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Amal Ahmad, Dominik Naeher, Sebastian Vollmer

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Platz der Göttinger Sieben 5 · 37073 Goettingen · Germany
Phone: +49-(0)551-3921660 · Fax: +49-(0)551-3914059

Email: crc-peg@uni-goettingen.de Web: http://www.uni-goettingen.de/crc-peg

The Political Economy of Patent Buyouts

Amal Ahmad[*] Dominik Naeher[†] Sebastian Vollmer[‡]

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Abstract

Incentivizing innovation through buyouts may alleviate the social costs associated with patent power, but the political economy and feasibility of this potentially important financing mechanism have been understudied. We study an international setting of countries with different innovation and financing capabilities, and where financing governments rely on taxes to fund buyouts and care about the electoral popularity of their decisions. Subsequent distributional conflict arises between countries as some may benefit from the now-public knowledge without contributing equally to financing, while taxpayers within in a country may disagree over the desired extent of tax financing for buyouts. We show that these conflicts reduce the feasibility of buyouts relative to patents, identify the conditions under which this harms global welfare, and discuss possibilities for overcoming these constraints. The international public good and public financing dimensions of buyouts emerge as essential for understanding their potential to supplant patents and to improve social welfare.

Keywords: Innovation, intellectual property rights, patents, buyouts, global public goods, public finance

JEL Codes: F13; H87; L1; O31; O34; O38

[*]University of Göttingen, Germany. E-mail: amal.ahmad@uni-goettingen.de.

[†]Corresponding author. University of Göttingen, 37073 Göttingen, Germany. Phone: +49 551 39-25279. E-mail: dnaeher@uni-goettingen.de.

[‡]University of Göttingen, Germany. E-mail: svollmer@uni-goettingen.de.

1 Introduction

It has long been acknowledged that patents, while incentivizing innovation, fail to lead to the first best outcome for society because they rely on the distortion-creating incentives of monopoly (Nordhaus, 1969; Wright, 1983; Shavell and van Ypersele, 2001). The monopoly structure generally results in too little innovation (dynamic loss) and in too-high pricing (static loss) relative to the social optimum. One area in which these issues are particularly salient is global health, as many life-saving drugs are inexpensive to manufacture once innovated but patents associated with their innovation can generate high prices which limit access to these technologies (Stiglitz and Jayadev, 2010; Quigley, 2015). In addition, the incentives for patent-driven investment in innovation tend to be too small relative to what is socially optimal, particularly when the burden of disease falls heavily on poor populations. For example, the latter has been argued to be a major contributing factor to the low private investment in HIV/AIDS vaccine research relative to the disease's high global health burden (Kremer and Snyder, 2006).

Within economics, a large 'optimal design' literature has explored how patent length and breadth can be structured to limit deadweight loss and the underprovision of innovation, but these losses cannot be eliminated altogether (Rockett, 2010). In practice, and in the case of pharmaceuticals in particular, innovating countries often pursue a mix of intellectual property rights and price subsidies to facilitate production of and domestic access to patented technology (Roin, 2014). This can limit the social losses from underproduction and overpricing to consumers in these countries, but it does not eliminate them, and the effects of imposing patents on consumers in the developing world can be severe (Chaudhuri et al., 2006).

This paper contributes to the theoretical literature exploring why patents, despite creating potentially large social costs, remain the predominant mode of incentivizing innovation, and we focus on buyouts as a potential alternative arrangement. In a buyout, the government transfers an ex-post reward to the innovating firm in exchange for placing the knowledge in the public domain and thereby permitting competitive production of the subsequent good.[1]

It is straightforward to show that, in a single economy setting, a social welfare maximizing government that transfers the amount which equates the firm's rewards with the social benefit of innovation can supplant monopoly power and incentivize innovation and production at the socially optimal level (Wright, 1983; Shavell and van Ypersele, 2001; Galasso, 2020). Since perfectly calculated and executed buyouts eliminate underproduction and deadweight loss, for the choice between patents and buyouts to be nontrivial it is necessary that there are costs to buyouts that can obstruct their feasibility. The literature on buyouts, discussed further below, has emphasized how information problems about the appropriate size of the transfer, or commitment problems relating to the credibility of the transfer from the government to innovating firms, can impede buyouts as an alternative to patents. In this literature, if certain mechanisms could mitigate the domestic information or commitment problem, buyouts would emerge as a welfare-improving substitute to intellectual property rights.

In this paper, we depart from the focus on government-firm frictions and explore (previously unstudied) distributional implications of buyouts that emerge from their public good and public financing dimensions. First, placing knowledge in the public domain in a multi-country world where not all countries contribute equally to buyout financing will result in a loss of profits for the financing country and in positive externalities for the rest of the world. Second, because buyouts are publicly financed, they may engender domestic conflict over the desired extent of tax financing, and such conflict will be influential if the government cares not simply about total welfare but about the welfare of politically important groups. In contrast, intellectual property rights finance innovation through market sales of subsequent private goods, and therefore circumscribe the externality associated with publicly available knowledge as well as the need for public financing.

It is our core argument that these political economy tradeoffs are critical to understanding the feasibility of buyouts as an innovation financing mechanism. Exploring these

[1] This arrangement has also been termed a 'prize' or a 'reward' in the literature. For consistency we will refer to it as a buyout throughout the paper.

issues requires moving away from the literature's assumptions of a closed economy and of a benevolent government. We do this sequentially, in two steps.

We begin by tackling the question of buyouts from an international perspective while maintaining the assumption of (national) welfare maximizing governments. Using a stylized exposition of two countries which differ in their size and innovation and financing capacity, we show that since a buyout reduces domestic monopoly distortion but also results in loss of profits in international markets, it is no longer necessarily welfare-maximizing for the innovating country relative to patents. We also consider a 'subsidy' regime —in which firms are subsidized only to facilitate competitive production domestically while their patent rights are maintained, for use in international markets[2]— and which is equivalent conceptually to a national buyout.[3] Our model shows that if a subsidy is possible, this becomes the dominant choice as it mutes the tradeoff between reducing domestic deadweight loss and preserving profits from abroad. We discuss how regime choice in this context affects the non-innovating country as well as total world welfare.

The result that buyouts are no longer necessarily pursued even in the absence of domestic frictions between the government and firms stands in stark contrast to the previous literature, in which buyouts are always resorted to in the absence of such frictions. We outline how intersovereign transfers, if they are possible and credible, would result in globally optimal buyouts as transfers internalize the global externality, but we also discuss why in practice such transfers are rare and difficult to implement. Moreover, we show that the finding that international distributional concerns impede buyout feasibility is robust to several extensions. This includes extensions of the model to an $N > 2$ country model, to porous borders where (unlicensed) resale of goods is possible from the innovating to non-innovating country, to a situation where both countries can innovate and implement buyouts in different sectors, and to extending the model to $N > 2$ countries.

Building on this baseline model, we then add the possibility of *domestic* distributional

[2]This scenario is inspired by the practice used in many advanced economies of using price subsidies to facilitate production of and access to drugs, while keeping the underlying monopoly power intact (Roin, 2014).

[3]We prefer the term 'subsidy' regime over 'national buyout' to stress the differentiation and to highlight how the monopoly distortion is removed.

concerns, by relaxing the assumption of a benevolent government. Instead, we model a democratic setting where parties choose policy to maximize their electoral victory probability.[4] With different voter groups and varying preferences over the extent of the tax-financing burden of buyouts or subsidies, we show that if all groups are equally important in the political calculus then the policy choices do not change from those undertaken by a benevolent planner. However, to the extent that some voter groups are more politically powerful, for example due to higher swing densities, government involvement in innovation financing becomes additionally informed by these considerations.

More precisely, we show that in the presence of strategic electoral concerns, the likelihood that buyouts are pursued becomes even smaller. In contrast, the likelihood that global patent protection is maintained increases, now *even if* national subsidies (akin to a national buyout) are an option. We explain the intuition for this result, which owes to public financing for buyouts and for subsidies now diverging from utilitarian policy choices, while investment by firms with patent rights is unaffected by this dimension. We also explore the consequences for the non-innovating country's as well as global welfare. Finally, intersovereign transfers no longer result in the globally optimal buyout regime, as transfers alleviate the global externality but not domestic conflict over public financing.

In light of these findings, buyouts of innovations that are useful internationally may be understood as belonging to the category of publicly financed goods with global externalities, with subsequent conflicts over the distribution of benefits and costs *between* countries and also *within* the taxpaying base of a country. Since an altruistic donor may help bridge the gap between pursued and optimal innovation levels, we also briefly discuss the relationship between this scenario and philanthropic initiatives seeking to expand access to patented products, mostly in the healthcare and pharmaceutical sectors.[5]

To situate our contribution, as noted earlier the theoretical literature on buyouts has focused on challenges in a single-economy setting with a welfare-maximizing government.

