

Essays on the Political Economy of International Agreements

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ABSTRACT

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This dissertation consists of three essays that sit at the intersection of international trade, political economy and the economics of innovation. It analyzes from a critical perspective the relationship between organized interest groups and international agreements on trade and intellectual property rights (IPR) protection and offers new theoretical insights, which it then supports empirically.

My first essay calls into question the logic of the standard Grossman-Helpman/Bagwell-Staiger model of trade agreements, according to which governments enter international treaties to prevent terms-of-trade manipulation and special interest politics has a trivial role. Despite its immense popularity, it remains inconsistent with observed trade policy and with the practitioners' understanding of trade treaties. By assuming that subsidies have additional political cost beyond their monetary cost, I show how international agreements result in the reduction of political protectionism through the crucial role of exporting lobbies in the negotiations process. At the same time, the model resolves three prominent puzzles in the literature: the terms-of-trade puzzle, the anti-trade bias puzzle and the inefficient redistribution puzzle. Finally I find empirical support for the model and my key assumption using data on US agricultural trade policy.

In the second essay I propose a model that considers the effect of firm lobbying for IPR protection in an international setting in innovation-driven economies. In particular, I compare the IPR protection level and global social welfare between the case when

countries set their IPR policies non-cooperatively and when they enter an international treaty, such as the TRIPS, TPP and TTIP. I find that lobbying necessarily leads to inefficient international agreements resulting in too much IPR protection and may even be welfare-reducing relative to no cooperation. I also show that international lobbying and high concentration of capital can further exacerbate this outcome. The model generates predictions consistent with patterns I find in the data on US firms' lobbying expenditures and the value of their international patent portfolios.

Finally, the third essay provides a critique of a popular structural patent valuation methodology that utilizes the stock market response to news about patent grants, first introduced by Kogan et al. (2012). Using their methodology (refined and improved in terms of the theoretical derivation), I perform a placebo estimation of US patent values and compare the results with the true patent value estimates as per Kogan et al's paper. I find strong evidence that the "true" patent value estimates are not driven by patent news announcements, but rather are an artifact of the estimation methodology itself and as such cannot be used for comparisons across different patent-holding firms and grant years. I further corroborate the external validity of this critique by applying the same method to a novel database of Chinese patents and finding that the same conclusion holds.

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To my grandfather, who would have been very proud.

*Beyond the Standard Model: How Trade Agreements reduce
Political Protectionism*

1.1 Introduction

The GATT (WTO) agreement has resulted in unprecedented worldwide trade liberalization since the end of the Second World War. Understanding the reasons that led to this historic transformation should be a central task for academic economists. Most of them regard the well-established work of Grossman and Helpman (1997) and Bagwell and Staiger (1997,2004) as the conventional wisdom when it comes to explaining trade agreements. These models share so much of their internal logic – indeed Grossman-Helpman can be interpreted as a micro-founded version of Bagwell-Staiger – that I will refer to them simply as “the standard model”. Yet the standard model, despite its popularity, is deeply inconsistent with certain features of actual trade agreements and the trade policies that we observe in reality. Moreover, there is a fundamental disagreement between the formal theory and most trade practitioners’ informal understanding of trade agreements, which include practicing economists, trade negotiators and diplomats who are actually involved

in crafting trade treaties.¹

This paper aims to bridge that gap by introducing a key assumption in the standard model, that will nevertheless radically alter the purpose of trade agreements and bring it in line with the practitioners' story, while at the same time resolving three popular puzzles that render the standard model inconsistent with reality: the terms-of-trade puzzle, the anti-trade bias puzzle and the inefficient redistribution puzzle. In particular, I assume that all fiscal outlays in the form of subsidies will incur additional political (or administrative) cost to the government, in addition to their monetary cost². This assumption doesn't hinge on any special feature of the standard model, but I believe that applying it in the micro-founded framework of Grossman-Helpman helps the formal exposition of my argument and allows for empirical testing, which this paper also does.

Before I go into the details of the model, I will take the time to outline the contradictions arising from the standard model. According to this view, the sole purpose of trade agreements is (or should be) to prevent governments from engaging in terms-of-trade (ToT) manipulation. If governments set trade policies unilaterally they will try to improve their terms-of-trade by setting "optimal tariffs" in the case of imports and "optimal export taxes" in the case of exports, thereby imposing a ToT externality on their trading partner. The government benefits from this terms-of-trade improvement only via the revenue it collects, so the government's concern with trade-tax revenue is absolutely central to the standard theory. The incentive to manipulate the ToT exists irrespective of the internal politics and any influence by special interest groups. A trade agreement

¹For in-depth discussion of the inconsistencies between the standard model and the practitioners' understanding refer to Regan (2015), whose paper greatly informs the discussion that follows.

²Justifications are discussed in more detail in the theoretical section.

enables cooperation between two governments who agree not to impose ToT externality on each other thereby maximizing their joint surplus. Special interest politics plays no role whatsoever in the motivation for trade agreements according to the standard model, even when these special interest groups are actively lobbying for the terms of the agreement. This is not to say that lobby groups have no effect on the final negotiated levels of trade protection - they obviously do, but the trade agreement does not reduce political protectionism, i.e. the component of the tariff (or subsidy) that is due to lobbying efforts remains the same before and after the agreement. Only the component of the tariff that is due to ToT manipulation is eliminated as a result of the trade treaty. But as much as the Grossman-Helpman model makes this distinction explicit by additively separating the two components in the expression for the unilateral equilibrium trade policy, Grossman (2016) tries to obfuscate it by claiming that they are two sides of the same coin and the criticism levied at the model is a matter of semantics. The confusion arises due to not distinguishing between cause and effect. Every tariff, irrespective of the causal motivation for setting it, will have both a protective effect on the import-competing industry, as well as an effect on the terms-of-trade. But whether the tariff is *motivated* by political protectionism, or terms-of-trade manipulation, or both, depends on whether the government is *aiming* to protect a politically influential industry, or raise revenue by improving the terms-of-trade effect, or both.

By contrast, in the practitioners' understanding of trade agreements there is very little emphasis on the governments' concern for the trade-tax revenue and through it - the terms-of-trade. While there may be a ToT externality, it is by no means the central goal of trade agreements to eliminate it. But rather, the start of trade negotiations changes

the political balance of forces, without which there cannot be a reduction in political protectionism. Due to the sudden mobilization of (at least some segment of) exporter interests, the practitioners' story goes³, the government will want to lower its tariffs if in exchange for losing support from its import-competing interests, it gains support from its exporting interests because it has succeeded in reciprocally expanding market access. Similarly, in my model the exporting interests are able to mobilize around lobbying for reducing the trading partner's tariffs once the negotiations open, because tariff reductions do not incur additional political cost, as opposed to the high-cost lobbying effort required for obtaining export subsidies⁴. Crucially, trade negotiations do not alter the balance of political forces by affecting their ability to organize (pretty ad-hoc assumption), but rather their potency by giving them a policy option previously unavailable in the non-cooperative context.

It is perhaps surprising that a model that makes special interest politics essentially irrelevant for trade treaties has become the dominant model for explaining them. Moreover, because ToT manipulation is the driving motivation behind trade agreements, it predicts that small countries that cannot affect their terms-of-trade would have no reason to ever enter such agreements, which clearly hasn't been the case for the 164 member states of WTO⁵. Furthermore, the standard model generates three prominent puzzles in

³Regan (2015) cites Pauwelyn (2008), Hudec (1992) pp.314-316, Krugman (1997) p.118, Destler (2005) pp.17, 253-254.

⁴Unlike the two-sector Bagwell-Staiger model, Lerner symmetry does not apply in the many-sector Grossman-Helpman model, so exporters will want to lobby only for export subsidies in the unilateral context. Applying the logic of my model to Bagwell-Staiger would require the additional assumption that exporters would *not* lobby for reducing domestic tariffs in the domestic import-competing sector even though that would affect the price of their product through Lerner symmetry. Regan (2014) discusses few justifications for such an assumption.

⁵There is a class of so called commitment models that explain why countries, including small economies,

the political economy of trade⁶. If trade agreements are meant to prevent terms-of-trade manipulation, that means they should prohibit export taxes and reductions in export subsidies. Instead, export taxes are not regulated whereas reducing export subsidies is not only allowed, but it is mandatory - export subsidies are fully banned under WTO. Moreover, even if countries are allowed to manipulate ToT for their exports, they never do it. This is known as the terms-of-trade puzzle. The anti-trade bias puzzle arises from the observation that the net effect of unilateral trade policies in the real world is to contract trade, whereas Levy (1999) shows that in a symmetric, two-country Grossman-Helpman world the effect of lobbying is to encourage net trade promotion⁷. The third conundrum is the inefficient redistribution puzzle which finds puzzling the prevalent use of trade policies as a means to redistribute income to special interests groups given that there are other more efficient ways to do it (such as production subsidies or lump sum transfers). A simple extension of the G-H model to include production subsidies will render trade policies unattractive as a redistribution mechanism. The status of certain policy instruments in WTO also presents a challenge for the standard model. Voluntary export constraints (VER's) and freely given import quotas were widely used before and therefore are strictly regulated by WTO even though they negatively affect the terms-of-trade. Thus their regulation in treaties can only be explained by dominant political protectionist motivations, while ToT motivations must play a minor role.

facing an irreversible costly decision may want to join an existing international treaty, but they cannot explain how such a treaty would reduce existing tariffs, nor the reciprocal nature of multi- and bilateral agreements.

⁶For more in-depth discussion of the puzzles, see Rodrik (1995).

⁷This puzzle is sometimes also known as the export subsidy transfer puzzle, because the theory implies that a country's export subsidies would be only partially countervailed by the trading partner's import tariffs, in effect transferring income to the foreign import-competing sector.

The assumption of politically costly fiscal outlays resolves all of the above mentioned puzzles by leading countries to rely more on unilateral tariffs for protectionism than on politically costly export and production subsidies. Trade negotiations serve as a forum for reconfiguring the balance of political forces by allowing special interests to influence directly their trading partners' policies, which is not possible in the non-cooperative context. Because this political reconfiguration from cooperation empowers the interests in favor of liberalization, trade agreements result in reduction of political protectionism. In the case of trade policies affecting prices directly, export lobbies acquire a new avenue for influencing their domestic price (reducing foreign tariffs), which is much more cost-effective than trying to raise export subsidies at home. Thus the assumption of politically costly subsidies is crucial. In the case of trade policies for quantitative restrictions (VER's, embargoes, quotas), the only avenue for exporters to affect these policies is to influence them directly through the trading partner, which is only possible under trade negotiations and cooperation⁸. Therefore, the assumption of politically costly policies is unnecessary in this case and the politically protectionist motive prevails even if these policies deteriorate the terms-of-trade. Finally, because the ToT motive is secondary to the political motive, even small countries benefit directly from cooperation on trade.

There are several papers in the literature that modify the Grossman-Helpman model by introducing non-standard assumptions with the aim of resolving some of its contradictions. Tovar (2009) and Freund, Ozden (2004) introduce loss aversion and reference dependence of the agents' preferences in a standard Grossman-Helpman framework in order to explain observed trade protection dynamics: its persistence over time and the

⁸I do not formally model this result here, but it is evident from the logic of the argument.

finding that industries experiencing losses are more likely to receive protection. By allowing for endogenous lobby formation, Tovar (2009) shows how her model resolves the anti-trade bias puzzle provided that the loss aversion coefficient is high enough and the country is undergoing liberalization, so that declining import-competing sectors have the most to gain from organizing. While this model captures salient features of the dynamics of trade protection⁹, it does not explain how trade agreements result in reduction of political protectionism, nor does it adequately address the other puzzles raised in the literature. Similarly, Limao and Panagariya (2006) introduce concern for inequality in the government's objective function which could generate the desired anti-trade bias, but leaves the core internal logic of standard model intact. Ethier (2007) considers the implications of assuming a lower government weight on trade-tax revenue (and thereby the ToT motivation) in the Grossman-Helpman model and shows that the only way to eliminate both the terms-of-trade puzzle and the anti-trade bias puzzle is to impose the unrealistic assumption of zero weight attached to government revenue. He correctly points out that this is not so much problematic because ToT concerns should necessarily matter¹⁰, but because the Nash equilibrium he gets consisting of prohibitive tariffs driving imports to zero is a singularity and not the limiting case as the weight on revenue goes to zero.

I test the model using data on US agricultural protection from before the implemen-

⁹Most empirical estimates of Grossman-Helpman find a significant constant term explaining trade protection levels. Ederington and Minier (2008) show that this finding contradicts the Grossman-Helpman model because it cannot be explained by extraneous political factors and amounts to deviations from welfare-maximizing behavior. Policy persistence might be a promising candidate for explaining this term, though this is not the subject of this paper.

¹⁰As Regan (2015) says: *"In the classic studies of United States trade policy from the Hawley-Smoot period to the present, there is not one word to suggest that tariffs were ever motivated in even the slightest degree by the desire for tariff revenue (whether to be deposited in the treasury or distributed to the citizenry.*

tation of the Uruguay Round Agreement on Agriculture (1995). I employ a non-linear censored IV-Tobit regression to directly estimate the parameters of the model and test its predictions. The estimation results for the US support the modified G-H model, while I find little evidence for the original G-H specification. Across all specifications the results reject the null hypothesis that there is no additional political cost to subsidies against the alternative that this coefficient is negative (greater cost). I find no evidence that terms-of-trade motivations are ever significant, which is in accordance with the practitioners' story. Moreover, the implied estimates for the government weight on social welfare are one of the lowest in the literature, whose unrealistically high estimates have presented a puzzle in empirical tests of the G-H model. Gawande and Hoekman (2006) also test the original G-H model using US agricultural data, which allows them to exploit both variation in export subsidies and import tariffs. However there are several problematic issues with their method. Because they don't have data on export supply elasticities, they set them equal to 2 for all sectors with no explanation. Another issue is that they use data from 1999 for the export subsidies which was after the entry into force of URAA (1995), when they became subject of international regulation. The identification equations used however are based on the assumption of no cooperation. Lastly, even though they find evidence in the data for differential government preference over different policy instruments, they lump together production subsidies with export subsidies (and non-tariff measures) without any theoretical justification in the model. My approach addresses these objections, so its estimates are arguably more reliable.

The paper proceeds as follows: First, I present the theoretical underpinnings of the model and analyze the non-cooperative equilibrium. Next, I consider the equilibrium

trade agreements that would result as consequence of cooperation between governments. This section also shows formally how trade agreements result in the reduction of political protectionism and how they resolve the puzzles discussed. In the empirical section, I give description of the data used, the estimating procedure and I discuss the results. The final section concludes.

1.2 Model

I start by presenting a micro-founded model of trade agreements that result in reduction of protectionism, as opposed to the mere elimination of the terms-of-trade externality that we find in the standard model. My approach follows closely the modeling framework of Grossman-Helpman (1997), which is considered to be the best micro-founded exposition of the standard model. However I introduce a key assumption in which I depart from the standard model: I assume that fiscal outlays and revenues are valued differently in the government's political support function, which I show has far-reaching implications regarding the fundamental purpose of trade agreements.

I consider two open economies trading with each other with similar underlying economic and political structure. Therefore I will describe in detail the Home country, while it is understood that the same setup applies to the Foreign country. There are N identical households (WLOG set $N=1$), each of which maximizes an additively separable utility function:

$$U = c_Z + \sum_{i=1}^n u_i(c_i) \tag{1.1}$$

where c_Z is the consumption of the numeraire good that doesn't generate consumer sur-

plus, whereas c_i denotes the consumption of goods $i=1,2,\dots,n$. The functions $u_i(\cdot)$ are differentiable, increasing and strictly concave. Let $d_i(p_i)$ be the demand (per capita) for good i ¹¹, while p_i denotes its internal domestic price. The offshore price is given by π_i and the ad-valorem tariff/subsidy by τ_i , and therefore $p_i = \tau_i \pi_i$.¹² If we define E to be the household's total spending and $S(p) \equiv \sum_i u_i(d_i(p_i)) - p_i d_i(p_i)$ the total consumer surplus that it derives from consumption of all non-numeraire goods, given a vector of goods prices p , then the household's indirect utility V can be written as:

$$V(E, p) = E + S(p) \quad (1.2)$$

All goods are produced competitively. The numeraire good sector uses only labor (at constant returns to scale), which we assume is always in sufficient supply such that this good is always produced. The labor units are chosen WLOG, such that the wage rate is set to 1. The other goods are also produced at constant returns to scale, but utilizing two inputs: labor and a sector-specific input, that is supplied inelastically. Let $\Pi_i(p_i)$ be the rent (profits) that the owners of the specific factor i earn¹³. Then, by the envelope theorem, the industry supply will be given by:

$$y_i(p_i) = \Pi'_i(p_i) \quad (1.3)$$

The government can only tax or subsidize imports and exports of non-numeraire

¹¹ $d_i(\cdot)$ can be obtained from the first-order conditions from consumer maximization as the inverse of $u'_i(\cdot)$.

¹²Similarly, for the Foreign country: $p_i^* = \tau_i^* \pi_i$.

¹³ $\Pi_i(\cdot)$ can be obtained from profit maximization at the industry level.

goods, and it can collect tax revenue or redistribute tax receipts equally (in per capita terms). Thus, $\tau_i > 1$ signifies either an import tariff or an export subsidy, while $\tau_i < 1$ is either an import subsidy or an export tax. The sector-specific revenue r_i will be:

$$r_i(\tau_i, \pi_i) = (\tau_i \pi_i - \pi_i) \left(d_i(\tau_i \pi_i) - \frac{y_i(\tau_i \pi_i)}{N} \right) \quad (1.4)$$

From now on, we normalize the total population $N=1$ without loss of generality.

In the international context, the world market for all goods clears, which allows us to solve for the off-shore market-clearing price $\pi_i(\tau_i, \tau_i^*)$ for all i :

$$d_i(\tau_i \pi_i) - y_i(\tau_i \pi_i) = y_i^*(\tau_i^* \pi_i) - d_i^*(\tau_i^* \pi_i) \quad (1.5)$$

The political economy framework utilizes the common agency approach by Grossman-Helpman. We assume that individuals can only claim (partial) ownership of a specific factor of at most one type. Lobby formation is exogeneously determined at the industry level, and each industry lobby consists of all owners of a particular specific factor type. Thus, each individual can belong to at most one lobby and will have a direct stake in the trade policy that pertains to that lobby. We assume that the specific factor owners of good i constitute α_i share of the total population, which reflects their interest in trade policies as consumers. In addition, they earn w_i income from their own labor. Then the joint welfare of lobby i will be given by:

$$W_i(\tau, \tau^*) = w_i + \Pi_i(\tau_i, \tau_i^*) + \alpha_i \left(\sum_i r_i(\tau_i, \tau_i^*) + S(\tau, \tau^*) \right) \quad (1.6)$$

The lobbies express their political demands through campaign contribution schedules $C_i(\tau, \cdot)$: they offer to contribute to the incumbent politician financial funds that depend on the particular trade policies implemented. The objective function that the lobby aims to maximize by adjusting its contribution schedule will be the expression in (1.6) net of this realized contribution. Under the non-cooperative (unilateral) regime of policy determination, the contribution schedules $C_i(\tau; \tau^*)$ can be conditioned only on the τ domestic policies implemented, taking the foreign policies τ^* as given. Whereas under the cooperative bargaining regime, $C_i(\tau, \tau^*)$ can be conditioned on both the τ domestic and τ^* foreign trade policies. In both cases, the lobbies act simultaneously taking as given the schedules of all other lobbies in both countries. The lobbies can influence only the politician in their respective country and their schedules cannot be observed by the foreign politician¹⁴.

Once the various lobbies have set their contribution schedules, in the second stage the incumbent politician chooses the optimal trade policy vector – either unilaterally or through international cooperation with other sovereigns – by maximizing a political welfare function G , which is a weighted average of the sum total of campaign contributions, the social welfare W and a **political cost term P** .

$$G = \sum_i C_i(\tau, \cdot) + a (W(\tau, \tau^*) + P(\tau, \tau^*)) \quad (1.7)$$

$$W(\tau, \tau^*) = l + \sum_i \Pi_i(\tau_i, \tau_i^*) + \sum_i r_i(\tau_i, \tau_i^*) + S(\tau, \tau^*) \quad (1.8)$$

¹⁴As a consequence, lobbies do not set their schedules strategically with respect to the Foreign government. See Grossman-Helpman (1997) for justification of this assumption.

The key assumption here is that trade policy-related fiscal outlays and revenues do not enter symmetrically in the political welfare of the politicians: fiscal outlays incur a higher political cost, over and above their monetary value, compared to fiscal revenues. This would imply that the government would prefer to give up tariff revenue than to spend a monetary equivalent amount on subsidies, even though they would both affect the fiscal balance the same. This assumption is in line with the practitioners' conventional wisdom (Regan, 2015) and the larger cultural and political context in which implicit subsidies through tax cuts (tariffs) are easier to obtain than explicit transfer subsidies. Dunkel and Roessler (2012), for example, argue that governments are reluctant to offer production subsidies as an alternative to tariffs, even when the subsidies would be more efficient.

One justification for this may be because subsidies have higher administrative cost of implementation than taxes and tariffs. Another may be because tax cuts are less transparent mechanism for political favoritism and thus incur lower political cost. However, the most compelling justification is arguably the electorate's preference for small government. This doesn't have to be necessarily a consequence of political ideology, but may arise from the government's choice of re-distributive policies. In the standard model, we assume voters are taxed and tariff proceeds are redistributed equally on per capita basis. But if we assume that a democratically elected government taxes everyone equally but redistributes only to a limited (marginalized or privileged) section of society, then taxation will be more politically costly because it would increase the likelihood that it's not re-elected and the electorate as a whole would prefer lower levels of government expenditures. Taxing imports on the other hand would not incur the same political cost because foreign importers do not get to vote.

If the fiscal outlays are more costly than fiscal receipts by a factor of δ , then the political cost term P can be written as:

$$P(\tau, \tau^*) = \delta \sum_i \mathbb{1}(r_i(\tau_i, \tau_i^*) < 0) r_i(\tau_i, \tau_i^*) \quad (1.9)$$

Under the non-cooperative trade war regime, governments set their trade policies unilaterally, ignoring the impact that their actions have on the other country. In accordance with Grossman-Helpman, an **equilibrium response** by a country to a policy choice by its trading partner can be defined as follows:

Definition 1: Let τ^* be an arbitrary trade policy vector chosen by Foreign. Then an equilibrium response to τ^* consists of a set of feasible¹⁵ contributions $\{C_i^o\}$ and a trade policy vector τ^o such that:

1. $\tau^o = \arg \max_{\tau} \sum_i C_i^o(\tau; \tau^*) + a(W(\tau, \tau^*) + P(\tau, \tau^*))$
2. For all organized lobbies i , there does not exist an alternative optimal trade policy vector $\tilde{\tau}^i$ and an alternative feasible $\tilde{C}_i(\tilde{\tau}^i; \tau^*)$ strictly preferred by the lobby, i.e. that satisfy:

- a) $\tilde{\tau}^i = \arg \max_{\tau} \tilde{C}_i(\tau; \tau^*) + \sum_{j \neq i} C_j^o(\tau; \tau^*) + a(W(\tau, \tau^*) + P(\tau, \tau^*))$
- b) $W_i(\tilde{\tau}^i, \tau^*) - \tilde{C}_i(\tilde{\tau}^i; \tau^*) > W_i(\tau^o, \tau^*) - C_i^o(\tau^o; \tau^*)$

Consequently, the Nash Equilibrium of this game will consist of two policy vectors τ and τ^* that are equilibrium responses to each other. To solve for it, we proceed as

¹⁵Feasible contributions are those that the lobby can afford, i.e. non-negative offers that do not exceed the aggregate income of the lobby's members.

in Grossman-Helpman (1997) ¹⁶. First we apply the Bernheim-Whinston (1986) theorem separately for each country taking the external prices as given in order to obtain the equilibrium response. The Bernheim-Whinston theorem states the optimization conditions¹⁷ that support the subgame perfect Nash Equilibrium between the lobbies and the government within each country.

There are many possible contribution schedules that constitute equilibrium responses to the above game, but we restrict our focus to the so called **globally truthful** equilibrium, which arises when lobbies truthfully reveal their valuation for all potential policies, i.e. the contribution schedules $C_i(\tau, \tau^*)$ mirror the curvature of the lobby's utility. Globally truthful contributions are a weakly dominant strategy for the lobbies. In this case, a lobby i would get the same payment for all policies (τ, τ^*) that induce positive contributions $C_i > 0$. Thus, deciding the contribution schedule boils down to deciding by what scalar $B_i > 0$ the lobby wants to shift its utility. Mathematically, the truthful contributions can be written as:

$$C_i(\tau, \tau^*) = \max\{W_i(\tau, \tau^*) - B_i, 0\} \quad (1.10)$$

Substituting (2.12), (1.9) and (2.15) in (2.9), taking the first-order condition with respect to τ_i (holding τ_i^* constant) and rearranging, we get an implicit expression for the

¹⁶For details about this solution approach, refer to Grossman-Helpman (1992) and Grossman-Helpman (1997).

¹⁷The theorem states that (given τ^*) $\{\{C_i\}_i, \tau^o\}$ is SPNE iff:

1^o. $C_i(\tau; \tau^*)$ are feasible $\forall i$

2^o. τ^o maximizes the government objective function $G(\tau, \tau^*)$ under (2.9)

3^o. τ^o maximizes the joint gov+lobby objective function $G + (W_i - C_i) \forall i$

4^o. $\forall i \exists \tau^i$ (vector), such that it maximizes $G(\tau, \tau^*) - C_i(\tau; \tau^*)$

equilibrium policy best response¹⁸:

$$\tau - 1 = \frac{(I - \alpha_L)}{a(1 + \delta_r) + \alpha_L} \frac{y}{(-m')\pi} + \frac{a\delta_r}{a(1 + \delta_r) + \alpha_L} \frac{m}{(-m')\pi} + \frac{m^*}{\tau^* m^{*'} \pi} \quad (1.11)$$

Here, we define I to be an indicator for whether the sector is organized into a lobby or not, α_L is the total share of sophisticated consumers that firm owners represent, $\delta_r \equiv \delta \mathbb{1}(r_i < 0)$ and $m(p) \equiv d(p) - y(p)$ and $m^*(p^*) \equiv d^*(p^*) - y^*(p^*)$ ¹⁹ denote Home and Foreign's import demand (if positive) or export supply (if negative) respectively. This expression decomposes the resulting trade policy intervention into three effects. The first term represents the political protectionism from the lobby. The third term represents the terms-of-trade effect from imposing tariffs on imports or taxes on exports and also equals by definition the elasticity of import demand (export supply). It is completely independent from the existence of lobbies (special interest politics) and stems from the government's ability to raise revenue by improving its terms of trade. These two terms are the exact same terms as in Grossman, Helpman (1997). The second term comes from the imposition of the additional political cost function, and only appears if the trade policy outcome results in costly fiscal outlays.

To analyze this equilibrium vis-a-vis Grossman-Helpman's standard model, consider the reduced form special case they also focus on, in which (without loss of generality) Home imports from Foreign and both countries have constant trade elasticities $\epsilon > 1$ and

¹⁸The index i is dropped henceforth, because it is understood that the derivation is for sector i , and the same approach applies for all sectors.

¹⁹Consistent with standard notation, $m' = \frac{dm(p)}{dp}$ and $m^{*'} = \frac{dm^*(p^*)}{dp^*}$. Also note that m' and $m^{*'}$ are always negative.

$\epsilon^* > 0$ respectively²⁰:

$$m(p) = m_0(p)^{-\epsilon} \quad (1.12)$$

$$m^*(p^*) = -m_0^*(p^*)^{\epsilon^*} \quad (1.13)$$

The off-shore price π can be expressed explicitly as a function of the decision trade policies by substituting the above expressions in the market-clearing condition (1.5).

$$\pi(\tau, \tau^*) = \left(\frac{m_0}{m_0^*}\right)^{1/(\epsilon+\epsilon^*)} \left(\frac{1}{\tau}\right)^{\epsilon/(\epsilon+\epsilon^*)} \left(\frac{1}{\tau^*}\right)^{\epsilon^*/(\epsilon+\epsilon^*)} \quad (1.14)$$

Then from expression (1.11) we derive the trade policies for the Home and Foreign country when both sectors are organized into lobbies:

$$\tau \left(1 - \frac{(1 - \alpha_L)}{a + \alpha_L} \frac{y(\tau\pi)}{\epsilon m_0(\tau\pi)^{-\epsilon}} \right) = 1 + \frac{1}{\epsilon^*} \quad (1.15)$$

$$\tau^* \left(1 - \frac{(1 - \alpha_L^*)}{a^*(1 + \delta_r^*) + \alpha_L^*} \frac{y^*(\tau^*\pi)}{\epsilon^* m_0^*(\tau^*\pi)^{\epsilon^*}} + \frac{a^* \delta_r^*}{a^*(1 + \delta_r^*) + \alpha_L^*} \frac{1}{\epsilon^*} \right) = 1 - \frac{1}{\epsilon} \quad (1.16)$$

The importing country (Home) will impose an import tariff because the right-hand side of (1.11) is always positive: both the import-competing lobby and the government want to tax imports thereby raising revenue, and therefore no additional political cost is incurred. However, for the exporting country (Foreign), both export subsidies and export taxes are possible, depending on whether the political support the government gets from the export lobby on the one hand is stronger than the additional political cost of subsidizing that industry compounded with the terms-of-trade effect on the other.

²⁰ m_0 and m_0^* are both positive constants.

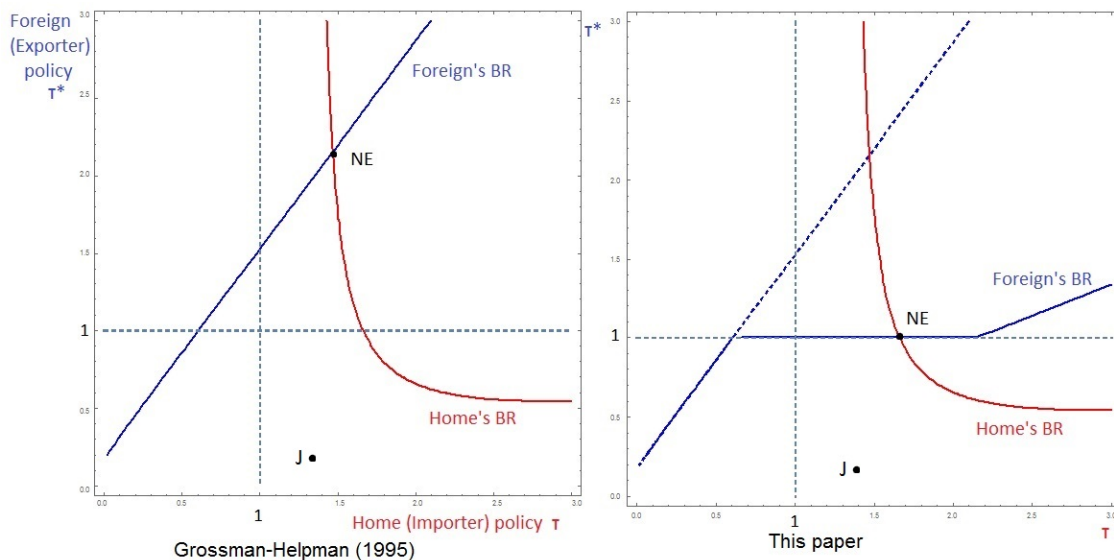


Figure 1.1: Non-cooperative Nash equilibria in the original G-H model vs. this model.

Figure 1 depicts three characteristic equilibria under the non-cooperative trade war regimes: J denotes the Johnson equilibrium first derived by Johnson (1953) when governments are only concerned with maximizing social welfare without any political influence²¹. The ad-valorem trade policies in this case are simply the inverse trade elasticities. The Grossman-Helpman (1997) equilibrium is reproduced on the left diagram and denoted by NE as the intersection of the two countries' best response curves when $\delta \rightarrow 0$, i.e. there is no additional political cost. The right diagram represents the trade war Nash equilibrium implied by the model from the intersection of the best response policies as given by (1.15) and (1.16).

The effect of the negative political cost term (when it applies) would be to decrease the equilibrium policy response τ^* for any given τ .²² Thus, depending on the value of τ ,

²¹The Johnson equilibrium corresponds to the limiting case when $a \rightarrow \infty$ and $a^* \rightarrow \infty$

²²The political cost term in (1.16) causes the intercept with the y-axis to decrease to $(1 - \frac{1}{\epsilon})(1 + \frac{a^* \delta_r^*}{a^*(1+\delta_r^*) + \alpha_L^* \epsilon^*})^{-1}$, because $\frac{y^*(p^*)}{m^*(p^*)} \equiv z(\frac{\tau}{\tau^*})$ is increasing in $\frac{\tau}{\tau^*}$ so it approaches 0 as $\tau \rightarrow 0$. At the same time, as $\tau^* \rightarrow \infty$, the term in brackets must go to 0, which determines the asymptotic behavior of

Foreign's best response could fall into three ranges: for low enough τ , the optimal policy response would be an export tax so $\delta_r^* = 0$; for $\tau \in (\tau_1, \tau_2)$ it's optimal not to intervene at all (corner solution); whereas if $\tau > \tau_2$ the optimal policy would be an export subsidy given by (1.16) when $\delta_r^* = \delta$. If we denote by x_{NE} the ratio of non-cooperative equilibrium policies $\frac{\tau}{\tau^*}$, it is easy to see that x_{NE} in this model is rotated clockwise relative to the one in Grossman-Helpman (1997), here represented by the ray from the origin OS . If the political cost of subsidies δ is "high enough", Foreign's best response will decrease²³ causing x_{NE} to rotate further clockwise until it reaches 1 and thus the model will generate the **anti-trade bias** that we observe in reality, namely that the net effect of unilateral trade policies is to contract trade (i.e. $x_{NE} > 1$), rather than expand it as the Grossman-Helpman (1997) model implies²⁴.

Cooperative regime: Trade agreements

Under a cooperative regime, national governments are allowed to negotiate and implement an agreement on trade policies (τ, τ^*) and compensate one another with a transfer payment R , which is to be distributed equally among the public. The lobbies are again allowed to lobby their domestic governments, but in this case they can condition their contribution schedules on the full policy vector that would be the result of the trade negotiation. Assume for simplicity that firm owners constitute a negligible share of sophis-

Foreign's best response by solving: $\frac{(1-\alpha_L^*)}{a^*(1+\delta_r^*)+\alpha_L^*} \frac{1}{\epsilon^*} z\left(\frac{\tau}{\tau^*}\right) = 1 + \frac{a^* \delta_r^*}{a^*(1+\delta_r^*)+\alpha_L^*} \frac{1}{\epsilon^*}$. It approaches asymptotically a value of τ^*/τ that is unambiguously lower than the equivalent Grossman-Helpman benchmark due to the effect of the political cost term and there is no restriction on how low it could get provided that δ is sufficiently large.

