routinely made, see for instance the discussion of Peter Sutherland (Director General of the GATT at the time) in relation to the Uruguay Round negotiations (Sutherland, 1993). For an attempt to establish the validity of the claim see Acheson and Maule (1999).

However, these results rely not only on the dataset used, but also critically on the assumptions employed to identify the impact of IPR standards on the speed of diffusion. In particular, the methodology employed assumes both a parametric form of the distribution of release dates as well as an assumption of exogenous selection. If either of these assumptions are incorrect, then the validity of the above conclusion is questionable. In order to examine the robustness of the results, each of these assumptions is relaxed. In place of an assumption about the parametric distribution of diffusion, non-parametric estimation techniques are coupled with the assumption of exogenous selection. The results of this exercise produce estimates which are consistent with the results of the parametric approach.

In order to relax the assumption of exogenous selection, the methodology set out in Manski (1989) is employed. The assumption of exogenous selection is that unobserved factors do not jointly determine both the speed of diffusion and the standards of IPR. While this assumption is strong, it is made primarily to identify point estimates of the association between the speed of diffusion and IPR. In making this assumption a researcher takes a strong position in relation to the selection problem. This problem arises from the fact that the data alone can not reveal what the speed of diffusion to a country with low IPR standards would have been if they had instead adopted high IPR standards. That is, the counterfactual is not revealed by the data.

In section 4 a methodology that does not require an assumption about the role of unobserved factors is utilized. These estimates make no assumptions based on prior information to restrict the distribution of the rates of diffusion associated with the counterfactual outcomes. An implication of relaxing the assumption of exogenous selection is that this methodology produces a bound on the possible outcomes rather than point estimates. Nevertheless the estimates restrict the range of outcomes. Therefore, any debate about the magnitude of the impact of IPR reform on diffusion must take place within these "no-assumption" bounds.

However, these "no-assumption" bounds are consistent with a wide range of possibilities. To narrow the range of outcomes, a number of alternative assumptions based on prior information are explored. I begin with an examination of the implications of the outcome optimization model of Manski (1995) which reflects the notion that IPR are a policy variable that a country can select. In this application of the model it is assumed that countries select IPR with the objective of minimizing the duration of diffusion. This assumption substantially reduces the range of possible outcomes from IPR reforms, however it does not isolate the sign of the impact of reforms on the speed of duration. While a model that allows for self selection of IPR is appealing, many countries have had the selection of their IPR mediated by the US under Special 301 of the Trade Act. To incorporate this selection mechanism, the skimming model of Manski and Nagin (1998) is applied to IPR and diffusion. Under this model reforms that raise IPR standards from a low level to a medium level are consistent with an increase in the speed of diffusion. However, further reform that raises standards from medium to high are associated with a decrease in the rate of diffusion. This non-monotonic relationship between IPR and diffusion is consistent with the predictions of the parametric model, even though the nature of prior information used is very different. Therefore, despite the ambiguity created by the selection problem, all of the alternative estimates presented in this paper are consistent with the inference that the association between the speed of diffusion and standards of IPR is non-monotonic.

In order to demonstrate these results section 1 describes the data while section 2 outlines the empirical questions and the selection problem. Section 3 presents results based on the Weibull specification, in addition to the assumption of exogenous selection. Section 4 discusses what can be learnt without making any assumptions about prior information, while section 5 explores the implications of the outcome optimization model and the skimming model. Section 6 presents the results of assuming exogenous selection in a non-parametric framework. Finally, section 7 discusses the consistency of the estimates under the various assumptions.

1. Data

The primary data source used in this analysis is the internet movie data base (imdb) which contains information on the release dates across countries of movies.[4] The quantity of interest is the period of time between the first release of a movie within the US and its first release in another country. Therefore, for a given movie a number of such periods (durations) will be generated, one for each country in which the movie is released. The unit of measure of these durations is days.

The study focuses on the top 99 grossing American (Hollywood) movies of 1998 within the US, and their subsequent release in 38 other countries. In total this combination of movies and countries yields 2251 observations. The complement to this set of observations consists of

[4] www.imdb.com

outcomes in which either the data was not available or the movie in question has not yet been released in some countries. Since it is not possible to tell which reason is relevant in any given situation, I will maintain the assumption that the reason for the censoring is exogenous or unrelated to the standards of intellectual property protection offered by a given country.

These duration data are combined with other movie and country characteristics. The movie characteristics are primarily taken from the imdb. Country characteristics are taken from the World Development Indicators. The measure of IPR is described in Ginarte and Park (1997) and has been extended to 1995.[5] Summary measures of duration and IPR are given in Table 1. Appendix 1 contains a full list of the variables used and their sources.

2. Empirical Questions and the Selection Problem

Studies examining the association between the speed of diffusion and IPR may draw distorted conclusions due to the selection problem. This identification problem results from the fact that we cannot observe what the counterfactual outcome would have been. For instance, once a country has selected low IPR, we observe the outcome for that level of IPR. We can not observe what would have happened if this country had instead selected a different level of IPR. Without imposing prior and unverifiable assumptions, the effect of IPR on diffusion cannot be identified.

To formally address the selection problem, I begin by distinguishing among three diffusion outcome variables. In particular let *d(s)* represent the duration or speed of diffusion of a movie to a country with IPR standards *s*. In this analysis, I evaluate *d(s)* when *s* is equal to low, medium and high. Thus, each observation includes three outcome variables: *d(low), d(med)* and *d(hi)*.

The methodology employed in this paper for assessing the impact of IPR reforms is to examine the distribution of *d(s)*. In particular, one measure of the impact on the speed of diffusion of moving from a given standard of IPR (*s*) to another standard of IPR (*s'*) is given by:

$$\Delta[s, s' \mid X] = P[d(s') < t \mid X] - P[d(s) < t \mid X] \quad (1)$$

That is, the impact of IPR reform can be measured as the difference in the conditional probability that diffusion will have occurred by *t* for a country that has IPR standards *s'* as opposed to IPR

[5] I would like to thank Walter Park for making this unpublished series available.

standards *s*. Notice that since the probabilities in equation (1) must lie between [0, 1], the impact of IPR reform defined by equation (1) must lie between [-1, 1]. Therefore, without data the width of the possible range of outcomes is bounded at two. For the purposes of this analysis, the impact defined by equation (1) will be assessed for two values of t ($t = 60, 120$). These two parts of the distribution provide a relatively concise way of summarizing the distribution, and give some insight into the dynamics of diffusion.