[4]For simplicity, we only do this in the innovating country and maintain the assumption that the government in the non-innovating country seeks to maximize welfare.

[5]These include initiatives such as the Advanced Market Commitment (Kremer et al., 2020, 2022) and the Health Impact Fund (Banerjee et al., 2010).

The majority of papers in this literature address information frictions that arise between the government and innovating firms when the government lacks information on the benefits and costs of the innovation; in this case, a buyout may generate lower welfare than patents despite the latter's distortionary effects (Wright, 1983; Scotchmer, 1999; Shavell and van Ypersele, 2001). Papers have outlined a variety of institutional mechanisms that can mitigate the information problem and improve the optimality of buyouts, depending on the assumptions made about the nature of the problem (Kremer, 1998; Chari et al., 2012; Weyl and Tirole, 2012; Galasso et al., 2016, 2018). In a departure from the information asymmetry literature, Galasso (2020) explores how commitment problems between the government and firms may obstruct the feasibility and effectiveness of a buyout even if the government has perfect information.[6]

Another body of literature uses trade models to explore patent enforcement versus infringement in an international setting, but with little discussion of buyouts as an alternative to patents.[7] In a simple North-South model where a Northern firm can innovate while a Southern firm can imitate its innovation if patents are not enforced by the government of the South, the interests of the North and South will generally conflict, with the South benefiting from the ability to imitate technology and the North harmed by it (Chin and Grossman, 1988). Similar conflicts of interest arise in situations where the Northern government can choose whether or not to require protection in the South (Deardorff, 1992), where the decision to invest in R&D in the North is not one-off but dynamic (Helpman, 1993), and where both Northern and Southern firms can innovate, to different degrees, and

[6]This occurs if the government is subject to stochastic shocks that may require it to divert resources to an alternative unforeseen investment, and if it faces a limited budget, so that it will not be able to credibly commit to a transfer of the requisite cash rewards to the innovator.

[7]There is very little formal work on patent buyouts in an international setting. An exception is Scotchmer (2004) but with major differences in conceptualization and conclusions. Scotchmer (2004) assumes at the outset that buyouts are less efficient in financing innovation than patents so that global buyouts are not Pareto optimal, as well as that innovators from both the South and the North compete in making the same innovations in each country. This leads to very different results than ours: specifically, the key political economy problem is that there is *too little* patent protection in the world due to national treatment of inventors, because patent protection creates profits not just for national investors but also for foreign inventors living domestically. Therefore, the profit distribution concerns identified by the paper are very different from those we consider. Scotchmer also does not consider domestic conflict over taxation and how the public financing nature of buyouts may impact regime choice, as we do.

patent protections are decided simultaneously as they trade (Grossman and Lai, 2004).[8]

Finally, although there is a wide literature which studies how the government's *political* objectives inform policy choice, to our knowledge no work has studied this with respect to patent buyouts or innovation subsidies. Both the literature on patent buyouts in a closed economy and the trade models on patent enforcement versus infringement in an international setting assume governments are driven solely by national welfare maximization. Therefore, they do not consider other objectives which may be salient in driving policy choices in this context. In contrast, we take into account that advanced economies at the frontier of innovation *also* tend to be democracies, and we show how this has nontrivial implications about whether the government chooses to finance innovation through buyouts or subsidies.

In sum, our paper augments the literature on buyouts with insight from trade and political economy, to show how international and domestic redistributive concerns can obstruct globally optimal buyouts even in the absence of any government-firm frictions. As a qualification, simplifying assumptions are made to facilitate exposition which we discuss transparently; for example, industrial structure is simplified by studying one-off R&D investment decisions, abstracting from potentially dynamic innovation processes and broader general equilibrium effects, and to solve the model analytically we employ specific functional forms for demand and surplus. We discuss these and other modelling choices throughout.

The paper is structured as follows. Section 2 models patent buyouts in an international setting with a benevolent government, and shows that international redistributive considerations impact whether the government engages in buyouts. Section 3 shows the robustness of the findings to a number of extensions. Section 4 adds electoral considerations and demonstrates how domestic distributional concerns further impact buyout feasibility. Section 5 discusses the results and possible limitations of the framework, and the last section summarizes and concludes.

[8]Careful empirical measurement of welfare effects on the South of patent protection is limited, with the exception of Chaudhuri et al. (2006) who construct demand curves to estimate large negative effects in India of TRIPS-triggered protection of antibacterial medicines.

2 Patent buyouts in an international setting

2.1 Setup

We start by studying a model with two countries (or regions), the industrialized North (N) and the less developed South (S). For now, we assume that each government's sole objective is to maximize national welfare.

Innovation consists of the development of new products, and all capacity to innovate is concentrated among firms in the North (this will be relaxed in Section 3.2). Once a product has been invented, it can be produced by firms in all countries at a constant marginal production cost, possibly subject to intellectual property rights such as patents. The products are consumed by n consumers in the world, of which a fraction of $\gamma \in (0,1)$ live in the North and the rest live in the South. Consumers feature identical preferences for the innovated products which can be represented by a linear inverse demand function, but they are heterogeneous in income.[9] We distinguish three income groups, $J \in \{R, M, P\}$ with incomes $y^R > y^M > y^P$, and where α^J is the respective population share such that $\sum_J \alpha^J = 1$. There is a proportional income-tax system, so that if innovation is publicly financed, each taxpayer in the financing country pays a fraction τ of income toward this.

The process of innovating is modelled as in Deardorff (1992). Specifically, there is a continuum of products indexed by $z \in \mathbb{R}^{\geq 0}$. To invent a product, firms must incur a research cost $R(z) > 0$. Each product is associated with a different optimal per-capita consumer surplus; that is, the surplus per capita generated under competitive production. Let the *ratio* of this surplus for product z to the product's research cost $R(z)$ be denoted by $s(z)$; that is, $s(z)$ captures the optimal per-capita consumer surplus that product z generates per unit of research cost. In choosing which products to develop, firms will thus focus on those products with the highest values of $s(z)$. Without loss of generality, let products be indexed in descending order of $s(z)$ so that the first product (indexed by $z = 0$) features the highest value of $s(z)$.

[9]The robustness of the theoretical insights to relaxing identical preferences and other modelling assumptions will be discussed in Section 5.

The level of innovation can be measured by a cutoff value $\hat{z}$. Specifically, if the products $z \in [0, \hat{z}]$ are invented, then the *total* research cost incurred by firms in the North is given by

$$I(\hat{z}) = \int_0^{\hat{z}} R(z)dz. \tag{1}$$

It is now possible to express the optimal per-capita consumer surplus per unit of research cost of the *marginal* invention as a function of the total research cost I; we denote this as $\tilde{s}(I)$. Since we have indexed products in descending order of s, $\tilde{s}(I)$ will be a weakly monotonically decreasing step function of I, implying diminishing marginal returns to investment in research (see Appendix A for an illustration). If the number of products is large so that these steps are very small, then $\tilde{s}(I)$ can be approximated with a continuous function. Moreover, following again Deardorff (1992), we assume that the speed by which diminishing returns to innovation occur is constant, so that $\tilde{s}(I)$ can be represented by a linear function of the form

$$\tilde{s}(I) = f - gI. \tag{2}$$

The intercept parameter $f > 0$ indicates how valuable inventions are in general; that is, how productive the innovation technology is.[10] The slope parameter $g > 0$ indicates the speed by which diminishing returns to innovation set in.

The level of innovation that is reached in equilibrium depends on the amount I that firms in the North invest in research, which will be endogenously determined according to the regime used to incentivize innovation, explored in detail in the next subsection.

For consumers, welfare depends both on the level of innovation and the way through which it is financed. Specifically, for any given value $I > 0$, a consumer's optimal welfare, denoted $c^{o,J}$, can be obtained by integrating equation (2) to I, to obtain optimal surplus from all innovation, and then subtracting any tax-financing burden:

$$c^{o,J}(I) = \int_0^{I} (f - gI)dI - \tau y^J. \tag{3}$$

[10] Formally, f is the optimal per-capita consumer surplus per unit of research cost of the highest priority invention; that is, of the product z with the highest value of $s(z)$.

Under a patent regime, it holds that $\tau = 0$ as innovation is financed through private profits. Under publicly financed innovation, however, $\tau > 0$ and the value of τ is that which ensures tax collection covers the chosen investment amount I.