²³See previous footnote.

²⁴Levy (1999) has shown that in a symmetric, two-country Grossman-Helpman world the effect of lobbying is to encourage net trade promotion.

ticated consumers, or equivalently that firms can only lobby for the trade policies directly affecting their sector, therefore setting $\alpha_L = \alpha_L^* = 0$. Irrespective of the particular bargaining procedure, the bargaining outcome will be such that no government will be able to increase its own welfare without lowering the welfare of its trading partner (also known as *politically efficient* outcome)²⁵. Therefore an equilibrium trade agreement will always result in political efficiency. More formally we can write (as in G-H (1997)):

Definition 2: An equilibrium trade agreement consists of a set of feasible contributions $\{C_i^o\}$ and $\{C_i^{*o}\}$ and a pair of policies (τ^o, τ^{*o}) such that:

1. $(\tau^o, \tau^{*o}) = \arg \max_{(\tau, \tau^*)} a^* G(\tau, \tau^*) + a G^*(\tau, \tau^*)$ ²⁶
2. For all organized domestic lobbies $i \in L$, there does not exist an alternative optimal trade policy vector $(\tilde{\tau}^i, \tilde{\tau}^{*i})$ and an alternative feasible $\tilde{C}_i(\tau, \tau^*)$ strictly preferred by the lobby, i.e. that satisfy:

$$\text{a) } (\tilde{\tau}^i, \tilde{\tau}^{*i}) = \arg \max_{(\tau, \tau^*)} a^* (\tilde{C}_i(\tau, \tau^*) + \sum_{j \neq i} C_j^o(\tau, \tau^*)) + a \sum_j C_j^{*o}(\tau, \tau^*) + aa^* (W(\tau, \tau^*) + P(\tau, \tau^*) + W^*(\tau, \tau^*) + P^*(\tau, \tau^*))$$

$$\text{b) } W_i(\tilde{\tau}^i, \tilde{\tau}^{*i}) - \tilde{C}_i(\tilde{\tau}^i, \tilde{\tau}^{*i}) > W_i(\tau^o, \tau^{*o}) - C_i^o(\tau^o, \tau^{*o})$$

3. For all organized foreign lobbies $i \in L^*$, there does not exist an alternative optimal trade policy vector $(\tilde{\tau}^i, \tilde{\tau}^{*i})$ and an alternative feasible $\tilde{C}_i^*(\tau, \tau^*)$ strictly preferred by the lobby, i.e. that satisfy:

$$\text{a) } (\tilde{\tau}^i, \tilde{\tau}^{*i}) = \arg \max_{(\tau, \tau^*)} a^* \sum_j C_j^o(\tau, \tau^*) + a (\sum_{j \neq i} C_j^{*o}(\tau, \tau^*) + \tilde{C}_i^*(\tau, \tau^*)) + aa^* (W(\tau, \tau^*) + P(\tau, \tau^*) + W^*(\tau, \tau^*) + P^*(\tau, \tau^*))$$

²⁵Grossman-Helpman (1997) discuss Rubinstein (1982) as one possible bargaining equilibrium that implements a politically efficient outcome.

²⁶Note the cross-matching of coefficients with national welfares necessitated by the fact that the transfers are to be redistributed to the public whose welfare the politicians value differently.

$$\text{b) } W_i^*(\tilde{\tau}^i, \tilde{\tau}^{*i}) - \tilde{C}_i^*(\tilde{\tau}^i, \tilde{\tau}^{*i}) > W_i^*(\tau^o, \tau^{*o}) - C_i^{*o}(\tau^o, \tau^{*o})$$

This two-country game has a structure equivalent to a setup in which a single world government maximizes the objective function given in a), taking as given the contributions from various interest groups from both countries. Therefore, the same solution approach utilizing the Bernheim-Whinston theorem for a single economy can be applied. Because of the existence of non-convexities in the objective function (through $\delta_r(\tau, \tau^*)$), we split the domain into four regions in order to find the optimal solution:

1. R1: $\forall(\tau, \tau^*) : \tau > 1 \cap \tau^* < 1$
2. R2: $\forall(\tau, \tau^*) : \tau < 1 \cap \tau^* > 1$
3. R3: $\forall(\tau, \tau^*) : \tau > 1 \cap \tau^* > 1$
4. R4: $\forall(\tau, \tau^*) : \tau < 1 \cap \tau^* < 1$

It can be shown that the optimal trade agreement cannot fall in R3 or R4, because the first-order conditions with respect to τ_i and τ_i^* on these domains are inconsistent with each other. The logic behind this result is the following: When we move the vector of trade policies along a certain ray from the origin $x_i \equiv \frac{\tau_i}{\tau_i^*}$, this results in a welfare transfer from one country to another while keeping internal prices fixed. At the same time, moving towards the origin starting from R3 and away from the origin starting from R4 would reduce the additional political cost P that the subsidies-paying government incurs. Thus, starting from R3 or R4, it will always be possible to increase joint welfare by reducing trade interventionism and the political cost associated with it.

After some manipulation, the first order conditions for R1 and R2 respectively²⁷ can

²⁷The two FOC's with respect to τ_i and τ_i^* (for any i) are linearly dependent and they reduce to a single

be expressed in terms of the policy ratio x and therefore do not uniquely determine the trade policy vector:

$$x_0 - 1 = \frac{y^*(x_0)}{a^*m^*(x_0)e^*} - \frac{y(x_0)}{am(x_0)e}x_0 \quad (1.17)$$

$$x_\delta \left(1 + \delta\left(1 + \frac{1}{e}\right)\right) - \left(1 + \delta\left(1 + \frac{1}{e^*}\right)\right) = \frac{y^*(x_\delta)}{a^*m^*(x_\delta)e^*} - \frac{y(x_\delta)}{am(x_\delta)e}x_\delta \quad (1.18)$$

In the above expressions, e and e^* signify the import and export elasticities, which are constant in the reduced form model considered here. x_0 and x_δ determine two "peak rays"²⁸, possible candidates for the global maximum representing the optimal trade agreement, provided that they fall under their assigned domains: $x_0 < 1$ and $x_\delta > 1$. There are three possible case scenarios. If both $x_0 < x_\delta < 1$ ²⁹, then $x_\delta \cap R2$ ³⁰ is the optimal solution, under which trade would be stimulated with export and/or import subsidies. If $x_0 < 1 < x_\delta$, then free trade (1,1) is the optimal (corner) solution. And finally, if both $x_0 > 1$ and $x_\delta > 1$, then $x_0 \cap R1$ is the optimal trade agreement allowing for tariffs and export taxes.³¹

Obviously if free trade is the outcome of the trade negotiations, the trade agreement will eliminate all sources of political protectionism, beyond just removing the terms-of-trade externality. But trade agreements reduce political protectionism even if they don't

FOC expressed as a function of x . There is one such equation for R1 given by (1.17) and one for R2 given by (1.18).

²⁸Equations (1.17) and (1.18) do not typically have unique solutions, but the local maxima of interest correspond to the smaller of the two solutions.

²⁹If both $x_0 < 1$ and $x_\delta < 1$, then $x_0 < x_\delta$, because the intersection of the left-hand side expressions of (1.17) and (1.18) is $\bar{x} = \frac{1+1/\epsilon^*}{1-1/\epsilon} > 1$. This property also guarantees continuity of the optimal policy ratio x on the entire parameter domain.

³⁰I use the same notation for x to denote both the value of the slope and the vector points corresponding to that ray $\{\forall(\tau, \tau^*) : \frac{\tau}{\tau^*} = x\}$, depending on context.

³¹Note that we didn't have to check separately for corner solutions along the borders $\tau = 1$ and $\tau^* = 1$, because their values are already captured by the "indifference rays" x .

necessarily result in free trade. To see that this is indeed the case, I will make use of the concept of *politically optimal policies*. Bagwell and Staiger (2004) define "politically optimal" policies as those that the governments would set non-cooperatively if they didn't try to manipulate the terms-of-trade. They represent the protectionist component of the unilateral tariff. In the standard model, Bagwell and Staiger show, the politically optimal policies are always politically efficient, i.e. they are exactly what governments would agree to if they were to negotiate a trade agreement. In other words, if governments were not motivated by the terms-of-trade motive when they set trade policies unilaterally, there would be no scope for any trade agreement to happen. Therefore, the entire purpose of trade agreements in the standard model is to eliminate the terms-of-trade externality.

In this model however, the politically optimal policies are never politically efficient. So even if governments ignore the terms-of-trade motive, there would still exist scope to negotiate a trade agreement and further reduce trade protection, that arises from the mobilization of exporter interests to lobby more cost-effectively for cutting foreign tariffs rather than obtaining domestic support in the form of export subsidies. If we subtract the politically optimal (PO) policies given by (1.19) and (1.20), divide by τ_{PO} , and compare the resulting expression with (1.17) and (1.18), we conclude that they are never equal i.e. they are never politically efficient.

$$\tau_{PO} - 1 = \frac{y}{a(-m')\pi} \quad (1.19)$$

$$\tau_{PO}^* - 1 = \frac{1}{a^*(1 + \delta)} \frac{y^*}{(-m^{*'})\pi} - \frac{\delta}{(1 + \delta)} \frac{\tau_{PO}^*}{e^*} \quad (1.20)$$

Figure 2 shows graphically the effect of a trade agreement in a vector policy space. In the example given with appropriate parameter choice $x_0 < 1 < x_\delta$, implying that free trade (FT) is the optimal trade agreement. Relative to the non-cooperative equilibrium (NE), the trade agreement lowers the importer's tariff. Compared to the politically optimal policies (PO), the trade agreement lowers tariffs and export subsidies further, owing to the mobilization of exporters to lobby for tariff reductions instead of export subsidies. We can utilize the same graph to analyze the model under the standard Grossman-Helpman assumptions, here denoted by the subscript "GH". In this case, the ray x_0 represents the set of all possible trade agreements, which clearly includes the politically optimal policy PO_{GH} . The conclusion is that once the terms-of-trade motive is eliminated for unilateral trade policies (move from NE_{GH} to PO_{GH}), governments have no incentives to negotiate a trade agreement³².

Now we turn to the resolution of the **terms-of-trade puzzle**, which requires that the exporting country should have no incentive to manipulate its terms-of-trade by implementing export taxes or cutting export subsidies (unless the terms-of-trade motive truly is dominant over the political motive). Formally, this can be formulated as the requirement that the trade agreement policy vector cannot be "north" of Foreign's best response. In the case when $x_0 < 1$, a sufficiently high value for δ would place x_δ in R1, which would imply that free trade is the optimal trade agreement. If the protectionist motive dominates over the terms-of-trade motive in the exporting country when the importing country practices free trade i.e. if $\tau_{BR}^*(\tau = 1) > 1$, then Foreign's best response corre-

³²Agreeing to implement another policy along x_0 does not constitute a qualitatively different trade agreement, but rather represents a welfare transfer from one government to another, which is already fully captured by the transfer payment R.

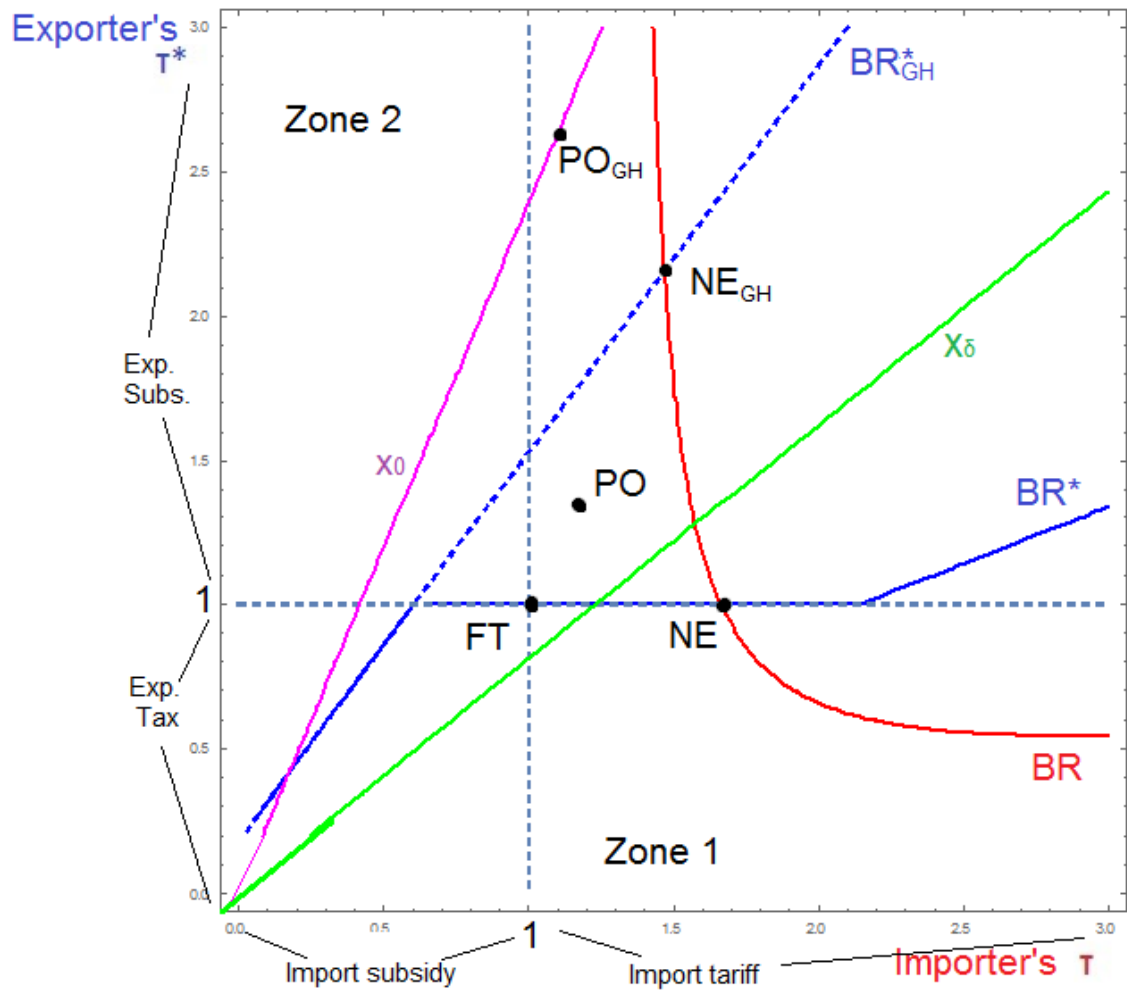


Figure 1.2: Equilibrium trade agreements and politically optimal policies in the original G-H model vs. this model.

spondence would pass right through free trade (1,1), so the requirement would be satisfied. Conversely, if the terms-of-trade motive dominates and $\tau_{BR}^*(\tau = 1) < 1$ (which is very rare in reality) then the trade agreement could and should stipulate provisions limiting the use of export taxes. In the case when $x_0 > 1$, $x_0 \cap R1$ will be the optimal trade agreement, which similarly would call for trade treaty provisions for (incomplete) restriction of export taxes, provided that the terms-of-trade motive heavily dominates in the exporting country s.t. $1 < \frac{\tau}{x_0} < \tau_{BR}^*(\tau)$ for some $\tau \geq 1$.

Inefficient redistribution puzzle

The inefficient redistribution puzzle highlights the fact that governments typically use inefficient policies in order to redistribute income to special interest groups even when other more efficient policies are available. In the context of trade, the puzzle applies to the use of tariffs instead of production subsidies or lump sum transfers³³. I argue in this paper that subsidies (fiscal outlays) incur additional political cost to the incumbent government. This cost may in principle reverse the preference ranking of redistribution policies, favoring more indirect measures such as tariffs and tax cuts over export subsidies, production subsidies and lump sum transfers.

To illustrate the argument analytically, I extend the model from the previous section to also include production subsidies as a possible policy instrument, but for simplicity I restrict it to a small organized import-competing sector that cannot influence its terms-of-trade. If t is the production subsidy and τ the tariff, the prices that the producers and consumers receive are: $p_S = \pi + \tau + t$ and $p_C = \pi + \tau$ respectively. Production subsidies, like all subsidies, incur additional political cost δ as a share of funds received, so the additional political term in the government objective function becomes: $P(\tau, t) = \delta y(p_S)t$. Solving as before, we obtain the first-order conditions for t and τ respectively:

$$t = \left(\frac{1 - \alpha_L - a\delta}{a + \alpha_L + a\delta} \right) \frac{y}{y'} - \left(\frac{a + \alpha_L}{a + \alpha_L + a\delta} \right) \tau \quad (1.21)$$

$$\tau = - \left(\frac{1 - \alpha_L}{a + \alpha_L} \right) \frac{y}{m'} + \left(\frac{a + \alpha_L + a\delta}{a + \alpha_L} \right) \frac{y'}{m'} t \quad (1.22)$$

³³Dixit (1985) lays out the argument about the inefficiency of trade policy as a redistribution mechanism, while Ederington and Minier (2008) confirm the finding in the context of the Grossman-Helpman (1992) model by showing that production subsidies would always be preferred to tariffs or export subsidies.

Thus we can solve explicitly for the two policies, which will be used simultaneously as long as $(1 - \alpha_L)(-d') > a\delta(-m')$:

$$t = \frac{y(1 - \alpha_L)d' - a\delta m'}{y'(a + \alpha_L + a\delta)d'} \quad (1.23)$$

$$\tau = \frac{-a\delta y}{(a + \alpha_L)d'} \quad (1.24)$$

If the political cost of subsidies δ is high enough s.t. $(1 - \alpha_L)(-d') < a\delta(-m')$, then tariffs will be strictly preferred to production subsidies ($t=0$):

$$\tau = -\frac{1 - \alpha_L}{a + \alpha_L} \frac{y}{m'} \quad (1.25)$$

Finally, if $\delta = 0$, then we get the familiar result that only production subsidies will be used as the less inefficient redistribution instrument:

$$t = \frac{1 - \alpha_L}{a + \alpha_L} \frac{y}{y'} \quad (1.26)$$

1.3 Data

In order to test the model we need to exploit variation in exporter support. Export subsidies for industry have been banned by the GATT since its establishment, but agricultural export and production subsidies were unregulated until the entry into force of the Uruguay Round Agreement on Agriculture on January 1st, 1995. Therefore, I use US data on average export subsidies in the period 1986-1990 from the country's notifications

to the WTO during the Uruguay Round negotiations. On the import protection side, I use the ad valorem equivalents of non-tariff measures³⁴ in 1999 at the HS 6-digit level which are not regulated by WTO, as calculated by Kee, Nicita and Olarreaga (2009) using Leamer's (1990) comparative advantage approach. Domestic production support data is available either as AMS (Aggregate Measure of Support) 1986-1988 average from USA's self-reported commitments on agricultural products to WTO, or as PCST (Producer Single Commodity Transfer) 1986-1990 average as calculated by OECD³⁵.

The rest of the data used comes from a variety of sources. Trade flows data from 1991 is from the UN Comtrade database. Agricultural output data from 1990 comes from the FAOSTAT database available online at the UN Food and Agriculture Organization website³⁶. I use Kee, Nicita and Olarreaga's (2008) estimates of import demand elasticities (for the period 1988-2001) at the HS 6-digit level, and Broda, Limao and Weinstein's (2006) export supply elasticity estimates for the period 1994-2003, which are estimated at the HS 4-digit level. Aggregation³⁷ is done at the level of author-defined "food groups" which roughly correspond to HS4-level products, but in some instances were optimally expanded in order to better match the data at hand on export subsidies, as well as the organizational structure of production (for example, milk, dairy, beef and hides were all joined to form cattle farming). Table 6 in the appendix gives a list of the food groups and the HS-codes

³⁴NTM's include price and quantity control measures, technical regulations, monopolistic measures, such as single channel for import, etc.

³⁵For detailed discussion of the differences between these two measures refer to Efland (2011).

³⁶In the few instances when only quantity output data was available, prices were acquired separately and deflated for the appropriate year, so that the gross production value of output could be calculated.

³⁷Aggregation is done using the TRI (Trade Restrictiveness Index) method developed by Anderson and Neary (1994; 2003), which aims to keep the home country welfare constant when aggregating. In the few cases (cattle, poultry and bee-keeping) when export elasticities of major subsectors are missing, we use the simple average method of aggregation.

included in each.

Campaign contributions by PAC's from 1990 obtained by the Center for Responsive Politics were used as a proxy for political organization by sectors³⁸. In empirical estimations of the Grossman-Helpman model the problem of endogenous regressors (import penetration ratio and political organization) arises due to reverse causality, as argued by Trefler (1993), which is alleviated by the choice of appropriate instruments. I instrument for political organization using data on the farm size averages (at sectoral food group level) for total wages paid and total employment obtained from the Quarterly Census of Employment and Wages (1990), as well as average total sales and harvested land area from the Agricultural Census (1992). The Agricultural Census also provides data on the value of capital invested (in terms of machinery, land and buildings) which along with total farmland can be used as an instrument for the import penetration ratio.

The farm averages are independent of the scale of production and are proxies for industry concentration, which is a key determinant of the capacity of agricultural producers to organize³⁹. Generally speaking, politically organized groups may find it easier to lobby against anti-trust regulation which would have a reverse impact on industry concentration. However, this objection carries much less weight in the case of agriculture, because the sector has been exempt from the application of antitrust laws since 1922⁴⁰. On the other hand, total farmland and the value of the capital stock invested in the product sector capture the comparative advantage and therefore are appropriate regressors for the

³⁸Assignment to food groups was based on CRP's own industry classification, as well as Beaulieu and Magee's (2004) PAC-SIC correspondence for campaign contributions by various food industries.

³⁹Trefler (1993b) also argues that industry concentration exogenously determines political organization and suggests several possible regressors.

⁴⁰See Capper-Volstead Act (P.L. 67-146), the Co-operative Marketing Associations Act (7 U.S.C. 291, 292)

import penetration ratio, at least during the short run time span this paper considers.

Because the data comes from a wide variety of sources, merging it is not trivial. For this purpose the following concordance tables were used: HS-SIC-NAICS from Pierce, Schott (2009), FCL-HS from FAOSTAT, HS'07-HS'92 from UN Stats. The HS-SIC and HS-NAICS matchings are based on 1992, the year used in the Agricultural Census data⁴¹. In case of multiple matches for the same HS 6-digit product, each match is associated with a weight (likelihood of match) based on the the number of HS 10-digit product lines associated with that particular HS6-SIC (or HS6-NAICS) match. Similarly, a food group may match to multiple HS 4-digit products, so we define weights based on trade volume (imports plus exports) to be associated with each match. Because of the manageable number of food groups, manual assignment was used whenever possible to improve upon the algorithmic assignment.

1.4 Estimation and results

The basis for structural estimation of the model under a non-cooperative regime is equation (1.11). Rewriting it in terms of elasticities, we'd get:

$$\frac{\tau_i - 1}{\tau_i} = \frac{(\theta_i - \alpha_L) z_i}{a(1 + \delta) + \alpha_L e_i} - \frac{a\delta}{a(1 + \delta) + \alpha_L e_i} \frac{1}{\tau_i} + \frac{1}{\tau_i e_i^*} > 0 \quad (1.27)$$

If the above expression is negative, then the optimal policy according to the model is either free trade as a corner solution, import subsidies or export taxes. Because we don't

⁴¹If a match doesn't exist for 1992, then use matches for the next available year that's closest to 1992.

observe any import subsidies and export taxes in the data, this implies that the model should be estimated using a Tobit regression with a lower boundary of 0.

The political participation index θ_i is usually treated in the literature and in the original Grossman-Helpman (1992) paper as a dummy variable, indicating whether the sector is politically organized or not. Bombardini (2008) and Gawande, Magee (2012) extend the G-H model to provide theoretical micro-foundations for treating θ_i as an index of partial political organization taking values between 0 and 1. In this paper I adopt the latter approach and I define θ_i as follows:

$$\theta_i = \begin{cases} \frac{x_i}{y_i \bar{\chi}} & \text{if } \frac{x_i}{y_i} \leq \bar{\chi} \\ 1 & \text{if } \frac{x_i}{y_i} > \bar{\chi} \end{cases}$$

Here, x_i stands for the campaign contributions donated by sector i , while y_i is its gross output. $\bar{\chi}$ is a cutoff value to be chosen that determines the level of campaign spending above which a sector is considered fully organized and involved in the political process⁴².

In order for the set of instruments used Z to be valid, we need to make sure that they are relevant, which can be inferred from the value of the first-stage F-statistic using the Stock, Yogo (2002) critical values⁴³. The other requirement for instrument validity is that they are exogenous, for which we conduct an overidentifying restrictions test using the Amemiya-Lee-Newey minimum χ^2 statistic.

⁴²The sectors with the highest campaign contributions per dollar of revenue are tobacco and the sugar industry, which are expected to lobby disproportionately more in order to influence regulation connected with the negative externalities associated with these sectors: obesity and smoking-related diseases. Therefore, it would be prudent to set $\bar{\chi}$ below their $\frac{x}{y}$ ratios, for example the ratio of the sector that is third in ranking. I check multiple values of $\bar{\chi}$ for robustness.

⁴³The Stock-Yogo values refer to linear 2SLS regressions, so may not be entirely appropriate as guidelines for non-linear IV structural estimation.

There are two competing approaches for dealing with the terms-of-trade term. We can put it on the left-hand side to merge it with the dependent variable, however in this case we would not be able to conduct an IV Tobit estimation of the model, but only purely OLS as in the standard Grossman-Helpman. The second approach and the one I pursue is to leave the terms-of-trade as a regressor meant to capture market power by specifying a particular functional form. I follow Broda, Limao and Weinstein's (2006) and choose a linear and a log specification⁴⁴. This approach is also advantageous because it will parse out any terms-of-trade motivations in setting trade policy from other considerations of lobbyist influence and political cost.

Formalizing the discussion hitherto, the estimating equations of the model have the following form:

$$\begin{aligned}
\frac{\tau_i^* - 1}{\tau_i^*} &= \beta_0 + \beta_1 \frac{z_i \theta_i}{e_i} + \beta_2 \frac{z_i}{e_i} + \beta_3 \frac{1}{e_i} + \beta_4 f\left(\frac{1}{e_i^*}\right) + \epsilon_i \\
\frac{z_i \theta_i}{e_i} &= \sum_j \gamma_{1j} Z_{ji} + u_{1i} \\
\frac{z_i}{e_i} &= \sum_j \gamma_{2j} Z_{ji} + u_{2i} \tag{1.28} \\
\frac{\tau_i - 1}{\tau_i} &= \begin{cases} \frac{\tau_i^* - 1}{\tau_i^*} & : \text{if } \frac{\tau_i^* - 1}{\tau_i^*} > 0 \\ 0 & : \text{if } \frac{\tau_i^* - 1}{\tau_i^*} \leq 0 \end{cases}
\end{aligned}$$

Note that the underlying theory deals with perfectly competitive sectors which can be ei-

⁴⁴As the authors write: "We use a log specification to minimize the influence of the outliers. The other motive for using the log specification is that the estimation procedure for the elasticities cannot yield non-positive estimates. Thus the distribution of estimates is skewed with positive deviations from the median vastly exceeding negative ones in magnitude. However, the density function of the log of the inverse export elasticity estimates has a pattern quite similar to a normal density plot."

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
z θ /e	0.0230*** (0.00893)		0.0586 (0.0804)	0.0248*** (0.00960)		0.0550 (0.0861)	0.0212** (0.00902)		0.0628 (0.0691)
Pol. Cost	-0.412*** (0.128)	-0.409*** (0.134)	-0.354** (0.160)	-0.446*** (0.138)	-0.446*** (0.144)	-0.392** (0.171)	-0.385*** (0.132)	-0.365*** (0.136)	-0.278* (0.162)
z/e		0.0200** (0.00781)	-0.0344 (0.0751)		0.0218*** (0.00841)	-0.0294 (0.0805)		0.0176** (0.00767)	-0.0419 (0.0642)
ToT (linear)				-0.00819 (0.0154)	-0.00971 (0.0131)	-0.00551 (0.0175)			
Ex. ToT (log)							-0.0253 (0.0899)	-0.0149 (0.0718)	-0.0307 (0.0971)
Im. ToT (log)							0.0800 (0.110)	0.0691 (0.0884)	0.0723 (0.112)
Constant	-0.0916 (0.117)	-0.101 (0.108)	-0.0476 (0.152)	-0.0921 (0.130)	-0.102 (0.119)	-0.0539 (0.163)	-0.0942 (0.131)	-0.0868 (0.114)	-0.0403 (0.146)
a	26		10	22		11	29		11
δ (or $\delta a/(1+a)$)	0.70	0.67	0.58	0.81	0.77	0.68	0.63	0.56	0.41
α	0		0.59	0		0.53	0		0.67
Observations	34	34	34	32	32	32	32	32	32

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.1: IV-Tobit baseline specification; Estimating (1.28) with $\bar{\chi} = 30$ cutoff for the political organization variable.

ther exporting or importing. In reality, each agricultural sectors both exports and imports, even for rather narrowly defined goods. Therefore, as a rule we get two observations out of every sector⁴⁵. We exclude those observations that don't make for "convincing" importing (or exporting) sectors by setting a cutoff for the import (export) penetration ratio $z > 100$.⁴⁶

The results for the baseline specification⁴⁷ are given in Table 1. The set of instruments includes: average sales per firm, average wages paid per firm, harvested land area, value of land and buildings capital per worker and value of machinery capital per worker. They pass the overidentification test for exogeneity⁴⁸ and they can be considered relevant with

⁴⁵In fact, importing and exporting sectors are sometimes demarcated differently due to data availability, so they don't necessarily match one-to-one.

⁴⁶Gawande and Hoekman (2006) use a cutoff of $z > 30$ to eliminate observations, but here that value would exacerbate the low power problem.

⁴⁷In the baseline specification $\bar{\chi} = 30$, which causes the distribution of θ to be centered around 0.7.

⁴⁸p-value=0.9

0.25 maximal bias relative to the OLS estimator at the 5% significance level⁴⁹ The results show that across all specifications the political cost term is negative as predicted by the theory, remains significant and explains a large share of the variation. This is evidence for the existence of additional political cost for fiscal outlays, though it is by no means conclusive, as there could be other models in which own sector elasticity enters the estimating equation. In regressions (1), (4) and (7) we find empirical support for the assumption that firm owners constitute a negligible share of the population ($\alpha_L = 0$). There is also evidence to assume all sectors are fully organized s.t. $\theta_i = 1, \forall i$ (regressions (2), (5) and (8)), but there is no evidence to reject both of these assumptions. Across all specifications, there is no evidence that the terms-of-trade motivation has any effect on trade policy once we control for the political cost term. This finding is in accordance with the practitioners' understanding of international agreements and at odds with the literature which finds such an effect, namely Broda, Limao, Weinstein (2006). However, even when the estimates are insignificant, their signs are in accordance with the theory, so there could be an issue of low power as there are only 32-34 observations.

Table 2 gives the estimates from a simple Tobit regression without instruments. The qualitative findings are very similar to the IV Tobit approach, but the quantitative estimates for all coefficients are significantly lower. Consequently, the implied structural parameters differ as well: δ is 0.1 instead of 0.6-0.8, whereas the weight on social welfare a is five times larger. Therefore, the inclusion of the political cost term reduces the estimate

⁴⁹The first-stage F statistics are 5.82 and 9.35, so they are above the relevant Stock-Yogo critical values. However, if we are interested in the maximal size bias of a 5% Wald test, then the instruments are somewhat "weak", because the critical value is 6.79.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
z θ /e	0.00361** (0.00139)		-0.00777 (0.00580)	0.00339** (0.00136)		-0.00743 (0.00567)	0.00360** (0.00138)		-0.00749 (0.00562)
Pol. Cost	-0.106*** (0.0326)	-0.111*** (0.0318)	-0.109*** (0.0302)	-0.102*** (0.0324)	-0.108*** (0.0316)	-0.107*** (0.0299)	-0.106*** (0.0327)	-0.112*** (0.0317)	-0.110*** (0.0300)
z/e		0.00362*** (0.00121)	0.0104* (0.00524)		0.00342*** (0.00119)	0.00991* (0.00512)		0.00362*** (0.00121)	0.0102* (0.00509)
ToT (linear)				0.000611 (0.00647)	0.000441 (0.00623)	0.000292 (0.00595)			
Ex. ToT (log)							-0.0139 (0.0357)	-0.0148 (0.0342)	-0.0139 (0.0325)
Im. ToT (log)							0.0306 (0.0409)	0.0329 (0.0393)	0.0326 (0.0376)
Constant	-0.0105 (0.0423)	-0.0167 (0.0417)	-0.0239 (0.0411)	0.00460 (0.0418)	-0.00177 (0.0412)	-0.00918 (0.0406)	-0.00249 (0.0430)	-0.00997 (0.0425)	-0.0174 (0.0419)
a	248		-116	265		-122	248		-120
δ (or $\delta a/(1+a)$)	0.12	0.12	0.12	0.11	0.12	0.12	0.12	0.13	0.12
α	0		1.3	0		1.3	0		1.4
Observations	56	56	56	52	52	52	52	52	52

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.2: Tobit (no instruments) specification with $\bar{\chi} = 30$ cutoff for political organization.

for a to values in the low range of what previous studies have found⁵⁰, though a value of 58 is still perplexingly high.

The estimating results might be biased due to the existence of an additional policy instrument, such as production subsidies. The previous literature⁵¹ has treated domestic support as equivalent to non-tariff measures, aggregating them additively in the dependent variable to capture overall protection without any theoretical basis. But as we saw in the theoretical section of this model, allowing for production subsidies leads to a substantially different estimating equation for the non-cooperative case in which tariffs and production subsidies are conditionally dependent on one another. Extending the theoretical model to the large country case, with $p_S = \pi(\tau_i, \tau_i^*, t_i, t_i^*)\tau t$, the first-order condition

⁵⁰Previous studies estimate a from 24 (Eicher-Osang (2002)) all the way to 3175 (Gawange-Bandyopandhyay (2000)).