The effects defined in equation (1), however, cannot be identified by the data alone as the outcome *d(s)* is observed only if a country had an IPR standard of *s*. Thus, for a country which had low IPR standards, *d(low)* is observed but *d(med)* and *d(hi)* are latent variables. Similarly, for countries with high IPR standards, *d(hi)* is observed but *d(low)* and *d(med)* are latent. This identification problem is highlighted using the law of total probability which shows that

$$P[d(s) < t | X] = P[d(s) < t \mid X, ipr = s]*P[ipr = s | X] + P[d(s) < t \mid X, ipr \neq s]*P[ipr \neq s | X] \qquad (2)$$

where *ipr* is the actual standard of IPR offered by a country. Since each observation contains information on *d(ipr)*, *ipr*, and *X*, the dataset identifies the selection probability $P[ipr = s \mid X]$, the censoring probabilities $P[ipr \neq \mathrm{s} \mid X]$, and probability of duration being less than t, conditional on the outcome being observed $P[d(s) < t | X, ipr = \mathrm{s}]$. Thus, the data reveals every term in the right side of equation (2) except the counterfactual probabilities, $P[d(s) < t \mid X, ipr \neq \mathrm{s}]$. Therefore, <u>in the absence of prior information restricting the distributions of *d(s)* and *ipr*, observations with *ipr* ≠ *s* reveal nothing about the latent outcome *d(s)*</u>. Thus, the data can not identify the distribution of outcomes that would be observed if all countries adopted high standards of IPR.

3. One Extreme: Estimates from the Weibull Model assuming Exogenous IPR.

To identify the factors that influence the diffusion of new products and technology, researchers rely on strong prior information restricting the distributions of observed and unobserved outcomes. These studies typically combine a parametric model with the assumption that factors such as firm size and market structure (and other factors) are exogenous. (See, for example, the surveys by Geroski, 2000, Karshenas and Stoneman, 1995). Using these assumptions along with duration data, researchers have found that a range of factors influence the speed of diffusion.

However, the role of market structure has produced relatively ambiguous results. A major problem is that market structure and rates of diffusion are likely to be endogenous. An inability to deal with this issue (largely due to a lack of appropriate instruments), further confounds the analysis. By focusing on a legal instrument that directly influences market structure, such as IPR, the issues associated with endogeniety bias in previous studies are mitigated. However, it is still possible that unobserved factors jointly determine the speed of diffusion and standards of IPR. Therefore, the issue of selection must still be confronted.

Aside from providing a different perspective on the factors that determine market structure this section employs similar techniques to those used in single country studies of diffusion. These techniques typically focus on the hazard rate, which is defined as,

$$h(t) = \lim_{dt \to 0} \frac{P(t \leq T < t + dt \mid T \geq t)}{dt}$$

This is interpreted as the probability of diffusion in the short interval after t, conditional on diffusion not having occurred before t. Once this conditional probability has been estimated, other features of the distribution can be derived.

Empirical models of diffusion have frequently assumed that the duration of diffusion follows a Weibull process. In particular, the hazard function is assumed to take the following form,

$$h(t; \gamma, x, p) = pt^{p-1} \exp\{x'\gamma\} \qquad (3)$$

Here, the vector γ and the scalar p are the unknown parameters. The choice of factors to be included in the vector of covariates follows the practice of the closed economy literature. This practice typically seeks to include variables that are likely to effect the profitability from adopting an innovation, and consequently the speed at which it is likely to diffuse.

Central among these variables in this study is IPR. The model also includes a quadratic term for IPR. The motivation for this is two fold. First, there is ambiguity in the theoretical literature about whether a more or less competitive environment is associated with faster diffusion.[6] On the

[6] This contrasts with the views expressed in the policy literature, see UNDP (2001).

one hand there is an increase in appropriability of rents from introducing the new product or technology when market power is increased, which tends to encourage faster diffusion. (See Reinganum, 1981). In contrast, Quirmbach (1986) constructs a model where the pace of diffusion is reduced by increases in market power due to a concern over the cannibalization of rents from existing products and technologies. This suggests that the relationship between market structure and diffusion need not be monotonic.

Moreover, in the case of IPR, where a major source of competition is likely to be from pirated versions of a movie, the release of a movie may be delayed in a country due to concerns over the extent of piracy if IPR are weak. In this case, undertaking the fixed expenditures involved in releasing a new film in a country with weak IPR may not be warranted if they are likely to result in a poor box office but a large market for the pirated product. Furthermore, releasing a movie quickly in a country with weak IPR may facilitate the spread of pirated copies not only within that country, but also to other countries, especially those that speak the same language. However, at the other extreme are markets with high IPR. Here, a studio maybe less concerned with the loss of box office revenues due to piracy, but rather the cannibalization of revenues that may potentially occur from competition with a studio's own product. To avoid this type of cannibalization of revenues, there is an incentive to stagger the release of movies further apart. This may be especially the case in comparison to the US release pattern, due to the legally sanctioned export cartel of the major Hollywood studios.[7]

To recap, despite the strong assumption about the parametric distribution of the duration of diffusion, the parameter vector can not be identified without additional assumptions. After all the data can not reveal *d(s)* when $ipr \neq$ s. The approach of the closed economy literature, and the one that is also pursued in this section, is to assume that the standards of IPR are exogenous.[8] That is, unobserved factors affecting the standards of IPR and the speed of diffusion are unrelated.

Under these assumptions maximum likelihood estimation is used to derive consistent estimates of the parameter vector γ and scalar p. The estimated coefficients, along with the asymptotic standard errors are reported in Table 2. One advantage of the Weibull model is that despite its

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[7] The Motion Picture Export Association (MPEA) was formed in 1945. Under the Webb-Pomerene Export Trade Act of 1918 the MPEA was able to claim an exemption from anti-trust laws as an organization exclusively engaged in overseas trade.

[8] In related international contexts where the association of the standard of IPR and intellectual property intensive transactions has been studied, this assumption or that of instrumental variable estimation has been employed (Maskus and Penubarti, 1995 and Smith, 1999 and 2001).

non-linear specification, the estimated coefficients have an interpretation that is analogous to the standard linear regression model. Therefore the estimated coefficients can be interpreted as partial derivatives of the hazard rate with respect to the covariate in question.[9]

The variables included account for the expected profitability of a given movie in a given country. The movie characteristics cover things such as genre, budget, quality and presence of a star. Of these factors, the budget, presence of a star and an Oscar nomination all have a positive and statistically significant impact on the hazard function. Interestingly, the quality measure defined by the San Francisco Chronicle's "Critical Consensus" is associated with a negative and statistically significant sign. Country characteristics such as demographics, language, and geographical region are all estimated to have statistically significant effects on the hazard function.