To obtain total optimal consumer welfare in country $i \in \{N, S\}$, $c^{o,J}$ is summed over all consumers in i. In the North, for example, where there are γn consumers, this gives

$$C^{o,N}(I) = \gamma n \int_0^I (f - gI)dI - \sum_J \alpha^J \gamma n \tau y^J, \tag{4}$$

which we simplify to

$$C^{o,N}(I) = S^{o,N} - \gamma n \tau y \tag{5}$$

by denoting with $y \equiv E(y) = \sum \alpha^J y^J$ the average income, and with $S^{o,i}$ the total optimal consumer surplus in country i. Note that if the tax burden is zero, as will be the case in a patent regime, optimal consumer welfare will be equivalent to optimal consumer surplus.

Another variable of interest is profit. Let $\Pi^i(I)$ denote the profit that firms in the North obtain from selling the invented goods to consumers in country $i \in \{N, S\}$, *before* netting out innovation costs. Since we assume competitive markets for production exist in each country, then if there are no barriers to the use of innovations, all firms will produce the subsequent good, sell at the competitive price, and make zero profit. Coupled with costly innovation expenses, this results in a net *loss*, so that no firm chooses to innovate without additional rewards. Under monopoly production enabled by patents, however, profits will generally be strictly positive.[11]

2.2 Innovation regimes

Incentives for innovation are determined by the innovation regime that is in place. At this stage, we will consider four types of regimes: a global patent regime, a global buyout regime (financed entirely by the North), a national subsidy regime, and a buyout regime

[11] More precisely, with linear inverse demand curves, monopoly profits will constitute a fixed share of the optimal surplus obtained under competitive production, and the remaining surplus will be split equally between consumers and deadweight loss.

with international transfers. In the first three cases, the North is the only strategic actor, whereas in the fourth case, surplus transfers between countries are possible, forming a strategic interaction space between the North and the South.

2.2.1 Global patent protection

In a regime of global patent protection, the innovating firms become monopoly producers in both countries.[12] In this case, research investment I^{Patent} maximizes Northern firms' profits from both regions net of the innovation cost. Letting $\hat{\Pi}$ denote this net amount, the optimal value of I^{Patent} solves

$$Max_{I^{patent}} \quad \hat{\Pi}(I^{Patent}) = \quad \Pi^N(I^{Patent}) + \Pi^S(I^{Patent}) - I^{Patent}. \tag{6}$$

As has been thoroughly discussed in the existing literature, the resulting value of I^{Patent} will be too small to yield the socially optimal level of innovation. The reason for this is that monopoly profits are always less than the social value of an invention. Some inventions that would be worthwhile to produce from a global welfare perspective will thus remain unexploited, because innovators are unable to extract the profits required to compensate them for the incurred research cost.[13] Also note that $\hat{\Pi}$ is not equal to welfare in the North under a patent regime, $W^{N,Patent}$, as the latter also includes consumer surplus. More precisely,

$$W^{N,Patent} = S^{\pi,N}(I^{Patent}) + \Pi^N(I^{Patent}) + \Pi^S(I^{Patent}) - I^{Patent}, \tag{7}$$

where $S^{\pi,N}$ denotes the consumer surplus in the North obtained under monopoly pricing.

[12] It does not matter for our analysis how the production is organized geographically, as long as all monopoly profits flow to the innovating firm in the North. For example, production may take place only in the North and the product is then exported to the South. Alternatively, the innovating firm may develop production capacity in the South or license out production to a producer in the South (retaining full monopoly profits).

[13] As described in Section 1, there are two effects through which a patent system leads to inefficiency. First, patents create monopoly distortion at the production stage which are associated with deadweight loss in consumer surplus ('static loss'). Second, and partly because of this distortion, patents never allow the innovator to extract the full social surplus of an invention. This in turn means that investment in research stays below optimum ('dynamic loss').

2.2.2 Domestically-financed global patent buyout

To overcome the inefficiency associated with a patent system, the literature has highlighted the possibility of buyouts (also referred to as rewards or prize schemes). Under a patent buyout, the government in the North purchases the patent from the innovator and places it into the global public domain. Without monopoly rights, the product can be produced and sold by firms anywhere in the world (an alternative buyout regime which removes patent protection in some foreign countries but not in others will be discussed as part of the N-country extension in Section 3.3). Given the assumed existence of competitive markets for production, the profits of all producers will then be equal to zero.

If there is no mechanism available to transfer surplus between countries, the government of the North designs and finances (via domestic taxes) the buyout by itself. Under the assumption of a government that maximizes total national welfare, I^{Buyout} (and thereby τ) will be chosen as follows:

$$Max_{I^{Buyout}} \quad W^{N,Buyout} = \quad C^{o,N}(I^{Buyout}) \tag{8}$$

$$s.t. \quad I^{Buyout} \leq \tau\gamma ny$$

where welfare is equal to total consumer welfare since profits are zero under a global buyout. In turn, total consumer welfare is defined as in equation (4) and takes into account tax financing for I^{Buyout}. The constraint states that taxes must be sufficient to cover innovation costs (in solving the model, we will assume that this taxation constraint is binding). Note that the South plays no role for the chosen value of I^{Buyout} because buyouts wipe out international profits, and any welfare effects on consumers in the South remain unconsidered by the Northern government.[14]

2.2.3 National subsidy (national buyout)

Instead of a global buyout strategy the North may also implement a national subsidy

[14] In the concluding remarks we discuss the possibility that, in practice, rich countries may have altruistic or strategic motives to consider welfare in poorer countries.

program which, in our model, is equivalent in implications to a *national* buyout (i.e., a buyout that removes patent protection only in the North while keeping patents intact in the rest of the world; see also the discussion in Section 3.3).

In a national subsidy regime, the government of the North offers to pay the innovators the difference between the monopoly price and the socially optimal price (i.e., the price that would prevail in a competitive market) for each unit of product sold in the *domestic* market. Legally, firms retain their monopoly powers, which in a multi-country world has the advantage (for the North) that firms can still sell as monopolists to the consumers abroad.

The optimal level of innovation, $I^{Subsidy}$, in this case maximizes total welfare which now consists of consumer welfare domestically and profits internationally (from the South):

$$Max_{I^{Subsidy}} \quad W^{N,Subsidy} = \quad C^{o,N}(I^{Subsidy}) + \Pi^{S}(I^{Subsidy}) \tag{9}$$

$$s.t. \quad I^{Subsidy} \leq \tau\gamma n y$$

where again the subsidy is tax-financed and therefore taken into account in $C^{o,N}$. For now, we assume no resale is possible internationally, so that all subsidized production stays in the North; otherwise, the ability to charge monopoly prices and profits in the South is compromised (the possibility of resale will be discussed in Section 3.1).

2.2.4 Buyout with international transfer

Finally, we allow for international surplus transfers so that the governments of the North and the South can cooperate on financing a patent buyout. The model then becomes strategic, involving two actors. We consider two possible scenarios as benchmarks, one where the North acts as the principal and offers a contract to the South, and one where the South is the principal and offers a contract to the North.[15] In both cases, a contract specifies the amount of a lump-sum transfer $T \in \mathbb{R}$ from the South to the North, and

[15]This is equivalent to considering an agreement between the North and the South where either the North or the South holds all bargaining power.

the level of innovation $I^{Transfer} > 0$ that the government of the North must implement through a buyout if the contract is accepted.[16]

The timing of the model with transfer is as follows. If the North acts as the principal, then first the government of the North offers a contract $\{I^{Transfer}, T\}$ to the South. Second, the government of the South decides whether to accept the contract or not. If the contract is accepted, the South transfers T to the North and the North implements a buyout such that the specified level of innovation $I^{Transfer}$ is reached. If the contract is rejected, then no transfer takes place and the North is free to implement any of the other possible innovation regimes. That is, the North then either keeps global patent protection intact, implements a national subsidy program, or finances a patent buyout by itself (choosing freely the size of the buyout and associated level of innovation). Finally, innovation and production take place according to the prevailing property rights regime.

If the South acts as the principal, the offered contract is designed by the government of the South, and the North decides whether to accept or reject it. The rest of the timing is the same as above. All parties are forward looking and there is no uncertainty. In particular, when offering the contract, the South anticipates the decision of the North (and vice versa if the North offers the contract).