⁵¹Gawande, Magee (2012), Gawande, Hoekman (2006)

for τ , conditional on the production subsidy t , can be expressed as:

$$\frac{\tau_i - 1}{\tau_i} = \frac{-(\theta_i - \alpha_L)t_i}{a(1 + \delta_r) + \alpha_L} \frac{z_i}{e_i} + \left(\frac{a + \alpha_L + a\delta}{a + \alpha_L + a\delta_r} \right) \frac{z_i e_i^S}{e_i} (t_i - 1) - \frac{a\delta_r - a\delta z_i(t_i - 1)}{a(1 + \delta_r) + \alpha_L} \frac{1}{e_i} + \frac{1}{\tau_i e_i^*} \quad (1.29)$$

Here e_i^S stands for the elasticity of producer supply, for which unfortunately there is no data available, so we proxy for it with the export supply elasticity but aggregate them using gross output shares as weights. Incorporating production subsidies in the estimation changes the political cost term and adds an additional term conditional on production subsidy. The resulting estimating system of equations⁵² is:

$$\begin{aligned} \frac{\tau_i^* - 1}{\tau_i^*} &= \beta_0 + \beta_1 \frac{z_i \theta_i t_i}{e_i} + \beta_2 \frac{z_i t_i}{e_i} + \beta_3 \frac{D_i - z_i(t_i - 1)}{e_i} + \beta_4 \frac{z_i e_i^S(t_i - 1)}{e_i} + \beta_5 f\left(\frac{1}{e_i^*}\right) + \epsilon_i \\ \frac{z_i \theta_i t_i}{e_i} &= \sum_j \gamma_{1j} Z_{ji} + u_{1i} \\ \frac{z_i t_i}{e_i} &= \sum_j \gamma_{2j} Z_{ji} + u_{2i} \end{aligned} \quad (1.30)$$

$$\frac{\tau_i - 1}{\tau_i} = \begin{cases} \frac{\tau_i^* - 1}{\tau_i^*} & : \text{if } \frac{\tau_i^* - 1}{\tau_i^*} > 0 \\ 0 & : \text{if } \frac{\tau_i^* - 1}{\tau_i^*} \leq 0 \end{cases}$$

Table 3 shows the results from the IV-Tobit estimation in (1.30), while the estimation in Table 4 treats all regressors as exogenous. We can conclude that the inclusion of the production subsidy conditional term matters in most specifications, however the sign is opposite of what the theory predicts - rather than being policy substitutes, production

⁵²To minimize degrees of freedom, we impose an approximating restriction: $a(1 + \delta_r) \rightarrow a$, which is very reasonable given the point estimates for a and δ . Nevertheless, we also run specifications with added interaction terms for the third (pol. cost), fourth (conditional) and fifth (ToT) term. The interacting term D_i equals 1 if the sector is exporting, and 0 otherwise.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
zt/e		0.00584 (0.00717)	-0.0725** (0.0317)	-0.0638** (0.0311)	-0.0720** (0.0341)	-0.0722* (0.0372)
zθt/e	0.0105 (0.00869)		0.105*** (0.0391)	0.0965** (0.0376)	0.0999** (0.0420)	0.101** (0.0438)
Pol. Cost	-0.0923 (0.0699)	-0.0610 (0.0658)	-0.190** (0.0932)	-0.107 (0.137)	-0.146 (0.103)	-0.0403 (0.179)
Pol. Cost * D				-0.0818 (0.0741)		-0.0990 (0.0991)
ToT	-0.00521 (0.00521)	-0.00446 (0.00577)	-0.00286 (0.00709)	-0.00476 (0.00670)		
Cond. term	0.0411 (0.0303)	0.0287 (0.0298)	0.0710* (0.0403)	0.0231 (0.0702)	0.0515 (0.0445)	-0.0106 (0.0938)
Ex. ToT (log)					0.00860 (0.0469)	0.00283 (0.0497)
Im. ToT (log)					-0.00689 (0.0520)	-0.0101 (0.0528)
Constant	0.0622 (0.0445)	0.0523 (0.0509)	0.102 (0.0674)	0.0974 (0.0713)	0.0883 (0.0721)	0.101 (0.0829)
a	86		7	9	8	9
δ (or δa/(1+a))	0.10	0.06	0.26	0.13	0.19	0.05
α	0		0.69	0.66	0.72	0.71
Observations	32	32	32	32	32	32

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.3: IV Tobit specification, conditional on production subsidies; Estimating (1.30) with $\bar{\chi} = 30$ cutoff for the political organization variable θ .

subsidies and trade protection measures seem to be policy complements. This is most likely due to omitted variable bias - an omitted factor that increases both trade protectionism and domestic support will result in a positive bias. Or it could also be a problem of mis-measurement, since we proxy for production supply elasticities with export elasticities⁵³. Otherwise, the results are qualitatively and quantitatively similar to those under the baseline specifications (without production subsidies). Most importantly, β_3 is still negative and significant, so political cost matters even after controlling for production subsidies.

⁵³Export supply elasticity is higher than production supply elasticity and to the extent that this measurement error is correlated with the dependent variable, it could bias the coefficient upward.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
z θ t/e	0.00942*** (0.00271)		0.0462*** (0.0169)	0.0468*** (0.0172)	0.0478*** (0.0168)	0.0482*** (0.0170)
zt/e		0.00555*** (0.00185)	-0.0246** (0.0110)	-0.0249** (0.0112)	-0.0253** (0.0109)	-0.0255** (0.0110)
Pol. Cost	-0.0899*** (0.0250)	-0.0663*** (0.0213)	-0.159*** (0.0414)	-0.188** (0.0860)	-0.166*** (0.0417)	-0.191** (0.0850)
Pol. Cost * D				0.0240 (0.0617)		0.0215 (0.0615)
ToT	0.00206 (0.00580)	0.00234 (0.00608)	0.00127 (0.00539)	0.00154 (0.00544)		
Cond. term	0.0415*** (0.0118)	0.0325*** (0.0107)	0.0666*** (0.0170)	0.0829* (0.0457)	0.0698*** (0.0172)	0.0843* (0.0452)
Ex. ToT (log)					-0.0207 (0.0302)	-0.0191 (0.0308)
Im. ToT (log)					0.0330 (0.0351)	0.0344 (0.0355)
Constant	-0.0307 (0.0404)	-0.0364 (0.0426)	0.00154 (0.0381)	-0.000773 (0.0389)	-0.00651 (0.0389)	-0.00820 (0.0395)
a	97		18	17	17	16
δ (or $\delta a/(1+a)$)	0.10	0.07	0.19	0.24	0.21	0.24
α	0		0.53	0.53	0.53	0.53
Observations	52	52	52	52	52	52

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.4: Tobit (no instruments) specification, conditional on production subsidies, with $\bar{\chi} = 30$ cutoff for θ .

Finally, Table 5 shows the results from a traditional IV estimation of the Grossman-Helpman model, which rests on the assumption that $\delta = 0$. Testing for the subsample of import sectors gives results that are quantitatively and qualitatively in accordance with the previous literature. Nevertheless due to low power, the lobbying coefficients are not always significant.⁵⁴ Omitting the political cost term in the estimation renders the terms-of-trade coefficient significant, however its negative sign and small magnitude are contrary to what the theory predicts, so it's unclear how much importance to attach to this finding, if at all any. If we run the estimation for the entire sample of importing and exporting sectors, none of the coefficients are significant.

⁵⁴To increase the power of the test, I exclude harvested farmland from the set of instruments which maximizes the number of observations.

VARIABLES	(1) y	(2) y	(3) y	(4) y	(5) y	(6) y
z/e	0.000436* (0.000228)		0.0106 (0.00992)	0.000513* (0.000277)		-0.00446 (0.0444)
z θ /e		0.000491* (0.000256)	-0.0116 (0.0113)		0.000583* (0.000316)	0.00565 (0.0504)
ToT				-0.00424*** (0.00154)	-0.00421*** (0.00155)	-0.00405* (0.00240)
Constant	0.121*** (0.0305)	0.121*** (0.0308)	0.119*** (0.0294)	0.147*** (0.0316)	0.148*** (0.0316)	0.156* (0.0849)
a		2037	-87		1715	176
α		0	0.91		0	0.79
Observations	30	30	30	28	28	28

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1.5: IV specification, standard Grossman-Helpman model.

I check the robustness of the results from multiple angles. First I consider different cutoffs⁵⁵ $\bar{\chi} \in \{10, 20, 30, 150\}$ for the definition of the political organization variable θ , both as a binary and partial variable between 0 and 1. The political cost coefficient is negative and significant across all IV-Tobit specifications and falls in the range (-0.47,-0.08). As before, there is evidence for the assumptions that either all sectors are organized or that firm owners constitute negligible part of consumers, but no evidence to reject both. Another robustness check pertains to the aggregation approach for the ad-valorem equivalents of the non-tariff measures which determine the dependent variable. Instead place of the TRI method, I use simple averaging, which it turns out doesn't affect the results substantially⁵⁶. Finally, using alternative measures for the agricultural domestic support, whether the OECD's PCST measure or GATT's AMS, also does not affect my

⁵⁵The choice of cutoffs is based on natural breaks in the data.

⁵⁶The point estimates are slightly higher.

conclusions from the estimations that take into account production subsidies.

1.5 Conclusion

In this paper I outlined how the standard model of international agreements that has been in use for over 20 years contradicts both the observed reality and the practitioners' understanding that special interest politics motivate the signing of trade treaties. I showed how adding the assumption of politically costly trade subsidies to the standard model can explain how trade agreements result in the reduction of political protectionism, as opposed to merely preventing terms-of-trade manipulation, and how it resolves three prominent puzzles in the political economy of trade literature. I then tested the empirical predictions of the model on US data on agricultural trade policy and found that the political cost term implied by the assumption is negative and significant across (almost) all specifications.

Understanding correctly the purpose of trade agreements matters not only because it's valuable in itself to have a coherent idea about how the world works, but also because it could well have practical relevance for trade disputes and the trade negotiations process. If trade negotiators for example were to take the standard model seriously, they would have to withdraw from trying to convince their trading partner to reduce tariffs further beyond the elimination of the optimal tariff component. If judges in trade disputes took the standard model seriously, they would be unbothered by a country raising its tariffs to protect a domestic industry as long as the terms-of-trade remained unaffected, because international agreements after all would be designed solely to prevent ToT manipulation. We would have lived in a world with significantly higher levels of trade protection than

the one in which we actually live in. But fortunately practitioners do not take the standard model seriously. To be taken seriously the literature needs to close the gap between theory and reality and I believe this paper contributes to that goal.

Lobbying for International Protection of Intellectual Property

Rights

2.1 Introduction

Starting with the signing of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 1994 under the auspices of WTO, international protection of intellectual property rights has been the topic of a heated debate in academic and policy circles alike. Developing countries argue that it is mostly Western innovative economies that benefit from the high level of intellectual property rights (IPR) protection mandated by the TRIPS at the expense of their poor citizens who pay high monopoly rents to foreign corporations. Faced with this political impasse, high-income countries have more recently turned their efforts to increased integration among themselves, as evidenced by the proposed Trans Pacific Partnership (TPP) and the Transatlantic Trade and Investment Partnership (TTIP)¹. With the globalization of markets, the rise of the innovation economy premised on a strong patent system, and the reduction of tariffs and even non-tariff barriers to near-zero levels, protection of IPR is guaranteed to gain even more in impor-

¹TPP (signed on 4 February 2016) is an agreement among 12 Pacific Rim nations: USA, Canada, Japan, Australia, New Zealand, Chile, Brunei, Singapore, Malaysia, Mexico, Peru and Vietnam. TTIP is a proposed agreement between the US and the EU, still under negotiations at the time of writing this paper.

tance in future trade negotiation agendas.

A crucial question for policymakers is whether cooperation in the area of IPR benefits the world as a whole and how those gains are distributed among the parties involved. The implementation of TRIPS spurred a rich theoretical and empirical literature on the economic implications of strengthening IPR in so called North-South models, where the North is modeled as the high-income country where innovation takes place, while the South only acquires the technologies developed in the North either through imitation or FDI². However, the asymmetric framework of innovators vs. imitators inherent in these models is inappropriate if we want to analyze North-North type IPR agreements, like the TPP and TTIP. Moreover, this literature sets the government's choice of policy to be exogenous, which is suitable for evaluation of the effects of TRIPS, but ideally we would want to endogenize policy choice so as to be able to analyze the outcome of strategic cooperation in a more general sense.

Notable exceptions from this pattern are Edwin L.-C. Lai and Larry D. Qiu, (2003) and Gene M. Grossman and Edwin L.-C. Lai (2004). Both papers model the simultaneous IPR policy choices by trade partners, whose asymmetry arises from different endowments rather than from imposing complete specialization into innovator vs. imitator country. They find that IPR agreements are Pareto-efficient but the winners (the innovation-intensive economies) may need to compensate the less innovation-intensive economies in order to implement the agreement³. This is because cooperation typically results in the

²Depending on the model specifications, these papers arrive at mixed conclusions regarding the effect that strengthening IPR in the South would have on the Southern growth rate and therefore Southern welfare, starting from a non-cooperative equilibrium. For a detailed survey of the literature on North-South models, see Breitwiser and Foster (2012).

³In Grossman and Lai (2004) compensation takes the form of transfer payments, whereas Lai and Qiu

internalization of externalities that countries impose on each other when they are not cooperating. IPR protection in one country benefits all firms, domestic and foreign, that are selling their products in that country and encourages investment in innovation, which in turn benefits both domestic and foreign consumers. The positive effect on foreign consumer surplus and foreign profits is ignored by the domestic country when setting its IPR protection non-cooperatively. It is a positive externality that results in an inefficiently low level of IPR protection. Cooperative agreements eliminate this externality, just as free trade agreements eliminate the terms-of-trade externality (Kyle Bagwell and Robert W. Staiger, 1997). Scholars and policymakers tend to ignore the difference in the source of the externality on the basis that both types of agreements are efficient and conflate them, as evidenced by the fact that a treaty like the TRIPS was on the WTO agenda at all. Similarly, proponents of TPP and TTIP, which concern largely investor property rights, dub them free trade agreements and by extension use well-established anti-protectionist logic to make their case for these treaties⁴.

I show in this paper that the distinction between IPR and free trade agreements is crucial and in the presence of lobbying can overturn traditional results on the benefits of cooperation. In the current literature the closest benchmark we have in order to think about the impact of lobbying on trade agreements is the generalized approach of K. Bagwell and R.W. Staiger (1997, 2009). They analyze the case of two politically motivated governments with two perfectly competitive sectors that lobby for sector-specific import tariffs. They conclude that trade agreements improve global efficiency by mutual reduc-

(2003) focus on market access in the form of lower tariffs for the good that is not patent-intensive.

⁴See Gregory Mankiw "Economists Actually Agree on This: The Wisdom of Free Trade" (April, 2015), The New York Times

tion of tariffs up to a certain level⁵, thereby eliminating the terms-of-trade externality that countries impose on each other when they don't cooperate⁶. Grossman and Helpman (1997) provide micro-foundations for Bagwell-Staiger's reduced form approach, but also allow for export subsidies to be used, which allows pro-export and import-competing lobbies to neutralize each other's influence. The more similar the lobbies are in terms of strength, the more this lobbying inefficiency is neutralized, resulting in efficient trade agreements in the perfectly symmetric case.

Unlike trade agreements on tariffs, I show that cooperation in the form of IPR agreements is not always Pareto-improving. In fact, my model shows that lobbying will necessarily lead to inefficient agreements between countries with organized innovation-driven sectors (North-North agreements), resulting in supra-optimal levels of IPR protection that in some cases could make the world worse off than if countries didn't cooperate at all. Intuitively, the lobbyists' influence always works to push the equilibrium outcome towards more IPR protection, so when countries don't cooperate and IPR protection is inefficiently low, lobbying brings it closer to the efficient level. However, when countries sign agreements to eliminate the externality, the effect of lobbies will be to increase IPR protection beyond the optimal level. The logic of Grossman and Helpman (1997) does not extend to lobbying for IPR protection, because the lobbies' interests, rather than being opposed, are perfectly aligned with one another: because governments cannot discriminate on the

⁵Trade agreements in the standard model can eliminate only the terms-of-trade component of the tariff, but not the "politically optimal" tariff component, which is due to the organized sectors lobbying for protection. In upcoming work, I describe a model in which trade agreements can also reduce the protectionist politically optimal tariffs.

⁶In a similar fashion for the case of imperfect competition, R. Ossa (2010) and J. Brander and B. Spencer (1992) show that trade agreements result in the elimination of tariffs that are due to delocation and profit-extracting externality respectively.

basis of origin⁷, increasing IPR protection in one country will benefit both domestic and foreign firms selling in that market. I also show that international lobbying, the proliferation of multinationals and higher knowledge capital concentration within countries and in countries where lobbies hold a lot of sway over the government can further increase the inefficiency of IPR agreements.

Similar results hold when we analyze the case of IPR agreements in the presence of organized imitation sectors that lobby to counter the influence of the innovation-oriented firms. This type of North-South agreements will be inefficient and supra-optimal under a weak sufficient condition⁸, and like North-North agreements, they will not always be Pareto-improving relative to no cooperation.

My theoretical approach takes the lobbying framework from Grossman and Helpman (1992) and imposes it on the innovation economy model developed by Grossman and Lai (2004) with a few key modifications. Rather than assuming identical firms and an aggregate R&D sector, I consider heterogeneous firms, each with a different capacity to innovate which determines the number of goods that the firm invents every period. Patents, when fully enforced, provide firms with the exclusive right to produce and sell the product during the duration of the patent lifetime.

Lobbies too will be at the firm level, and firms will be allowed to lobby the national government for IP protection policies that affect all firms equally, namely patent en-

⁷The principle of national treatment, a core principle of most international trade treaties including the WTO, states that the state must provide equal treatment to imported and locally produced goods.

⁸The sufficient condition states that the ratio of the government susceptibility to lobbying by imitators in the South relative to that by innovators in the North needs to be smaller than the patent premium under maximum IPR protection. In other words, the asymmetry in terms of political systems should be smaller than the asymmetry in terms of profits between innovators and imitators.

forcement and patent lifetime. Lobbying is modeled as a common agency game where firms post contribution schedules conditional on implementing desired policies, just like in Grossman and Helpman (1992). Conducting the analysis at the firm level, though not consequential for the welfare implications, will allow us to determine the lobbying contribution by each firm thus generating a testable prediction that I show holds in the data, as well as endogenize lobby formation both at the level of in-house firm lobbies and at the level of trade associations, unlike Grossman and Helpman (1992) where sectors were exogeneously assigned lobbies. In Bombardini (2008) lobby formation is also endogenous, but lobbies are allowed to be formed only at the level of industries, which doesn't produce any testable predictions regarding individual firm lobbying contributions nor does it explain why firms sometimes prefer to lobby separately.

The role of lobbying by patent-holders is central for my conclusions, so it is worth taking the time to present some stylized facts to support the claim that corporate lobbying plays a crucial role in international negotiations in reality as well. From January 2012 to February 2014 during the negotiations for TTIP, the proposed trade agreement between the USA and the EU, 597 behind-closed-doors meetings in which TTIP was discussed took place between lobbyists and the EU Trade Commissioner, members of her Cabinet and the director general of DG Trade — almost twice a day on average. Of these, 88% were with business lobbyists⁹. Of course, this statistic captures only a fraction of the full extent of lobbying as there are numerous other EU institutions and national governments where corporations could lobby for particular TTIP provisions. In the US, the data is a lot more transparent because all firms are required by law to report all lobbying expenditures on a

⁹Source: Corporate Europe Observatory

quarterly basis, provided they are above \$12,500. Up until 2016, US companies spent an estimated total of \$507 million on lobbying for TTIP or TTP-related issues.¹⁰ In 2015, the year when lobbying for TTIP/TTP was most intensive, estimated expenditures for this purpose totaled \$148 million, which represents 4.6% of the total lobbying expenditures that year.

The TPP and TTIP are complex pieces of legislation and do not only contain provisions regarding IPR, so not all lobbying for these agreements can be considered as lobbying for IPR. Nevertheless, the final chapter on intellectual property of the TPP contains strong provisions that go beyond the TRIPS-plus aspects that the US had already negotiated on a bilateral basis with countries such as Australia, Chile, and Peru, and affect both scope, length and enforcement of patents, copyrights, trademarks and trade secrets.¹¹ Moreover, legal mechanisms such as the investor-state dispute settlement further strengthen enforcement of the various protections envisioned in the treaty. A simple comparison between the top manufacturing sectors that lobbied for TPP/TTIP as a share of revenue and those with the highest patent premiums¹²(Figure B.3 in the appendix) – namely pharmaceuticals and biotechnology first and foremost, but also machinery, electronics equipment, and chemical manufacturing – reveals a high correlation of 0.74 and provides evidence that IPRs constitute a key concern for lobbyists.

Analysis of targeted lobbying expenditures at the firm level confirms the link between IPR and TPP/TTIP. I find that, controlling for firm size (revenue), firms with larger in-

¹⁰Own calculations from data gathered by the Center for Responsive Politics. Details about the data and the methodology of calculation are given in the Appendix B.1.

¹¹Gina M. Vetere, Marty Hansen, Marney Cheek and Jay Smith "What's New in the TPP's Intellectual Property Chapter", Global Policy Watch

¹²Patent premium is defined as the proportional increment of the value of innovations by patenting them

ternational patent portfolios lobbied more for these agreements during the negotiations phase, as the model predicts. In particular, a 1% increase in the value of the citation-GDP-weighted Pacific patent portfolio is associated with a 0.15% increase in TPP-related lobbying, whereas 1% increase in the value of the citation-GDP-weighted European patent portfolio is associated with a 0.08% increase in TTIP-related lobbying. Though modest, these point estimates are only 3 to 6 times smaller than the coefficient on sales which is considered in the empirical literature to be the best predictor of lobbying expenditures. The estimates are robust to different measures of patent portfolio value. The details about the data can be found in the Appendix B.1 and the results from the regression in Appendix B.2.

The remainder of the paper proceeds as follows: I will first describe the benchmark case for the closed economy to describe and provide the basic intuition about the model. Then I will consider the non-cooperative case of two (or more) countries choosing their policies simultaneously, after the lobbies have posted their contribution schedules. Next I consider the case of cooperation in the form of international patent agreements and analyze the outcome vis-a-vis the non-cooperative and the efficient outcome. I identify the exact parameter range for which the non-cooperative outcome Pareto-dominates the cooperative outcome. Intuitively, the effect of lobbying under no cooperation needs to be strong enough to compensate for the negative effect on IPR due to free riding on the trading partner's strong IP provision.

The model remains tractable without affecting the main conclusions even if we add extensions such as fixed lobbying costs, fixed patenting costs, multiple countries, Cournot competition (imitation sector), and international and collective lobbying. Some of these

extensions are considered as I describe the model, others in separate subsections towards the end.

2.2 Theoretical Model

Innovation

I begin by analyzing the case of a single closed economy, whose insights will then be used in the next sections to address the question of two or more countries in an international setting in the non-cooperative and cooperative case respectively. I start by describing the framework of the innovation-driven economy from Grossman, Lai (2004), but instead of using an aggregate R&D like they do, I impose heterogeneity in the firms' capacity for innovation.

The economy has two sectors: one that is perfectly competitive and produces a homogeneous good and another that is research-intensive and consists of a fixed number of firms, each producing a continuum of differentiated goods. Each differentiated good has a finite lifetime of $\bar{\tau}$ periods. During the good's lifetime, it can be produced and consumed providing utility to consumers, after which the technology "expires" and it cannot be produced anymore. The homogeneous good, by contrast, does not provide utility to consumers and has infinite lifetime.

There are M sophisticated consumers with identical preferences and we assume income is distributed such that each of them is able to consume all available varieties and then consumes the homogeneous good with the remainder of his budget. The number of

sophisticated consumers is exogenous and is a fraction of the total population. This assumption can be justified if we suppose that the differentiated varieties don't provide any utility to a consumer before a certain threshold level of consumption of the homogeneous good is reached. Thus, population size, total income and income distribution together determine the number of sophisticated consumers, which captures market size.¹³

The representative sophisticated consumer maximizes a utility function discounted across time:

$$U(t) = \int_t^\infty u(z)e^{-\rho z} dz \quad (2.1)$$

where $u(z)$ is the z^{th} period utility given by:

$$u(z) = y(z) + \sum_{j=0}^{n(z)} h[x(j, z)] \quad (2.2)$$

Here I denote the consumption of the homogeneous good at time z as $y(z)$, and the consumption of variety j at time z as $x(j, z)$. $n(z)$ is the number of active differentiated varieties whose lifetime hasn't expired by period z . These varieties generate consumer surplus via $h(x)$. We assume that $h'(x) > 0$, $h''(x) < 0$, $h'(0) = \infty$, and $x h''(x)/h'(x) < 1$ for all x , thus ensuring a positive demand for all varieties and finite prices charged by profit-maximizing firms. The consumer's first-order condition (FOC) with respect to consump-

¹³Alternatively, we can suppose that M does reflect population size and every consumer is sophisticated, or rather the varieties are more akin to research-intensive necessities (like pharmaceuticals) than luxury goods. However, in this case M will not vary with total income and any extra income that rich people earn will be spent on consumption of the homogeneous good which does not give any consumer surplus. At the expense of tractability, we could even assume two sectors - one producing luxuries that only consumers with high purchasing power could afford and the other producing necessities that every consumer needs.

tion of variety j gives the individual (inverse) demand:

$$h'[x(j, z)] = p(j, z) \quad (2.3)$$

where $p(j, z)$ is the price of variety j at period z .

On the supply side, goods are invented as a result of each firm's own R&D capacity, represented by a privately owned fixed knowledge capital H_i and its associated R&D function. The number of newly invented varieties by firm i at time t is given by a CES function:

$$\phi_i(t) = F_i(L_{Ri}(t)) = \left(b \left(\frac{L_{Ri}(t)}{l} \right)^{1-\beta} + (1-b)H_i^\beta \right)^{1/\beta} \quad (2.4)$$

Here L_{Ri} represents the amount of labor employed by the firm in R&D and l is the unit labor requirement in the perfectly competitive sector for the production of the homogeneous good. Here we assume $\beta \leq 1/2$ which Grossman and Lai show is a sufficient condition for the second-order condition to hold for any interior FOC solution for the patent policy. We also assume that there is enough labor in the economy to always produce the homogeneous good, so then FOC(y) will set the wage equal to the marginal product of labor, i.e. $w = 1/l$.

Once a good is invented, the firm acquires a patent for it with a duration of $\tau < \bar{\tau}$. During the duration of the patent, every period there is ω chance that the patent holder's exclusive right to sell the product will be enforced.¹⁴ Both τ and ω are policy choice variables to be decided by the government. If the patent is enforced during a given

¹⁴Alternatively, ω can be thought of as the share of the country's territory in which the patent is enforced each period.

period, the firm will operate in a monopolistic regime able to set its price and reap profits. Conversely, there is a $1 - \omega$ chance that the patent won't be enforced and the good will be sold in the competitive regime, where any firm may produce it at a price equal to its marginal cost: $p_c = l w = 1$.¹⁵ After the patent has expired and before the end of the good's lifetime, it is always produced in the competitive regime.

Under the monopolistic regime, profit (per good per consumer) maximization for a monopoly yields:

$$\frac{p(x_m) - l w}{p(x_m)} = -\frac{x_m h''(x_m)}{h'(x_m)} \quad (2.5)$$

where x_m denotes the consumption per consumer this regime. The above equation determines x_m , from where it is straightforward to derive the optimal (variable) profit per consumer $\pi = (p_m - 1)x_m$ and the individual consumer surplus $CS_m = h(x_m) - p_m x_m$. Similarly, in the competitive regime, firms earn zero profits and individual consumer surplus $CS_c = h(x_c) - x_c$, where x_c is the individual consumption under perfect competition pinned down by the inverse demand $h'(x_c) = p_c = 1$.

The labor market equilibrium condition states that the wage has to equal the marginal product of labor in both the manufacturing and the R&D sectors of each firm. If by v we denote the value of the patent, for the R&D sectors (for all i) the equilibrium condition is:

$$w = v F'_i(L_{Ri}) \quad (2.6)$$

¹⁵In the open economy version of the model, the imitator firms may compete with their cheap generic versions from abroad, so even if the country maintains a relatively high level of IPR protection where no domestic firm is allowed to produce a copied product, there could still be smuggled imports that patent enforcement would have to deal with.

The value of the patent v equals the discounted expected profits throughout its duration:

$$v = \frac{\omega M \pi}{\rho} (1 - e^{-\rho \tau}) \equiv M \pi \Omega(\tau, \omega) \quad (2.7)$$

Notice that the value of $\Omega(\tau, \omega)$ fully conveys the effect of government policies (τ, ω) - they matter only insofar they affect the valuation of patents. In this sense patent length and patent enforcement are policy substitutes and only the overall level of IPR protection given by Ω matters.

The equilibrium condition equating national savings S and national investment in R&D ($=w \sum L_{Ri} = w L_R$) gives an expression for total expenditure E on goods as a function of national income I for every period:

$$E = I - S = (w L + \omega n(t) M \pi) - w L_R \quad (2.8)$$

As the derivation hitherto suggests, the equilibria of interest are stationary, in the sense that the rates of innovation ϕ_i are constant over time.

Lobbying

The political economy setup is motivated by the seminal model "Protection for Sale" by Grossman and Helpman (1992). Like the original paper, lobbies offer contribution schedules conditional on different policy outcomes to be implemented by the government. The government, or rather politicians, in turn maximize their own welfare, which is a weighted average of total contributions collected by lobbyists and the aggregate social

welfare. However, instead of exogenously assigning lobbies at the level of industries like Grossman and Helpman (1992), we allow every firm to choose whether or not to lobby for IPR protection and determine its own contribution schedule, subject to a fixed cost of operating its in-house lobby paid in hired labor. Because of this fixed cost, only large enough firms will decide to lobby in equilibrium, which is consistent with what we observe in reality.

The process of lobbying consists of two phases. In the first phase, all firms simultaneously decide whether to lobby and if yes, they submit non-negative contribution schedules $C_i(\Omega)$ to the government: if the government implements policy Ω , the politician will receive $\sum_i C_i(\Omega)$ worth of donations for his election campaign¹⁶. $C_i(\Omega)$ is defined for all feasible Ω . In the second phase, the government chooses policy Ω once and for all by maximizing:

$$G(\Omega) \equiv \sum_{i \in L} C_i(\Omega) + a W(\Omega) \quad (2.9)$$

where a is the weight on the utilitarian social welfare W discounted across time, and L is the set of firms that will decide to lobby in equilibrium.

Notwithstanding any principal-agent considerations, the objective function of the firm's lobby is given by the joint welfare of the firm's owners. We assume that firm i 's owners constitute α_i share of the sophisticated consumers M and contribute δ_i share of total labor employed L . We impose the restriction $\alpha_i < H_i/H$ which reflects the realistic fact that firm ownership is more concentrated than the distribution of consumer surplus

¹⁶Alternatively, this expenditure can be thought of as funds spent on lobbying for the particular policy issue in the firm's favor, whereby money spent translates directly into additive influence on the politician's preferences.

in the economy. Firm i 's owners invest in R&D in firm i in the form of salaries for labor employed in research and hold the patent rights on all inventions that are produced as a result. Thus, like in reality, ownership is pre-requisite for investment, or conversely investment is means to ownership (equity finance). We assume that any individual can be (partial) owner of at most one firm. So whatever money is not re-invested in firm i by its owners must be money spent on purchasing goods: $E_i = \Pi_i + \delta_i w L - w L_{Ri}$, where Π_i is the joint profit earned by firm i 's owners. Under these assumptions, the lobby discounted welfare of firm i at time $t=0$ is given by:

$$W_i(\Omega, t = 0) = PDV_0(E_i(\Omega) + \alpha_i CS(\Omega)) + \Lambda_i^0 \quad (2.10)$$

In equation (2.10), PDV_0 is an operator expressing the present (at time $t=0$) discounted value of the terms in brackets: firm i 's owners' expenditure on goods and their consumer surplus (as α_i share of overall consumer surplus CS), whereas Λ_i^0 denotes the welfare to be derived from patents that had been invented before time 0. By assumption, patent protection decided at $t=0$ applies only to patents awarded after this time. For goods invented beforehand, whatever IPR protection was in effect at the time of invention is applicable. For this reason, Λ_i^0 is a separate term independent of Ω and will not affect the optimization problem. Without loss of generality, we can also assume that firm owners are pure capital owners and don't provide any labor i.e. $\delta_i=0$, because it won't affect optimization.

Counting only the goods invented after $t=0$, in each period we calculate the number of goods that will be sold under a monopolistic regime (thus yielding π and CS_m to owners), and the number of goods sold under competitive regime (yielding CS_c to owners), and

then discount them across time applying (2.1). Substituting these results in (2.10), we get:

$$W_i(\Omega, 0) = \frac{\pi M \Omega \phi_i(\Omega)}{\rho} - \frac{w L_{Ri}(\Omega)}{\rho} + \frac{\alpha_i M \Omega \phi(\Omega)}{\rho} \left(C S_m + C S_c \frac{\bar{T} - \Omega}{\Omega} \right) + \Lambda_i^0 \quad (2.11)$$

Here, I define \bar{T} to be a discounting factor for the product lifetime equal to $\frac{1-e^{-\rho\tau}}{\rho}$.

Similarly, we calculate society's welfare at time t=0 by adding up all expenditures on goods and the consumer surplus they generate, and by counting and discounting goods just like for the individual firm's lobby.

$$W(\Omega, 0) = \Lambda^0 + \frac{w(L - L_R(\Omega))}{\rho} + \frac{M \Omega \phi(\Omega)}{\rho} \left(\pi + C S_m + C S_c \frac{\bar{T} - \Omega}{\Omega} \right) \quad (2.12)$$

To find the subgame perfect Nash equilibrium of this two-stage game, I follow the approach of Grossman and Helpman and apply Bernheim, Whinston (1986) theorem, which states the optimization conditions that support the SPNE equilibrium¹⁷. Assuming that the contribution schedules are differentiable at the optimum, it follows that $C'_i(\Omega_o) = W'_i(\Omega_o)$, which is known as local truthfulness. Substituting this result in the first order condition for (2.9), we get the expression:

$$\sum_{i \in L} W'_i(\Omega_o) + a W'(\Omega_o) = 0 \quad (2.13)$$

I substitute (2.11) and (2.12) in (2.13), take the derivatives with respect to Ω and

¹⁷The theorem states that $\{\{C_i(\cdot)\}_i, \Omega_o\}$ is SPNE iff:

1°. $C_i(\Omega)$ are feasible $\forall i$

2°. Ω_o maximizes the government objective function $G(\Omega)$

3°. Ω_o maximizes the joint gov+lobby objective function $G(\Omega) + (W_i(\Omega) - C_i(\Omega)) \forall i$

4°. $\forall i \exists \Omega_i$, such that it maximizes $G(\Omega) - C_i(\Omega)$

substitute the following expressions: $w = v F'_i(L_{Ri})$, $\frac{\partial v}{\partial \Omega} = M\pi$ and $\frac{\partial \phi_i}{\partial v} = \left(\frac{-(F'_i(L_{Ri}))^2}{F_i(L_{Ri}) F''_i(L_{Ri})} \right) \frac{\phi_i}{v} \equiv \gamma(\Omega) \frac{\phi_i}{v}$.¹⁸ Rearranging the result gives us the following implicit formula for the optimal IPR protection:

$$CS_c - CS_m - \pi \frac{\zeta + a}{\alpha_L + a} = \gamma(\Omega) \left(CS_m + CS_c \frac{\bar{T} - \Omega}{\Omega} \right) \quad (2.14)$$

Here ζ is defined as the share of firms in terms of knowledge capital that are lobbying in equilibrium¹⁹. α_L is the share of sophisticated consumers comprised of the owners of lobbying firms. The variable $\gamma(\Omega)$ measures the responsiveness of innovation to IPR protection and under our CES assumption for R&D it is equal to $\frac{b}{(1-b)(1-\beta)} \left(\frac{L_{Ri}}{l H_i} \right)^\beta$, but it can be shown it is invariant across firms.