Most interestingly, the impact of IPR standards on the speed of diffusion is estimated to be non-monotonic. In particular, if a country has a standard of IPR less than 3.09, then an increase in the IPR standards is associated with an increase in the hazard of diffusion. In contrast, a decline is predicted for countries that have an IPR measure greater than 3.09. Countries with IPR standards in the neighborhood of 3.09 include: Argentina, Brazil, Czech Republic and Slovakia. While the reason for the non-monotonic relationship is not pinned down by these estimates, the implications of the result are nonetheless important. This result suggests that if a country undertakes IPR reforms, it needs to think carefully about the possible costs and benefits of this reform. The costs of IPR reform tend to be more immediate and obvious, such as the potentially detrimental implications of enhancing the market power of already dominant firms. However, the benefits of IPR reform are typically delayed or less well articulated. One suggested benefit of IPR reform is that it may contribute to a faster diffusion of new products and technologies. The results of the estimates presented in this section suggest that such conjectures should not be accepted unquestioningly, and in fact may need to be heavily qualified.

However, as was pointed out at the beginning of this section, these result rely not only on the dataset used, but also critically on the assumptions employed to identify the impact of IPR standards on the speed of diffusion. In particular, this section has examined the Weibull

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[9] It should be noted that the coefficient estimates presented in table 2 do not directly translate into estimates of the impact of IPR reform defined in equation (1). The estimated impacts given the Weibull model specification are presented in tables 3 and 4 and discussed in section 7.

parametric form of the hazard function along with the assumption that the standards of IPR are exogenous. The next section considers the implications of relaxing both these assumptions.

4. Another Extreme: Estimation with No Prior Information

Rather than relying on the strong identifying assumptions used in the previous section, another approach to examining the impact of IPR on diffusion is to ask what can be learned in the absence of any assumptions that are invoked to address the selection problem.[10] Recall that, in the absence of prior information, equation (1) is not identified. A selection problem occurs because the data fail to reveal $P[d(s) < t \mid X, ipr \neq s]$, the counterfactual probabilities. However, the data may still reveal information about the distribution of the latent variable, $d(s)$. In particular, since the unidentified counterfactual probabilities $P[d(s) < t \mid X, ipr \neq s]$ must lie between 0 and 1, bounds can be placed on the possible values of $P[d(s) < t \mid X]$.

A sharp upper bound is found by setting $P[d(s) < t \mid X, ipr \neq s] = 1$ in equation (2), while the lower bound sets these unobserved probabilities equal to 0. Writing these bounds out gives:

No assumption upper bound on $P[d(s) < t| X]$

$$P[d(s) < t \mid X, ipr = s]*P[ipr = s| X] + P[ipr \neq s| X] \quad (4)$$

No assumption lower bound on $P[d(s) < t| X]$

$$P[d(s) < t \mid X, ipr = s]*P[ipr = s| X] \quad (5)$$

The bounds on these individual distributions can then be used to construct bounds on the impact of IPR reform, that is, bounds can be placed on equation (1). The bounds on the impact of IPR reforms on diffusion are given by:

No assumption upper bound on $\Delta[s, s' \mid X]$

$$P[d(s') < t \mid X, ipr = s']*P[ipr = s'| X] + P[ipr \neq s'| X] - P[d(s) < t \mid X, ipr = s]*P[ipr = s| X] \quad (6)$$

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[10] The techniques employed in this section are based on Manski (1989).

No assumption lower bound on $\Delta[s, s' \mid X]$

$$P[d(s') < t \mid X, ipr = s']*P[ipr = s' \mid X]$$
$$- P[d(s) < t \mid X, ipr = s]*P[ipr = s \mid X] - P[ipr \neq s \mid X] \qquad (7)$$

In addition to making no assumptions about the joint distribution of *d(s)* and IPR, the utilization of this bounding technique has important implications for the way in which the covariates *X* are used. From this section of the paper forward, covariates are merely used to define subpopulations of interest. This differs from the standard framework (as adopted in section 3), where researchers attempt to correctly choose a set of control variables such that the exogenous selection assumption applies. This leaves much room for debate about whether or not the researcher omitted important explanatory variables and the extent of the resulting bias. In contrast, the techniques employed in this and the next two sections do not assume that IPR standards are exogenous conditional on any given set of covariates. Therefore the question: "What is the impact on the speed of diffusion of IPR reform among countries with covariates *X*?" is well defined regardless of how the subpopulations are specified. In this framework, there is no correct set of control variables.

With this in mind, I focus on the impact of reforms on countries with different per capita incomes. The choice of these subpopulations is motivated by the World Trade Organization's TRIPs agreement which differentiates between countries depending on the stage of development.[11] To capture the distinctions made within the TRIPs agreement, countries are divided into high and low income. For each of these subpopulations, the remainder of this paper is devoted to examining the implications of a number of alternative assumptions for identifying the impact of IPR reforms on the speed of diffusion.

Tables 3 and 4 present the impact of reforms under various assumptions regarding prior information for low and high income countries respectively. The first two rows of each table demonstrate the inferences that can be made without utilizing any assumptions about prior information and therefore are the results associated with equations (6) and (7). These bounds are sharp, that is, no other inference can be drawn without imposing some restriction on the joint distribution of *d(s)* and *ipr*. As we will see, these bounds are typically very wide, nevertheless they serve two useful purposes. First, since they are based on very mind assumptions, they provide a bound on the range of outcomes that are possible. Secondly, they serve as a sobering

[11] See Maskus (2000) for an overview and analysis of the TRIPs agreement and IPR reform more generally.

reminder that the data alone can not provide all the answers, and that precise answers typically rely on implicit or poorly motivated assumptions about prior information.

To focus on the key issue, the bounds have been presented in such a way as to consider the impact of marginal changes in IPR standards. In the case of the no assumption bounds, the first row presents the results for a change from low standards of IPR to medium standards of IPR, while the second row considers the subsequent increase in standards from medium IPR to high IPR. The results are presented in this way in order to investigate the possibility of either non-monotonic effects of IPR reform, as suggested by the Weibull model, or isolate some decreasing returns to IPR reform. Either characteristic would be consistent with a government being reluctant to move to a set of high IPR standards from an initial position of low or medium standards.

While these no assumption bounds do reduce the range of possible outcomes associated with reform, their information content is relatively limited. The tightest bounds for low income countries are associated with a move from low IPR standards to medium standards, with a width of slightly more than one. This represents a reduction of the range of possible outcomes by around 50% compared to the case where no data is available.[12] In particular this set of bounds implies that the worst that can happen to a low income country, if it were to move from low to medium IPR standards, is a reduction in the rate of diffusion of around 50 percentage points. In contrast the most optimistic outcome associated with the same reform can not produce an increase in the rate of diffusion of greater than 50 percentage points. This conclusion holds regardless of whether the cutoff point considered is 60 days or 120 days. Therefore any debate over the impact of IPR on diffusion for low income countries must be conducted within the limits set by these bounds.