To illustrate, suppose the North is principal. Given that international profits are zero under a buyout, the maximization problem of the Northern government is given by

$$Max_{I^{Transfer},T} \quad W^{N,Transfer} = \quad C^{o,N}(I^{Transfer}) \tag{10}$$

$$s.t. \quad I^{Transfer} \leq \tau\gamma ny + T$$

$$s.t. \quad \text{Participation constraint of South}$$

The constraints state that (i) the transfer decreases the extent to which a buyout is financed with Northern taxes, and (ii) the South must be at least as well off in this regime as it would be under the outside option pursued by the North in the absence of transfers (which

[16]We do not restrict T to be positive; however, it will never be optimal for the North to transfer surplus to the South in our setup.

will be determined below).

2.3 Solution

The solution to the model is formally derived in Appendix B. It consists of specifying the innovation regime, level of innovation, and associated distribution of welfare resulting under any possible combination of parameter values. We then use the resulting expressions to determine when each regime emerges as the equilibrium outcome in the model. In addition, we calculate total world welfare, W^W (i.e., summing up the welfare of each country) associated with each regime to examine whether, and to what extent, each regime creates inefficiency from a global welfare perspective.

In what follows, we summarize the findings in the form of propositions and discuss their underlying intuition and implications.

Proposition 1. *For given parameter values f, g, and n, there exists a cutoff value $\overline{\gamma}_1$ of γ that determines whether the North fares better under global patent protection or under a domestically-financed global buyout. If $\gamma < \overline{\gamma}_1$, then $W^{N,Buyout} < W^{N,Patent}$, and vice versa. There is a range of parameter value combinations for which $W^{N,Buyout} < W^{N,Patent}$ even though $W^{W,Buyout} > W^{W,Patent}$.*

Proof. See Appendix B.4. □

Proposition 1 compares a patent system to a global buyout. It implies that, in the absence of international surplus transfers, it can be rational for the North to abstain from implementing a patent buyout, even if such a buyout would increase global welfare relative to a patent regime. Importantly, this result holds despite the government knowing the social value of each invention and the absence of commitment issues or other frictions.

This result is therefore in stark contrast to the findings in the existing microeconomic literature on buyouts (see the studies cited in Section 1), which typically find that buyouts are always preferable to patents in a single-economy setting if the government is able to pay the innovator the 'correct' amount. In contrast, the results in Proposition 1 show that once we move to a world of multiple countries, this is not necessarily the case anymore.

Specifically, we find that as long as the market (population) share of the North is not too large (i.e., $\gamma < \overline{\gamma}_1$), the North fares better by keeping patent protection intact than by implementing a global buyout, even if a buyout would increase global welfare relative to a patent regime.

The intuition behind this result is based on three factors in the model. First, when moving from a patent regime to a buyout the North loses the monopoly profit obtained from the Southern market. The larger the global market share of the South (i.e., the smaller γ), the larger is this loss. Thus, smaller values of γ tend to make a buyout less attractive to the North. Second, and relatedly, the choice of regime affects firms' incentives to invest in research. As shown in the proof of Proposition 1 (in Appendix B.4), for sufficiently small values of γ it holds that $I^{Buyout} < I^{Patent}$.[17] Although this implies lower costs of innovation, it also reduces consumer surplus in the North since each additional product that is invented generates surplus. In equilibrium and for small values of γ the latter effect dominates, so that a lower level of innovation is detrimental to the North (see also Appendix B.4). Thus, a lower value of γ also makes buyouts less attractive by reducing innovation relative to a patent regime. Third, implementing a buyout increases consumer surplus in the North by eliminating the static deadweight loss associated with monopoly pricing, but this potential gain is smaller, the smaller the relative size of the North is. Therefore, in this way as well, smaller values of γ work towards making a buyout less attractive to the North.

Note that the implications for the South are ambiguous, due to the fact that a buyout can have two opposing effects on consumer surplus in the South. On one hand, the elimination of monopoly pricing under a buyout tends to increase consumer surplus in the South. On the other hand, as argued above, a domestically-financed buyout can lead to a lower level of innovation than the one achieved under a patent system, which hurts all consumers, including those in the South.

Accordingly, the proof of Proposition 1 shows that the effect on world welfare of moving from patents to a domestically-financed buyout can be positive or negative, depending on

[17] In contrast, it always holds that $I^{Buyout} > I^{Patent}$ when the North benefits from a buyout, i.e., when $\gamma > \overline{\gamma}_1$.

the value of γ. This implies that there can be situations where patent protection is globally preferable to a buyout even when there are no information and commitment problems. Conversely, there is a range of parameter value combinations for which a patent system is inferior from a global perspective, but the North, considering only its own welfare, chooses to maintain global patents.

The results in Proposition 1 are based on a comparison of the international welfare distributions under a patent system and a buyout. Additionally, however, the North might also implement a national subsidy program, in which consumers in the North pay competitive prices while consumers in the South pay monopoly prices. The next proposition summarizes the results when these three regimes are compared.

Proposition 2. *For welfare in the North it holds that* $W^{N,Subsidy} > W^{N,Patent}$ *and* $W^{N,Subsidy} > W^{N,Buyout}$. *A national subsidy also leads to higher welfare in the South than a patent regime, so that globally* $W^{W,Subsidy} > W^{W,Patent}$. *Whether a subsidy leads to higher global welfare than a domestically-financed buyout depends on the parameter values. For given parameter values* f, g, *and* n, *there exists a cutoff value* $\overline{\gamma}_2$ *of* γ *that determines whether global welfare is higher under a subsidy or a buyout. If* $\gamma > \overline{\gamma}_2$, *then* $W^{W,Subsidy} < W^{W,Buyout}$, *and vice versa.*

Proof. See Appendix B.5. □

Proposition 2 implies that, in the absence of international surplus transfers, the North's dominant strategy is to implement a national subsidy. This is intuitive, as a national subsidy allows the North to eliminate the static deadweight loss associated with monopoly pricing at home, as a buyout would, while maintaining monopoly profits abroad; it is therefore preferable to both a patent system and a global buyout regime. Second, a subsidy also increases welfare of the North by generating a higher level of innovation than achieved under a buyout or a patent system. It generally holds in the model that $I^{Subsidy} > I^{Buyout}$ and $I^{Subsidy} > I^{Patent}$ (see Appendix B.3). This increase in innovation benefits the North because each additional product that is invented generates domestic consumer surplus as well as additional profits from the Southern market.

It can be shown (see Appendix B.5) that Southern welfare is strictly greater under a subsidy in the North than under a global patent system, so that a subsidy unambiguously raises global welfare relative to a mere patent system. Intuitively, this is because the South is subject to static losses arising from monopoly pricing under both a patent regime and under a subsidy in the North, while dynamic losses are smaller under a subsidy program due to the higher level of innovation.

In contrast, whether a subsidy also leads to higher welfare in the South (and globally) relative to a buyout depends on the relative sizes of the two countries. For sufficiently large values of γ (i.e., $\gamma > \overline{\gamma}_2$), global welfare is *lower* under a national subsidy than under a global buyout, even though the North strictly prefers the former. This is because, with a smaller Southern market and therefore limited international profits, there is limited increase in innovation when moving from a buyout to a subsidy. The positive effect on the South from the increase in innovation when moving to a subsidy is therefore attenuated, relative to the negative effect associated with monopoly pricing. If the Southern market is sufficiently small such that $\gamma > \overline{\gamma}_2$, the losses to the South from a national subsidy, relative to a buyout, exceed the gains to the North. Global welfare is lower, meaning that in this case the North's dominant strategy of national subsidies is harmful to global welfare.

The next proposition clarifies how the results change when international surplus transfers are feasible.

Proposition 3. *If international surplus transfers are possible, then the equilibrium outcome is Pareto optimal and involves a global buyout with $T > 0$ that stipulates the globally efficient level of innovation. The exact size of T and resulting distribution of welfare depend on the relative bargaining power of each country.*

Proof. See Appendix B.6. □

Combining the results in Proposition 3 with those in Proposition 2 implies that the presence of a technology for international surplus transfer is both necessary and sufficient for achieving a Pareto optimal outcome in the model. Without international transfers, the North's dominant strategy of national subsidies leads to an inefficiently low level of innovation, where some products that would be worthwhile to invent from a global welfare perspective remain unexploited. If international surplus transfers are possible, then it is in the best interest of both countries to cooperate on financing a buyout which ensures that the globally efficient level of innovation is reached; that is, all products z are invented for which the total optimal consumer surplus (achieved under competitive pricing) in both countries is greater than the research cost. Both the North and South will benefit from such a move relative to their position under the subsidy status quo.

Whereas the size of the transfer and the resulting distribution of welfare gains depend on the relative bargaining power of each country, the buyout amount and associated level of innovation are independent of the distribution of bargaining power (in line with Coase, 1960).[18] Importantly, the result that both countries will find it optimal to agree on a buyout if international transfers are possible is independent of the parameter values of the model, and thus does not depend on the relative sizes of the North and the South.