The optimization condition (2.14) reflects the fact that the government chooses the policy that balances between the static cost (dead-weight-loss) from a marginal increase in IPR on the left-hand side and the dynamic benefits of higher research output on the right-hand side. Grossman, Lai (2004) show in their appendix that if $\beta \leq 1/2$ then the right-hand side is decreasing in Ω , so the second-order condition holds globally, which guarantees that the interior solution given by (2.14) is unique and is a (global) maximum. Simplifying even further, if we assume that $\beta = 0$ (the Cobb-Douglas case), $\gamma = b/(1-b)$ becomes independent of Ω and M, and consequently, the optimal Ω is not affected by the size of the market M.

¹⁸This last derivative we obtain by differentiating (2.6) with respect to v and substituting it in $\frac{\partial \phi_i}{\partial v} = F'_i(L_{Ri}) \frac{\partial L_{Ri}}{\partial v}$

¹⁹In fact, the derivation gives a different ratio - the share of new innovation coming from lobbying firms: $\frac{\sum_{i \in L} \phi_i}{\phi}$, but it can be shown that if the R&D function is CES as we assumed, that ratio also equals the share of knowledge capital owned by lobbying firms: $\frac{\sum_{i \in L} H_i}{H}$.

In order to fully characterize the equilibrium, we also need the set of firms that will be lobbying which is also endogenous. In general, multiple subgame perfect Nash equilibria can exist, some of which may be inefficient. As in Bernheim and Whinston (1986) we restrict our focus on truthful equilibria, which arise when the contribution payment functions C_i are globally truthful. A truthful contribution is a feasible (non-negative) contribution schedule that mirrors the curvature of the lobby's utility. The lobby will get the same payment net of fixed lobby costs f for all policies Ω that induce positive contributions $C_i > 0$. Thus, deciding the contribution schedule boils down to deciding by what scalar $B_i > 0$ the lobby wants to shift its utility. Mathematically, the truthful contributions can be written as:

$$C_i(\Omega) = \max\{W_i(\Omega) - B_i, 0\} \quad (2.15)$$

Focusing on truthful equilibria is less restrictive than it may seem. As Whinston and Bernheim show, the set of best-response strategies to *any* strategies played by the other lobbies contains a truthful contribution function, thus the lobby incurs no cost from playing a globally truthful strategy. Second, truthful equilibria implement Pareto-efficient outcomes. Third, only truthful equilibria are stable to non-binding communication among the players (i.e. they are "coalition proof").

In equilibrium, lobby i will have increased the scalar B_i until the government is indifferent (or rather marginally prefers) between choosing the optimal policy Ω_o and another policy Ω_{-i} that the government would choose when lobby i would contribute 0, taking all other lobbies' equilibrium contributions as given. Thus the lobby wishes to reduce its

contribution as much as possible without inducing the government to deviate to another policy that it considers inferior. We can use the government indifference condition to back out the scalars B_i for all i .

$$B_i = a(W(\Omega_o) - W(\Omega_{-i})) - \sum_{j \in L, j \neq i} W_j(\Omega_{-i}) + \sum_{j \in L} W_j(\Omega_o) \quad (2.16)$$

Finally, for all lobbies that contribute a positive amount as opposed to not lobbying at all, the following inequality that reflects this preference has to hold in equilibrium as well:

$$W_i(\Omega_{-i}) < B_i - f \quad (2.17)$$

Figure 1 depicts this equilibrium graphically for two firms. The curves $G_i G_i$ representing different combinations of policy Ω and payment C_i are indifference curves for the government when the contribution schedule of the other firm is taken as given by lobby i . If lobby i makes no contributions (corresponding to the x axis), the government will maximize its utility by choosing Ω_{-i} . But the optimal policy Ω_o must also lie on this curve because of the government indifference condition discussed earlier. This is the condition that pins down the scalar B_i . The truthful contribution schedule is given by the positive portion of the $C_i(\Omega) - B_i$ curve (and it equals zero for negative values), so the government will maximize its utility at Ω_o , the point where $C_i(\Omega)$ is tangent to the government indifference curve $G_i G_i$. Because the government indifference curve is given by $C_i(\Omega) = \text{const} - (W(\Omega) + \sum_{j \in L, j \neq i} C_j(\Omega))$, equation (2.13) guarantees that the tangency condition holds for all $i \in L$. Notice also that the positive portion of the truthful

contribution schedule is an indifference curve for the lobby (because it guarantees the same utility $B_i - f$), so in other words the lobby has chosen a contribution schedule that maximizes its utility subject to keeping the government away from deviating. Finally, condition (2.17) which determines whether the firm will set up an in-house lobby is met only if the distance $d_i \equiv |W_i(\Omega_{-i}) - B_i|$ is larger than the fixed cost f .

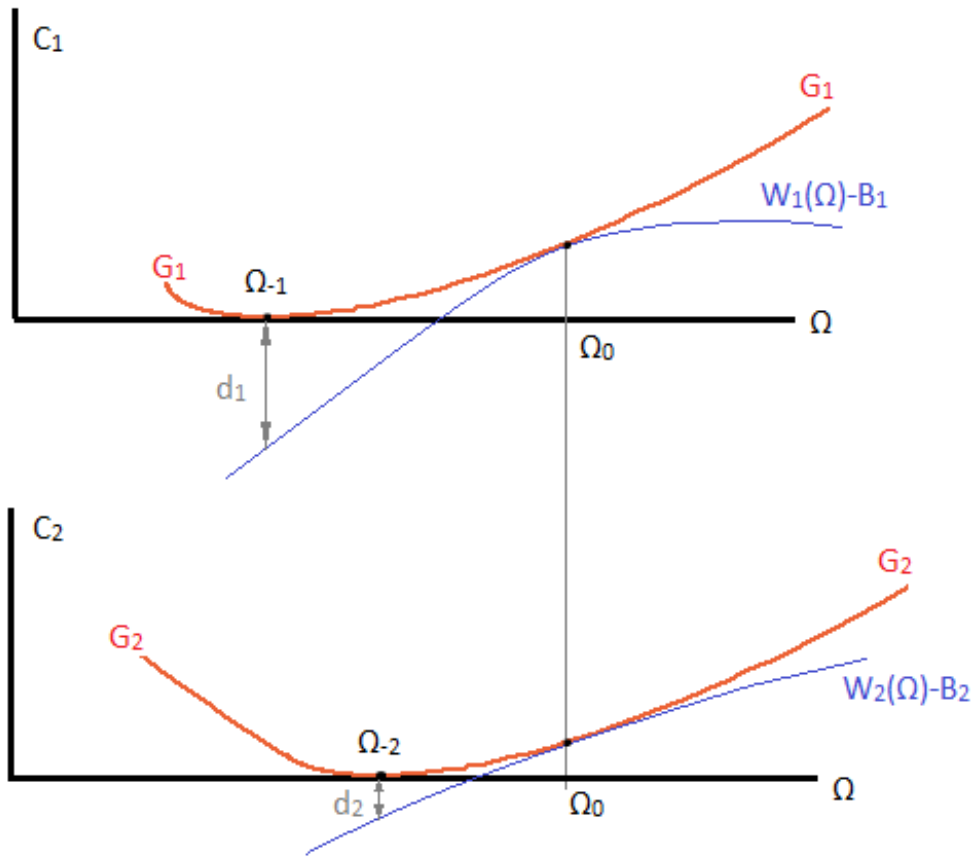


Figure 2.1: Contribution schedule equilibrium for two firms

It can be shown that d_i is monotonically increasing in H_i as expected²⁰: Larger firms are more likely to establish in-house lobbies. It follows from this that if condition (2.17) fails for a firm with knowledge capital H_i then it must also fail for all smaller firms. In

²⁰See Appendix A.1 for proof.

equilibrium, there will be a cutoff \bar{H} below which firms will find it too costly to establish lobbies. Unfortunately there is no explicit condition that pins down this cutoff, because it will depend among other things on the distribution of knowledge capital among the different firms. However, it can be easily found by backward reasoning: starting from a candidate equilibrium in which all firms lobby, we check if (2.17) holds for all $i \in L$ as assumed. If not, we discard the smallest firm from the set of lobbying firms until the assumption is met, thus producing the set of lobbying firms in equilibrium, since no firm has incentive to drop out nor to start lobbying.

If the fixed costs of lobbying are zero, all firms will lobby in equilibrium ($\zeta = 1$) and the resulting level of protection will be independent of the concentration of capital or whether they are organized in separate lobbies or a single trade association²¹. This assumption, though somewhat unrealistic, makes finding the equilibrium more straightforward and does not affect the conclusions of the paper regarding welfare. Nevertheless, once fixed costs of lobbying are introduced, capital concentration starts to matter for the optimal policy because ζ is affected by the fixed cost. An industry with a low capital concentration will have many small firms unwilling to lobby, therefore producing a lower level of IPR protection Ω_o . On the other hand, organizing into a single industry-wide lobby will offer a major cost-saving advantage of paying the fixed cost only once, so smaller firms will now participate in the lobbying effort and the resulting policy Ω_o will be as high as in the case of zero fixed costs ($\zeta = 1$). Thus we can explain industry-wide lobby forma-

²¹Curiously enough, simulations show that when capital is more concentrated (or when lobbying is conducted through an industry-wide association), the total contributions that the government receives are higher than if capital was less concentrated into a higher number of smaller firms. This might be one reason why firms prefer to lobby separately.

tion endogenously: firms will choose to lobby together when the cost savings achieved through lower fixed lobbying costs outweigh the increase in firm contributions that joint lobbying entails (see footnote) net of any coordination costs.

In the existing literature, firms are believed to lobby individually typically on policies that differentially affect them compared to other competitors, whereas when it comes to policies affecting all firms equally they tend to free ride on the lobbying efforts of larger competitors or decide to lobby through trade associations. Thus, if an industry is highly concentrated it should be able to overcome the free riding problem and form a trade association to collectively lobby the government²². In this model, capital concentration will affect the level of IPR protection only insofar it determines which firms are profitable enough to afford an in-house lobby department, and has nothing to do with collective action failure.

Notice that even though the interests of the firms are perfectly aligned, free riding is not an issue in this model, because firms' lobbying efforts are complementary to one another. As in all common agency games, lobbies are able to devise their contribution schedules such that each firm will want to contribute funds and induce the government to increase IPR protection further, given what other firms have already contributed. The only reason why it might decide not to lobby is because the fixed cost of setting up a lobby might be too prohibitive. M. Bombardini (2008) also shows that in the presence of fixed lobbying costs high capital concentration results in more lobbying and therefore more protection, however she analyzes the individual incentives of firms to participate in the joint lobbying effort without allowing them to lobby separately and assumes that

²²Olson (1971), Bergstrom et al. (1986), Gawande (1997), Bombardini (2012)

all firms have to pay a fixed cost in order to join the industry lobby, so there is no cost-saving advantage. But if industry-wide lobbies are less cost-effective and there is no free rider problem that they could help solve, then firms would choose to lobby separately if allowed.

How does the equilibrium level of IPR protection Ω_o compare to the efficient level Ω_{eff} that prevails when there is no lobbying? Setting $a \rightarrow \infty$ in (2.14), equivalent to the government putting all weight on social welfare and none on lobby contributions, would give the first-order condition for Ω_{eff} , which differs from (2.14) in that the lobbying term $\frac{\zeta+a}{\alpha_L+a} \equiv \theta$ disappears, yielding the result of Grossman and Lai (2004). Notice that because $\alpha_i > H_i/H$ by assumption, $\zeta > \alpha_L$ and therefore $\theta > 1$. Because the right-hand side of (2.14) is decreasing in Ω and the lobbying term shifts down only the left-hand side, we can conclude that:

Proposition 1: Lobbying in a closed economy causes patent protection to be above the welfare-maximizing level Ω_{eff} .

Moreover, the higher the share of α_L consumers that lobbying firm owners represent, the more they internalize the dead-weight loss resulting from their lobbying activities, and the closer is Ω_o to the efficient level.

Global regime: non-cooperative case

In this section, I extend the closed economy model to the non-cooperative case of two countries: USA (U) and EU (E), both with identical preferences, identical R&D innovation functions and identical lifetime of goods $\bar{\tau}$. The countries differ by their market size

M, their labor endowments L, the unit labor requirements l , as well as the total stock and distribution of knowledge capital H, which would result with different levels of IPR protection in autarky.

Consistent with how the real world works, We assume equal national treatment of patent applicants: A country affords the same patent protection to all patented goods sold within its borders regardless of their national origin. If there are no costs to patenting, firms will always apply for a patent to sell in both countries irrelevant of where the good was produced, so the value of all patents will be given similarly as in (7):

$$v = \pi(M_E\Omega_E + M_U\Omega_U) \quad (2.18)$$

As long as the homogeneous good is produced in both countries, the costs of production will be the same: $l_Uw_U = l_Ew_E = 1$, so location of production is irrelevant as well. It will be possible for firms to separate the innovation process from the production process and outsource production abroad (so trade costs won't play a role).

The lobbying process is conducted in two phases as before. In the first phase, all firms set their contribution schedules simultaneously. In the second phase, each government simultaneously decides the optimal Ω_U or Ω_E taking the other as given. Following Grossman, Helpman (1997), I assume that firms can only lobby their own domestic government for policies and that they don't know the contribution schedule of the lobbies abroad. Therefore, they will be able to condition their strategies only on the policy outcome in the other country. Similarly, assume that the domestic government doesn't know the foreign contribution schedules and vice-versa, therefore lobbies don't set their contri-

bution schedules strategically with respect to the foreign government's decision. With these assumptions in place, we can define the Nash equilibrium for the non-cooperative two countries scenario as follows:

Definition 1: A Nash Equilibrium consists of two sets of contribution schedules $\{C_{U,i}^*(\Omega_U, \Omega_E)\}_i$ and $\{C_{E,i}^*(\Omega_E, \Omega_U)\}_i$, and a policy vector $[\Omega_U^*, \Omega_E^*]$ such that for each $J \in \{U, E\}$:

1. Ω_J^* maximizes the objective function $\sum_{i \in L_J} C_{J,i}^*(\Omega_U, \Omega_E) + a_J W_J(\Omega_U, \Omega_E)$, taking the other country's Ω_{-J}^* as given.
2. For every lobby i there is no other feasible alternative function $C_{J,i}^A$ and policy Ω_J^A that would give the lobby a strictly higher welfare, whereby Ω_J^A is the optimal response by government J , taking the other country's Ω_{-J}^* as given.

Like for the case of the closed economy, the Bornheim-Whinston theorem applies and yields the first-order condition:

$$\sum_{i \in L_J} \frac{\partial W_{J,i}(\Omega_U, \Omega_E)}{\partial \Omega_J} + a_J \frac{\partial W_J(\Omega_U, \Omega_E)}{\partial \Omega_J} = 0 \quad (2.19)$$

Proceeding as before (counting goods, discounting, substituting partial derivatives and rearranging), we get expressions for the best response functions:

$$CS_c - CS_m - \pi \mu_J \frac{\zeta_J + a_J}{\alpha_J + a_J} = \gamma(\Omega_U, \Omega_E) \frac{M_J \Omega_J}{M_U \Omega_U + M_E \Omega_E} \left(CS_m + CS_c \frac{\bar{T} - \Omega_J}{\Omega_J} \right) \quad (2.20)$$

Here, γ is the same for both countries (because the R&D functions have identical CES specification), whereas I define μ_J as the share of innovation taking place in country J ,

which can be shown equals the share of knowledge capital that is found there: $\mu_J \equiv \frac{\phi_J}{\phi_S + \phi_N} = \frac{H_J}{H_S + H_N}$. We also define ν_J as the market weighted share of IPR protection in country J: $\frac{M_J \Omega_J}{M_U \Omega_U + M_E \Omega_E}$.

Comparing (2.14) and (2.20), it can be concluded that ceteris paribus countries lower their IPR protection levels after opening up to trade, conditional on maintaining the same set of lobbyists²³. Just as Grossman and Lai (2004) show, liberalization worsens IPR protection because countries benefit from each other's R&D, so they have incentive to free ride and invest less in domestic innovation. But the presence of lobbying mitigates this incentive through two channels. First, the existence of the lobbying term $\frac{\zeta_J + a_J}{\alpha_J + a_J} \equiv \theta_J$ causes higher levels of patent protection in that country compared to no lobbying, holding foreign patent policy constant. And second, opening up may intensify lobbying further, because firms that didn't lobby under autarky because the fixed costs were too high may now find it profitable to do so because the value of their patents will have increased by being able to sell in both markets.

The Nash equilibrium will also be affected by lobbying. Limiting the analysis to the linear case when the innovation functions are Cobb-Douglas ($\beta=0$), we get explicit linear expressions for the best response functions given in (2.20)²⁴. The linear best response functions will be decreasing in the other player's policy as long as the IPR protection policy doesn't exceed the lifetime of the product $\Omega < \bar{T}$, so the levels of protection in each country are strategic substitutes. The Nash equilibrium in this case is given by their

²³This effect can be immediately seen by noticing that in equilibrium the right-hand side of (2.20) which is decreasing in Ω_J is further decreased by ν_J compared to (2.14), whereas the left-hand side constant is shifted up by μ_J .

intersecting point. As discussed, an increase in the lobbying term θ_J (the presence of lobbying) would push the best response function of country J outward, thus leading to a new Nash equilibrium whereby the IPR protection in country J increases, but it decreases in the trading partner. Intuitively, foreigners free-ride on domestic lobbying efforts to strengthen patent protection.

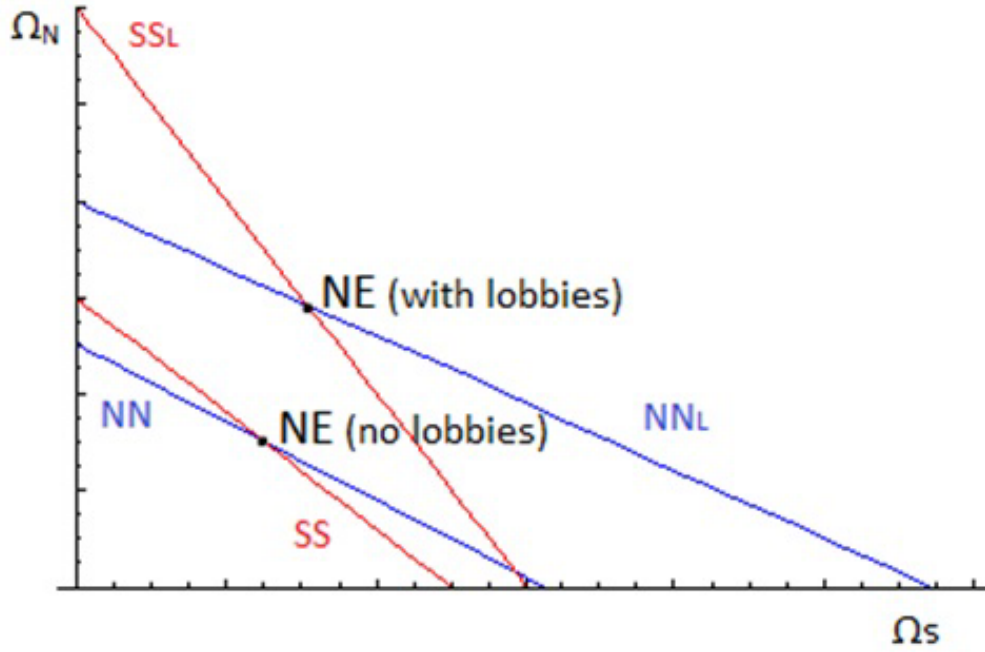


Figure 2.2: The effect of lobbying on the non-cooperative Nash equilibrium (NE): The colored lines (SS and NN) represent the best responses of each government in the policy space $\Omega_N \cdot \Omega_S$

If both θ_E and θ_U increase (evaluate the effect of lobbies in both countries simultane-

²⁴The explicit best response function for the US is:

$$\Omega_U = \frac{\gamma CS_c \bar{T}}{(1 + \gamma)(CS_c - CS_m) - \theta_U \pi \mu_U} + \Omega_E \frac{-(CS_c - CS_m - \pi \theta_U \mu_U)}{(1 + \gamma)(CS_c - CS_m) - \pi \theta_U \mu_U} \frac{M_E}{M_U} \quad (2.21)$$

For the EU:

$$\Omega_U = \frac{\gamma CS_c \bar{T}}{(CS_c - CS_m) - \theta_E \pi \mu_E} \frac{M_E}{M_U} + \Omega_E \frac{-((CS_c - CS_m)(1 + \gamma) - \pi \theta_E \mu_E)}{(CS_c - CS_m) - \pi \theta_E \mu_E} \frac{M_E}{M_U} \quad (2.22)$$

ously), we can derive a sufficient condition for the direction of change of NE policies. The joint effect of lobbying under no cooperation is represented graphically in Figure 2.

Proposition 2: For the Cobb-Douglas case, if $\Delta\theta_U\mu_U/M_U > \Delta\theta_E\mu_E/M_E$ then Ω_U^* must increase. If the opposite is true, then Ω_E^* must increase²⁵.

Another sufficient condition, analogous to the one Grossman and Lai derive, can be used to explain differing levels of IPR protection.

Proposition 3: If $M_U > M_E$ and $\mu_U\theta_U > \mu_E\theta_E$, then $\Omega_U^* > \Omega_E^*$.²⁶

So knowledge capital stock and market size of sophisticated consumers determine which country will get a higher level of IPR protection in equilibrium, but the political system can magnify these asymmetries. The US may have higher level of protection (also because US government is more susceptible to lobbying (low a_U), or because US society is highly unequal so US patent holders constitute a low percent of sophisticated consumers (low α_U), or because capital is more concentrated so higher share of firms participate in lobbying (high ζ_U).

Grossman and Lai (2004) show that the Nash equilibrium level of IPR protection in the world is always sub-optimal from a global social planner's perspective. With lobbying that doesn't have to be the case, because lobbies push the NE in the direction of the efficient frontier, which consists of all linear combinations that maximize global welfare $[\Omega_E, \Omega_U]$ s.t. $M_E\Omega_E + M_U\Omega_U = \Omega_{eff} \equiv \text{argmax}\{W_E(\Omega) + W_U(\Omega)\}$. Solving this optimization

²⁵The proof of Proposition 2 can be found in Appendix A.2.

²⁶The proof of this proposition is the same as in Grossman, Lai (2004), just replacing $\mu_J\theta_J$ for μ_U .

problem as before yields an expression for the efficient world level of IPR protection Ω_{eff} :

$$CS_c - CS_m - \pi = \gamma(\Omega_{eff}) \left(CS_m + CS_c \frac{M\bar{T} - \Omega_{eff}}{\Omega_{eff}} \right) \quad (2.23)$$

Whether the NE will be above or below the efficient global level of IPR protection will depend in general on the number of countries and active lobbies. If we restrict the choice of parameters to Nash equilibria that are interior solutions, i.e. all governments impose at least some IPR protection in the non-cooperative case, then:

Proposition 4: The NE world level of protection $\Omega_{NE} \equiv \sum M_j \Omega_j^*$ will be above the efficient level Ω_{eff} iff $\pi(\bar{\theta} - 1) > (CS_c - CS_m)(J - 1)$, where $\bar{\theta} \equiv \sum \theta_j \mu_j$ is the R&D-weighted average lobbying constant and J is the number of countries.

Proof: We sum up the first-order conditions (2.20) for all J countries to get:

$$J(CS_c - CS_m) - \pi\bar{\theta} = \gamma(\Omega_{NE}) \left(CS_m + CS_c \frac{M\bar{T} - \Omega_{NE}}{\Omega_{NE}} \right) \quad (2.24)$$

Comparing the expression for Ω_{NE} with the expression for Ω_{eff} from (2.23), notice that the right-hand sides are identical. So $\Omega_{NE} > \Omega_{eff}$ is true iff $\pi(\bar{\theta} - 1) > (CS_c - CS_m)(J - 1)$, or equivalently iff $\bar{\theta} > J + (J + 1)DWL/\pi$. QED

The more countries there are, the higher the externality due to free-riding, so the less likely it is for Ω_{NE} to overshoot the efficient level. The term DWL/π captures the extent to which society loses from IPR protection relative to the gain that patent holders get. If lobbying is strong enough and the loss to society small enough such that governments are susceptible to lobbying, then there will be over-protection of IPR at the global level. Then

lobbying will not only compensate for the free-riding externality that countries impose on each other in a non-cooperative environment, but it will in fact overshoot the world efficient level, so a Pareto-efficient agreement about IPR would have to lower global IPR protection and counter the influence of lobbies.

Global regime: cooperative IPR agreements

In this section I apply the model to the case of cooperative agreements between 2 countries regarding IPR protection. Cooperative agreements involve binding agreements whereby parties are allowed to compensate each other with transfer payments conditional on implementing the agreed policies.²⁷ In the context of the IPR lobbying model discussed, the parties are the politicians in each country that are maximizing their objective functions which consist of the weighted social welfare, the contributions from the domestic lobbies and the transfer payment received from the trading partner. Therefore, a cooperative agreement will not yield an efficient outcome whereby world social welfare is maximized, but rather a politically efficient outcome, which is defined as follows.

Definition 2: A politically efficient (PE) bargaining outcome is:

$$[\Omega_U, \Omega_E]_{PE} = \operatorname{argmax} \Gamma \equiv a_U G_E(\Omega_U, \Omega_E) + a_E G_U(\Omega_U, \Omega_E) \quad (2.25)$$

where $G_J \equiv \sum_{i \in L_J} C_i + a_J(W_J + R)$ for $J \in \{U, E\}$.²⁸

²⁷The compensatory payments do not have to be monetary in nature and can generally include concessions in any zero-sum policy area of interest to the signatory parties. For example, Lai and Qiu (2003) model this compensation in terms of market access for developing countries that export less research-intensive goods.

²⁸The reason (proof) for why definition 2 conforms with the concept of a cooperative agreement in an

We assume initially that firm owners constitute a negligent percent of sophisticated consumers, so $\alpha_E = \alpha_U = 0$. This will simplify the analytics of finding the equilibrium bargaining outcome, because it implies that the lobbying contribution strategies do not have to be conditioned on transfers R (since society's welfare which includes R will not enter the firm's objective function). Later we can relax this assumption once we have shown that any transfer payment can be replicated by choosing the appropriate vector of policies, holding Γ constant. Proceeding from definition 2, we introduce the definition for cooperative agreements on IPR:

Definition 3: An equilibrium IPR agreement is a set of contribution schedules $\{C_{U,i}^*(\Omega_U, \Omega_E)\}_i$ and $\{C_{E,i}^*(\Omega_E, \Omega_U)\}_i$, and a policy vector $[\Omega_E^*, \Omega_U^*]$ such that for each country $J \in \{E, U\}$:

1. $[\Omega_E^*, \Omega_U^*]$ maximizes Γ^* , constructed using the sets of equilibrium contributions
2. For every lobby i there is no other feasible alternative function $C_{J,i}^A$ and policy vector $[\Omega_E^A, \Omega_U^A]$ that would give the lobby a strictly higher welfare, whereby $[\Omega_E^A, \Omega_U^A]$ maximizes Γ_i^A , constructed using $C_{J,i}^A$ for the contribution of lobby i and equilibrium contributions (marked by *) for all other firm lobbies.

Comparing this definition with the benchmark scenario of a closed economy, we can see that the politically efficient bargaining outcome is analogous to the case of a single world government that decides on a two-dimensional policy vector by maximizing its objective function Γ , which consists of appropriately weighted social welfares and contri-

international setting as defined in the preceding paragraph is elaborated in Appendix A.3. The proof basically shows that if the agreed upon policy vector doesn't maximize Γ . we can construct transfer payment R such that politicians in both countries gain by switching to $\text{argmax } \Gamma$.

butions from all firm lobbies. Therefore, the approach to solving this problem is analogous to the approach of finding optimal policy in a closed economy discussed in the previous section, only taking into account the different weighting factors. Thus, assuming differentiability around the optimum and taking all steps as before, we write the first-order condition for the maximization problem in vector form²⁹:

$$a_U \sum_{i \in L_E} \nabla W_{E,i} + a_E \sum_{i \in L_U} \nabla W_{U,i} + a_U a_E (\nabla W_E + \nabla W_U) = 0 \quad (2.26)$$

Substituting the derivative expressions as before and rearranging, we get the two first-order conditions for the optimal policy vector, which are identical due to the symmetry inherent in the objective function Γ :

$$CS_c - CS_m - \pi \left(1 + \frac{\mu_U \zeta_U}{a_U} + \frac{\mu_E \zeta_E}{a_E} \right) = \gamma(\Omega_U, \Omega_E) \left(CS_m + CS_c \frac{M\bar{T} - (M_U \Omega_U + M_E \Omega_E)}{M_U \Omega_U + M_E \Omega_E} \right) \quad (2.27)$$

We can conclude that this optimization problem doesn't have a unique solution, however the optimal market size-weighted world level of IPR protection $M_N \Omega_N + M_S \Omega_S \equiv \Omega$ is uniquely determined, because γ depends on the policies only through the value of the patent $v = \pi \Omega$. We call this optimum the politically efficient world level of IPR protection Ω_{PE} . All linear combinations of policies which satisfy the solution of (2.26) are possible outcomes of an equilibrium agreement. Notice that if we vary Ω_N and Ω_S while keeping $M_U \Omega_U + M_E \Omega_E = \Omega_{PE}$, lobbies' payoffs will not be affected, but the individual countries' social welfare obviously are, one at the expense of the other. This transfer of welfare

²⁹The vector operator ∇ denotes the vector of partial derivatives of the function to which it is applied with respect to its arguments, in this case the decision variables Ω_U and Ω_E .

mimics the payment transfers R that the governments exchange. Thus allowing transfer payments or not is irrelevant for the solution of the optimization problem. Adjusting innovation policies to the benefit of one country can substitute the monetary transfers with which the country is compensated by its trading partner in order to implement a politically efficient world level of IPR protection.

Comparing the politically efficient global level of IPR protection given by (2.27) with the socially efficient one given by (2.23), it is obvious that $\Omega_{PE} > \Omega_{eff}$ due to the additional term $1 + \frac{\mu_U \zeta_U}{a_U} + \frac{\mu_E \zeta_E}{a_E}$ in the left-hand side in (2.27). In other words:

Proposition 5: International agreements on IPR protection in the presence of lobbying will always be inefficient (supra-optimal).

This conclusion about the effect of lobbying is different from the case of free trade agreements described by Grossman and Helpman (1997), where the politically efficient outcome of trade negotiations can neutralize the inefficiencies that each separate lobby causes, because their interests are opposed to one another, which renders trade agreements always preferable to no cooperation. Rather than neutralizing each others influence, in this model lobbies complement each other, because their interests are perfectly aligned. This allows for the possibility that a world with no cooperation on IPR may be better off (yielding higher global welfare) than one governed by IPR agreements.

Assume for simplicity that the R&D function is Cobb-Douglas ($\beta = 0$), there are no lobbying costs ($\zeta = 1$) and denote the ratios $\pi/(CS_c - CS_m)$ as $p \in (0, 1)$ and $(CS_c - CS_m)/CS_c$ as $c \in (0, 1)$. Consider the case of J countries and restrict consideration to interior solutions for now³⁰.

³⁰Interior solutions are $\Omega_{PE} \in (0, M\bar{T})$ and $\Omega_J^{NE} \in (0, \bar{T})$ for $\forall J$. This means that no country wants

Proposition 6: World welfare is higher under no cooperation than under IPR agreement, i.e. $W(\Omega_{NE}) > W(\Omega_{PE})$ if and only if the following holds:

$$\left(1 + \frac{J-1}{\frac{1}{1-b} - p\bar{\theta}}\right)^{\frac{1}{1-b}} < 1 + \frac{J-1}{1 - p\bar{\theta} + bp} \quad (2.28)$$

This condition delimits a range of values for $\bar{\theta} > \bar{\theta}_{min}$ for which Proposition 6 holds when the lobbyists' influence is high enough.³¹ A smaller number of countries J (irrespective of the distribution of sophisticated consumers among them) or a smaller dead-weight loss relative to $(CS_c - CS_m)$ imply a smaller externality due to free-riding if not cooperating, so the more likely it is that the world economy is better off under no cooperation (lower $\bar{\theta}_{min}$). Similar inequalities hold in the case of corner solutions, some of which are derived in Appendix A.5.

From (2.27), the ratio that determines the magnitude of the inefficiencies inherent in international IPR agreements is $\frac{\mu_J \zeta_J}{a_J}$. As expected, lower weights on social welfare by governments cause higher distortions, which are magnified by the share of innovation taking place in that country. Thus distribution of knowledge capital among countries matters, as does the distribution of knowledge capital among firms within countries, because it determines which firms will decide to lobby. Distortions will be the lowest if knowledge capital is more concentrated in countries whose governments are less susceptible to lobbying (higher a_J) and less concentrated within the countries themselves (lower ζ_J).

to offer 0 IPR protection in the non-cooperative case, which typically holds in North-North environments when countries have similar research capacities. The parameter restrictions implied by this assumption are given by (A.7), (A.8) and (A.9).

³¹The proof for this proposition can be found in Appendix A.4.

International agreements governing IPR protections most always require that countries signatories implement identical regulation, i.e. they strive to implement harmonized patent regimes at least on paper, because internal enforcement (proxied in the model by ω) cannot be effectively enforced at the international level. However it is worth noting that, just as Grossman and Lai (2004) show for the benchmark case with no lobbies, harmonization is neither sufficient nor necessary condition for efficiency. In fact, the harmonized politically efficient level of IPR protection, which would be the expected outcome of international negotiations in the presence of lobbying, will always be globally inefficient.

Extension: International lobbying

One of the assumptions of the model was that firms are only allowed to lobby with their respective domestic government. In reality, multinational firms are allowed to lobby foreign governments via their foreign subsidiaries, or even directly, subject to more stringent disclosure requirements (Foreign Agents Registration Act, 1938). Moreover, there has been a resurgence of international business associations, such as the Transatlantic Business Council, that lobby on agreements such as TPP and TTIP. We can extend this model in the simplest case scenario to analyze the effect of international lobbying in the cooperative case by allowing for foreign lobbying contributions and assuming equal fixed costs of lobbying across countries f . In this case, firms would decide to put all their lobbying effort in the country with the lower a_j , because it would result in maximum impact on Γ , the objective function of the hypothetical world government they are trying to influence.