For high income countries the narrowest bounds are associated with a move from medium IPR to high IPR, resulting in a width of 1.1. This implies a 45% reduction in the range of possible outcomes. With a cutoff set at 60 days, the most pessimistic outcome of this reform would be to reduce the rate of diffusion by 73 percentage points and the most optimistic is that it would increase the rate of diffusion by 37 percentage points. In contrast, setting a cutoff at 120 days produces a slightly more positive picture with a lower bounds on the reduction in the rate of diffusion being 52 percentage points and an upper bound of 59 percentage points. Nevertheless,

[12] Recall that the width of the bound without data is 2.

the width of the bounds at each cutoff points allows for large range of possible impacts of IPR reform.

The main point of this section is summarized in the first two bars of Figure 1, which relate to IPR reform for a low income country.[13] These two bars illustrate the information contained in the *data alone*, with the first bar representing the impact of reform from low IPR standards to medium standards of IPR, while the second bar represents the impact of reform from medium to high IPR. As can be seen from the height of the two bars, the data alone can not isolate the impact of reforms. Therefore, the confidence that one has in claims about the impact of IPR reform really depend on the credibility of the assumptions made in order to identify the impact of reforms (i.e. how credible are the assumptions about prior information).

5. Narrowing the Bounds

The last section illustrated that in order to derive useful inferences about the impact of IPR reforms on the speed of diffusion, prior information must be utilized. However, the point estimates displayed in section 3 remain suspect due to the strong assumptions about prior information that were invoked. In this section I present estimates that rely on alternative, less restrictive assumptions. After describing each assumption, non-parametric estimates of the effects defined by equation (1) are presented. In total three assumptions are examined. The first set of results impose the assumptions of the outcome optimization model of Manski (1995) to the IPR and diffusion context. Then the skimming model of Manski and Nagin (1998) is considered, followed by a model that assumes that IPR are exogenous without imposing a parametric assumption about the distribution function.[14]

5.1 Outcome Optimization

A natural assumption to examine when countries have a choice over the standards of IPR is that they choose these standards with some objective function in mind. In the current context it is assumed that countries only care about the speed of diffusion and therefore select the standard of

[13] Figure 2 presents similar information for high income countries.
[14] Other approaches to narrowing the no assumption bounds are considered by Pepper (2000) and Manski and Pepper (2000).

IPR that generates the fastest rates of diffusion. While this represents a narrow objective function, it does allow the identifying power of maximizing behavior to be explored directly, offering an alternative to the assumption that IPR are randomly assigned to countries. For those willing to make this assumption, its identifying power comes from the restrictions it implies for the joint distribution of *d(s)* and *ipr*, since now it must be the case that any change in the standard of IPR of a country will result in a slower rate of diffusion. Using this prior information, the bounds on the possible impact of IPR reform can be narrowed substantially.

Formally the outcome optimization assumption requires that if $ipr = s'$, then $d(s') < d(s)$ for all t and for all $s \neq s'$. This implies that $P[d(s) < t \mid X, ipr = s'] < P[d(s') < t \mid X, ipr = s']$. This allows the upper bound of $P[d(s) < t \mid X]$ to be tightened compared to that given by equation (4). The new tighter upper bound is given by:

Outcome optimization upper bound on $P[d(s) < t \mid X]$

$$P[d(s) < t \mid X, ipr = s]*P[ipr = s \mid X] + P[d(s') < t \mid X, ipr = s']*P[ipr = s' \mid X] + P[d(s'') < t \mid X, ipr = s'']*P[ipr = s'' \mid X] \quad (8)$$

A comparison with equation (4) reveals that the no assumption upper bound counterfactual probabilities, that took on values of unity, have been replaced by values that represent smaller upper bounds by the optimizing assumption (i.e. $P[d(s') < t \mid X, ipr = s']$ replaces 1, and $P[d(s') < t \mid X, ipr = s']$ also replaces 1 in determining the upper bound on $P[d(s) < t \mid X]$). Since the outcome optimization assumption has no implications for the lower bound, it remains the same as under the no assumption case given in equation (5). Nevertheless the bounds on equation (1) can be tightened to:

Outcome optimization upper bound on $\Delta[s, s' \mid X]$

$$P[d(s') < t \mid X, ipr = s']*P[ipr=s'] + P[d(s'') < t \mid ipr = s'']*P[ipr=s''] \quad (9)$$

Outcome optimization lower bound on $\Delta[s, s' \mid X]$

$$- P[d(s) < t \mid ipr = s]*P[ipr = s] - P[d(s'') < t \mid ipr = s'']*P[ipr=s''] \quad (10)$$

Note that since the upper bound is always positive and the lower bound is always negative, the assumption of outcome optimization can not identify the sign of the impact of IPR reform on the speed of diffusion. Nevertheless further insight into the potential impact of IPR reform can be gained due to the narrowing of the bounds. The results implied by equations (9) and (10) are given in the third and fourth rows of Tables 3 and 4.

By adopting the assumption of outcome optimization, the width of the bounds are reduced substantially. The tightest bounds for low income countries are associated with a move from low IPR standards to medium standards, with a cutoff of 60 days. The width of the bounds for this cell is 0.26, which represents a range of outcomes which is 74% narrower than the no assumption case. Furthermore, this implies that the worst that can happen to a low income country, if it were to move from low to medium IPR standards, is a reduction in the rate of diffusion of around 10 percentage points. In contrast the most optimistic outcome associated with the same reform can not produce an increase in the rate of diffusion of greater than 16 percentage points.

In addition, the tightness of the bounds under the outcome optimization assumption are suggestive about the implication of the marginal impact of IPR reforms for low income countries. Focusing on a cutoff of 60 days, the lower bound of Δ[*low, med*] is greater than the lower bound of Δ[*med, hi*], with the same ranking holding for the upper bounds. While these bounds are consistent with a number of hypotheses, it is interesting to note that by adopting the most optimistic perspective leads to the conclusion that there are decreasing marginal returns from IPR reform. Similarly, adopting the most pessimistic perspectives, the marginal losses from IPR reform are increasing.[15] This is also apparent from the third and fourth bars of Figure 1.

For high income countries, a slightly different story emerges. Once again, the assumption of outcome optimization generates relatively tight bounds, with the widths of Δ[*low, med*] and Δ[*med, hi*] being 0.26 and 0.28 respectively for a 60 day cutoff. However, in this case the most optimistic view generates upper bounds on the rates of diffusion which are relatively similar, suggesting constant marginal benefits to IPR reform. Similarly, the most pessimistic view suggests constant marginal losses from IPR reform.

Therefore, for those who are willing to make the assumption of outcome optimization, the bounds can be narrowed substantially. Nevertheless, the results of this assumption still permit a wide range of possibilities. In particular, if one adopts an optimistic position then IPR reform is predicted to exhibit diminishing marginal returns, especially for low income countries.