3 Extensions

Before introducing electoral concerns to the model (in Section 4), we explore three extensions of the baseline model discussed above. This helps to demonstrate the robustness of some of our key theoretical findings from Section 2 to alternative modelling choice (the roles of the other simplifying assumptions made to keep the model tractable will be discussed in Section 5.2). First, we study the possibility of unlicensed resale of goods in the case of a national subsidy in the North. Second, we consider what happens when both countries can innovate in different sectors. Third, we extend the baseline model to $N > 2$ countries with the possibility of buyouts that remove patent protection in some (targeted) foreign countries while keeping patents intact in other parts of the world.

3.1 Unlicensed resale

So far, the national subsidy case has abstracted from the possibility of unlicensed

[18] Intuitively, the welfare of each country is higher if it has more bargaining power, and the amount transferred from the South to the North is smaller if the South has more bargaining power (see Appendix B.6).

resale; that is, that products may be bought at subsidized prices in the North and then sold to consumers in the South. In relaxing this assumption, we allow for different degrees of resale. This is captured by the variable $r \in [0,1]$ which specifies the share of the North's monopoly profits in the Southern market that are lost due to resale. The North's surplus under a national subsidy with resale is then given by

$$W^{N,Resale} = S^{o,N}(I^{Resale}) + (1-r)\Pi^{S}(I^{Resale}) - I^{Resale}. \tag{11}$$

If $r = 0$, this corresponds to the baseline model with zero resale (in Section 2). If $r = 1$, there are no constraints to resale so that the price consumers pay in the South equals the competitive (subsidized) price in the North and foreign profits to the North are fully eliminated. For values $r \in (0,1)$, resale is partially possible. For example, one may think of this case as capturing constraints to resale, such as legal constraints or costs due to tariffs, which prevent perfect resale.

The presence of resale affects the implications of the model in several ways, but some key results remain intact. The main insights are summarized in the next proposition.

Proposition 4. *If resale is possible with $r \in (0,1)$, then $I^{Resale} < I^{Subsidy}$ and a national subsidy is not necessarily the dominant strategy of the North in the absence of international transfers. While it generally holds that $W^{N,Resale} > W^{N,Buyout}$, whether $W^{N,Resale}$ is larger than $W^{N,Patent}$ depends on the parameter values. For given values f, g, n, and r, smaller values of γ make a patent system more attractive to the North than a national subsidy with resale. International surplus transfers still generate a Pareto optimal equilibrium outcome with the globally efficient level of innovation, though the size of T and associated distribution of welfare now depend on the value of r.*

Proof. See Appendix B.7. □

Under a national subsidy program, the presence of resale reduces the level of innovation and the welfare of the North. The latter effect happens both along the intensive and extensive margin. There is a cut on the profits at any given level of innovation (the intensive margin) as some consumers in the South are able to purchase goods at prices below the monopoly prices. In addition, there are less products available to make profits (the extensive margin) since resale leads to a lower level of innovation.

Proposition 4 states that, as long as resale is only partial (i.e., $r \in (0,1)$), the North still strictly prefers a national subsidy over a domestically-financed buyout (as in Proposition 2).[19] However, for certain parameter value combinations, resale causes a national subsidy to be less attractive to the North than global patent protection. Hence, the presence of resale can alter the result from Proposition 2 that a subsidy is always the North's dominant strategy in the absence of international transfers.

At the same time, the presence of resale leaves intact the result from Proposition 3 that, if international surplus transfers are possible, the equilibrium outcome consists of a buyout which stipulates the globally efficient level of innovation. In this case, merely the size of the transfer and associated distribution of welfare are affected by resale, as the threat point of the North (to implement a national subsidy or patent system instead of a buyout) is weakened when resale is possible.

3.2 Two innovating countries

In the baseline model, all capacity to innovate was concentrated among firms in the North. We now allow for innovation capacity also in the South and show that, as long as the countries innovate in different sectors, the model's main implications remain intact.

Suppose firms in both the North and South can innovate but in different (non-overlapping) sectors. For example, this may reflect that the two countries are structurally different, perhaps along the development gradient, with one country innovating in a capital-intensive sector while the other innovates in a labor-intensive sector. Production and pricing of the subsequent goods are a function of the innovation regime chosen by the innovating firms' government. Each country's welfare is a function of innovation in both sectors and therefore of innovation policies in both countries. More precisely, we now assume that the world population derives welfare from two different optimal consumer surplus curves (two

[19] Under perfect resale (i.e., $r = 1$), the North would be indifferent between a subsidy and a domestically-financed buyout (see Appendix B.7).

curves each similar in structure to Figure A1 in Appendix A), and that welfare is additively separable in each sector. The parameters f and g are allowed to differ across sectors.

Within each country, the government has the same set of options regarding the spectrum of domestically-produced inventions as in the baseline model: to implement a global patent regime, a national price subsidy, or a patent buyout. The model's equilibrium in this case can be obtained as the result of a simple 3-by-3 simultaneous game with the strategy space $\{Patent, Subsidy, Buyout\}$ for each player.

For each country, instituting a patent regime or subsidy involves a decision problem paralleling that in equation (6) and (9), respectively. In addition, we consider two possible strategies for buyouts. Country $i \in \{N, S\}$ may finance innovation in its sector through a buyout considering only its own welfare, same as in the baseline model for the North. Alternatively, buyouts may involve a cooperative strategy (e.g. based on reciprocity) in which each country acts as a global welfare maximizer in its sector. This possibility of a 'cooperative buyout' emerges precisely because of possible benefits to such other-regarding preferences, through reciprocity. The following proposition summarizes the results.

Proposition 5. *With both countries innovating in non-overlapping sectors, each country picks price subsidies for its sector as a dominant strategy, resulting in a {Subsidy,Subsidy} equilibrium. For buyouts that focus on maximizing domestic welfare only, world welfare under $\{Buyout, Buyout\}$ may be smaller or larger than that of $\{Subsidy, Subsidy\}$, depending on the parameters of the model. For cooperative buyouts, there exist parameter value combinations for which both countries are worse off in the subsidy equilibrium than in a mutual buyout, resulting in a Prisoner's Dilemma. In both cases, only feasible and credible transfers outside the game can move the world to the globally optimal buyout regime.*

Proof. See Appendix B.8. □

Even when innovation capacity is spread across countries, then so long as it is concentrated in different sectors, price subsidies will remain a dominant strategy. The logic is that each country calculates that it will be better off if it subsidizes its own sector regardless of what the other country chooses to do, thereby making buyouts a non-credible strategy (one on which each player has an incentive to renege).

Moreover, Proposition 5 implies that subsidies in both sectors hold as the unique equilibrium regardless of how mutual buyouts would compare in terms of world welfare. In fact, when the buyout strategy is cooperative (reciprocal), then a mutual buyout would not only optimize world welfare but also make each country better off than it would be under the subsidy equilibrium. The result is a Prisoner's Dilemma structure, with both countries stuck in the Pareto inferior equilibrium.[20] As with the single-innovating country case, transfers (outside the game) which compensate each country for the externality generated by its sector would motivate buyouts. However, the credibility of these transfers would rely on enforceable and binding supra-national contracts (as will be discussed in more detail in Section 5.3).

3.3 Targeted buyouts with $N > 2$ countries

Another limitation of the baseline model with two countries is that it does not allow to study buyouts which remove patent protection in some (targeted) foreign countries while keeping patents intact in other parts of the world. In this section, we consider an N-country model extension that allows for studying such "targeted buyouts".

Suppose the world is comprised of $N > 2$ countries index by $i \in \{1, ..., N\}$. As before, all countries feature the same demand function (i.e., parameters f and g) but there is heterogeneity in size and innovation capacity. Specifically, the respective global market shares, denoted γ_i, may differ across countries. We focus on the case where all innovation capacity is concentrated in country N and analyze the optimal strategy of this country when its government chooses between a global patent system and a targeted buyout where patent protection is removed in a subset of countries $\{m, ..., N\}$ while remaining intact in the rest of the world; that is, in countries $\{1, ..., m-1\}$. We will refer to this regime as *Buyout*(N, m). For now, we focus on the case where no international transfer technology is available, so that any buyout must be financed by the government in country N via domestic revenues.

[20]The Prisoner's Dilemma can also arise for finitely repeated dynamic games, or for infinite horizon dynamic games with sufficiently low discount factors.