Solving the optimization problem with this new weight, gives the first-order condition for the world level of protection with international lobbying:

$$CS_c - CS_m - \pi \left(1 + \frac{\mu_E \hat{\zeta}_E + \mu_U \hat{\zeta}_U}{a_{min}} \right) = \gamma(\Omega_U, \Omega_E) \left(CS_m + CS_c \frac{M\bar{T} - (M_U \Omega_U + M_E \Omega_E)}{M_U \Omega_U + M_E \Omega_E} \right) \quad (2.29)$$

By comparing the left-hand sides of (2.27) and (2.29), it is obvious that by allocating their lobbying expenditures most efficiently, international lobbies cause cooperative agreements to result in even stronger over-protection of IPR, i.e. even more globally inefficient Ω_{PE} .

The extent of international lobbying can also be determined by the extent to which firms establish multinational subsidiaries. Suppose there were trade costs per unit of good exported and a certain fixed cost of establishing offshore production operations in order to reach foreign destination markets. In this case, only the largest firms above a certain capital cutoff would have large enough trade volumes, so as to be profitable for them to offshore production and become multinationals. Further suppose that the fixed cost of lobbying the foreign government directly is prohibitively high, which can be justified by the higher regulatory and informational costs of hiring foreign lobbyists. However, if the multinational firms lobbies through its foreign subsidiary it would pay a lower fixed lobbying cost, just as the other foreign firms. Then large multinational firms will be able to participate in foreign lobbying and thus they will lobby the government that is more susceptible to lobbying influence (lower a_j), while non-multinationals will only lobby their domestic government. It is easy to see that this setup will allow for trade agreements that are intermediate cases between the cooperative regime under no

international lobbying, whose IPR outcome is given by (2.27), and the other extreme when all firms are allowed to lobby internationally given by (2.29). So the degree of global economic integration and proliferation of multinationals can strengthen the lobbyists' influence across borders, which renders IPR agreements even more inefficient. Notice that this reconfiguration of lobbying interests across borders can be a sufficient reason for a new strictly welfare-reducing IPR agreement to be signed among countries that have already signed an IPR agreement that eliminates the free-riding externalities that persist under no cooperation.

Extension: Patenting costs

So far we assumed that patents are automatically granted at no cost in all countries for all inventions, which caused the value of the patent to be independent of the firm which produced it. In order to make the model more realistic and more applicable for empirical testing, we consider an extension where firms pay fixed costs of patenting every period, very much like the annual renewal costs that firms pay in reality. The costs could be firm-country specific in general, depending on the firm's history of business and legal operations in the particular country.³² For simplicity, we focus on the Cobb-Douglas case ($\beta = 0$) and we'll assume two types of firms: a set of firms D that face prohibitive costs of patenting abroad and therefore choose only to patent the invention in the domestic market, and a set of firms X that also choose to patent and export the good abroad where

³²Alternatively, we can motivate this variation in patenting decisions more realistically by assuming that the patenting costs are the same for all firms, however the product varieties that the firms invent are "bundled" into goods that then get sold to market, provided that the profits from that "bundled" good are worth its patenting costs in a particular country.

they face no patenting costs. The share of X-firms in economy J in terms of knowledge capital is given by η_J , so the share of D-firms is $1 - \eta_J$. It follows that D-firms and X-firms will hold patents with different values $v_D = \pi M_J \Omega_J$ and $v_X = \pi(M_U \Omega_U + M_E \Omega_E)$ respectively. Because exporters have more valuable patents, the marginal product of labor employed in R&D is higher, so they will choose to employ more labor and consequently produce more patents ϕ_i .

It can be shown that firms with international patent portfolios (X-type) will contribute more in the cooperative equilibrium than D-type firms with identical knowledge capital stock because they have a higher potential return on each dollar spent lobbying. More formally:

Proposition 7: Assume two identical firms with knowledge capital H_i and $\alpha_i = 0$, of which one has prohibitive patenting costs abroad (D-type) and the other has 0 patenting costs abroad (X-type firm). Further assume that their CES research output function is Cobb-Douglas: $\beta = 0$. Then in the equilibrium of lobbying for IPR agreements, their contributions satisfy $C_X > C_D$.³³

This prediction is consistent with firm-level lobbying data, namely that lobbying expenditures for TPP and TTIP increased with the value of the firm's international patent portfolio in the relevant jurisdictions, conditional on firm total sales. The details about the data collection and analysis can be found in Appendix B.1 and Appendix B.2.

³³The proof is given in Appendix A.6.

Extension: Cournot competition and North-South agreements

The setup so far assumed that in each innovation-driven economy profit-making firms lobby for more IPR protection, whereas goods are produced competitively (or imported from abroad) at zero profit whenever the patent is not enforced. This framework is most appropriate for analyzing North-North type of IPR agreements. To analyze North-South type of agreements, whereby the Southern economy is based on imitating patented products, we consider a version of the model with identical setup, except that rather than perfect competition, sophisticated goods are produced costlessly under Cournot competition by identical imitator firms whenever the patent is not enforced. The number of firms N allowed to imitate will be given exogeneously given for each country. Each imitator firm will be able to imitate all goods (including foreign) whose patent is not being enforced in the current period³⁴. In general each country could have an innovation and imitation sector³⁵, but the South, naturally, will contain more imitator firms than the North, whereas the North will dominate the South in terms of knowledge capital stock. A Cournot competitive regime generates positive profit for the imitators, which gives them a stake in the IPR outcomes and a motivation to engage in lobbying, but with interests opposed to those of the innovator-firms.

Given product demand (2.3) and the number of imitators N , we can solve for the Cournot regime (indexed by C): imitator firms will earn a joint profit of $\pi_C = x_C(p_C - 1)$

³⁴This assumption of unlimited capacity for imitation will be key for the influence of imitators on the equilibrium outcome relative to innovators.

³⁵Without loss of generality, we could even assume some overlap between the innovation and the imitation sector, i.e. some firms would be able to both innovate and imitate, but for simplicity, for now assume the sectors are separate.

per good and individual consumer surplus $CS_C = h(x_C) - x_C$, where x_C is the individual consumption under Cournot competition pinned down by $x_C = \frac{N(1-h'(x_C))}{h''(x_C)}$.

Counting the non-enforced yet-to-be-invented goods and discounting across time, we can write the discounted welfare at time t=0 of a given imitator firm whose owners constitute a negligible share of sophisticated consumers³⁶ as:

$$\tilde{W}_i(\Omega, 0) = \frac{\pi_C M(\bar{T} - \Omega)\phi(\Omega)}{N\rho} + \tilde{\Lambda}_i^0 \quad (2.30)$$

For simplicity, assume that the fixed lobbying cost $f=0$, so that all firms, both innovators and imitators, lobby in equilibrium. Solving the same as before for the closed economy case, we get an expression for the resulting level of IPR protection Ω :

$$CS_C - CS_m - (\pi_m - \pi_C)\theta = \gamma(\Omega) \left(CS_m + (CS_C + \pi_C\theta) \frac{\bar{T} - \Omega}{\Omega} \right) \quad (2.31)$$

As before, lobbying in a closed economy will unambiguously result in supra-optimal level of IPR protection, because the lobbying term $\theta = \frac{1+a}{a} > 1$ will decrease the left-hand side of (2.31) and will increase its right-hand side.

In the global cooperative regime, the politically efficient level of world IPR protection Ω_{PE} can be calculated following the same procedure as earlier to get:

$$CS_C - CS_m - (\pi_m \bar{\theta} - \pi_C \tilde{\theta}) = \gamma \left(CS_m + (CS_C + \pi_C \tilde{\theta}) \frac{\bar{T}M - \Omega_{PE}}{\Omega_{PE}} \right) \quad (2.32)$$

Here, $\bar{\theta}$ is the capital-weighted average of the lobbying terms, whereas $\tilde{\theta} \equiv \sum_J \frac{N_J}{N} \theta_J$

³⁶This assumption is not consequential for the results, but simplifies the algebra.

is the lobbying average weighted by the number of imitator firms in each country. If imitator firms are concentrated in countries that are very susceptible to lobbying (high θ_J), whereas knowledge capital is concentrated in countries with low θ_J , then it could happen in principle that the political influence of imitators dominates over the influence of innovators to such a large extent that Ω_{PE} overshoots the efficient level. Nevertheless, we can specify a sufficient condition for which IPR agreements will be globally inefficient resulting in too much protection.

Proposition 8: If $\pi_m(\bar{\theta} - 1) > (\tilde{\theta} - 1)\pi_C$ holds³⁷, then $\Omega_{PE} > \Omega_{eff}$.³⁸

An analogous version of Proposition 6 will hold for North-South agreements as well.³⁹ As before, assume for simplicity that the R&D function is Cobb-Douglas ($\beta = 0$), there are no lobbying costs ($\zeta = 1$), $\alpha_L = 0$ and denote the ratios $\pi_m/(CS_C - CS_m) \equiv p_m$, $\pi_C/(CS_C - CS_m) \equiv p_c$ and $(CS_C - CS_m)/CS_C \equiv c \in (0, 1)$. For the case of interior solutions:

Proposition 9: World welfare is higher under no cooperation than under IPR agreement, i.e. $W(\Omega_{NE}) > W(\Omega_{PE})$ if and only if the following parameter restriction holds:

$$\left(1 + \frac{J-1}{\frac{1+p_c\tilde{\theta}}{1-b} - p_m\bar{\theta}}\right)^{\frac{1}{1-b}} < 1 + \frac{J-1}{\frac{1+p_c\tilde{\theta}}{1-b} - p_m\bar{\theta} - \frac{b(1+p_c-(1-b)p_m)(1+p_c\tilde{\theta})}{(1-b)(1+p_cc)}} \quad (2.33)$$

Due to the complicated nature of this expression, not much can be learned it, how-

³⁷For the most extreme case of two completely specialized countries, an innovating North (N) and an imitating South (S), the sufficient condition becomes $\pi_m a_N > \pi_C a_S$. Also note that the ratio $\frac{\pi_m}{\pi_C}$ is the patent premium under maximum IPR protection $\Omega = \bar{T}$.

³⁸This can be easily seen by comparing the social planner's IPR level (given by setting $\theta \rightarrow 1$ in (2.31)) and the politically efficient IPR level in (2.32). The sufficient condition ensures that the left-hand side of (2.32) is smaller, which guarantees that $\Omega_{PE} > \Omega_{eff}$.

³⁹The proof for Proposition 9 is analogous to the proof for Proposition 6.

ever it guarantees the fact that there exists a parameter range for which no cooperation is preferable to an agreement on IPR. To summarize, even for North-South models in which imitators earn profits and can lobby for less IPR protection, modified versions of the welfare implications still hold: IPR agreements will be inefficient provided that the asymmetry in institutions and endowments is not larger than the asymmetry in profits (expressed through the sufficient condition in Proposition 7) and IPR agreements will not be Pareto-improving provided that the conditions in Proposition 8 are true.

2.3 Conclusion

This paper is the first in the literature to develop a highly tractable general equilibrium model in order to analyze the effect of lobbying for IPR protection during international negotiations for IPR-related trade agreements. The analysis showed that these agreements have different welfare implications than traditional trade agreements regulating tariffs. While trade agreements about tariffs can sometimes be inefficient but are always desirable because they make the world better off than no cooperation, by contrast, IPR agreements among innovating economies are always inefficient and can sometimes make the world worse off than if there was no agreement at all in place. I also showed that under the realistic assumption of fixed lobbying costs, high capital concentration increases the inefficiency of IPR agreements, as does international lobbying.

These are not merely theoretical assumptions of the model, but rather salient features of the global trade order. Given the dominant influence of corporate lobbying during the trade negotiations for TPP and TTIP, as well as the widely recognized increase in

capital concentration on a global scale, policymakers and academics have a good reason to be increasingly skeptical about the benefits of IPR agreements from pure efficiency considerations. At the very least, it is necessary to differentiate conceptually between trade agreements on tariffs and IPR trade agreements and stop using the standard anti-protectionist argumentation to push for international cooperation in this area, because as we saw it is not always Pareto-improving relative to no cooperation.

Even though it is difficult to observe in reality the exact conditions under which IPR agreements reduce global efficiency, the analysis shows that it is more likely to happen if there are fewer countries involved or if the dead-weight loss is small relative to the loss in consumer surplus, which is more consistent with goods with highly inelastic demands. The TTIP seems to fit this description well, since it involves only two parties, the USA and the EU, and it targets largely pharmaceutical products with highly inelastic demands, judging by the industries' lobbying efforts. As for the political factors, the more susceptible governments are to lobbying, the more firms establish an international presence and the more concentrated firm ownership becomes, the more likely it is that countries might be better off without an agreement on IPR. It is worthy to note that all these institutional factors have been on the rise globally in recent years.

If policymakers insist on the efficiency gains from implementing IPR agreements, they should either reverse these political trends or completely insulate trade negotiations from lobbyist influence. If they fail to do so, then the public might be right to view these agreements with a healthy dose of skepticism, and this assessment holds without even considering the other types of inefficiencies associated with the patent system⁴⁰ and the

⁴⁰See Baker (2005) for an overview.

distributional impact of strengthening IPR through cooperation, which would evidently benefit R&D-oriented corporations at the expense of consumers without a proper compensation scheme.

To properly analyze the distributional effects of IPR agreements a more sophisticated model is needed that would explicitly model consumers' income and therefore purchasing power. Another avenue for future research on the topic are empirical tests. Even though it is difficult to devise a direct test of the theory, researchers could try to measure the welfare effect of TPP and TRIPS, after a sufficient time from their implementation has passed. If a negative effect on consumer welfare is found, this model would provide a convincing explanation.

*Can the Stock Price Response to Patent News Be Used to
Estimate Their Value?*

3.1 Introduction

In the innovation economics literature, a number of methodologies have been developed that utilize stock market movements to estimate the economic value of patents.¹ The stock market approach to patent valuation is advantageous over the more direct approach of counting forward-citations as a proxy for the patents' scientific value because it measures their economic value in monetary terms and thus is comparable across time and across different industries. At the same time however, the theoretical justification for this approach is grounded in the assumption of rational investors and the efficient market hypothesis, which do not hold true in the strict sense. So how reliable really are patent estimates based on the stock market approach? - is the question that this paper sets to answer.

While most methodologies in the literature exploit stock price variation over longer periods to estimate intangibles such as patents, one subclass of models relies more heavily on the efficient market hypothesis and exploits the stock market's reactions to news about patents to estimate their private economic value. Stock prices are assumed to follow a

¹For example: Pakes (1985), Austin (1993), Hall et al.(2005), Nicholas (2008)

random walk conditional on all current information. When some news is announced, such as granting a patent for an application that had been filed and whose approval was subject to uncertainty in the eyes of the investors, the stock price of the patent-holding firm adjusts to reflect this positive change in the market value of the firm's portfolio of intangible assets. Using this rationale, Kogan et al. (2012) developed an influential structural estimation method and applied it to US patent data.

In this paper, I argue that this method produces highly unreliable estimates that have very little to do with the patents' actual values. It begins with the observation that the yearly aggregates of Kogan et al.'s patent value estimates follow the stock market historic trend, indicating that either the estimation methodology is flawed because it misinterprets market-wide stock price fluctuations as informative signals about the value of the patent, or that the subjective patent valuation itself, on average, is driven by the same behavioral forces that cause the market to experience bubbles - when investors feel irrationally optimistic they are more likely to overvalue the newly issued patents. To empirically test these hypotheses, I apply the Kogan et al. (2012)'s methodology to the same US stock market data, but I use random placebo patent grant dates instead. I find that the yearly aggregates of the placebo estimates are quantitatively similar to the true data estimates and both follow the stock market trend closely. The same conclusion holds true when we compare the aggregates at the level of individual companies or industries - there is no significant difference between the placebo and the true estimates. This evidence suggests that the Kogan et al.'s methodology is not a reliable estimation strategy for patent values, at least in the case of the US. This could be the case because US stock prices may not reflect the value of their underlying intangible assets. If, by contrast, market prices did reflect

all available information, the method could still fail as long as the news for patent grants were not informative for investors, possibly because they already knew the patent would get approved or stock prices take much longer to adjust.

To examine the external validity of this conclusion, I then apply the same estimation method to Chinese patent and stock market data utilizing a novel database of Chinese patent applications by publicly traded firms. China's rapid economic development has been accompanied by phenomenal annual growth of 20% in patent filing activity reaching a record-breaking 1.33 million filings for invention patents in 2016², more than twice as many as the second-ranked US. About 90.7% of the total number of patent applications were filed by domestic applicants³. Here too I find that the yearly and firm aggregates of patent value estimates based on actual grant dates are quantitatively very similar to the placebo estimates. The data shows that the annual averages follow the historic trajectory of the Chinese stock market, suggesting that the flaws of the method are inherent in the valuation methodology and do not arise from the institutional particularities of any given market.

To improve upon the methodology, I re-derive Kogan et al (2012)'s measure while accounting for the possibility that multiple patents can be granted to a given firm on the same day, which produces more precise estimates consistent with the theory. Because the national patent offices typically announce patent grants once a week, this is quite often the case in empirical data, including the US and Chinese data. Therefore using a model premised on single patent grants per day, as Kogan et al. do, can lead to a significant

²Xin, Wang: "Patents evidence of China's past, future growth", China Daily, 1/12/2017

³Source: State Intellectual Property Office (SIPO)'s website

upward bias in patent value estimates. Although this theoretical correction improves the internal consistency of the method, it does not change the negative results concerning its external validity.

To be sure, Kogan et al. (2012) do test the validity of their measure by checking it against the number of forward-citations, a more established and straight-forward measure of patents' realized value. To do this, they run regression specifications to determine whether the private value of patents that they estimate is positively related to the number of forward-citations they acquire, but the coefficient obtained, though positive, is never significant under the preferred log-log or log-linear specifications.⁴ It is only significant under a fully linear specification, which the authors agree is not appropriate due to the extreme skewness of both variables. Nevertheless, they are able to show that the correlation coefficient under their preferred specification is larger than what the coefficients would be in cases where we used random placebo grant dates - all clustered around 0. While this can be interpreted as evidence that the patent value estimate bears some relation to its underlying value, it does not invalidate the conclusion of this paper that the magnitude of the estimates is not driven by patent news but by other unrelated stock price fluctuations, which makes the method unreliable especially for comparing valuations of patents that were granted across different years and across different firms.

The paper proceeds as follows: In the next section, I describe in details the theoretical underpinnings of the estimation method. Section 3 applies (replicates) the method and

⁴The preferred specification for the regression used is: $\log(1 + C_j) = a + b \log \hat{\xi}_j + cZ_j + u_j$. Here, C_j is the number of forward-citations, whereas $\hat{\xi}_j$ is the estimated value of the patent. Z_j are controls for firm, technology-class and grant-year fixed effect and their interactions, the firm's log volatility and log market capitalization.

the placebo test to Kogan et al.'s US data and discusses the observations. In Section 4 the method is applied to the Chinese data and the results are discussed. The final section concludes.

3.2 Theory

Estimation method

The calculation of the private economic value of patents follows closely the methodology developed by Kogan et al. (2012), which exploits stock price reaction to news about patent approvals. Unlike their original method I also account for the empirical fact that firms are sometimes granted multiple patents on the same day. Kogan et al. assume in their derivation that there is at most one patent granted daily and then they divide their estimated value by the number of patents granted, without providing theoretical justification. Instead, I derive the estimation procedure from the ground up taking into account this possibility, which gives different results. In addition, I also take into account the ownership structure of the companies.

We assume that the market values of patents ξ_j filed by firm i are known to market participants before they are granted and they have a prior π_j about the probability for approving the patent application. This is a reasonable assumption since in China patent applications for inventions are published in the relevant patent gazette by SIPO 1.5 years after submitting the initial application, while granting them typically takes 3-5 years. Similarly, the USPTO publishes granted patents in the Official Gazette every Tuesday,

on average 32 months after filing, and publishes the patent application on Thursdays 18 months after filing⁵. The review procedure for utility and design patents differs significantly in China. They are granted immediately upon a cursory examination, so their implied prior in the data is 100%, which renders stock price movements uninformative about the value of utility and design patents. In the US, design patents are not published until they are granted. For this reason, I limit the focus of my sample to invention patents only.

Firms have complex ownership structure, so if patent j is awarded to a subsidiary in which the parent firm i has partial ownership ω_j , we assume that the firm will be entitled to the profits accruing from the patent-holding subsidiary in proportion to its ownership share. Therefore, when N patents partially owned by parent firm i are granted on the same date, the stock market price reaction to this news is:

$$\Delta V_i = \sum_{j=1}^N \omega_j (1 - \pi_j) \xi_j \quad (3.1)$$

A 3 day announcement window $[T, T + 2]$ is chosen during which the stock price is expected to adjust to the news about a successful patent application⁶. To purge the stock return⁷ from any general movements in the market and construct the firm's market-

⁵Before 2000 when the American Investor Protection Act entered into force, patent applications were not publicized by USPTO. However, Kogan et al. (2012) find no evidence that the market was any less informed about the value of patents prior to 2000 than after the passage of this act.

⁶The 3-day is chosen based on a natural break in the data, because the patent grants are usually released on Wednesdays (China) or Tuesdays (US), whereas the stock markets are closed on weekends. Kogan et al. (2012) also choose a 3-day window in their paper. Alternative windows were chosen as robustness checks.

⁷CSMAR calculates the stock return by adjusting for the effects of activities such as cash dividends, rights offerings and share splits in order to reflect stock price changes that are due purely to market forces.

adjusted (idiosyncratic) return, we apply the capital asset pricing model (CAPM)⁸. Kogan et al. (2012) however construct the idiosyncratic return assuming perfect correlation ($\beta = 1$) between all firm returns and the market return due to data unavailability. They employ the preferred approach of using beta-matched market portfolio for a limited subsample of firms for robustness check and conclude that the results are quantitatively similar.

The idiosyncratic return R to firm i during the 3-day announcement window d can be decomposed into news from patent approval announcements $p_{id} = \frac{\Delta V_{id}}{V_T}$ and a component due to unrelated firm-specific factors ϵ_{id} . The patent news signal can be further decomposed into N components that are due to each patent approval announcement v_j :

$$R_{id} = p_{id} + \epsilon_{id} = \sum_j \omega_j v_j + \epsilon_{id} \quad (3.2)$$

If multiple patents are granted on the same day to the same firm, it is impossible to estimate separately its constituent underlying contributions. To estimate individual patent valuations in this case I assume that the values of these patents are equal. If V_T denotes firm i 's total market valuation on the day the patents are granted, the value of each patent $\xi_j = \xi$ will be:

$$\xi = \frac{E[p_{id}|R_{id}]V_T}{\sum_j \omega_j (1 - \pi_j)} \quad (3.3)$$

We assume that the prior $\pi_j = \pi$ is the same for all invention patents and we estimate it

⁸The idiosyncratic excess return is constructed as the firm's return net of the return of the beta-matched market portfolio. The firms' beta parameters are estimated using time series regressions for each firm, excluding those days that are "contaminated" by patent news announcements within a 5-day window timespan. The market return is calculated as the weighted average of all stock returns, where the total market values are used as weights. For robustness, I also check for non-weighted and current-value-weighted market averages.

non-parametrically for China as the share of successful applications from the total number of applications in the sample: $\hat{\pi}=38.45\%$.⁹

Next we make assumptions about the distributions of v_j and ϵ_{id} , whose parameters we allow to vary across firms and time (in years, designated by t). Following Kogan et al. (2012), the stock market return to individual patent grants is assumed to be always positive and half-normal: $v_j \sim N^+(0, \sigma_{vit}^2)$, while the idiosyncratic noise $\epsilon_{id} \sim N(0, \sigma_{eit}^2)$ is Gaussian. Because the distributions for the set of v_j 's granted are the same, the sum of corresponding ownership shares $\sum \omega_j \equiv \Omega_{id}$ acts as a scaling factor for the parameter σ_{vit} , so $p_{id} \sim N^+(0, \Omega_{id}^2 \sigma_{vit}^2)$. If we define $\delta_{itd} \equiv \frac{\Omega_{id}^2 \sigma_{vit}^2}{\sigma_{eit}^2 + \Omega_{id}^2 \sigma_{vit}^2}$, then the expected return p_{id} conditional on the realized market-adjusted return R_{id} :

$$E[p_{id}|R_{id}] = \delta_{itd} R_{id} + \sqrt{\delta_{itd}} \sigma_{eit} \frac{\phi(-\sqrt{\delta_{itd}} \frac{R_{id}}{\sigma_{eit}})}{1 - \Phi(-\sqrt{\delta_{itd}} \frac{R_{id}}{\sigma_{eit}})} \quad (3.4)$$

The signal-to-noise ratio $\alpha \equiv \frac{\sigma_{vit}^2}{\sigma_{eit}^2}$ which determines δ_{itd} is constrained to be constant across firms and time while the variances differ, so α reflects the increase in volatility of any firm's idiosyncratic returns around patent grant dates. Define I_{id} as a dummy variable for the 3-day announcement window d of firm i . To estimate α , we run the following regression over non-overlapping 3-day intervals with additional controls Z_{id} added (such as day-of-the-week of the announcement and firm-year fixed effects) is:

$$\log(R_{id}^2) = \alpha I_{id} * \Omega_{id}^2 + c Z_{id} + u_{id} \quad (3.5)$$

⁹For the US, I use Carley et al. (2015)'s estimate of 56%.

To see how the above regression yields an estimate for α , first note that a squared half-normally distributed variable and a squared normally distributed variable both have scaled χ_1^2 distributions. Thus for our distributional assumptions, $R^2 = p^2 + \epsilon^2 + 2p\epsilon$, and therefore $E(R^2) = \sigma_\epsilon^2$ when $I=0$ and $E(R^2) = \Omega^2\sigma_v^2 + \sigma_\epsilon^2$ when $I=1$. It can be easily shown that $E(\log(R^2)) = \log(E(R^2)) - 1$, from which the expression for α follows by substituting (3.5), once for $I=0$ and once for $I=1$, and subtracting the two expressions¹⁰.

Finally, estimation of $\sigma_{\epsilon_{it}}^2 = E(\epsilon_{it}^2)$ is done non-parametrically: We take into consideration only those days unaffected by patent grant announcement (outside the 3-day adjustment windows). On those days, $\epsilon_{id} = R_{id}$, so $\sigma_{\epsilon_{it}}^2$ is estimated as the average of the squared market-adjusted returns in a given year t for a given firm i . If estimation is in terms of daily stock returns r_{iT} (serially uncorrelated), then $\hat{\sigma}_{\epsilon_{it}}^2 = 3\hat{\sigma}_{rit}^2 = 3 \sum_{T=1}^n \frac{r_{iT}^2}{n}$.

Placebo test

To run the placebo estimation, I implement the same strategy described in the previous section, except with randomized grant dates. The purpose of the placebo is to simulate a signal for each patent consisting purely of the noise error term drawn from the same distribution from which the noise term for the "true" signal is drawn, but this signal would be treated by the estimation procedure *as if* it consisted of both an informative news component and an unrelated firm-year-specific noise component. To achieve this, I let the placebo grant date for each patent j be a random draw from the year of the actual grant date. This ensures that the noise term ϵ_{id} is drawn from the same distribution as the noise term in the "true" estimation. Because the distribution for the noise term is the same, the

¹⁰ $\log(x + 1) \approx x$ is also used in the derivation.

optimal estimation strategy even when considering placebo signals is to use the "true" (i.e. best available) estimates for the parameters that specify it ($\hat{\alpha}$ and $\hat{\sigma}_{\epsilon it}^2$), which are obtained using the "true" grant dates. That is to say, the placebo estimation utilizes the estimate for α we get from the auxiliary regression (3.5) using actual grant dates, as well as the variance parameters for each firm-year pair estimated non-parametrically. This approach minimizes the sources of randomness in the patent value estimates and ensures that any observable differences between the true and the placebo estimates would be attributable exclusively to the effect of the patent news. Indeed, using placebo grant dates to estimate α for the purpose of the placebo estimation would yield $\alpha = 0$ at least theoretically¹¹ which renders estimation impossible.

If the efficient market hypothesis that forms the theoretical basis of this methodology is true, then the placebo estimation should produce patent value estimates of significantly lower magnitudes than their corresponding "true" estimates. Moreover, in the absence of a news signal, any spatial (across firms) or temporal (across years) pattern observed would be entirely due to the noise component of the returns and the assumption that allows $\sigma_{\epsilon it}$ to vary across firms i and years t .¹² This means that if we detected an identical spatial or temporal pattern in the "true" patent value estimates, it would not be attributable to any differences in patent values, but rather would be an artifact of the estimation methodology

¹¹If there is no patent news for firm i at time T , which is the most likely outcome for a random placebo draw of T , then $v_{iT} = 0$ and thus $\sigma_{v_{iT}}^2 = 0$.

¹²For placebo dates with no informative signals ($R_{id} = \epsilon_{id}$), the theoretical average of the estimated patent value calculated by equation (3.4) becomes:

$$E[E[p_{id}|R_{id} = \epsilon_{id}]] = \sqrt{\delta_i} \sigma_{\epsilon it} E \left[\frac{\phi(-\sqrt{\delta_i} \frac{\epsilon_{id}}{\sigma_{\epsilon it}})}{1 - \Phi(-\sqrt{\delta_i} \frac{\epsilon_{id}}{\sigma_{\epsilon it}})} \right] \quad (3.6)$$

itself, which would make it inadequate for comparing patents across different firms and different years.

3.3 Estimation: US patents

Before applying the placebo test to the US data, I use the original Kogan et al. (2012)'s estimates from the authors' webpage to examine the historical trend. Figure 1 plots the average and median patent valuations in each year and superimposes the S&P 500 index¹³ at the beginning of the year. We notice that both the annual median and average patent estimates track closely the S&P 500, surging when the market is booming and collapsing when the bubble busts. Remember that the patent valuations are estimated based on market-adjusted returns (stock price movements net of overall market returns), so the observed pattern cannot be due to the estimation picking up the overall market return component.

There are two hypothesis that can explain the observed synchronization between stocks and patents valuations, which are not mutually exclusive. It may be that patent valuation itself, on average, is driven by the same behavioral forces that cause the market to experience bubbles, so that bullish investors overvalue the newly issued patents, while bearish investors undervalue them. The valuation trend may also be driven by the noise component of the returns: equation (3.6) shows that the parallel trends could result from allowing the parameter σ_{eit} to vary across years t , provided that the variance of the market

¹³The S&P 500 index is meant to capture the overall price movements on the US stock market and is based on the market capitalizations of the 500 largest publicly traded companies listed on the NYSE or NASDAQ. Source: CRSP database.

returns, σ_ϵ^2 , is proportional to the total market capitalization, i.e. the S&P 500 index. Then, as equation (3.4) shows, this effect is amplified by the firm's market valuation $V_{i,T}$, which is expected to move broadly in sync with the market. If we plot the non-parametrically estimated variances of the firms' daily returns across different years as in Figure C.2 and C.3, we can see that these parameters do seem to track upheavals in the market, which constitutes supporting evidence for the latter hypothesis.

To examine to what extent the news component (signal) of the observed returns drives the historical trend of patent estimates, I conduct a placebo test, just as described in the previous section, which eliminates the signal as a source. To serve as a more reliable basis for comparison, I also replicate Kogan et al's estimation using the same US data with actual patent grant dates. In applying the method, I implement a few theoretical refinements that were already discussed in Section 2 and do not impact the conclusions regarding the validity of the methodology. The stock market data comes from the Center for Research in Security Prices (CRSP) via WRDS, while the patent data is the same data that Kogan et al (2012) used and can be found on Professor Stoffman's website. All values are real and use 2009 as base year.

Figure C.4 plots the annual averages and medians of patent value estimates using the actual grant dates, while Figure C.5 does the same using placebo grant dates. We see that both trends follow closely the behavior of the stock market and are remarkably similar, indicating that the news signal has negligible effect on the patent valuation estimates and it is mostly the noise component attributable to market-wide fluctuations that drives the historic evolution of the patent value estimates.

To confirm that the magnitudes are not significantly different, I calculate the difference

between the annual averages (medians) of the "true" estimates and the annual averages (medians) of the placebo estimates and show them in Figure C.7 (Figure C.8). In Figure C.7 the differences cluster around 0, with slightly positive values after 1998, but with very high p-values above 0.8. Thus we can conclude that there is no evidence in any year that the average patent value estimates differ from their placebo counterparts. The equivalent conclusion can be reached by looking at the differences in annual medians in Figure C.8, that cluster around 0 from both sides. In other words, there is no evidence whatsoever that the historic trends observed are driven by the patent news announcements. Therefore, this estimation method is not appropriate for the purpose of comparing patents with different grant years.

The next question of interest is whether the patent news component has any influence on the average patent valuations we observe across different firms. To answer it, we apply the placebo test to the cross-firm pattern using the same argumentative logic above. Figure C.9 plots the difference between the firm averages of "true" patent value estimates and the corresponding firm average of the placebo estimates¹⁴. On the x-axis we plot the p-value associated with that difference and with a null hypothesis which states that the signal is fully absent and thus the placebo and the actual estimates are drawn from the same distribution implying a difference in averages centered at 0. Again, we see that the differences cluster pretty close to 0 from both sides for nearly all firms. For the few exceptions that have a high point estimate the p-values are still high enough, such that the difference is not significantly different from 0. Similarly, the differences between

¹⁴Firms with less than 16 patents granted were omitted from the sample due to the unreliability of statistical inferences for such a small sample of observations.

the firm's median of the "true" patent value estimates and the median of the placebo estimates are all clustered around 0 from both sides, as Figure C.10 shows. Therefore, there is no evidence that the cross-firm differences in patent valuations arise from patent announcements, but rather are consequence of different variances in daily returns and different market capitalizations. In conclusion, it would be unreliable to use the estimates obtained via this method to compare patent values across different firms.

Our inference that the patent announcement has negligible effect on the stock price is further corroborated by the estimate for $\hat{\alpha} = 7 \cdot 10^{-5}$ in the auxiliary regression (3.5).¹⁵ Not only is the magnitude of the signal-to-noise ratio α very small, but it is also statistically indistinguishable from zero¹⁶, which is exactly what one would expect if there was no informative news signal. Kogan et al (2012) unfortunately do not report the significance and magnitude of their α estimate.