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[15] A similar interpretation holds for the 120 day cutoff.

5.2 Skimming Model

While assuming that countries have choice over their standards of IPR seems a reasonable assumption to explore, it does ignore the fact that IPR have been influenced to a large degree by both multilateral and bilateral pressure. In particular, the US has sought to influence the IPR of low income countries through the use of special 301 of the Trade Act of 1974. The general motivation for special 301 is to ensure that US persons have adequate and effective protection of their intellectual property rights in foreign markets. This is a broad motivation that has been used extensively to encourage countries to reform their IPR regimes. Therefore, special 301 provides a mechanism for the US to have an impact on the selection of IPR standards in other countries. This raises the possibility that the USTR, in administering special 301, tries to make IPR look as effective as they can.

One way to examine this type of external pressure on countries is the skimming model contained in Manski and Nagin (1998). Under this model, IPR standards are assumed to be selected in order to maximize the apparent effectiveness of IPR on diffusion. In the present context it is assumed that there are three types of countries, those that naturally have high rates of diffusion, those with moderate rates of diffusion and those with low rate of diffusion. To maximize the apparent effectiveness of IPR on diffusion, the high types are allocated high IPR, in effect they are skimmed off. The next step in the skimming process is to consider the allocation of medium standards of IPR. Since the moderate types have the best outcome of the remaining types they are allocated medium standards of IPR. Finally, the low standards of IPR are allocated to the low types.[16]

If one is prepared to accept the assumptions of the skimming model it can be shown that the bounds on equation (1) now depend on the comparison being made.[17] Since the focus is on the merits of different marginal changes, only these bounds will be presented.

Skimming upper bound on $\Delta[low, med \mid X]$

$$P[d(med) < t \mid X, ipr = med]*\{P[ipr = med \mid X] + P[ipr=low \mid X]\} + P[ipr=hi \mid X] - P[d(low) < t \mid X, ipr = low]$$

[16] While it may seem that this process has to yield an outcome that differs from the outcome optimization model, Manski and Nagin (1998) show that it is possible for the two models to give the same prediction.
[17] The details of the derivation of these bounds is contained in appendix 2.

Skimming lower bound on $\Delta[low, med \mid X]$

$P[d(med) < t \mid X, ipr = med]*\{P[ipr = med \mid X] + P[ipr=hi \mid X]\}$

$\quad - P[d(low) < t \mid X, ipr = low]*P[ipr=low \mid X] - P[ipr=hi \mid X] - P[ipr = med \mid X]$

Skimming upper bound on $\Delta[med, hi \mid X]$

$P[d(hi) < t \mid X, ipr = hi]$

$\quad - P[d(med) < t \mid X, ipr = med]*\{P[ipr = med \mid X] + P[ipr=hi \mid X]\}$

Skimming lower bound on $\Delta[med, hi \mid X]$

$P[d(hi) < t \mid X, ipr = hi]* P[ipr=hi \mid X]$

$\quad -P[d(med) < t \mid X, ipr = med]*\{P[ipr = med \mid X] + P[ipr=low \mid X]\} - P[ipr=hi \mid X]$

Unlike the bounds of the previous sections, the sign of the impact can potentially be determined. This follows because the upper bounds in principle can be either positive or negative. The results for the skimming model are presented in the fifth and sixth rows of Tables 3 and 4.

The most striking feature of these results is that the impact of a move from medium to high IPR standards is predicted to be negative for three of the four cases considered. This result is most pronounced for low income countries with a 60 day cutoff. In this case, even the most optimistic prediction is that the rate of diffusion will be 12 percentage points *lower* for a reform that increases the standard of IPR protection from medium to high. This stands in direct contrast to the most optimistic view of a reform that raises IPR standards from low to medium which predicts an increase in the rate of diffusion of 6 percentage points.

The results for the high income countries are similar, although the immediate impact of raising IPR to a high standard is not as pronounced. For a high income country, the most optimistic view under the skimming model sees the rate of diffusion decreased by 4 percentage points if standards are raised from medium to high for a 60 day cutoff. This negative impact is predicted to persist to the 120 day cutoff, although the negative impact has moderated to a decrease of 1 percentage point by that time.

Therefore, for those that are willing to accept the assumptions of the skimming model, it can be concluded that there maybe positive marginal benefits associated with a reform that increases IPR standards from a low level to a medium level, but the incentives to move from medium standards of IPR to high standards of IPR are not associated with a higher rate of diffusion for either high or low income countries. Once again Figure 1 highlights the role played by the assumptions about prior information. The results for the skimming model are summarized in the fifth and sixth bars. As is evident from the position of the two bars, a non-monotonic impact of reform is consistent with the skimming model.

6. Exogenous Selection

In section 3, the assumption that unobserved factors affecting both the duration of diffusion and the level of IPR standards are unrelated was combined with the Weibull model to identify the effects of IPR standards on the speed of diffusion. Here, I examine the implications of assuming only that the standard of IPR is exogenous. This assumption states that $P[d(s) < t \mid X] = P[d(s) < t \mid X, ipr = s]$. Thus, without any additional restrictions (such as assuming that the hazard function is Weibull), the exogenous selection assumption identifies the impact on the rate of diffusion of IPR standards. These results are reported in the seventh and eighth rows of Tables 3 and 4 .

These non-parametric estimates predict that the impacts of reforms are broadly similar across income groups, with results that mirror the predictions of the skimming model. Once again, the impact of reform from medium to high IPR is predicted to be negative for both income groups, but now also for both cutoffs. These effects are, once again, most pronounced for low income countries.

The benefits of reform that raise standards from low to medium, while positive overall, are not predicted to be large. For low income countries, such reforms are predicted to raise the rate of diffusion by 5 percentage points at the end of 60 days. However, all the benefits are exhausted by 120 days where the rates of diffusion under both regimes is predicted to be the same. Therefore, there is some incentive for low income countries to raise their standards of IPR from low to medium, but under the assumption of exogenous IPR there is no incentive linked to higher rates of diffusion to raise standards further.

7. Consistency of the Estimates

The alternative models and estimates presented in sections 3 through 6 reflect the identifying power of various assumptions. Another function of the no-assumption bounds is to test hypotheses restricting the joint distribution of *d(s)* and *ipr*. A model should be rejected if, for any value of *X*, the estimates lie significantly outside of the no-assumptions bounds, while, if the estimates lie within these bounds, the model cannot be rejected. Since, by construction, the results of sections 5 and 6 are necessarily contained within these no-assumption bounds, this test only applies to the Weibull model. The results for the Weibull model are presented in the ninth and tenth rows of Tables 3 and 4. Since the no-assumption bounds are wide the power of this test is relatively low, and in all cases the results of the Weibull model are consistent with the no-assumption bounds.