It will be useful to define the total market share of all foreign countries included in the targeted buyout as

$$\gamma_m = \sum_{i=m}^{N-1} \gamma_i, \tag{12}$$

and the total market share of the rest of the world (for which patent protection remains intact) as

$$\gamma_r = \sum_{i=1}^{m-1} \gamma_i. \tag{13}$$

Clearly, it holds that $\gamma_r + \gamma_m + \gamma_N = 1$. We also allow for the two benchmark cases where either $\gamma_m = 0$ or $\gamma_r = 0$. The former corresponds to a national buyout where patent protection is only removed in country N itself (note that, in our model, this is equivalent to the national subsidy case studied above). We will refer to this case as *Buyout*(N). The case where $\gamma_r = 0$ corresponds to a buyout where patent protection is removed globally. This is equivalent to the domestically-financed global buyout regime studied in Section 2. The optimal strategy for the innovating country N is determined by the national surplus generated under each innovation regime, and can be characterized as follows.

Proposition 6. *Let there be $N > 2$ countries. Then it holds that $W^{N,Buyout(N)} > W^{N,Patent}$ and that $W^{N,Buyout(N,m)}$ is strictly increasing in γ_N and decreasing in γ_m. The larger γ_N, the larger is the range of values of γ_m for which $W^{N,Buyout(N,m)} > W^{N,Patent}$.*

Proof. See Appendix B.9. □

Given the equivalency of a national buyout and a national subsidy in our model, these results imply that the results from Propositions 1 and 2 remain intact in an N-country setting. Specifically, Proposition 6 states that a national buyout dominates both a global patent system and all targeted buyouts with $\gamma_m > 0$, including a global buyout (i.e., when $\gamma_m = 1 - \gamma_N$ and $\gamma_r = 0$). This is intuitive, as in these regimes neither the achieved level of innovation nor the North's welfare depend on the number of different countries (what matters is the global market share of the rest of the world, $1 - \gamma_N$, but not how many countries the rest of the world comprises). Moreover, the last part of Proposition 6 implies that the feasibility of a domestically-financed global buyout (i.e., setting $\gamma_r = 0$) over a patent system depends positively on γ_N (as in Proposition 1).

At the same time, allowing for more than two countries also shows that it is possible that the innovating country prefers a targeted buyout that includes other countries (i.e., $\gamma_m > 0$) over a system of global patent protection. In particular, the last part of Proposition 6 states that this will be more likely the case the larger γ_N is. One interpretation of this results is that larger countries can afford to include a higher share of the global foreign population (or global market) in their targeted buyouts and still fare better than under global patent protection. Intuitively, this is due to the fact that larger countries gain relatively more from reducing monopoly distortion at home (and the associated deadweight loss in consumer surplus) when replacing patents with a buyout regime.

An alternative interpretation of this result can be obtained when considering I as not being universal, but as capturing only the innovations within one particular sector or one particular product family. For what types of products or sectors are buyouts more likely feasible? The results in Proposition 6 suggest that innovating countries will be more likely to consider buyouts for products in which they have a large global market share themselves (e.g., products which are mostly consumed domestically). In contrast, the incentives for a country to implement buyouts in export-oriented sectors or for patented technologies which are mostly used abroad should be expected to be much smaller.

Now consider what happens if international surplus transfers are feasible in financing targeted buyouts. The globally efficient level of innovation will only be reached if all countries participate and make transfers to the innovating country N in proportion to γ_i (mirroring the results from Proposition 3). In addition, country N may now be willing to implement an internationally-financed targeted buyout even if only a subset of foreign countries participate in financing the buyout. This follows from the fact that a national buyout in country N is associated with deadweight loss in the rest of the world. If country N is able to extract the increase in consumer surplus arising in any foreign country from including that country in a targeted buyout, this will unambiguously make both countries (weakly) better off.

Summarizing, the model with finitely many countries generates the following implications regarding the optimal composition of patent buyouts. If international surplus transfers are not feasible, then the innovating country N will implement a national buyout (or subsidy) with patent protection in the rest of the world, leading to deadweight loss in each foreign country. Otherwise, the equilibrium outcome will feature an internationally-financed buyout involving all countries for which international surplus transfers are feasible (and patent protection in the other countries).

4 Adding domestic distributional concerns

So far, the focus of has been on international distributional concerns, and we have abstracted from domestic distributional issues by assuming that the government in the North simply seeks to maximize national welfare. But domestic distributional conflict is likely to arise over tax-financed goods, with groups disagreeing over the desired extent of tax financing, and this conflict will impact policy choice if it impacts voting in a setting where electoral popularity is a priority for the government. Drawing on the outline of pre-election voting models in Persson and Tabellini (2002), we will now relax the assumption of a welfare maximizing government in the North and instead assume first-order electoral concerns, and explore public investment choices in such a setting.[21]

4.1 Setup

In addition to the setup described in Section 2.1, let there be two political parties (or candidates), A and B, in the North and let voters care about the economic public policy I as well as some ideology dimension. In this context, I is total *public* investment in innovation research. Let I_p be the public investment campaigned for by party $p \in \{A, B\}$ in a given electoral cycle, and $\sigma^{jJ} \gtrless 0$ be a measure of the ideological bias toward party B of person j in group J; that is, $\sigma^{jJ} > 0$ implies this individual ideologically prefers B.

[21] Maintaining the assumption of a benevolent government in the South does not impact the choice of buyouts versus patents or versus subsidy regimes, as the South's choices do not influence equilibrium outcomes in these regimes. They would only impact the calculation of intersovereign transfer amounts, but without impacting the suboptimality of such transfers (i.e., all subsequent propositions would continue to hold).

Then for a buyout or subsidy regime, voter j in group J prefers party A if

$$c^J(I_A) > c^J(I_B) + \sigma^{jJ}, \tag{14}$$

where c^J measures group-specific welfare from the public investment, which is given by a concave function whose form depends on the innovation regime, specified further below. We assume that under a global patent regime individuals vote solely on the basis of ideological preferences as they do not consider innovation financing to be part of the political platform; in this case, voter j in group J simply votes for party A if $\sigma^{jJ} < 0$.[22]

Like Persson and Tabellini (2002), we assume that while the ideological bias σ^{jJ} is measured at the level of the individual, it has a group-specific *distribution* on the uniform support

$$\Big[\delta - \frac{1}{2\phi^J}, \quad \delta + \frac{1}{2\phi^J}\Big], \tag{15}$$

where $\delta \in \mathbb{R}$ measures average relative popularity of candidate B in the whole population (across groups) and $\phi^J > 0$ measures group-specific swing density.[23] Groups with a higher value ϕ^J are more swing-voter-dense because their votes are more tightly clustered around the population mean.

Party B's popularity δ is itself a random variable which has a uniform distribution on

$$[\delta^* - \frac{1}{2\psi}, \quad \delta^* + \frac{1}{2\psi}], \tag{16}$$

with parameters $\delta^* \in \mathbb{R}$ and $\psi > 0$. This implies that the average bias for party B in any given election cycle is not known ex-ante, but is drawn from a distribution with a *long-run* mean of δ^*. A higher value of ψ implies there is greater concentration around δ^*, and so less spread or uncertainty about which δ materializes in any given cycle.

The timing of the election cycle is as follows. Parties announce policy platforms while knowing the distributions of σ^{jJ} and δ but not their realizations, then people vote, then

[22] Even if voters responded differently to a patent regime, the results of the model hold because parties act symmetrically, such that electoral victory probabilities are equalized (see the next subsections).

[23] Having average affinities differ complicates the analysis without changing the nature of the results.

policy is followed through. To see how investment choice affects voting behavior, note that, from equation (14), the swing voter in each group J is the one who is indifferent between two parties so that

$$\sigma^J \equiv c^J(I_A) - c^J(I_B). \tag{17}$$

Since all voters in group J with preferences $\sigma^{jJ} < \sigma^J$ prefer party A, and given the distribution for σ in equation (15), the overall vote share party A receives is

$$v_A = \sum_J \alpha^J \phi^J \Big[\sigma^J - \delta + \frac{1}{2\phi^J}\Big]. \tag{18}$$

The probability that A wins the elections is therefore given by[24]

$$Prob[v_A \geq 0.5] = Prob\left[\sum_J \alpha^J \phi^J \Big[\sigma^J - \delta + \frac{1}{2\phi^J}\Big] \geq 0.5\right], \tag{19}$$

which can be simplified to

$$Prob[v_A \geq 0.5] = \frac{1}{2} + \psi\left[\frac{\sum_J \alpha^J \phi^J [c^J(I_A) - c^J(I_B)]}{\sum_J \alpha^J \phi^J} - \delta^*\right]. \tag{20}$$

In equilibrium, and facing symmetric conditions, both parties converge toward the same policy choice $I_A^* = I_B^*$, which is calculated by taking the derivative of p_A (p_B) with respect to I_A (I_B) subject to any other restrictions. From equation (20), this is the I which yields

$$\sum_j \alpha^J \phi^J \frac{\partial c^J}{\partial I} = 0. \tag{21}$$

Importantly, consumer welfare $c^J(I)$ is different for each regime, as it depends on factors such as whether consumers can benefit from profits or transfers from abroad. The next subsections outline this in more detail and then discuss the implication for innovation regime choice.