The parameter α is of central importance for the estimation. Low values of α imply that the signal is very weak compared to the noise and is therefore uninformative for the agent. So no matter what the return is, it will not have a significant effect on the end estimate, which will be determined almost exclusively by our distributional assumptions about the noise error term (the parameters δ and $\sigma_{\epsilon_{it}}^2$). This implies that our placebo estimates should be very similar to their corresponding "true" estimates, as long as the noise

¹⁵The auxiliary regression was carried out on a subsample of the data from 1994 to 1997 due to computational limitations. Choosing a different subsample produced similar estimates - slightly above (and sometimes even below!) zero and statistically insignificant. The absolute estimates of patent valuations are highly sensitive to the estimated value of $\hat{\alpha}$ with comparatively large standard errors, which also imparts large standard errors on the absolute patent value estimates. Nevertheless, alternative estimates of the value of this signal-to-noise ratio only imply different scaling for the patent valuations, whereas the main quantitative conclusions of the paper (trends over time, significance) remain unaffected.

¹⁶p-value=0.87

parameters are the same (for a given firm i and year t), which is exactly the restriction we imposed on the placebo test. Allowing the variance parameters to vary by years and firms is a realistic assumption, but it is precisely the reason that makes comparison of patent valuations across different firms and years impossible. Figure C.11 proves that the prediction which follows from the logic above is borne out in the data: the correlation between the "true" and placebo estimates at the level of individual patents is 0.995. It is only logical then that the yearly and firm aggregates will also be similar.

3.4 Estimation: Chinese patents

We showed that the Kogan et al's method is not reliable when we want to estimate US patents across different firms and different grant years. But it could be that the US market is special in this sense - that patent announcements do not translate into stock responses, whether it's because the announcement are not informative for the market participants, or the investors are not rational enough to incorporate this knowledge in their investment strategy. Perhaps there are other markets where stock prices are more responsive to patent news. To check the external validity of this claim, I implement the stock price response method as outlined in Section 2 using Chinese stock market data and a novel dataset of Chinese patents. Because this is the first time that this patent estimation method has been applied to Chinese patent data, I provide a more in-depth overview of the institutional changes that have influenced patent valuation in China in Appendix C.1.

The data used comes from two main sources: the CSMAR database (WRDS) which has historic data on stock market price movements as well as market indices and returns

for both the Shanghai and the Shenzhen stock exchanges spanning the period from 1990 until 2016; and a very recent database (Chinese Patent Data Project - CPDP) constructed by He, Tong, Zhang and He (2016), which contains patent applications to the SIPO linked to publicly listed Chinese companies. The CPDP database covers A-share companies¹⁷ listed on the Shanghai and Shenzhen stock exchanges. It contains 222,651 filed patent applications, of which 38.8% concerning invention patents, with grant years ranging from 1992 to 2011. The CPDP database also contains supplementary datasets on subsidiary trees, with precise corporate ownership structure.

Based on a set of 30,030 invention patents estimated, the average patent valuation is 76.9 million ¥, whereas the median is 16.1 million ¥, which implies an extremely skewed distribution. At current exchange rates, the median patent valuation in China is \$2.3 million, which is remarkably similar to Kogan et al's median estimate for the USA: \$2.2 million. The empirical distribution of estimated patent valuations is given in Figure C.12, and as we can see seems to be consistent with the assumption of a half normal distribution for the stock price reaction to patent news announcements. Details about the patent value distribution are given in Table C.1 in the appendix.

Next we analyze the historic trend in patent valuation over the period 1993-2011. Figure C.13 gives a bar graph of the average patent valuations in each year and superimposes the two composite A-share market indices¹⁸ for the Shanghai Stock Exchange and the Shenzhen Stock Exchange. We notice that the average patent valuation reaches its maxi-

¹⁷A-shares can be traded by Chinese residents, in contrast to B-shares which can only be traded by foreigners.

¹⁸Composite market indices are meant to capture the overall price movements on the stock market and are comprised of properly weighted contributions from all listed firms with A-shares.

mum in 2007 when the stock market index also peaks, after which it sharply declines.

Figure C.14 is analogous to Figure C.13, with median instead of average patent valuations for each year. But unlike previously, here the correlation with the stock market movements is much more muted. This suggests that to the extent that irrational exuberance drives investors' valuation of patents, it does not affect them equally across the board, but rather has stronger impact on a limited subset of patents with high potential economic value, and a much weaker effect on the median patent. Bullish investors pick their "winner" patents, the promising technologies of the future, and bid their price up above all others. Figure C.15 illustrates how the patent valuation distribution gets even more skewed when the market is experiencing a bubble, represented by the widening gap between the mean and the median. To the extent that the patent estimates are driven by the firm-year-specific noise term, the historic trajectories in Figure C.15 suggest that most patenting activity takes place in firms that do not experience large swings during stock market booms, or at least not to the same degree as more established major companies.

As before, I use placebo grant dates to differentiate between these sources of variation and test the hypothesis that patent announcements determine the cross-sectional and temporal patterns observed in the set of patent value estimates. The conclusions are very much the same as what we observed in the case of the US. The placebo estimation produces historic trends quantitatively very similar to the yearly trend of the actual patent value estimates. Figure C.16 depicts this similarity by plotting their yearly medians and the yearly averages side by side. Figure C.17 proves that the differences in yearly averages cluster around zero and are statistically insignificant, because their p-values are larger than 0.9

for all years under consideration.¹⁹ Moreover, the yearly medians for the most recent years even seem to be higher for the placebo estimation, which is exactly opposite of what the theory behind this methodology would predict. Therefore, there is no evidence that the historic trends observed are due to the effect of patent news announcements on stock prices, which renders the methodology unreliable for cross-temporal comparisons.

Next we examine whether patent announcements have measurable impact on patent valuation across different firms. Figure C.18 plots the difference between the firm averages of "true" patent value estimates and the corresponding firm average of the placebo estimates²⁰ against the p-value associated with that difference on the x-axis (for a null of difference=0). Here too, the differences cluster pretty close to 0 from both sides for nearly all firms and there is no evidence they are significantly different than 0. Similarly, the differences between the firm's median of the "true" patent value estimates and the median of the placebo estimates are all clustered around 0, as Figure C.10 shows. Therefore, there is no evidence that the cross-firm differences in patent valuations arise from patent announcements, but rather are consequence of different variances in daily returns and different market capitalizations. In conclusion, it would be unreliable to use the estimates obtained via this method to compare patent values across different firms.

Finally, just as in the US case, the above observations are the mathematical consequence of a very low $\hat{\alpha}$ estimate of 0.0003, that is statistically insignificant²¹. Choosing

¹⁹To achieve more reliable statistical inference, we omit years with 15 or less observations.

²⁰Again, firms with less than 16 patents granted were omitted from the sample due to the unreliability of statistical inferences for such a small sample of observations.

²¹Due to computational limitations the sample was limited to patents granted between 1993 and 2006.

alternative sample ranges or alternative adjustment windows²² wasn't consequential for the significance of α . As a result, there is a very high correlation of 0.994 between the "true" patent value estimates and their corresponding placebos, represented on Figure C.20.

3.5 Conclusion

This paper uses placebo data to evaluate the validity of the patent valuation methodology developed by Kogan et al. (2012) and finds that the resulting estimates are unreliable, especially for purposes of comparing patent values across different firms and years. This conclusion is based on the observation that the true patent value estimates are almost identical with their placebo counterpart estimates, a finding corroborated in two different institutional and economic contexts - the US and China. This implies that the patent value estimates are mainly determined by the distributional parameters and restrictions we impose on the noise term, while the effect of the news component about patent grants is quantifiably negligible and completely drowned by the noise.

The methodology fails to deliver reliable estimates because the chain of assumptions necessary for it to be valid breaks at some point. The assumptions required can be ordered according to their strictness, each higher level failure more damning for the market efficiency hypothesis (EMH) on which the method is built. EMH maintains that all stocks are rationally priced according to the value of their real underlying assets, and this is knowledge that is perfectly shared by all investors. Keeping this hypothesis intact, it could be

²²Limiting the adjustment window to 2-day produces an even lower $\hat{\alpha} = 0.00009$

that the news announcement for granting are simply not informative because investors know ahead of time that the patent would be granted. It is true that patent applications are published ahead of the grant date, but it would be quite a theoretical stretch to assume that regular investors possess the required competency to evaluate a patent application and determine with high accuracy its approval outcome. Rather than scaling down the already too long list of strong assumptions, this explanation would add one more to it.

An alternative explanation would be to assume information diffusion frictions which would negatively impact the rate of stock price adjustments. This explanation would invalidate any patent valuation methodology based on stock price responses to news about patents, but would not be detrimental for the validity of other valuation methodologies based on stock market data that utilize estimates of Tobin's q equations, such as for example the approach of Hall et al. (2005).

The above explanations did not call into question the rational behavior of investors or their perfect (eventual) knowledge of the facts. If either of these two key assumptions of EMH fails, then the validity of all methodologies based on stock market price fluctuations becomes disputed. The investors may possess perfect knowledge of the patent values and learn immediately that a patent has been granted, but as long as they do not make rational purchasing decisions of stocks, conditional on this available information, then the stock prices will not reflect the value the underlying patent portfolio. Conversely, if all investors behaved perfectly rationally²³, but they did not have reliable knowledge about the value

²³Note that here we assume that investors have some priors (however inaccurate) about the value of the patent and would act in accordance with these beliefs. Some researchers believe that when people do not have well defined priors, they might not feel compelled to take any action, which might be considered a deviation from rationality.

of the patents granted, then the patent estimates would not reflect anything about the underlying value of patents, but would be an aggregate of the investors' widely disparate and inaccurate beliefs.

It remains an open question which of these assumptions is the culprit for the failure of Kogan et al.'s methodology to yield reliable estimates of patent values. Hopefully future empirical and theoretical work will give more informed answers, perhaps by applying a similar placebo estimation to other stock market-based methodologies that don't necessarily rely on patent news announcements. Whatever the theoretical explanation, I believe the critique outlined in this paper rests on compelling empirical evidence. As of January 2018, there are 249 other papers on Google Scholar that cite Kogan et al (2012). If using patent news announcement to estimate patent values is unreliable, then this conclusion also calls into question the conclusions of all other papers that possibly use this methodology to produce patent estimates to answer other empirical questions of interest.

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Appendix A

Lobbying for international protection of IPR: Theory

A.1 Monotonicity

Proof: We want to show that if $H_1 > H_2$ then $d_1 > d_2$. Substituting the expression (2.16) for B_i in the definition of $d_i = B_i - W_i(\Omega_{-i}) > 0$ we get:

$$d_i = a\Delta W(\Omega_o; \Omega_{-i}) + \sum_{i \in L} \Delta W_i(\Omega_o; \Omega_{-i}) \quad (\text{A.1})$$

where the notation $\Delta W(\Omega_o; \Omega_{-i}) = W(\Omega_o) - W(\Omega_{-i})$ is used. Take two firms that differ only marginally in the knowledge capital stock, so $H_1 = H_2 + dH$ for a an infinitesimally small positive dH . Because the solution to (2.14) is continuous and positively correlated with ζ , it follows that $\Omega_{-2} = \Omega_{-1} + d\Omega$. Using expression (A.1), we can write the difference $d_1 - d_2$ as:

$$d_1 - d_2 = a\Delta W(\Omega_{-2}; \Omega_{-1}) + \sum_{i \in L} \Delta W_i(\Omega_{-2}; \Omega_{-1}) \quad (\text{A.2})$$

Dividing this expression by $d\Omega$ yields an equation in terms of the first-order differentials evaluated at Ω_{-1} :

$$\frac{d_1 - d_2}{d\Omega} = aW'(\Omega_{-1}) + \sum_{i \in L} W'_i(\Omega_{-1}) > 0 \quad (\text{A.3})$$

This expression is exactly the same as the first-order condition (2.13), but is evaluated at $\Omega_{-1} < \Omega_o$ (below the global maximum), therefore it must be positive. Thus, $d_1 - d_2$ must be positive as well.

A.2 Proof of Proposition 1

If $\Delta\theta_U\mu_U/M_U > \Delta\theta_E\mu_E/M_E$ then Ω_U^* must increase. If the opposite is true, then Ω_E^* must increase.

Proof: Using the linear best response functions (2.21) and (2.22), we calculate the Nash equilibrium to be:

$$\Omega_U^* = CS_c\bar{T}\gamma \frac{(CS_c - CS_m)(1 + \gamma - \frac{M_E}{M_U}) + \pi(\theta_U\mu_U\frac{M_E}{M_U} - \mu_E\theta_E)}{(CS_c - CS_m)^2((1 + \gamma)^2 - 1) - \pi\bar{\theta}\gamma(CS_c - CS_m)} \quad (\text{A.4})$$

$$\Omega_E^* = CS_c\bar{T}\gamma \frac{(CS_c - CS_m)(1 + \gamma - \frac{M_U}{M_E}) + \pi(\mu_E\theta_E\frac{M_U}{M_E} - \theta_U\mu_U)}{(CS_c - CS_m)^2((1 + \gamma)^2 - 1) - \pi\bar{\theta}\gamma(CS_c - CS_m)} \quad (\text{A.5})$$

If both lobbying terms θ_U and θ_E increase due to the formation/strengthening of lobbying, then $\bar{\theta}$ must increase as well, so the denominator in both countries will decrease. If $\Delta\theta_U\mu_U/M_U > \Delta\theta_E\mu_E/M_E$ holds, then the numerator in (A.4) will increase, so Ω_U^* will unambiguously increase as well. Whereas if the opposite inequality is true, the numerator in (A.5) will increase, resulting in an unambiguous increase in Ω_E^* .

A.3 Motivation for Definition 2

A politically efficient (PE) bargaining outcome is:

$$[\Omega_U, \Omega_E]_{PE} = \text{argmax } \Gamma \equiv a_U G_E(\Omega_U, \Omega_E) + a_E G_U(\Omega_U, \Omega_E) \quad (\text{A.6})$$

where $G_J \equiv \sum_{i \in L_J} C_i + a_J(W_J + R)$ for $J \in \{U, E\}$.

Proof by contradiction: We aim to show that the politically efficient bargaining outcome with transfers maximizes the objective function Γ . Suppose that it doesn't, i.e. there exists another vector $[\Omega_U, \Omega_E]^A$ that maximizes Γ . This discrepancy can be decomposed as $\Delta\Gamma = a_U \Delta G_E + a_E \Delta G_U > 0$. If both terms are positive, then both governments would gain from agreeing to implement $[\Omega_U, \Omega_E]^A$ and no transfers are needed. If one term is negative the other must be positive, so the government that would gain from switching to $[\Omega_U, \Omega_E]^A$ (for example, the USA) is able to construct a transfer payment R just below $\frac{\Delta G_U}{a_U}$ (which is marginally smaller than the US net gain) in order to compensate the EU. So the EU government objective function increases by $a_E R \rightarrow \frac{a_E \Delta G_U}{a_U}$, which will outweigh the loss experienced due to a different policy regime $\Delta G_E > -\frac{a_E \Delta G_U}{a_U}$. So we can construct a transfer payment, such that both governments (politicians) would gain from switching to $[\Omega_U, \Omega_E]^A$, therefore an agreement that doesn't maximize Γ cannot be a politically efficient bargaining outcome.

A.4 Proof of Proposition 6

Assume $\beta = 0$, $f = 0$ and define $p \equiv \pi/(CS_c - CS_m)$ and $c \equiv (CS_c - CS_m)/CS_c$.

Consider only interior solutions for $\Omega_{PE} \in (0, M\bar{T})$ and $\Omega_J^{NE} \in (0, \bar{T})$ for $\forall J$. Then:

$$W(\Omega_{NE}) > W(\Omega_{PE}) \text{ if and only if } \left(1 + \frac{J-1}{\frac{1}{1-b}-p\bar{\theta}}\right)^{\frac{1}{1-b}} < 1 + \frac{J-1}{1-p\bar{\theta}+bp}.$$

Proof: If Ω_{NE} and Ω_{PE} are interior, they can be determined by the expressions (2.25) and (2.24). Because the *R&D* function is Cobb-Douglas, and therefore $\gamma = b/(1-b)$, we get closed form expressions for the resulting patent protection levels Ω_{PE} from (2.25) and for Ω_{NE} from (2.24). We write out the components of $W(\Omega_{NE}) > W(\Omega_{PE})$ using (2.12), and substitute for Ω_{PE} and Ω_{NE} , while setting $\zeta = 1$ because there are no lobbying costs by assumption. Finally, after canceling some terms and rearranging we get the required inequality.

For the two-country case ($J=2$), the Nash equilibrium interior solution is given by solving the system of best-response equations (2.21) and (2.22). The (interior) politically efficient level of IPR Ω_{PE} is given by (2.25). Denote by m the ratio $\frac{M_U}{M_E}$. Then, the parameter restrictions implied by the assumption of interior solutions $0 < \Omega_E^{NE} < \bar{T}$, $0 < \Omega_U^{NE} < \bar{T}$ and $\Omega^{PE} < M\bar{T}$ are the following:

$$0 < p(\theta_E \mu_E m - \theta_U \mu_U) + \frac{1}{1-b} - m < c\left(\frac{2-b}{1-b} - p\bar{\theta}\right) \quad (\text{A.7})$$

$$0 < p(\theta_U \mu_U \frac{1}{m} - \theta_E \mu_E) + \frac{1}{1-b} - \frac{1}{m} < c\left(\frac{2-b}{1-b} - p\bar{\theta}\right) \quad (\text{A.8})$$

$$\bar{\theta} < \frac{c-b}{(1-b)cp} \quad (\text{A.9})$$

The existence of a range of parameters such that Proposition 6 holds is also confirmed by

running simulations with different parameter choices. The more similar the countries are, the more likely they are to fall within the valid parameter range for interior solutions.

A.5 Proposition 6 for corner solutions

Assume $J = 2$, $\beta = 0$, $f = 0$ and define $p \equiv \pi/(CS_c - CS_m)$, $c \equiv (CS_c - CS_m)/CS_c$ and $m \equiv \frac{M_U}{M_E}$.

(i) Consider the case when Ω^{NE} is a corner solution with complete free riding by one of the countries and $\Omega_{PE} \in (0, M\bar{T})$ interior. Without loss of generality assume that $\Omega_N^{NE} \in (0, \bar{T})$ and $\Omega_E^{NE} = 0$. Then $W(\Omega_{NE}) > W(\Omega_{PE})$ if and only if:

$$\left(\frac{(1 + \frac{1}{m})(\frac{1}{1-b} - p\mu_U\theta_U)}{\frac{1}{1-b} - p\bar{\theta}} \right)^{\frac{1}{1-b}} < \frac{(1 + \frac{1}{m})(\frac{1}{1-b} - p\mu_U\theta_U) - \frac{b}{1-b} + pb}{1 - p\bar{\theta} + bp} \quad (\text{A.10})$$

Proof: Substituting $\Omega_E^{NE} = 0$ in (2.20) for $J=U$, we get the NE world level of protection $\Omega_{NE} = M_U\Omega_U^{NE}$. The rest of the derivation is similar as in Appendix A.4: We write out the components of $W(\Omega_{NE}) > W(\Omega_{PE})$ using (2.12) and substitute for Ω_{PE} from (2.25) and Ω_{NE} , while setting $\zeta = 1$ because there are no lobbying costs by assumption. Finally, after canceling some terms and rearranging we get the above inequality (A.10). The parameter restrictions corresponding to this type of corner solutions are given by (A.8), (A.9) and (A.11):

$$p(\theta_E\mu_E m - \theta_U\mu_U) + \frac{1}{1-b} - m < 0 \quad (\text{A.11})$$

(ii) Consider the case when Ω^{NE} is interior and $\Omega_{PE} = M\bar{T}$ is corner solution, describing the situation when the returns to innovation or the strength of lobbying

are so large that the countries agree to offer maximum possible IPR protection. Then $W(\Omega_{NE}) > W(\Omega_{PE})$ if and only if:

$$\left(\frac{c}{b}(2 - b - p(1 - b)\bar{\theta})\right)^{\frac{1}{1-b}} < \frac{2 - p\bar{\theta} + pb}{b\left(\frac{1}{c(1-b)} - \frac{1}{1-b} + p\right)} \quad (\text{A.12})$$

Proof: We write out the components of $W(\Omega_{NE}) > W(M\bar{T})$ using (2.12) and substitute for Ω_{NE} from (2.24), while setting $\zeta = 1$ because there are no lobbying costs by assumption. After some algebraic manipulation we get the above inequality. The parameter restrictions corresponding to this type of corner solutions are given by (A.7), (A.8) and (A.13):

$$\bar{\theta} > \frac{c - b}{(1 - b)cp} \quad (\text{A.13})$$

A.6 Proof of Proposition 7

A firm that has an international patent portfolio (X type) will lobby more for a cooperative IPR agreement than an identical firm (same H_i) with only domestic patent portfolio (D type).

Proof: We want to show that the difference between the equilibrium contributions $C_X(H_i)$ and $C_D(H_i)$ is positive. Assume that both firms Di and Xi are in the EU and both are lobbying in equilibrium. Substituting expression (2.16) in (2.15) for the case of a single world government maximizing Γ , we get that the contributions of each firm can be

written as:

$$C_{Xi} = a_E \Delta W(\Omega_{-Xi}, \Omega_{PE}) + \sum_{j \in L_E, j \neq Xi} \Delta W_{E,j}(\Omega_{-Xi}, \Omega_{PE}) + \frac{a_E}{a_U} \sum_{j \in L_U} \Delta W_{U,j}(\Omega_{-Xi}, \Omega_{PE}) \quad (\text{A.14})$$

$$C_{Di} = a_E \Delta W(\Omega_{-Di}, \Omega_{PE}) + \sum_{j \in L_E, j \neq Di} \Delta W_{E,j}(\Omega_{-Di}, \Omega_{PE}) + \frac{a_E}{a_U} \sum_{j \in L_U} \Delta W_{U,j}(\Omega_{-Di}, \Omega_{PE}) \quad (\text{A.15})$$

where the notation $\Delta W_i(\Omega_j, \Omega_k) = W_i(\Omega_j) - W_i(\Omega_k)$ and each Ω is the world level of patent protection under the indexed regime: $_{PE}$ being a cooperative regime with all firms lobbying and $_{-Di}$ a cooperative regime without the firm Di participating in lobbying.

Substituting the expressions for D and X-type of firms in (2.26) for the cooperative case and solving as before gives us the following first order condition for the EU and a symmetric one for the USA:

$$\begin{aligned} & (\mu_E + \mu_U \eta_U) \Delta CS - \pi \left(\mu_E + \mu_U \eta_U + \frac{\mu_E \zeta_E}{a_E} + \frac{\mu_U \zeta_U^\eta}{a_U} \right) = \\ & = \gamma \left((\mu_E \eta_E + \mu_U \eta_U) \left(CS_m + CS_c \frac{M\bar{T} - \Omega}{\Omega} \right) + \mu_E (1 - \eta_E) \left(CS_m + CS_c \frac{\bar{T} - \Omega_E}{\Omega_E} \right) \right) \end{aligned} \quad (\text{A.16})$$

Here ζ_J is the share of lobbying firms in country J, ζ_J^η is the share of exporting firms in country J that lobby (as a share of all firms in J in terms of capital), and $\mu_J < 1$ is the share of total world knowledge capital allocated in J. If we substituted for $\eta_J = 1$ (all firms export at no cost), we'd get the same expression as in the benchmark cooperative case (2.27). Unlike before, now we have an asymmetric system of equations that jointly gives the politically efficient policy vector. Notice that $\Omega_{-Xi} < \Omega_{-Di} < \Omega_{PE}$, because if

firm Xi doesn't lobby both ζ_E and ζ_E^η are reduced by H_i , whereas if firm Di abstains only ζ_E is affected, resulting in a higher level of protection when the economically weaker firm Di is absent.

Using (A.14) and (A.15), we can write:

$$C_{Xi} - C_{Di} = a_E \Delta W(\Omega_{-Di}, \Omega_{-Xi}) + \sum_{j \in L_E} \Delta W_{E,j}(\Omega_{-Di}, \Omega_{-Ei}) + \frac{a_E}{a_U} \sum_{j \in L_U} \Delta W_{U,j}(\Omega_{-Di}, \Omega_{-Xi}) + \Delta W_{Di}(\Omega_{-Di}, \Omega_{PE}) + \Delta W_{Xi}(\Omega_{PE}, \Omega_{-Xi}) \quad (\text{A.17})$$

Notice that the term $a_E \Delta W(\Omega_{-Di}, \Omega_{-Xi}) + \sum_{j \in L_E} \Delta W_{E,j}(\Omega_{-Di}, \Omega_{-Xi}) + \frac{a_E}{a_U} \sum_{j \in L_U} \Delta W_{U,j}(\Omega_{-Di}, \Omega_{-Xi}) = \Gamma(\Omega_{-Di}) - \Gamma(\Omega_{-Xi}) > 0$ because $\Gamma(\Omega)$ is evaluated below the unique global maximum and $\Omega_{-Xi} < \Omega_{-Di}$. Thus to prove the proposition it suffices to show that the remaining term of (A.17): $\Delta W_{Di}(\Omega_{-Di}, \Omega_{PE}) + \Delta W_{Xi}(\Omega_{PE}, \Omega_{-Xi})$ is positive. Using (2.11), we substitute for the individual firm owners' welfares in terms of the different world levels of patent protection Ω so we get:

$$(b^{\frac{b}{1-b}} - b^{\frac{1}{1-b}}) H_i \pi \left((\Omega_{PE})^{\frac{1}{1-b}} - (\nu_E^{PE} \Omega_{PE})^{\frac{1}{1-b}} \right) + (b^{\frac{b}{1-b}} - b^{\frac{1}{1-b}}) H_i \pi \left((\nu_E^{-Di} \Omega_{-Di})^{\frac{1}{1-b}} - (\Omega_{-Xi})^{\frac{1}{1-b}} \right) \quad (\text{A.18})$$

The expression $(b^{\frac{b}{1-b}} - b^{\frac{1}{1-b}}) > 0$ and $\nu_E^L \in (0, 1)$ is the market-weighted share of world patent protection afforded in the EU under the specified set of lobbying firms L. Because $f(x) = x^{\frac{1}{1-b}}$ is an increasing function, the first term $(\Omega_{PE})^{\frac{1}{1-b}} - (\nu_E^{PE} \Omega_{PE})^{\frac{1}{1-b}}$ is clearly positive.

If we solved (A.16) for Ω and substituted it in the expression for ν_E , we'd get that:

$$\nu_E = \frac{C_E}{A_E - A_U B + C_E + C_U B + \sqrt{(A_E - A_U B - C_E + C_U B)^2 + 4C_E C_U B}}$$

$$A_E \equiv \frac{1}{2} \left(M C S_c \bar{T} (\mu_U \eta_U + \mu_E \eta_E) - \frac{\Delta C S}{\gamma} (\mu_E + \mu_U \eta_U) + \frac{\pi}{\gamma} (\mu_E + \mu_U \eta_U + \frac{\mu_E \zeta_E}{a_E} + \frac{\mu_U \zeta_U^\eta}{a_U}) \right)$$

$$B \equiv \frac{\mu_E + \mu_U \eta_U}{\mu_U + \mu_E \eta_E} \quad ; \quad C_E \equiv C S_c \bar{T} \mu_E (1 - \eta_E) M_E \quad (\text{A.19})$$

From (A.19) we can conclude that $\nu_E^{PE} < \nu_E^{-Di}$, because ν_E is inversely related to ζ_E via A_E and because $\zeta_E^{PE} = \zeta_E^{-D} + \frac{H_i}{H_E}$, whereas A_U will not be affected if firm Di doesn't lobby. Therefore, for the negative contribution from the second term we have: $(\nu_E^{-Di} \Omega_{-Di})^{\frac{1}{1-b}} - (\Omega_{-Xi})^{\frac{1}{1-b}} > (\nu_E^{-Di} \Omega_{-Di})^{\frac{1}{1-b}} - (\Omega_{-Di})^{\frac{1}{1-b}} > (\nu_E^{PE} \Omega_{-Di})^{\frac{1}{1-b}} - (\Omega_{-Di})^{\frac{1}{1-b}}$, which in absolute terms is smaller than the positive contribution from the PE-term, because $\Omega_{-Di} < \Omega_{PE}$. Thus the whole term (A.18) is positive, which is sufficient to conclude that (A.17) is positive as well and $C_{Xi} > C_{Di}$.

Appendix B

Lobbying for international protection of IPR: Empirics

B.1 Data description

I gather and match cross-sectional data at the consolidated (parent) firm level from three sources: firm sales data from the Compustat (North America) database, lobbying expenditure data compiled by the Center for Responsive Politics¹ and data on patent applications and grants from the PATSTAT database². The sample is limited to publicly traded companies in the US. Country-level data for GDP was sourced from the World Bank, whereas country-level indices of patent protection were calculated using the methodology of Juan C. Ginarte and Walter G. Park (1997)³.

To construct the patent portfolios for the firms in our sample we use the 2015 Autumn edition of PATSTAT which contains data at the level of individual patent applications (including grants and citations) from over 100 national and international patent offices. We limit our interest only to jurisdictions associated with the countries involved in the TPP and TTIP negotiations⁴. Because multiple patent publications across different jurisdic-

¹The data is available for public use on the CRP's website OpenSecrets.org

²Full name: EPO Worldwide Patent Statistical Database created and managed by the European Patent Office

³The most recently available Ginarte-Park indeces from 2010 are used.

⁴Namely: the US Patent Office, the European Patent Office, the national patent offices of the countries members of EPO, and the patent offices of Japan, Australia, Canada, Chile, Brunei, New Zealand, Peru,

tions can be associated with a single patented invention, we consider an innovation to be defined at the extended (INPADOC) patent family level⁵. We discard patents for which the (latest) application was filed before 1997 and thus will have expired in 2017, the expected year of entry into force of TPP. We proxy for the number of citations at the INPADOC family level by taking the maximum number of citations among the DOCDB patent families associated with each INPADOC family. We later use the number of citations to construct citation-weighted patent portfolios that capture the quality dimension of different patent inventions.

To match the data across the different datasets first we apply the same name cleaning and standardization algorithm to all variables containing firm names. Next we assign patent inventions (INPADOC families) to the firms contained in the Compustat database by matching on the set of firm patent applicants associated with that invention. If multiple such parent company matches are found, we consider for valid the firm with the most recent fiscal report, implying it is still active and hasn't been acquired by another firm. If no Compustat firm entry matches any of the patent applicants, then most likely all patent applicants are subsidiaries, so we find additional matches by using the company hierarchy implied by the INPADOC family structure⁶: We assign the remaining patent

Malaysia, Mexico, Singapore and Vietnam

⁵A single INPADOC family contains all documents directly or indirectly linked to one specific priority patent document. Thus any member shares at least one priority with at least one other member.

⁶We construct the parent-subsidiary correspondence for each Compustat firm entry as follows: We assume that an unmatched patent applicant is a subsidiary of a matched patent applicant if they can be found within the same INPADOC family. If there are multiple parents implied per subsidiary, we take for valid the parent that (in order of application of criterion): a) has a more recent fiscal filing, b) appears as a match with highest frequency, and c) has the largest total number of implied subsidiaries. We assign manually the parents for the few remaining ambiguous matches. Note that this method of matching may not deal properly with research collaborations in cases when both collaborators apply for patents in different jurisdictions.

inventions to Compustat parent entries whose subsidiaries show up as patent applicants. If multiple subsidiaries within an INPADOC family match to conflicting Compustat entries, we consider for valid the match whose parent firm filed the most recent fiscal report. If this criterion doesn't give a unique match, we consider for valid the one that appears as a patent applicant with highest frequency.

Once we have matched every invention to a firm, we can construct a variety of weighted patent portfolio variables for each firm. These portfolios are defined across three criteria:

- The entity we choose to count: number of patent applications, number of granted patent applications, number of citation-weighted patents (each citation counts as 1) or number of duration-weighted patents (each remaining year of patent lifetime counts as 1)
- The selection of jurisdictions: only USA (domestic), only EPO, TPP participants, European national patent offices, EPO+Pacific countries (international portfolio) or all jurisdictions
- The choice of weights for each jurisdiction (country): GDP-share in world GDP (2014) or the product of GDP-shares and the Ginarte-Park indices of patent protection (2010)

The Center for Responsive politics has assembled individual firm lobbying expenditure data, which US firms are required by law⁷ to report to the Senate's Office for Public Records on a quarterly basis. Reports can either be self-filed or submitted by hired lobbying firms.

⁷Lobbying Disclosure Act (1995)

Each quarterly report, in addition to the total amount of lobbying expenses⁸, contains a detailed checklist of pre-defined issue areas for which the firm lobbied any branch of the government, as well as a more detailed description of the issues discussed for each checked issue. Unfortunately, lobbying expenses are not broken down by issue, so we proxy the amount of TPP/TTIP-related expenditures by multiplying the total quarterly amount with the fraction of the number of reported issues from the checklist whose detailed issue description contains any TPP/TTIP-related words or phrases⁹. To fit the framework of the model, the lobbying data is aggregated across time into a single period (q3:2007-q4:2015) during which negotiations for TPP and TTIP take place.

My method of estimating the TPP/TTIP-related lobbying expenditures presents an obvious limitation of the data, because our implicit assumption that lobbying efforts are spread equally across issues may not be justified. An additional limitation comes from the fact that a significant share of lobbying expenditures happens through trade associations, who do not disclose the sources of their finances. However, if it is the case that companies' financial contributions in trade associations are in proportion to their individual lobbying expenditures, this limitation will not bias the resulting estimates.

B.2 Regression

⁸Expenses are rounded to the nearest \$10,000 and the firm is not required to submit a report if the total expenses are below \$12,000 for self-filers and \$3,000 for lobbying firms.

⁹Besides the obvious "TTP", "TTIP" and their variations, we consider as related also bills granting fast-track trade promotion authority to the President, whose purpose was the smooth passing of the above agreements, namely: "H.R.1295", "S.995", "H.R.1895", "H.R.2146", "Trade promotion authority", "Trade Priorities and Accountability Act" and their variations.

VARIABLES	TPP-related					TTIP-related				
	(1) US only	(2) EPO	(3) Intl	(4) Pacific	(5) All	(6) US only	(7) EPO	(8) Intl	(9) Pacific	(10) All
Log Sales	0.531*** (0.0822)	0.515*** (0.0824)	0.519*** (0.0825)	0.528*** (0.0826)	0.529*** (0.0823)	0.337*** (0.105)	0.329*** (0.106)	0.331*** (0.106)	0.335*** (0.106)	0.335*** (0.105)
US portfolio	0.13*** (0.04)					0.095** (0.04)				
EPO portfolio		0.15*** (0.05)					0.08* (0.05)			
Intl portfolio			0.14*** (0.04)					0.12*** (0.05)		
Pacific portfolio				0.15*** (0.04)					0.12** (0.05)	
All patents					0.13*** (0.04)					0.095** (0.04)
Constant	7.384*** (0.792)	7.485*** (0.790)	7.461*** (0.792)	7.407*** (0.794)	7.402*** (0.792)	9.394*** (1.051)	9.426*** (1.048)	9.423*** (1.051)	9.401*** (1.054)	9.406*** (1.051)
Observations	181	162	172	172	181	107	100	102	102	107
R^2	0.282	0.281	0.277	0.285	0.282	0.171	0.153	0.201	0.198	0.173

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

I run the following firm-level cross-sectional reduced form regression

$$\log(LobbyExp)_i = \alpha_0 + \alpha_1 \log(Sales)_i + \alpha_2 \log\left(\sum_{J \in TPP} s_J^{GDP} Citations_{i,J}\right) + \epsilon_i \quad (\text{B.1})$$

The dependent variable is lobbying expenditures on TPP and TTIP-related issues, on the left and right half of the table respectively. The international portfolio includes the juris-

dictions J of the countries signatories of the respective agreement. The patent stocks are weighted by the number of citations and then by s_J^{GDP} - the share of GDP of country J in world GDP. The coefficients on the portfolios are positive and significant as the theory predicts.