A more refined test can be conducted using the narrower bounds of both the outcome optimization and skimming models. By comparing estimates derived under the various assumptions, we can test the joint hypothesis that these assumptions are valid. In particular, point estimates made under the exogenous selection assumption can be compared to the estimates made under alternative assumptions. If the estimates derived under these different information sets do not overlap, then at least one of the maintained assumptions may be invalid. However, as can be seen from Tables 3 and 4, not only do the regions associated with the outcome optimization and skimming models overlap, but the predictions of the non-parametric exogenous IPR model are contained within this common intersection. This is a relatively strong test, with the smallest common intersection having a width of just 0.03. Therefore, the predictions are remarkably robust across the alternative assumptions examined.

A general sense of this consistency is gained from Figure 1 and Figure 2. These figures summarize the predictions under the various assumptions about prior information of the impacts of IPR for cut offs of 60 days for both low income (figure 1) and high income (figure 2) countries. The first bar of every pair of bars represents the impact of reform from low IPR standards to medium standards of IPR, while the second bar represents the impact of reform from medium to high IPR. As is evident from these figures, a non-monotonic relationship between the standards of IPR and diffusion is consistent with all assumptions about prior information, while an increasing relationship is not.

8. Conclusion

Traditional thinking about intellectual property rights suggests a monotonically increasing relationship between IPR and the speed of diffusion of new products and technology. Since IPR reform is likely to be associated with some negative effects, this positive effect has been emphasized in the policy literature. However, theoretical models predict a more complicated relationship between IPR and diffusion, one which is determined in part by a force that raises diffusion due to greater security associated with higher IPR, but also slows the rate of diffusion due to an increase in monopoly power from higher IPR. Our analysis of data on the international release pattern of Hollywood movies provides evidence on the outcome of these two forces: although moderate standards of IPR encourage the spread of movies, either weaker or stronger property rights tend to decrease the speed with which American movies are released abroad. This empirical finding is consistent with a variety of specifications, including the random assignment of IPR, self selection of IPR and externally imposed IPR. Overall, it appears that while some IPR recognition may encourage diffusion, very strong IPR may actually retard the speed of diffusion.

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Table 1

Summary Measures

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Duration (days)	122.7	91.4	1	833
IPR	3.5	0.69	1.23	4.57

Table 2

Weibull Model

Variable	*Coeff. est.*	*Standard Error*
IPR	1.00*	0.34
IPR^2	-0.16*	0.054
GDP per capita	0.006***	0.004
Population	0.0013**	0.0008
Film Budget	0.011*	0.001
Oscar Nomination	0.15*	0.02
Presence of a "star"	0.22*	0.05
Critical Rating	-0.056*	0.018
Domestic Film Production	-0.0017**	0.0008
English speaking country	0.24**	0.12
Share of pop. < 14 years old	-0.04	1.27
Share of pop. > 65 years old	-5.2*	1.90
constant	-9.28*	0.91
p	1.65	0.02
N	2251	
Log Likelihood	-2347.1	

* statistically significant at the 1% level.
** statistically significant at the 5% level.
*** statistically significant at the 10% level.
The model also included both geographic region and movie genre dummies.

Table 3

Impact of IPR reform on the Rate of Diffusion to Low Income Countries

Process of IPR selection		$t = 60$ bounds *lower upper*	$t = 120$ bounds *lower upper*
No Assumptions	Δ[*low, med*]	[-0.51, 0.50]	[-0.51, 0.50]
	Δ[*med, hi*]	[-0.60, 0.84]	[-0.79, 0.67]
Outcome Optimization	Δ[*low, med*]	[-0.10, 0.16]	[-0.30, 0.33]
	Δ[*med, hi*]	[-0.26, 0.10]	[-0.60, 0.30]
Skimming	Δ[*low, med*]	[-0.51, 0.06]	[-0.49, 0.01]
	Δ[*med, hi*]	[-0.29, -0.12]	[-0.62, 0.11]
Exogenous IPR			
Non-parametric	Δ[*low, med*]	0.05	0
	Δ[*med, hi*]	-0.24	-0.18
Weibull	Δ[*low, med*]	0.01	0.01
	Δ[*med, hi*]	-0.05	-0.07

Table 4

Impact of IPR reform on the Rate of Diffusion to High Income Countries

Process of IPR selection		*t = 60* bounds *lower upper*	*t = 120* bounds *lower upper*
No Assumptions	Δ[*low, med*]	[-0.89, 0.87]	[-0.89, 0.87]
	Δ[*med, hi*]	[-0.73, 0.37]	[-0.52, 0.59]
Outcome Optimization	Δ[*low, med*]	[-0.07, 0.19]	[-0.53, 0.53]
	Δ[*med, hi*]	[-0.07, 0.21]	[-0.17, 0.53]
Skimming	Δ[*low, med*]	[-0.67, 0.55]	[-0.39, 0.14]
	Δ[*med, hi*]	[-0.66, -0.04]	[-0.16, -0.01]
Exogenous IPR			
Non-parametric	Δ[*low, med*]	0.01	-0.12
	Δ[*med, hi*]	-0.07	-0.08
Weibull	Δ[*low, med*]	0.01	0.02
	Δ[*med, hi*]	-0.04	-0.05

Appendix 1: Data and sources

List of movies

Saving Private Ryan, Armageddon, There's Something About Mary, A Bug's Life, The Waterboy, Dr. Dolittle, Rush Hour, Deep Impact, Godzilla, Patch Adams, Lethal Weapon 4, The Truman Show, Mulan, You've Got Mail, Enemy of the State, The Prince of Egypt, The Rugrats Movie, Shakespeare in Love, The Mask of Zorro, Stepmom, Antz, The X-Files, The Wedding Singer, City of Angels, The Horse Whisperer, Six Days Seven Nights, Star Trek: Insurrection, Blade, Lost In Space, A Perfect Murder, The Parent Trap, Ever After, Hope Floats, U.S. Marshals, The Man In The Iron Mask, A Civil Action, Snake Eyes, What Dreams May Come, Small Soldiers, Halloween: H2O, Mighty Joe Young, Practical Magic, The Negotiator, Meet Joe Black, Ronin, The Siege, Pleasantville, The Faculty, I Still Know What You Did..., Primary Colors, Urban Legend, How Stella Got Her Groove Back, Out of Sight, Sphere, The Thin Red Line, Jack Frost, Mercury Rising, Bride of Chucky, A Night at the Roxbury, Madeline, Wild Things, The Object Of My Affection, The Big Hit, Paulie, Bulworth, Great Expectations, Can't Hardly Wait, Fallen, The Avengers, One TRUE Thing, Rounders, Beloved, Quest For Camelot, He Got Game, Psycho, Hard Rain, Mafia!, Species II, The Replacement Killers, The Odd Couple II, Babe: Pig in the City, The Big Lebowski, Disturbing Behavior, 54, A Simple Plan, Dead Man On Campus, Twilight, Soldier, Dark City, Blues Brothers 2000, Les Miserables, Desperate Measures, Hush, Black Dog, Living Out Loud, I'll Be Home For Christmas, Holy Man, Sliding Doors, Deep Rising, Fear and Loathing in Las Vegas, The Newton Boys