[24]It follows that the probability that B wins is $1 - Prob[v_A \geq 0.5] = \frac{1}{2} + \psi\left[\frac{\sum_J \alpha^J \phi^J [c^J(I_B) - c^J(I_A)]}{\sum_J \alpha^J \phi^J} + \delta^*\right]$.

4.2 Innovation regimes

4.2.1 Global patent protection

With patents in place, it is innovating firms which choose how much investment financing to undertake. Since firms are motivated by profit maximization and not by electoral concerns, the objective function that determines investment in innovation remains the same as in equation (6).

4.2.2 Domestically-financed global patent buyout

In a buyout regime, investment is tax-financed. Through policy announced leading up to the electoral cycle, I^{Buyout} and associated taxes are now chosen by each party (symmetrically) to maximize the probability of election victory, subject to the taxation sufficiency constraint. The maximization problem of each party is

$$Max_{I^{Buyout}} \quad Prob[v_p(I^{Buyout}) \geq 0.5] \tag{22}$$

$$s.t. \quad I^{Buyout} \leq \tau\gamma ny$$

Given the expression for the probability of electoral victory in equation (20), I^* is therefore that which satisfies the first order condition in equation (21), in addition to the constraint that investment is not greater than the amount of taxes collected for this purpose.

Since votes are a function of public investment I through its impact on consumer welfare, it is necessary to specify how welfare is a function of I under a buyout. Given that the taxation constraint is binding, so that $\tau = \frac{I}{\gamma ny}$, we obtain for a Northern consumer in group J

$$c^J(I) = \int (f - gI)dI - \frac{I}{\gamma ny}y^J. \tag{23}$$

This is the same individual consumer welfare derived earlier under a buyout (equation 3), but the difference is in how these preferences are *aggregated* for optimization. With a welfare maximizing government, preferences are simply added (as in equations 4 and 8), whereas with electoral concerns, preferences are weighted by swing densities (equation 21), with more swing groups receiving a higher share.[25]

4.2.3 National subsidy (national buyout)

In a subsidy regime with electoral concerns, public investment is again determined by what maximizes electoral victory chances subject to the taxation constraint:

$$Max_{I^{Subsidy}} \quad Prob[v_p(I^{Subsidy}) \geq 0.5] \tag{24}$$

$$s.t. \quad I^{Subsidy} \leq \tau\gamma ny$$

with $I^{Subsidy}$ being that which satisfies equation (21) and the taxation constraint.

The difference to a buyout setup is that now voters benefit not only from consumer surplus domestically but also from profits internationally, which are preserved under a subsidy regime. Assuming that each voter owns an equal fraction of the producing firms (and thus profits), consumer j's welfare in the North becomes

$$c^J(I) = \int (f - gI)dI - \frac{I}{\gamma ny}y^J - \frac{1}{\gamma n}\Pi^S(I), \tag{25}$$

where the last part is the per-voter share of profits from the South.[26]

4.2.4 Buyout with international transfer

As before, an international transfer would relax the taxation constraint while also introducing a participation constraint for the country acting as agent. Assuming the North is the principal, policy under electoral concerns in the North will be set according to

$$Max_{I^{Transfer},T} \quad Prob[v_p(I^{Transfer}) \geq 0.5] \tag{26}$$

$$s.t. \quad I^{Transfer} \leq \tau\gamma ny + T$$

[25] It can be shown that if swing densities are the same (i.e., $\phi^J = \phi$), then these optimization decisions are equivalent.

[26] Having groups benefit differently from profits, such as higher income groups owning larger firm shares, does not change the qualitative results in the propositions.

$$s.t. \quad \text{Participation constraint of South}$$

with $I^{Transfer}$ being that which satisfies equation (21) in addition to the taxation and participation constraints. With zero profits but a looser taxation requirement so that $\tau = \frac{I-T}{\gamma ny}$, consumer welfare becomes

$$c^J = \int (f - gI)dI - \Big(\frac{I-T}{\gamma ny}\Big) y^J. \tag{27}$$

4.3 Solution

To solve the model with electoral concerns, note first that since in equilibrium both parties make symmetric choices, $I_A = I_B$, and given equation (20), the victory probabilities for A and B are:

$$Prob[v_A \geq 0.5] = \frac{1}{2} - \psi\delta^*, \tag{28}$$

$$Prob[v_B \geq 0.5] = \frac{1}{2} + \psi\delta^*. \tag{29}$$

Therefore, electoral victory chances ultimately reflect fundamental (ideological) preferences, and this holds irrespective of whether the parties engage in investment in a domestically-financed buyout, in a subsidy, or in a transfer-facilitated buyout regime.[27] Moreover, it can be confirmed that, also for a patent regime, the probabilities of victory for A and B are those in equations (28)-(29).[28]

The main differences between regimes are therefore optimal investment level (by the government or by firms) and subsequent welfare implications, while electoral victory chances are equalized in equilibrium. Given equal chances of victory for Northern parties among all regimes, we assume governments weakly prefer regimes with higher national welfare.

Second, the model revolves around politically important heterogeneity among voters,

[27] Within a given public investment regime, parties still choose $I_A = I_B > 0$ because to do otherwise results in loss of votes to the opponent. It is not an equilibrium strategy to choose $I = 0$ within domestically-financed buyout, subsidy, or transfer-facilitated buyout regimes.

[28] This can be seen with our assumption that voters vote only on ideological preference, so that $c(I_A) = c(I_B) = 0$. However, it would also hold more broadly as long as actions by the parties are symmetric, since $c(I_A)$ and $c(I_B)$ cancel out in the electoral victory probability equation (20).

in this case differences in swing-density, ϕ^J. For ease of notation, we use

$$\Delta \equiv \frac{\big(\sum_j \alpha^J \phi^J y^J\big)}{\big(\sum_j \alpha^J \phi^J\big) y} \tag{30}$$

to denote an expression that recurs repeatedly in the solutions (Appendix C) and which captures the extent of voter swing heterogeneity. To understand this expression, note that the denominator is average swing density in the population ($\sum_j \alpha^J \phi^J$) multiplied by overall average income (y). In contrast, the numerator is an expression of population- and swing-weighted income; that is, each group's income is weighted by its population share *and* its swing density.

If all groups have the same fixed swing density, i.e. $\phi^J = \bar{\phi}$, so that there is no heterogeneity in their political importance, the expression reduces to[29]

$$\Delta = \frac{\bar{\phi}\big(\sum_j \alpha^J y^J\big)}{\bar{\phi}\big(\sum_j \alpha^J\big) y} = 1. \tag{31}$$

In contrast, differential swing densities imply that $\Delta \neq 1$. More precisely, if the wealthier income group is more swing-dense, then $\Delta > 1$ (swing-weighted income is higher than average income), and vice versa.

In what follows, we summarize the main findings from the model with electoral concerns in the form of Propositions 7-9, which are structured to be parallel to Propositions 1-3 in Section 2. The proofs are in Appendix C.

Proposition 7. *The presence of electoral concerns (i.e., when $\Delta \neq 1$) reduces the scope for buyouts relative to patents. Specifically, the range of parameter value combinations (f, g, n) for which $W^{N,Buyout} < W^{N,Patent}$ is increasing in $|\Delta - 1|$, including when globally it holds that $W^{W,Buyout} > W^{W,Patent}$.*

Proof. See Appendix C.3. □

Proposition 7 compares a patent system to a domestically-financed global buyout in the presence of electoral concerns in the North. It implies that it is now even more likely,

[29]This is owing to the definition of average income, $y \equiv \sum_j \alpha^J y^J$, and since $\sum_j \alpha^J = 1$.

relative to the baseline model in Section 2, that the North will abstain from implementing a buyout. This holds even if a buyout would increase global welfare relative to a patent regime, and regardless of which voting block is more politically important; that is, regardless of whether $\Delta > 1$ or $\Delta < 1$.

This result owes to the fact that investment choices under a buyout are non-optimal for the North, from a social welfare point of view, to the extent that they emphasize the distributional priorities of some voter groups over others. By contrast, investment choices under a patent regime, which are driven by profit considerations, are unaffected by this dimension; as a result, the welfare advantage of buyouts relative to patents for the North diminishes. Given equal electoral victory probabilities in equilibrium and the second-order consideration of welfare in regime choice (as discussed above), the North will therefore be less likely to replace a global patent regime with a global buyout.