B.3 Patent premium and lobbying

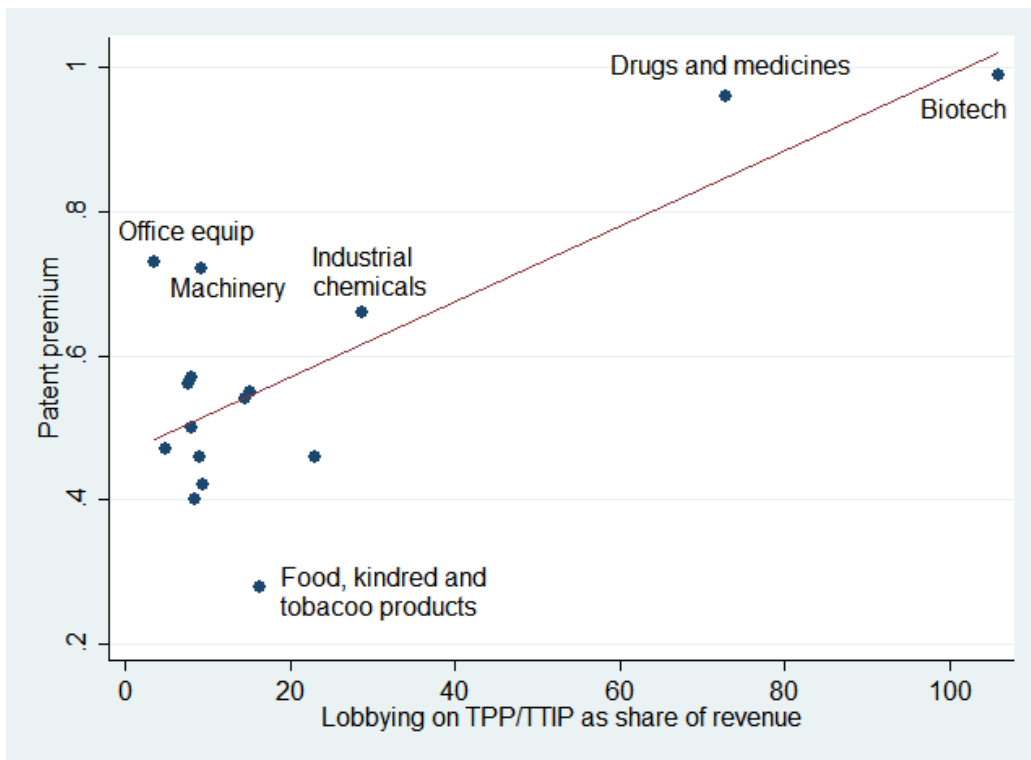


Figure B.1: Correlation between the estimated lobbying expenditures on TPP and TTIP as a share of total sales and the patent premiums at the sectoral level. The correlation coefficient is 0.74. Patent premium estimates are from Arora et al. (2008) and it is defined as the proportional increment of the value of innovations by patenting them. The data on lobbying expenditure is described in Appendix B.1.

Appendix C

Can the stock price response to patent news be used to estimate their value?

C.1 Historical background: IPR protection in China

Since the first patent legislation was passed in 1984 as a result of economic liberalization, Chinese patent law has undergone three substantial amendments: the first Amendment of Patent Law in 1992 following the signing of the Memorandum of Understanding between China and the USA, the Second Amendment (2001) related to China's entry into WTO and the most recent Third Amendment in 2009. Moreover, China regularly develops and implements medium and long-term plans and strategies for boosting scientific and technological innovation. The latest (13th) such five-year plan (2016-2020) aims to bring R&D to 2.5% of GDP by 2020 so that China becomes an innovative nation. I will give a brief historical overview of the most important developments in Chinese patent law that have placed the country firmly on the path to fulfilling its innovative potential. The discussion that follows is not meant to be exhaustive of all the legal changes that took place with each revision, but will instead focus on the relevant legal aspects that affect patent valuation, namely duration and enforcement-related regulations¹.

¹For more detailed discussion of the amendments, refer to Lin, Wood, Jang (2004) and Yu (2001).

The first law regulating patents in China was passed by the Standing Committee of the People's Congress on March 12th 1984, after much debate and opposition from certain industry groups and politicians concerned with ideological purity. It is modeled after the European patent law with three types of patents: inventions, design and utility model patents. The law specified patent duration of 15 years starting from the filing date of the application for invention patents, and 5 years (extendable for 3 more) in the case of design and utility patents. After 18 months from the application filing and the completion of an initial examination, SIPO publishes the patent application in the relevant Patent Gazette, which is released once a week in hard copy. This publishing marks the earliest date from which infringement can be claimed. Granting of the invention patent happens after a more comprehensive examination typically 3-5 years from the the date of the filing. Unlike inventions, design and utility patents are approved upon initial examination typically within a year from the filing date.

This law had a rather limited scope of patentability which excluded pharmaceuticals and chemicals among other things. Use and sale of a product without knowing the fact that the product was produced and sold without the permission of the patent owner was not considered infringement, as well as its use for scientific and research purposes. Patent Administrative Bureaus were established to settle patent disputes due to the weak and disorganized judicial system at the time. Red tape was also an issue, since government approval and permits had to be obtained if a Chinese entity wanted to file for a patent abroad or assign a patent to a foreign entity.

The Sino-US trade negotiations commenced in 1989 in relation to the American review of China's MFN status as a candidate for WTO membership and ended with the the signing

of the Memorandum of Understanding between the two powers on January 17th, 1992. This agreement outlined a series of reforms to Chinese IPR law which were translated into subsequent pieces of legislature², most notably the (First) Amendment of the Patent Law signed on September 4th, 1992. This amendment extended the duration of invention patents from 15 to 20 years, and utility and design patents from 5 to 10 years. It expanded patenting scope by protecting pharmaceutical and chemical products and modifying the definition of patent right to include process patents (type of utility patent). In terms of enforcement, the law specified strict conditions for granting compulsory licenses and custom procedures for stronger border enforcement of IPR.

The Second Amendment revision was passed on August 25th, 2000 and entered into force on July 1st, 2001 as a requirement for China's WTO entry in order to bring Chinese IPR regulation in compliance with the TRIPS³ Agreement, binding for all WTO members. This amendment contained various provisions for stronger patent enforcement. For example it expanded the basis for infringement by including all acts of sale, import or production of a patented product or product obtained from a patented process regardless of whether the infringing party knew whether the product was under patent protection or not. However, the party would not be liable for infringement damages provided that they could prove the product comes from a legitimate source, which made it possible for patent owners to find and deal with the infringing producer directly. The amendment also introduced preliminary injunction procedures, allowed for judicial review for com-

²Other relevant bills affecting trade secrets, copyright law and customs procedures were: Regulations on the Administrative Protection of Chemicals, and Regulations on the Administrative Protection of Pharmaceuticals (1992); Anti-Unfair Competition Law (1993); and Regulations on Custom Procedures for the Protection of Intellectual Property Right (1995).

³Agreement on Trade-Related Aspects of Intellectual Property Rights, effective since January 1st, 1995.

pulsory licensing decision in case either party is not satisfied, abolished the foreign filing license requirement and reduced requirements for excessive support documentation in patent applications.

In 2009 the most recent revision was passed with enforcement and duration of patents largely unaffected. The third revision changed the novelty standard for assessing prior art⁴ from only publications to any known art or technology available to the public before the filing date anywhere in the world. This rule closed the loophole for patent hijacking that would typically happen at trade shows outside China. Among other things, the amendment also introduced specific guidelines for compensation of inventors in case that no contract exists, and introduced a foreign filing license requirement for foreign entities (typically parent companies) that want to file for a patent abroad first for an invention made in China.

Based on the discussion above, we can trace the evolution of the Chinese patent system through 4 stages (regimes): 1984-1992, 1992-2001, 2001-2009 and 2009-today. The estimation focuses on patents granted under the second (pre-WTO: 1992-2001) and third (post-WTO: 2001-2009) regimes⁵.

⁴Prior art consists of all information available to the public in any form before a given date that is used to determine a patent's claims of originality.

⁵Because the last 2009 revision didn't bring any substantial changes in terms of the institutional determinants of patent valuation (enforcement and duration), we could also treat the period from 2001 until today as a single regime for all intents and purposes.

C.2 Distribution of Chinese patent value estimates

Percentiles	Patent Value (in millions ¥)		Patent Value (in millions ¥)
1%	0.8	Mean	76.9
5%	1.7	Std. Dev.	199.7
10%	2.6	Minimum	0.2
25%	6.2	Maximum	2,242.2
50%	16.1		
75%	40.4	Skewness	5.1
90%	186.5	Kurtosis	35.5
95%	405.1		
99%	1,059.4	Observations	30,016

Table C.1: Descriptive statistics for the distribution of Chinese patent value estimates (using actual grant dates)

C.3 Figures

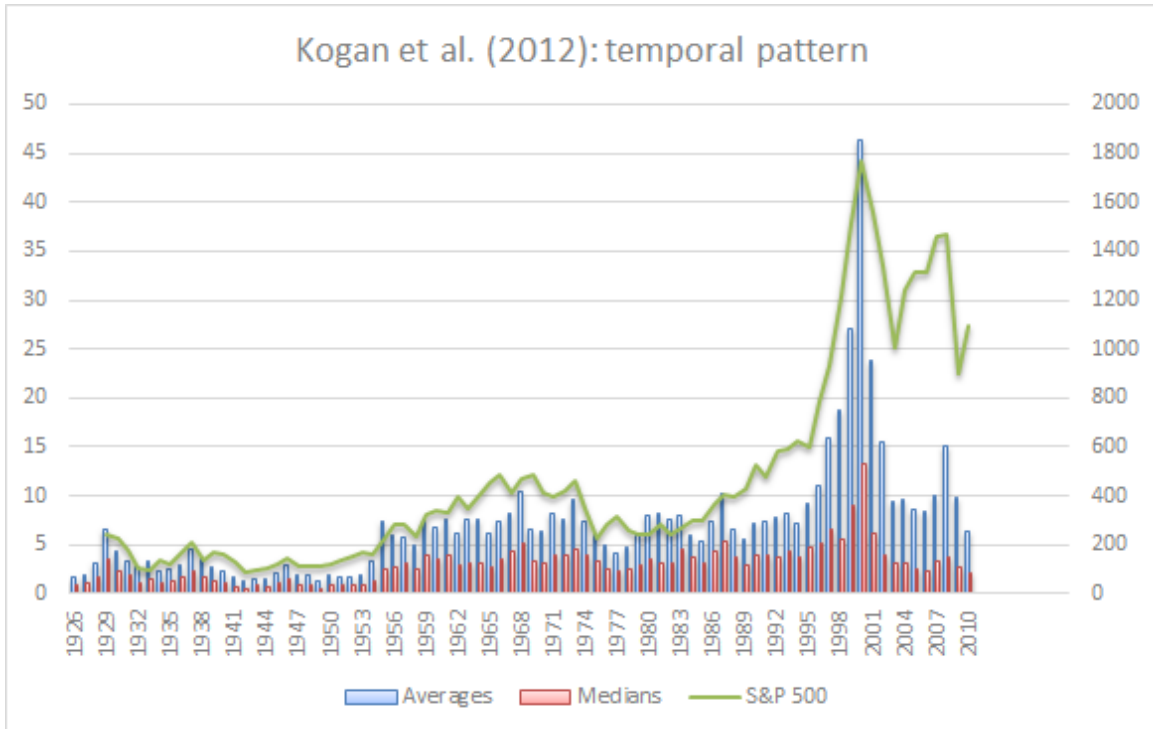


Figure C.1: Trends of yearly averages and medians of patent value estimates by Kogan et al. (2012) - left-hand axis: in millions USD. S&P 500 index - right-hand axis.

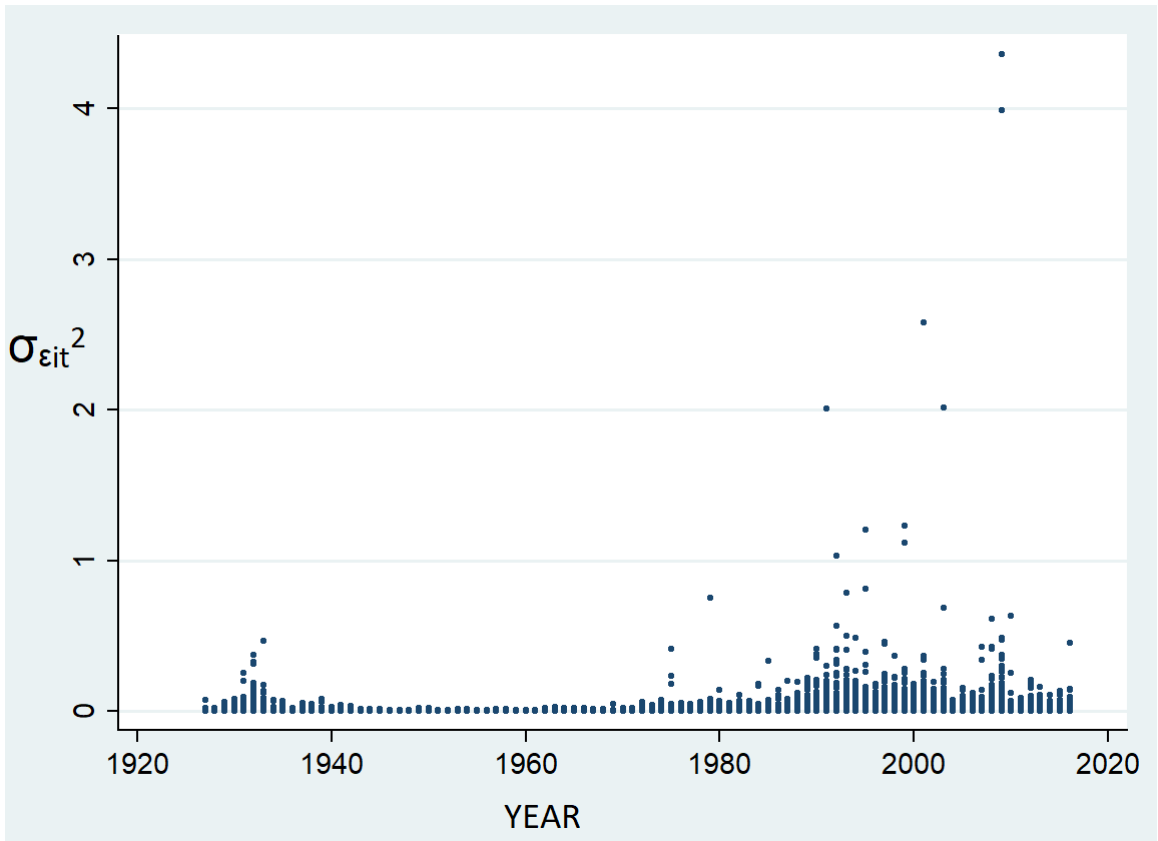


Figure C.2: Plot of the non-parametrically estimated idiosyncratic noise variances for a given firm i and year t .

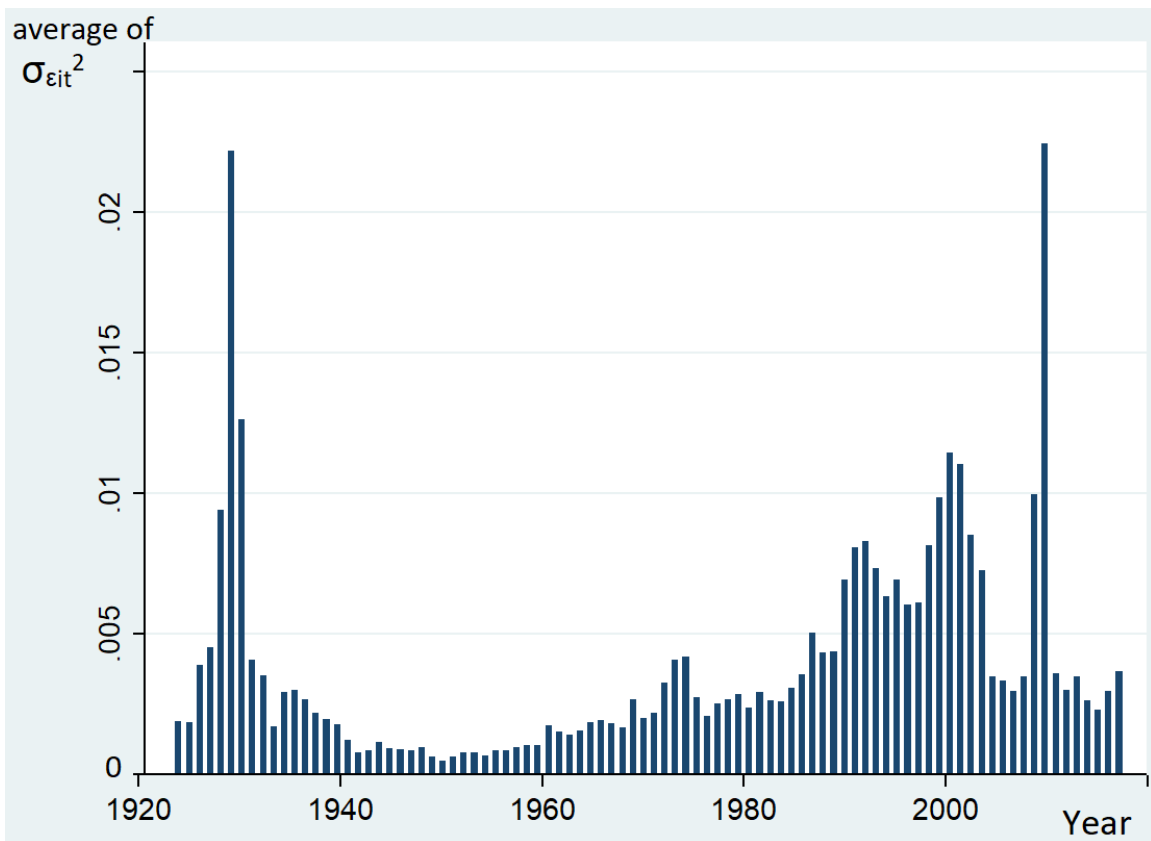


Figure C.3: Plot of the yearly averages of the non-parametrically estimated idiosyncratic noise variances for a given year t

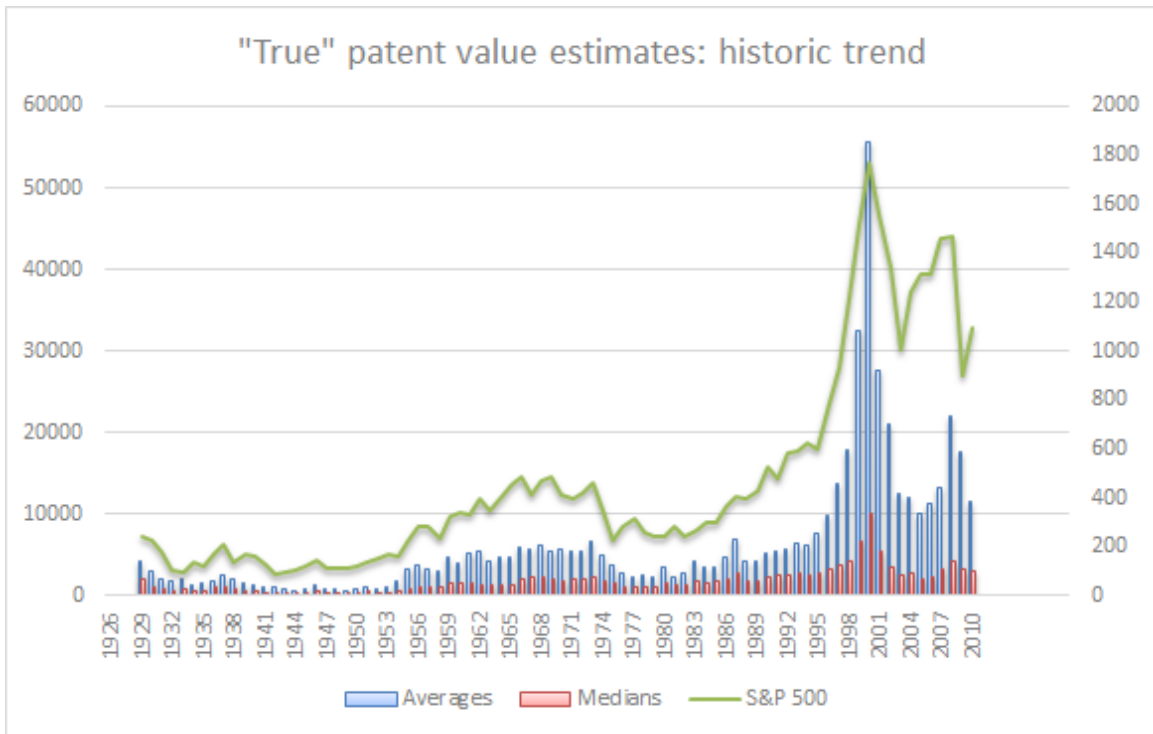


Figure C.4: Trends of yearly averages and medians of patent value estimates using actual patent grant dates - left-hand axis: in 1000's USD. S&P 500 index - right-hand axis.

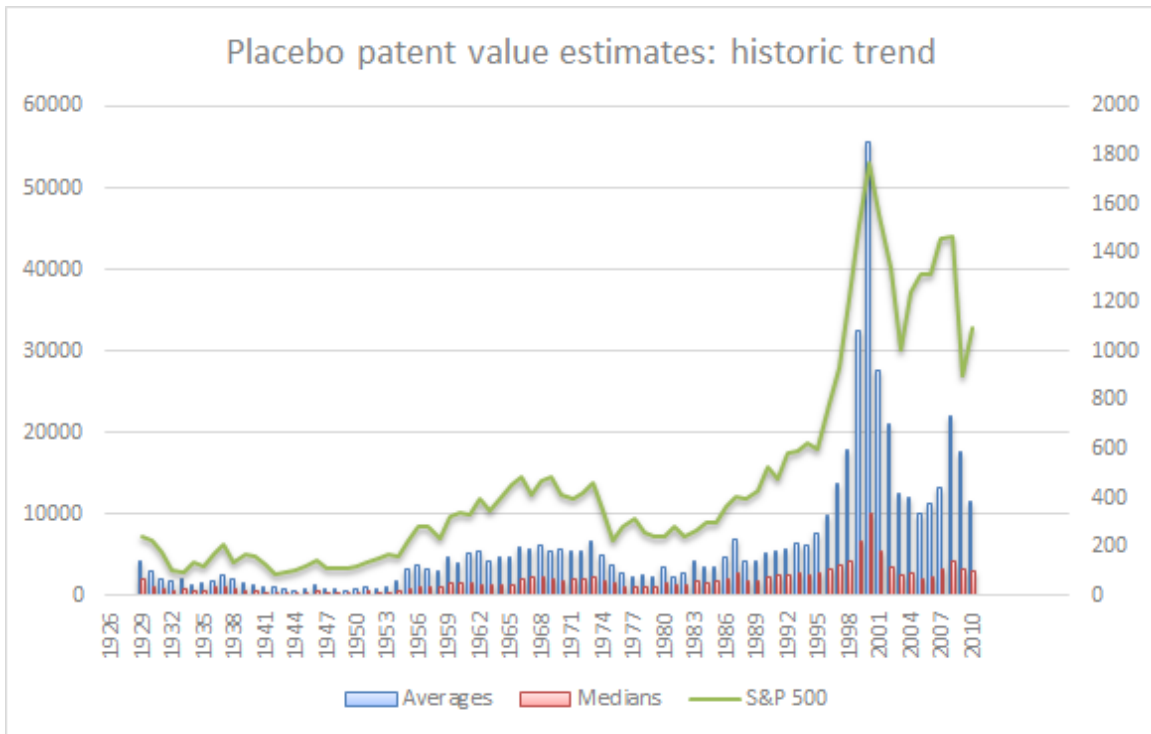


Figure C.5: Trends of yearly averages and medians of patent value estimates using placebo patent grant dates - left-hand axis: in 1000's USD. S&P 500 index - right-hand axis.

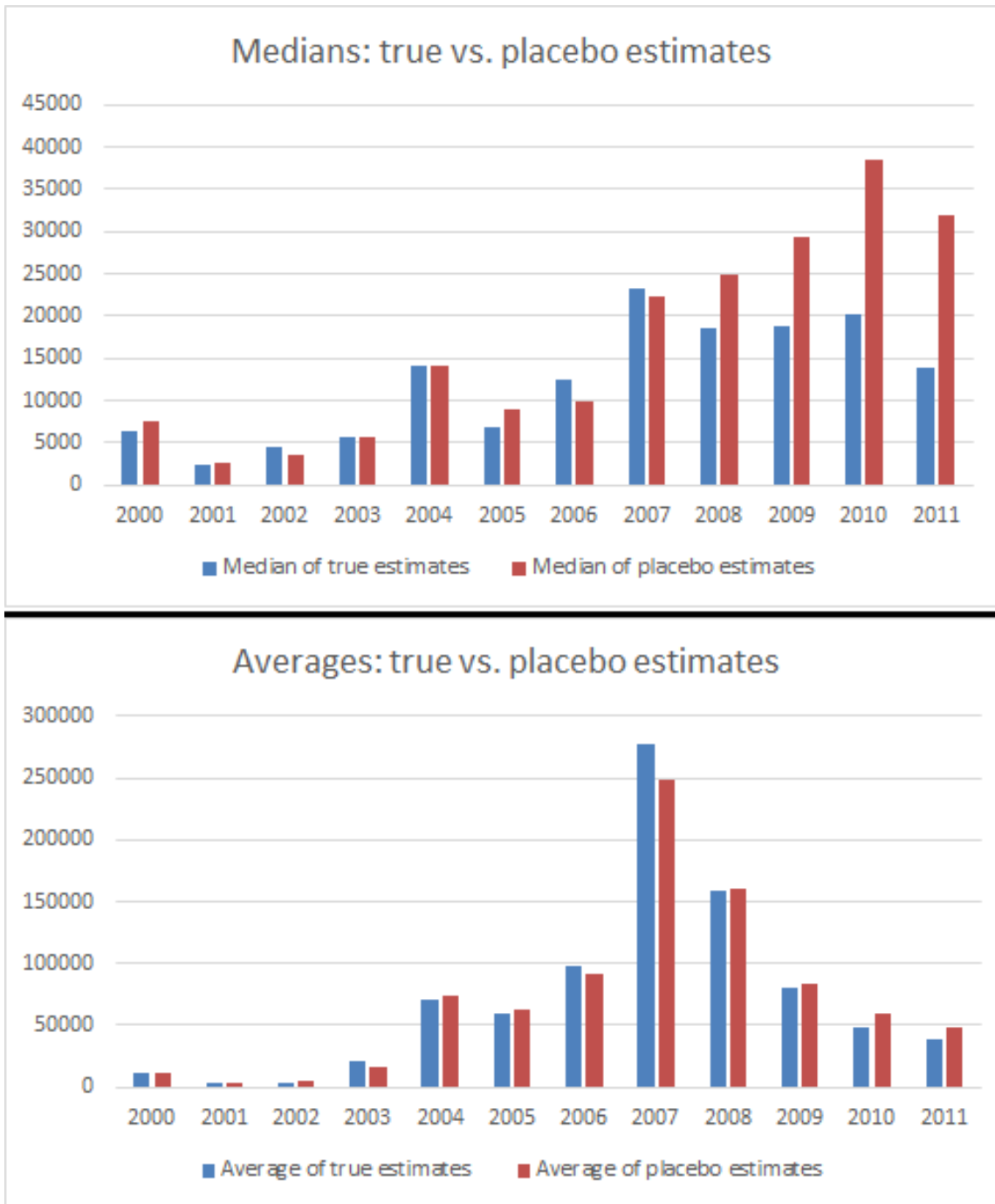


Figure C.6: Side-by-side comparison of trends of yearly averages and medians of "true" patent value estimates vs. their placebo counterparts - left-hand axis: in 1000's USD. US data.

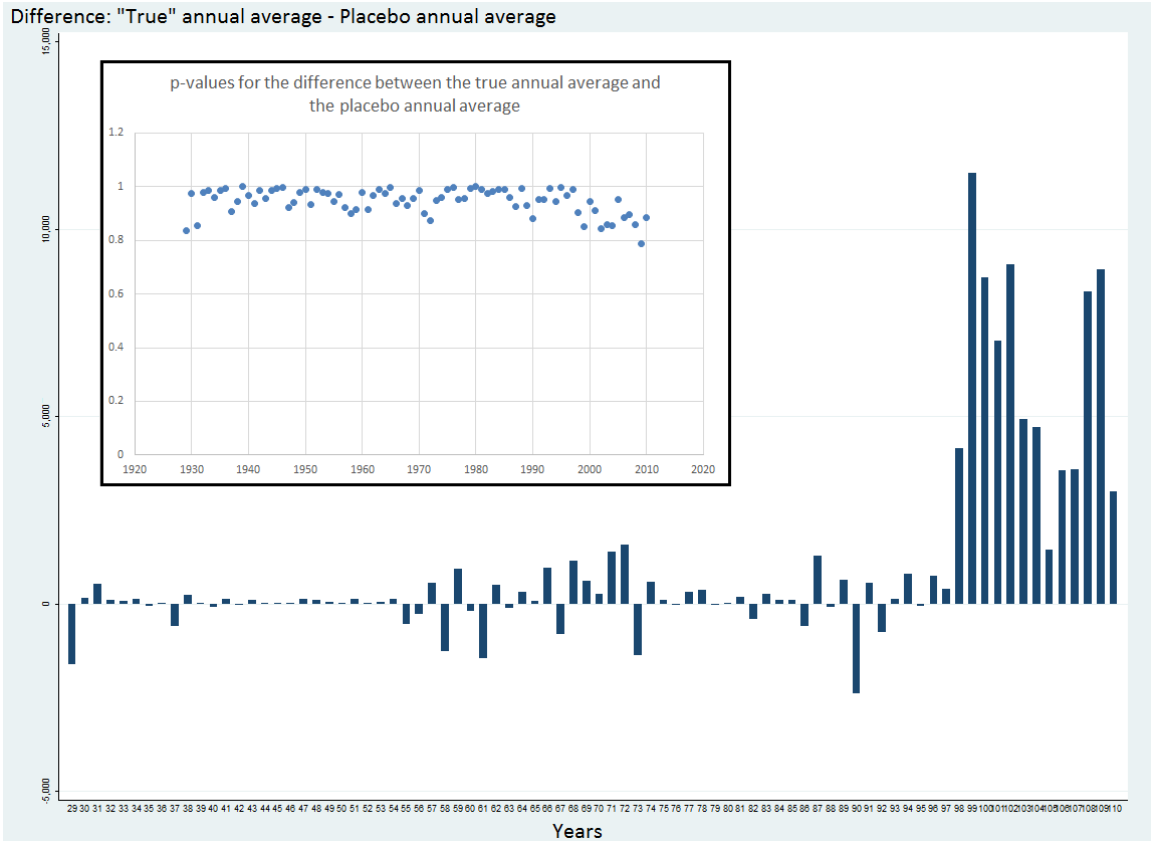


Figure C.7: For each year, the difference between the yearly average of the "true" patent estimates and the yearly average of the placebo patent value estimates. In 1000's USD. The inside diagram plots the associated p-value for each year, under the null that the difference is zero.

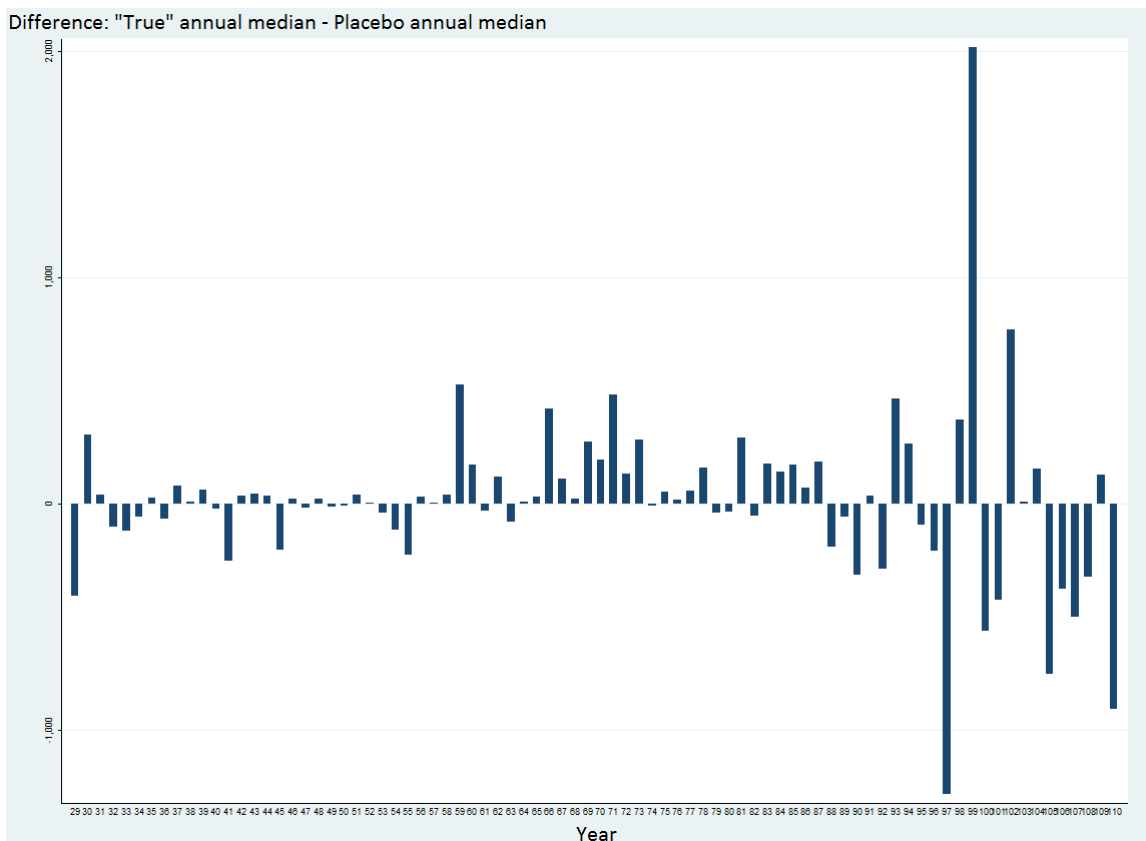


Figure C.8: For each year, the difference between the yearly median of the "true" patent estimates and the yearly median of the placebo patent value estimates. In 1000's USD.