List of countries

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Colombia, Czech Republic, Denmark, Finland, France, Germany, Hong Kong, Hungary, Iceland, Indonesia, Israel, Italy, Japan, Korea, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Romania, Russia, Singapore, Slovakia, South Africa, Spain, Sweden, Switzerland, Thailand, UK

duration: days between theatrical release in US and theatrical release in specified country
source: derived from www.imb.com

IPR: Ginarte and Park index for 1995. Source: Walter Park (unpublished)
Low IPR: less than 3, Medium IPR: between 3 and 3.75, High IPR: greater than 3.75

GDP per capita. Source: World Development Indicators

Film Budget, millions. Source: www.imdb.com

Oscar nomination, dummy. Source: www.imdb.com

Presence of a "star", dummy. Source:
ris.ss.uci.edu/econ/personnel/devany/web/papers/starlist.html

Critical rating, San Francisco Chronicle's Critical Consensus
source: wwww.sfgate.com/eguide/movies/criticalconsensus/

Population shares. Source: derived from World Development Indicators

Domestic Film Production. Source: Screen Digest (1999)

Genre. Source: www.tvguide.com

Appendix 2

The Skimming Model

In this application it is assumed that there are three types, A, B and C. The A types are assumed to naturally receive new products very quickly. While the B types are assumed to receive new products at a more moderate pace. Finally the C types receive things very slowly.

Very simply the skimming model is just an assumption about prior information. The easiest way to think about it is too focus on the what is being restricted.

For instance, in relation to high IPR:

$P_a[d(hi) < t| X] \geq \pi_1 > P_b[d(hi) < t| X] \geq \pi_1' > P_c[d(hi) < t| X]$

In relation to medium IPR

$P_a[d(med) < t| X] \geq \pi_2 > P_b[d(med) < t| X] \geq \pi_2' > P_c[d(med) < t| X]$

In relation to low IPR

$P_a[d(low) < t| X] \geq \pi_3 > P_b[d(low) < t| X] \geq \pi_3' > P_c[d(low) < t| X]$

If a decision maker or social planner wanted to make IPR look the best it could, it would make A types choose high IPR. Once this top group had been singled out it, the decision maker's problem is to try to make IPR look as good as possible in the remaining groups. So it would assign type B's to medium IPR and type C's to low IPR.

Note that there is no restriction on the relative values of the π's (except between π and π') so an outcome in relation to the marginal impact of IPR reform is not being assumed.

What bounds are implied by these assumptions?

The upper bound on $P[d(hi) < t| X]$ is now $P[d(hi) < t| X, ipr=hi]$

The lower bound on $P[d(low) < t| X]$ is now $P[d(low) < t| X, ipr=low]$

What about $P[d(med) < t| X]$? Under the skimming model it must be the case that:

$$P[d(med) < t| X, ipr=med] \\ = P_b[d(med) < t| X] \geq \pi_2' > P_c[d(med) < t| X] = P[d(med) < t| X, ipr=low]$$

So the upper bound can be tightened by replacing the no information assumption that $P[d(med) < t| X, ipr=low]$ is at most 1 with the counterfactual that $P[d(med) < t| X, ipr=low]$ is at most $P[d(med) < t| X, ipr=med]$.

Similarly the lower bound can be tightened.

$$P[d(med) < t| X, ipr=hi] \\ = P_a[d(med) < t| X] \geq \pi_2 > P_b[d(med) < t| X] = P[d(med) < t| X, ipr=med]$$

So the lower bound can be tightened by replacing the no information assumption that $P[d(med) < t| X, ipr=hi]$ is at least 0 with the counterfactual that $P[d(med) < t| X, ipr=low]$ is at least $P[d(med) < t| X, ipr=med]$.

These bounds now can be used to derive upper and lower bounds on the impact of IPR reform:

Skimming upper bound on $\Delta[low, med \mid X]$

$$P[d(med) < t \mid X, ipr = med]*\{P[ipr = med| X] + P[ipr=low| X]\} + P[ipr=hi| X] - P[d(low) < t \mid X, ipr = low]$$

Skimming lower bound on $\Delta[low, med \mid X]$

$$P[d(med) < t \mid X, ipr = med]*\{P[ipr = med| X] + P[ipr=hi| X]\} - P[d(low) < t \mid X, ipr = low]*P[ipr=low| X] - P[ipr=hi| X] - P[ipr = med| X]$$

Skimming upper bound on $\Delta[med, hi \mid X]$

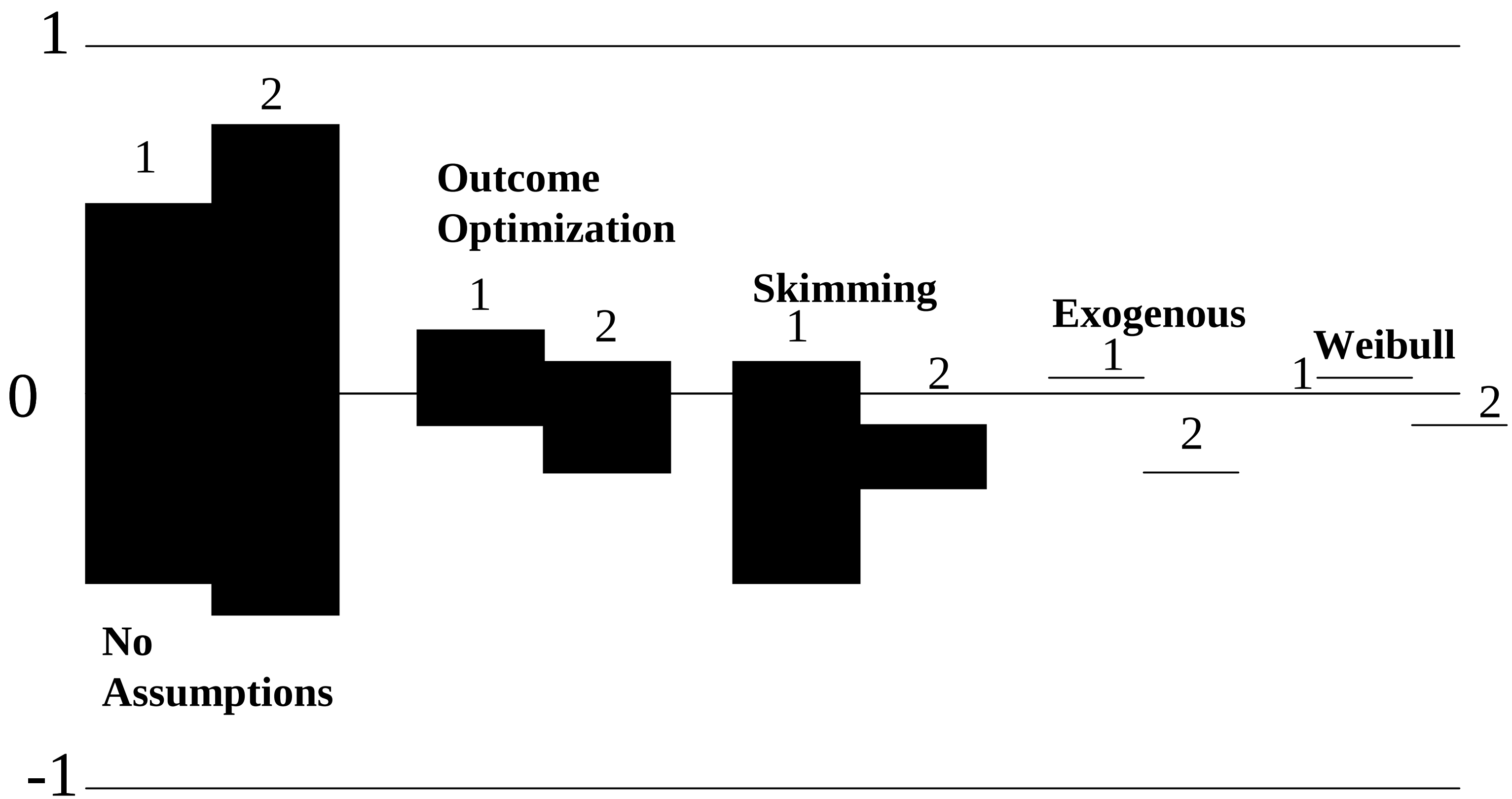
$$P[d(hi) < t \mid X, ipr = hi] - P[d(med) < t \mid X, ipr = med]*\{P[ipr = med| X] + P[ipr=hi| X]\}$$

Skimming lower bound on $\Delta[med, hi \mid X]$

$$P[d(hi) < t \mid X, ipr = hi]* P[ipr=hi| X] - P[d(med) < t \mid X, ipr = med]*\{P[ipr = med| X] + P[ipr=low| X]\} - P[ipr=hi| X]$$

Figure 1

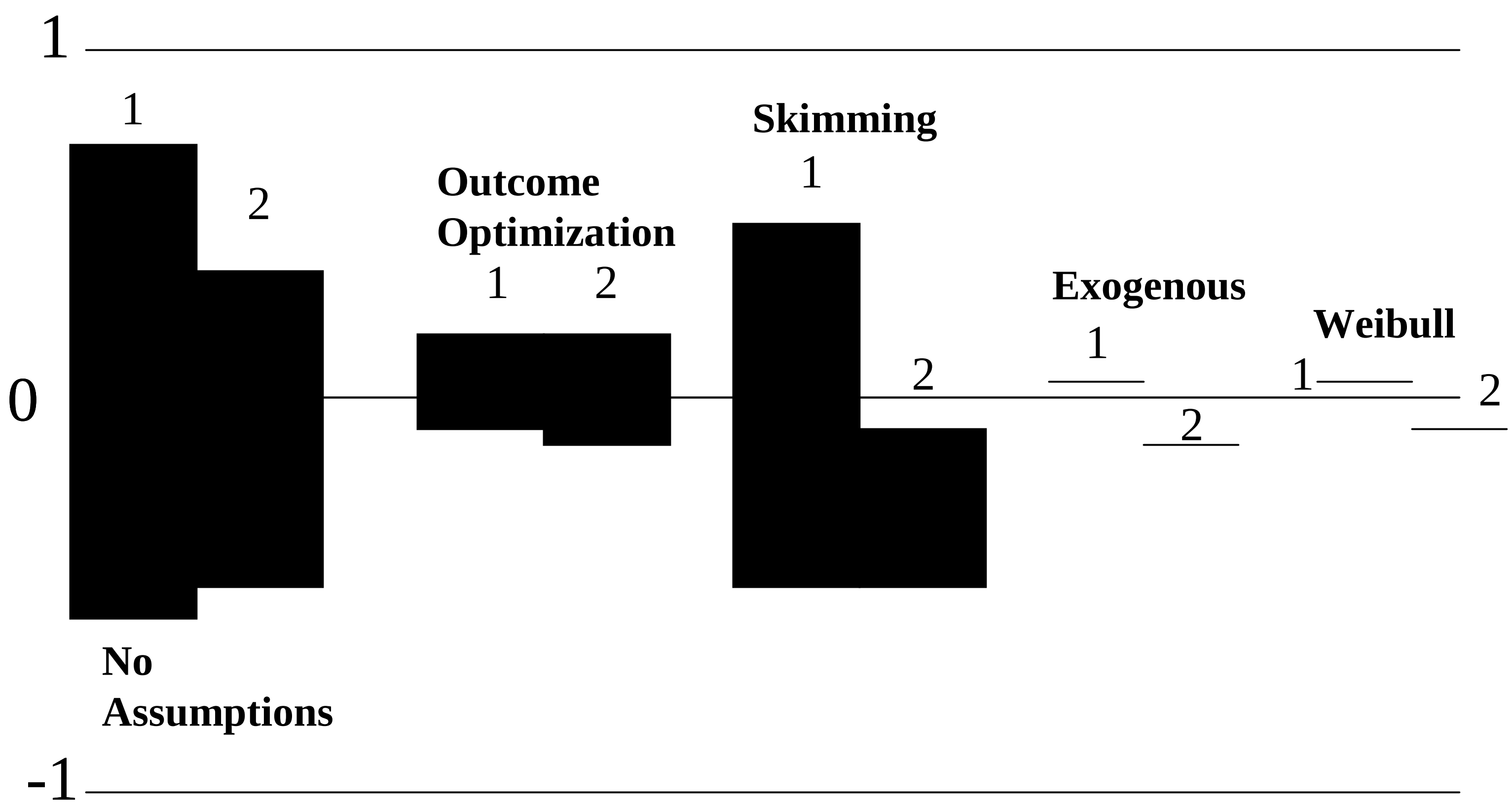
Impact of Reform
Low Income Countries



1 =△ [low, med, *d* < 60]
2 =△ [med, hi, *d* < 60]

Figure 2

Impact of Reform
High Income Countries



1 = △[low, med, d < 60]
2 = △[med, hi, d < 60]