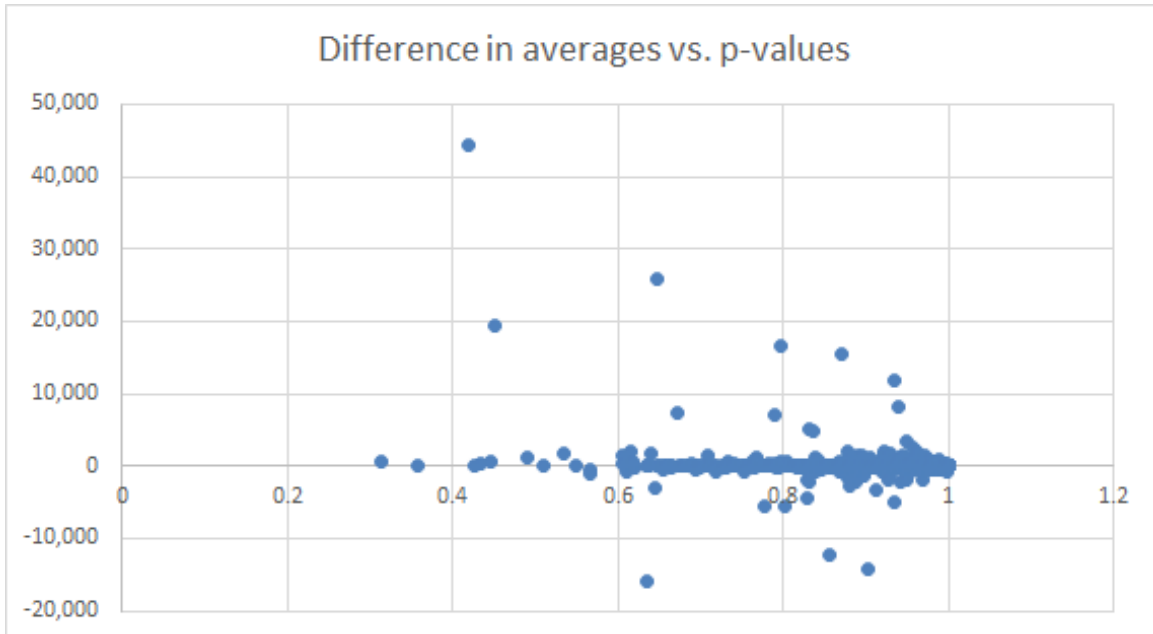


Figure C.9: For each firm, the difference between the firm average of the "true" patent estimates and the average of the placebo estimates of the value of its patents. In 1000's USD. On the x-axis the associated p-value is plotted, under the null that the difference is zero.

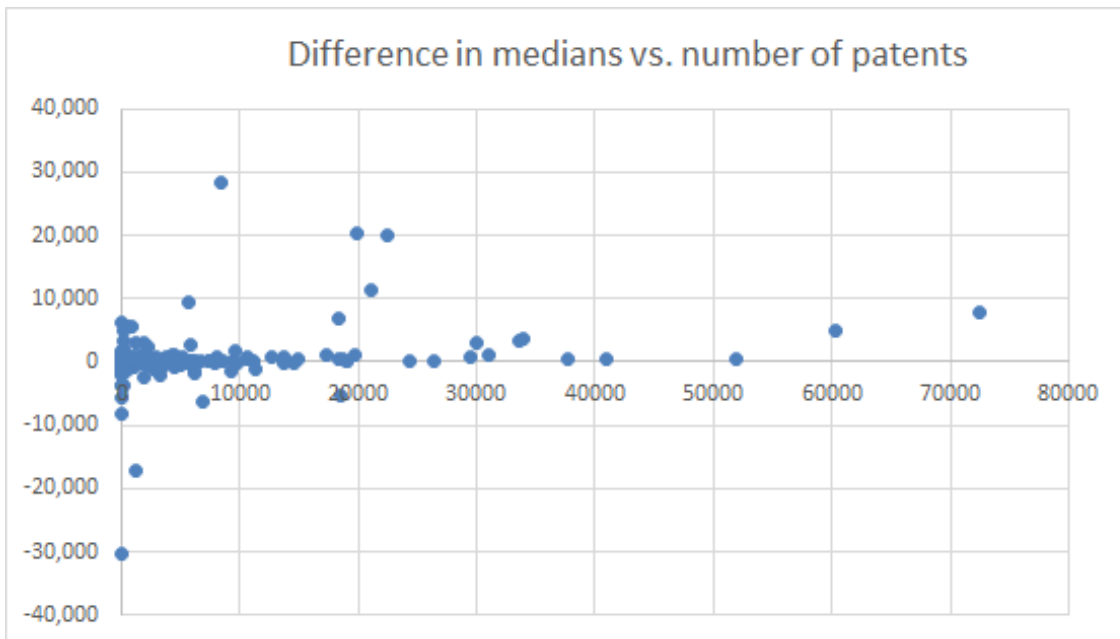


Figure C.10: For each firm, the difference between the firm median of the "true" patent estimates and the median of the placebo estimates of the value of its patents. On the x axis is the associated total number of patents granted to the firm.

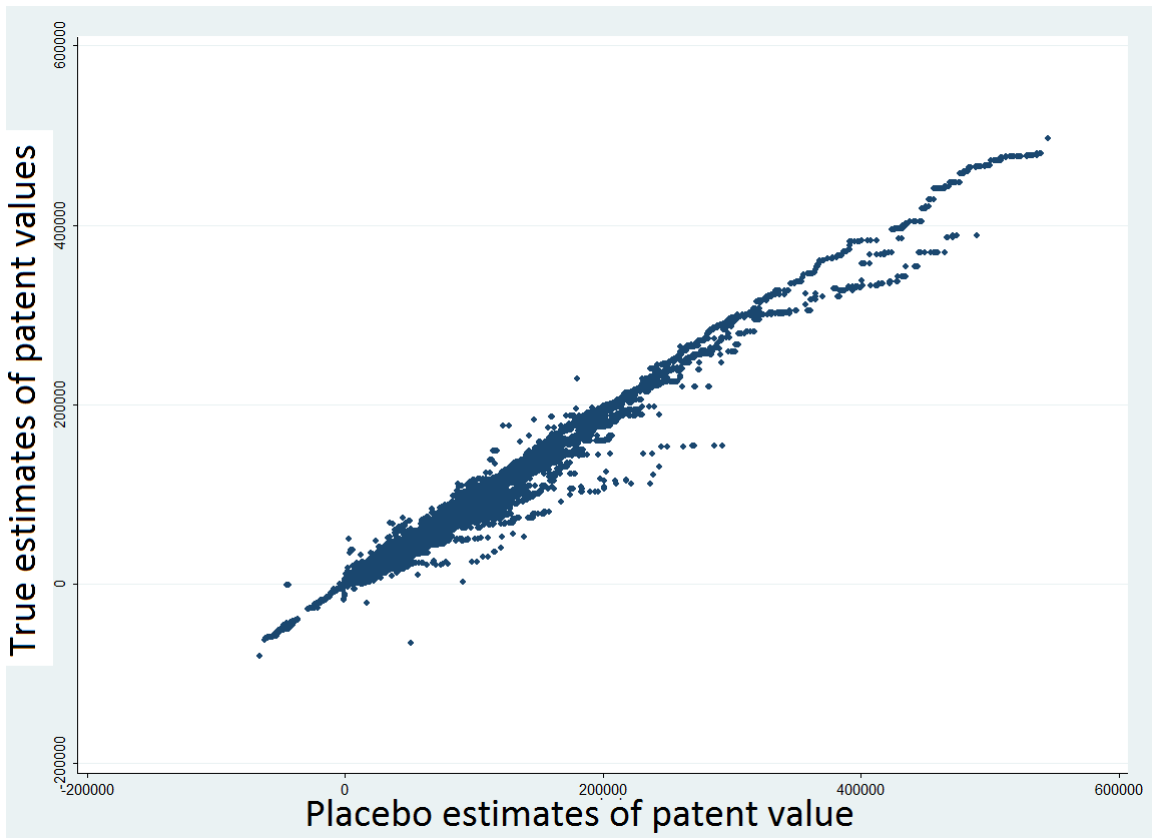


Figure C.11: Scatter plot between "true" patent value estimates and their placebo counterparts, at the level of individual patents (in 1000's USD). US data. The correlation is 0.994.

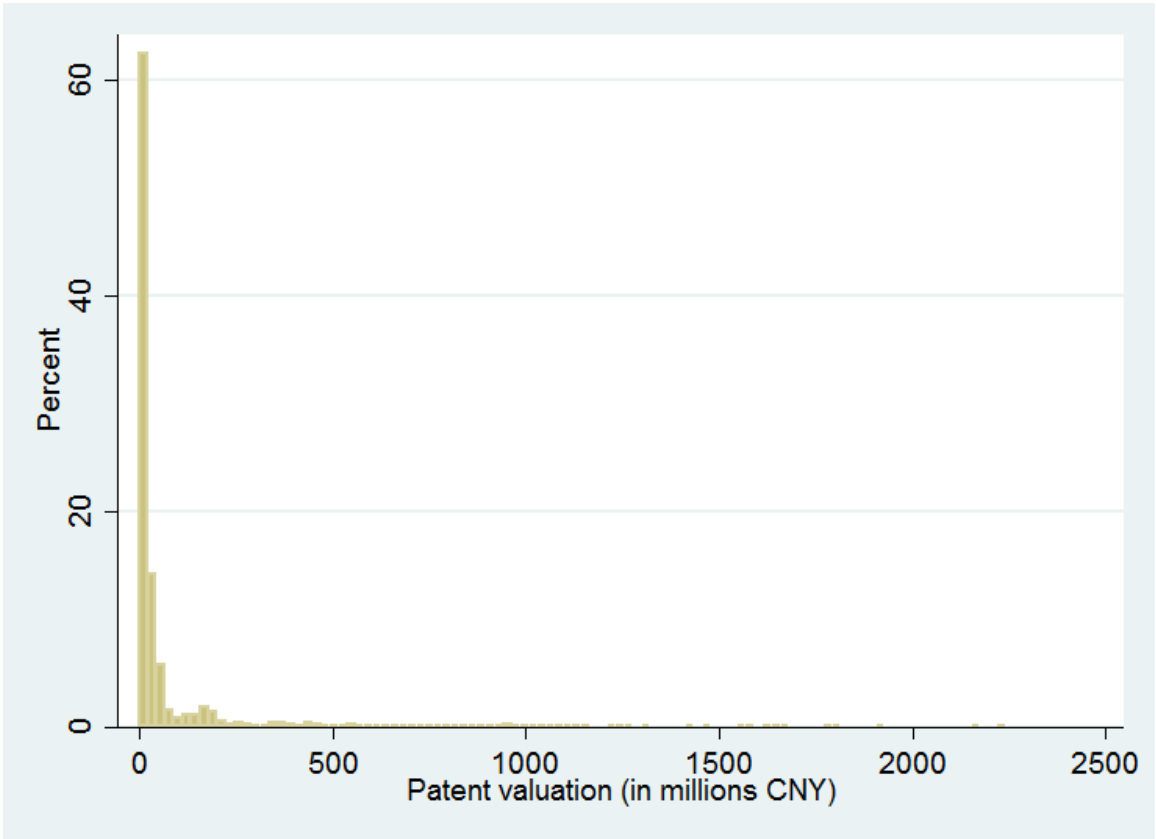


Figure C.12: Empirical distribution of the estimated private valuations of inventions patents.

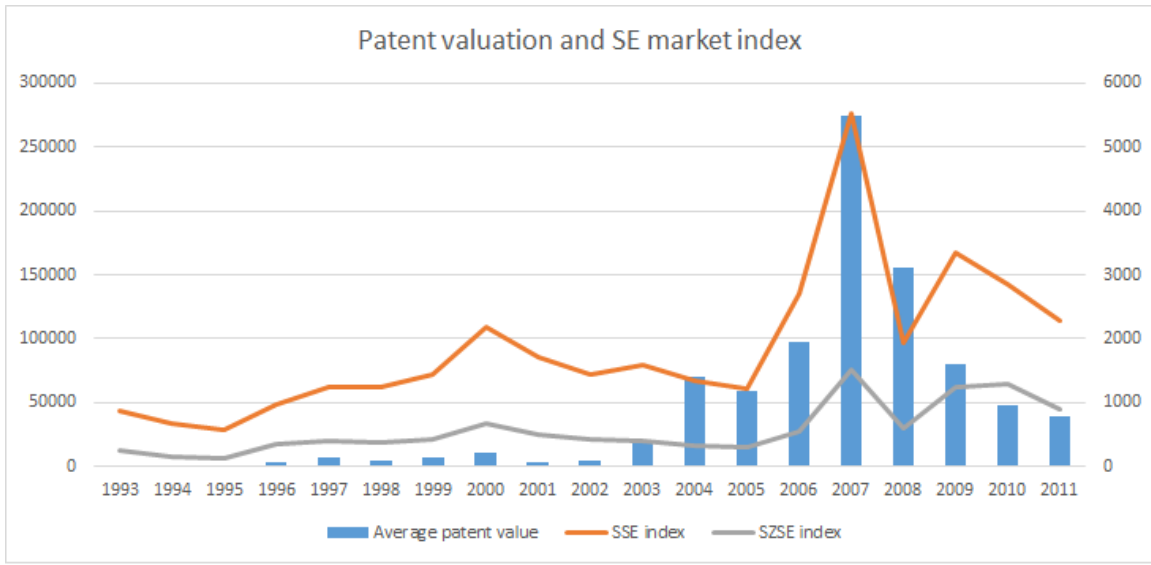


Figure C.13: Evidence for "irrational exuberance" in patent valuation. The bars represent the average patent valuation each year over time (left axis, in 1000's ¥). The trend lines (right axis) represent the SSE A share index (SHA: 000002) and the SZSE A share index (SHE: 399107) respectively for China's two stock exchanges.

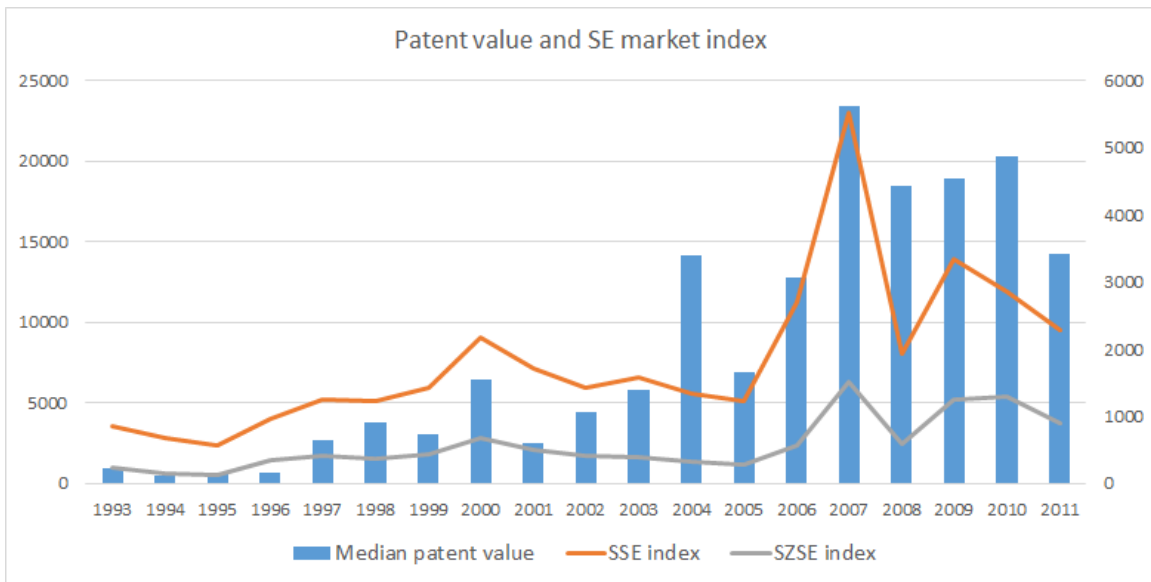


Figure C.14: The median patent valuation exhibits a long-term upward trend. The bars represent the median patent valuation each year over time (left axis, in 1000's ¥). The trend lines (right axis) represent the SSE A share index (SHA: 000002) and the SZSE A share index (SHE: 399107) respectively for China's two stock exchanges.

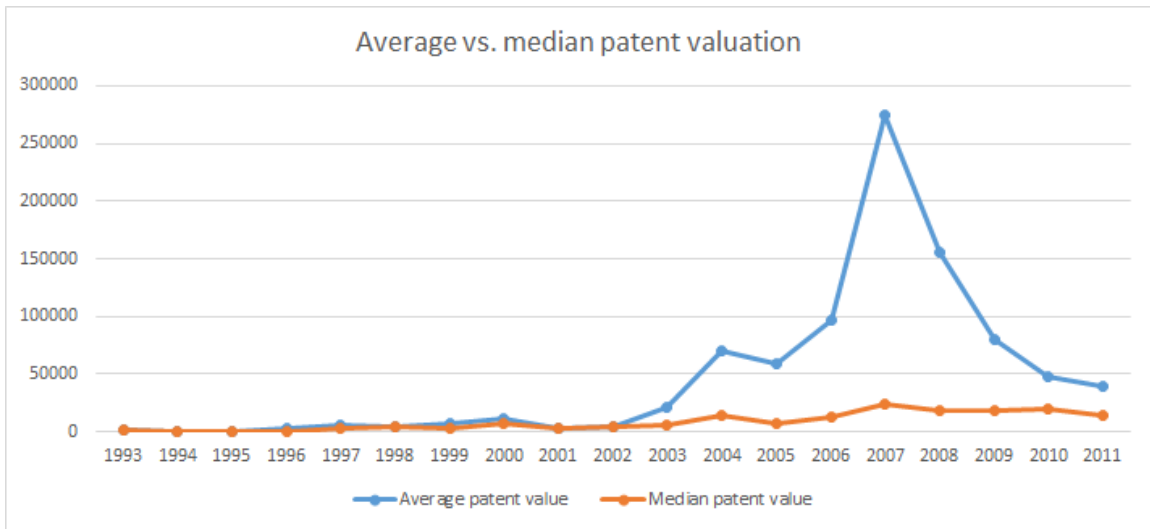


Figure C.15: Yearly trends of the median patent valuation vs. the average patent valuation (Y axis: 1000's ¥). The distribution becomes more skewed during stock market bubbles.

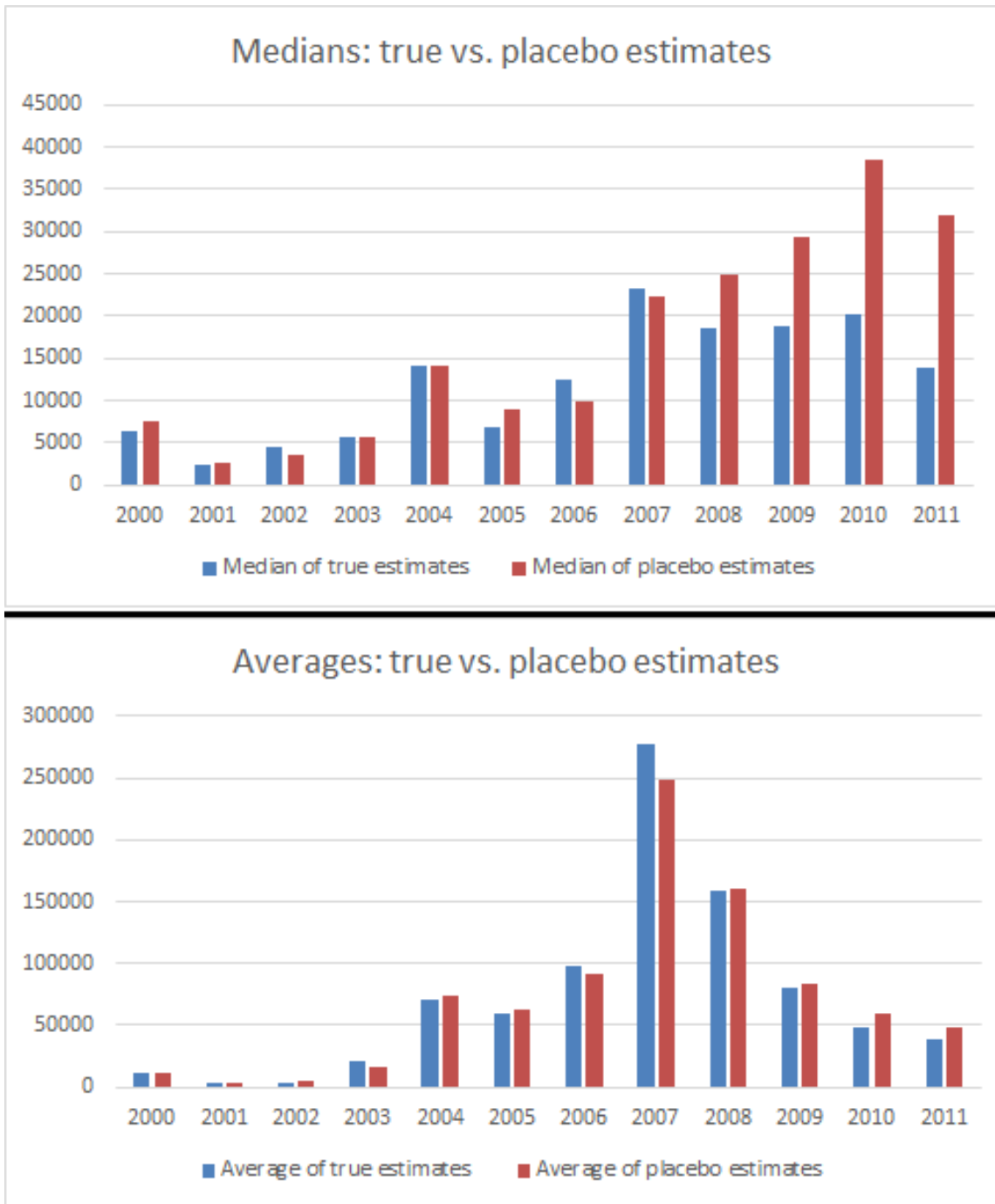


Figure C.16: Side-by-side comparison of trends of yearly averages and medians of "true" patent value estimates vs. their placebo counterparts - left-hand axis: in 1000's ¥. Chinese data.

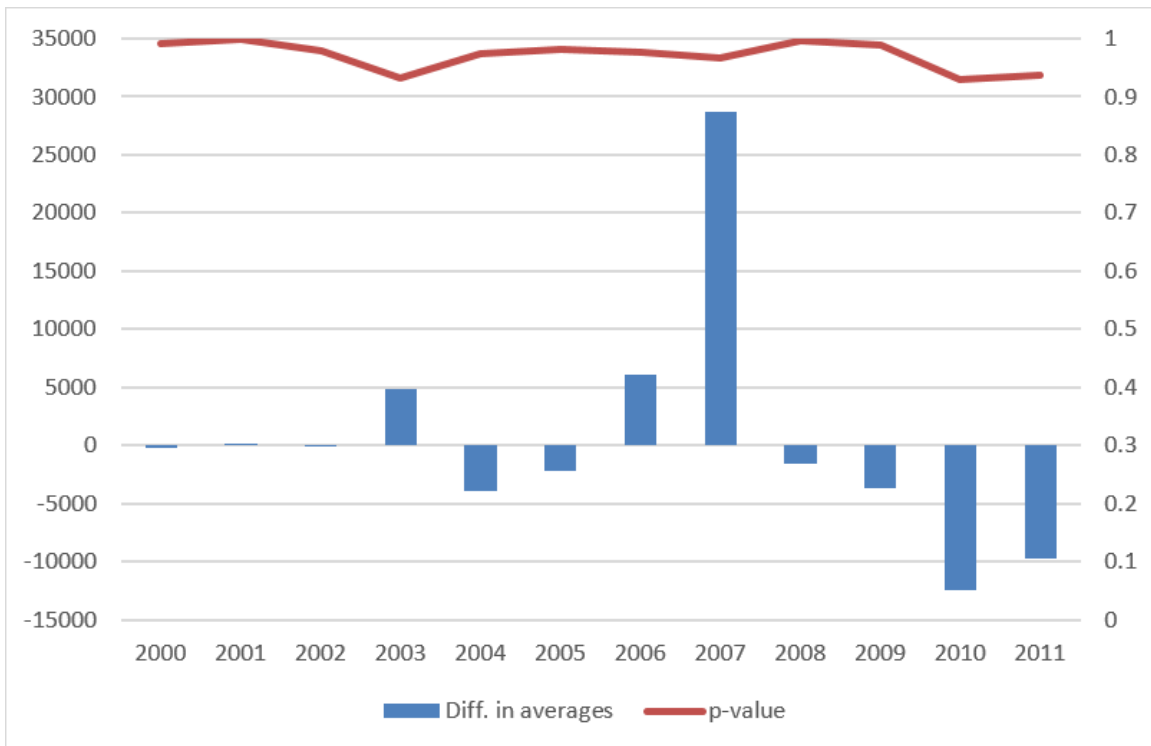


Figure C.17: For each year, the difference between the yearly average of the "true" patent estimates and the yearly average of the placebo patent value estimates. In 1000's ¥. The red line plots the associated p-value for each year, under the null that the difference is zero.

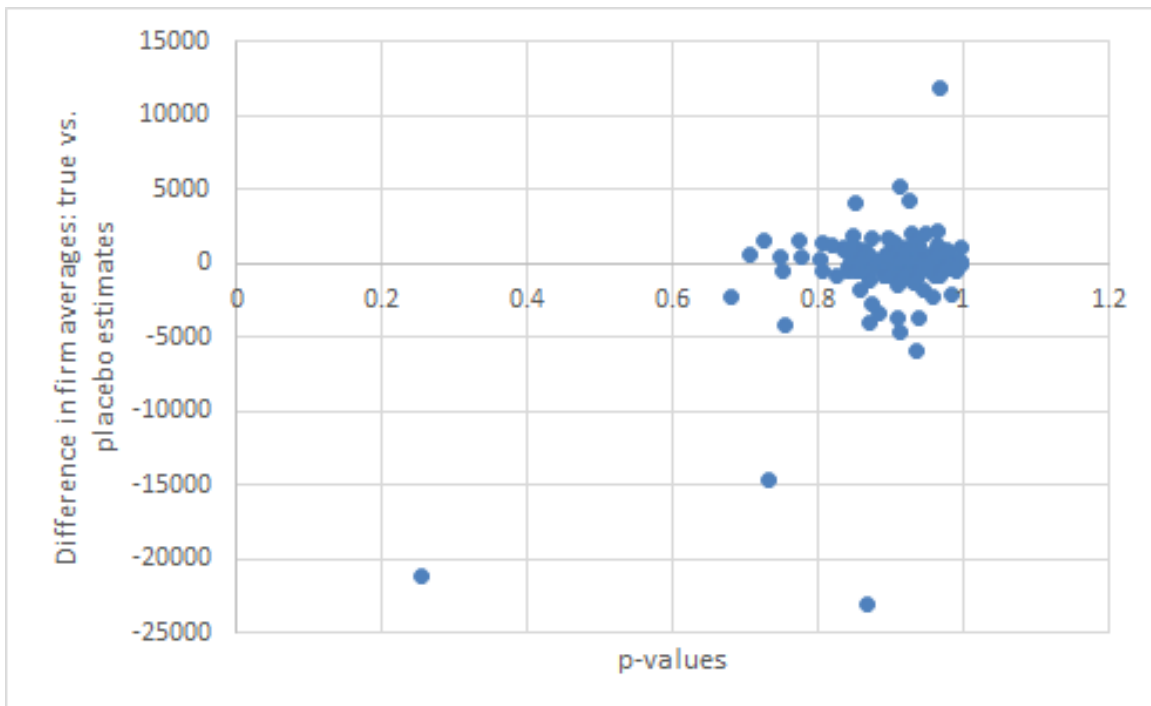


Figure C.18: For each firm, the difference between the firm average of the "true" patent estimates and the average of the placebo estimates of the value of its patents. In 1000's ¥. On the x-axis the associated p-value is plotted, under the null that the difference is zero

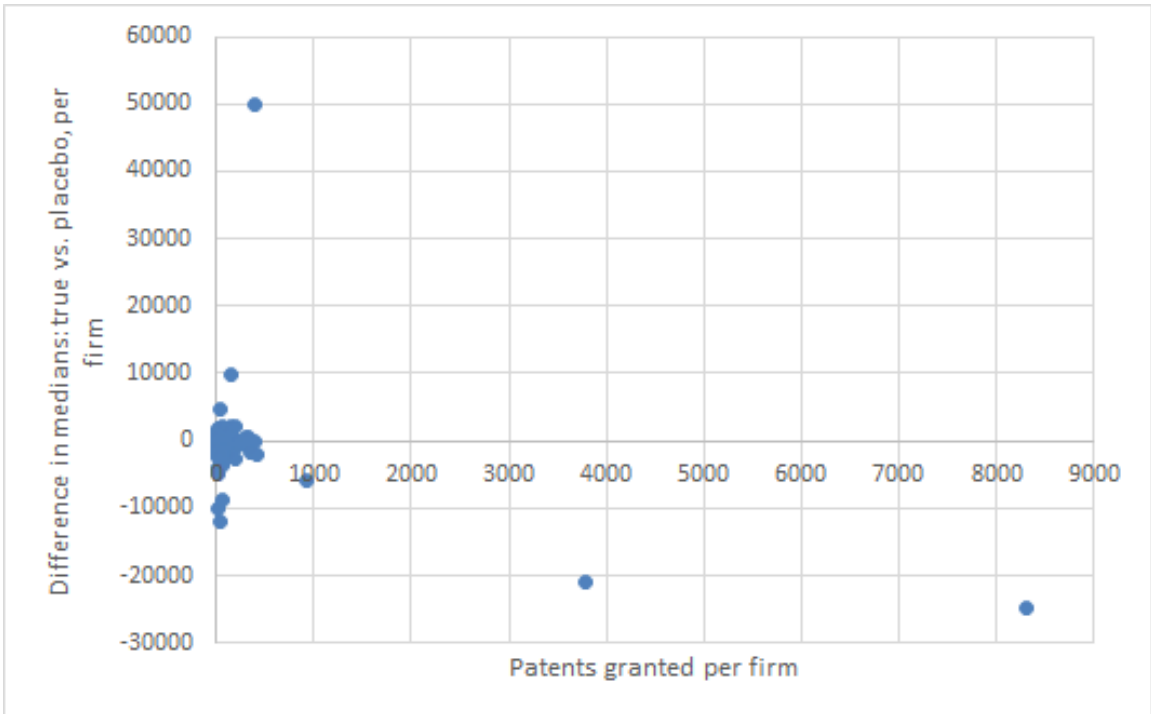


Figure C.19: For each firm, the difference between the firm median of the "true" patent estimates and the median of the placebo estimates of the value of its patents. In 1000's ¥. On the x axis is the associated total number of patents granted to the firm.

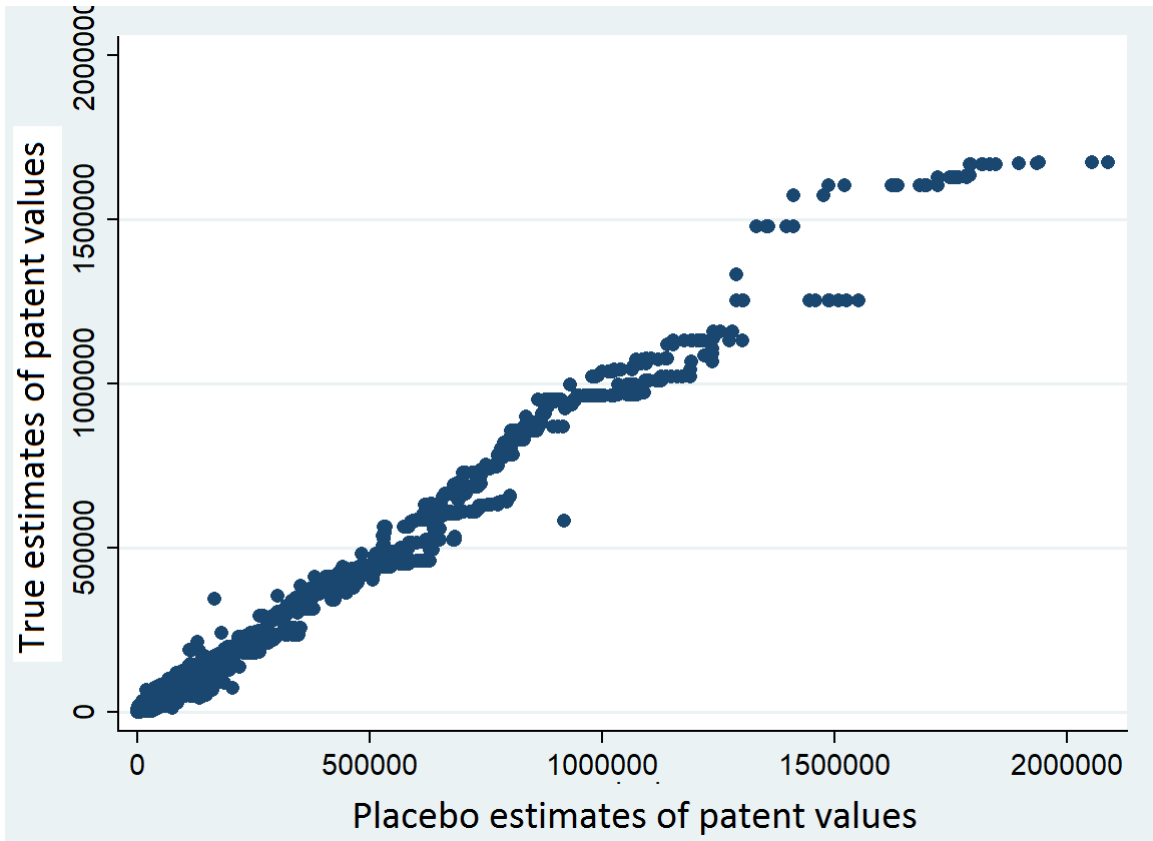


Figure C.20: Scatter plot between "true" patent value estimates and their placebo counterparts, at the level of individual patents (in 1000's ¥). Chinese data. The correlation is 0.994.