The implications for the South, and therefore for world welfare, continue to be ambiguous, and will now depend not only on population shares but also on which voting block in the North has more political weight. As shown in Appendix C, to the extent that the higher income group in the North y^R is more politically important (i.e., $\Delta > 1$), investment under a buyout will be too low, as there is fiercer opposition to tax-based redistribution, and the South benefits less from a buyout than it does in the setup in Section 2. The intuition behind this is that the wealthier pay a higher absolute amount of their income under a flat-rate tax (and certainly under a progressive tax), so that they have lower relative benefit per unit of innovation and prefer less public financing. In contrast, to the extent that the lower income group y^P is more politically important ($\Delta < 1$), investment under a buyout will be high and will allow the South to reap more benefits from the externality associated with buyouts. In this case, the narrowing of the space for buyouts can be a net negative for world welfare (see the proof of Proposition 7).

The next proposition summarizes the results when a subsidy regime (or national buyout) is also an option for the North.

Proposition 8. *With electoral concerns, it still holds that* $W^{N,Subsidy} > W^{N,Buyout}$*, but there is now a range of parameter value combinations for which* $W^{N,Subsidy} < W^{N,Patent}$*.*

This range is increasing in Δ.

Proof. See Appendix C.4. $\square$

Proposition 8 implies that, even if it is possible for the North to implement a subsidy (akin to a national buyout), this will no longer necessarily be its dominant strategy. In particular, while subsidies are still more desirable for the North than a domestically-financed global buyout, they are no longer necessarily preferable to a global patent regime, and there is a range of parameter value combinations for which the North may choose to maintain global patents.

The intuition behind this result is as follows. Between subsidies and global buyouts, investment under both is impacted by electoral concerns, and it remains true that $I^{Subsidy} > I^{Buyout}$ (see Appendix C.2). Therefore, for the North, a subsidy still has the same two advantages over buyouts: it preserves international profits while eliminating static deadweight losses associated with monopoly pricing at home, and it also increases welfare by generating a higher level of innovation than under buyouts. As before, each additional product invented generates domestic surplus as well as monopoly profits from markets abroad.

However, between subsidies and global patents, only the former's investment levels are impacted by electoral concerns. If the wealthier group y^R is sufficiently important for votes, then investment under a subsidy may be *lower* than under a patent regime, so that $I^{Subsidy} < I^{Patent}$. In this case, it is possible that the welfare loss from lower innovation under a subsidy outweighs the gain from removing monopoly deadweight losses, so that global patents are preferable from a Northern welfare perspective.

The next proposition takes into account the possibility of international surplus transfers between countries.

Proposition 9. *With electoral concerns, transfer contracts set by the Northern government do not generate a Pareto optimal global buyout, and total investment in innovation deviates from the globally efficient level. Global welfare is lower than its optimal level, and the gap increases with* $|\Delta - 1|$.

Proof. See Appendix C.5. □

Proposition 9 implies that the presence of a technology for international surplus transfers is no longer sufficient for achieving a Pareto optimal outcome when investment decisions are affected by electoral concerns. In particular, a transfer contract $\{I^{Transfer}, T\}$ designed by the Northern government and driven by domestic distributional considerations will lead to suboptimal investment and world welfare levels.

The key intuition for this result is as follows. Previously, in the baseline model in Section 2, the key disincentive toward a global buyout for the North lay in the international distribution implications, in particular that the South would benefit from the buyout without paying for it. In this case, transfers from the South to the North entirely removed the externality regardless of which entity designed the contract. In contrast, under electoral concerns, the Northern government is acting not only to minimize 'free-riding' by the South, an issue which transfers would address, but also to strategically appease important voter groups. The latter is a domestic political economy dimension that transfers do not get rid of; that is, transfers do not eliminate the fact that some domestic taxation is required to implement a global buyout (otherwise, the participation constraint of the South would not be met) nor do they remove conflict between different Northern voter groups over the desired extent of taxation.

5 Discussion

5.1 Summary of results

Our model shows that, because buyouts may have global externalities and are publicly financed, the choice of innovation regime depends on the effect on international profit as well as domestic welfare redistribution; these considerations arise even in the absence of the information and commitment problems considered in the literature on buyouts. Abstracting from these distributional issues undermines the challenges toward instituting buyout regimes even if the latter are globally welfare enhancing.

The first key challenge we identify relates to the potential global externalities from non-patented innovation. While patents are in effect financed by all consumers worldwide who purchase the resulting products, the cost of buyouts would, in the absence of feasible international transfers, be borne solely by (the taxpayers of) the innovating country; therefore, the key tradeoff facing the North, assuming the government prioritizes maximizing social welfare, is between reducing deadweight loss from patents and losing international profit from buyouts. Facing a choice only between global patents and global buyouts, the innovating country's government will still choose to finance a buyout if the costs of free riding are lower than the domestic costs of monopoly pricing, and it will keep patents globally if the converse condition applies, irrespective of how this impacts world welfare.

The model also emphasizes that arrangements which weaken this tradeoff for the North would render buyouts a moot point. In particular, what we call national subsidy pricing can stem the harmful effects of patents to Northern consumers while maintaining profits from captive international markets. In light of this, a mixed-incentives approach in which the cost of patented products is subsidized in advanced countries, for example through health insurance for drugs, while allowing innovating firms to retain the underlying patents, emerges as a domestically desirable choice and does not need to be explained by the problems highlighted in the previous literature. Once again, as long as the decision to maintain or remove patents is undertaken by the government of the innovating country, the welfare of the rest of the world will be an afterthought.

In this case, only intersovereign transfers override international coordination problems and generate what resembles a single-economy market. Only in this case, therefore, we obtain conclusions mirroring those of a single closed economy: that without information and commitment problems, the achieved innovation regime in equilibrium is a buyout which generates the Pareto optimal level of innovation. We also show that the results are robust to a number of extensions such as unlicensed resale, innovation by both countries, and the possibility of targeted buyouts in an $N > 2$ country world.

The second key challenge we identify is that the tax financing for buyouts has important implications for *domestic* welfare distribution. At the very least, different income groups may have conflicting desires over the extent of taxes levied. While this does not impact public investment when the government simply maximizes *aggregate* welfare (Section 2), it does factor into investment choice when consumer heterogeneity is important for political purposes, as in when these groups are differentially important in the electoral calculus of governments that seek primarily to maximize electoral popularity.

Once electoral concerns are added to the model, the results emphasize that investment choices in publicly financed regimes, whether buyouts or subsidies, tilt more heavily toward the desires of politically influential groups. As a result of this distortion, welfare in the North with these regimes is less than would be achieved under the pure aggregation (the first-best from a domestic point of view). In equilibrium, vote shares reflect fundamentals and are equalized across regimes; with second-order welfare concerns, patents become even more likely relative to both global and national (i.e. subsidy) buyout regimes. Moreover, intersovereign transfers no longer generate the Pareto optimal level of innovation, because they override the international coordination but not the domestic distributional issues.

5.2 Scope and limitations

This section discusses the assumptions underlying our model, focusing on the robustness of the findings to alternative modelling choices. The discussion is mostly framed in terms of the baseline model (from Section 2) but similar conclusions can be drawn about the model with electoral concerns in the features it shares with the baseline model.

Linear surplus function of innovation. Like other studies in the literature, we work with a linear surplus function $\tilde{s}(I)$ of innovation, implying that the speed by which diminishing returns to innovation occur is constant. Relaxing this feature will affect the tradeoffs facing the North in choosing between different innovation regimes, so that the quantitative results (e.g., the derived expressions of the cutoff values $\overline{\gamma}_1$ and $\overline{\gamma}_2$) will be sensitive to changes in the functional form of $\tilde{s}(I)$. Focusing on the policy implications of the model, this also means that the ability to form cases for or against certain innovation regimes will vary across different functional forms. However, as long as $\tilde{s}(I)$ is a continuous decreasing function, the qualitative predictions of the model will remain largely the same. For example, the result in the baseline model that the North's dominant strategy in the absence of international transfers involves a national subsidy (Proposition 2) would also hold if $\tilde{s}(I)$ is continuous, decreasing, and either concave or convex. The same applies to the result on the optimality of internationally-financed buyouts in Proposition 3.[30]

Identical linear demand functions. The model also assumes that consumers in all countries feature the same inverse demand functions for all goods, and that these functions take a linear form. Linearity of demand ensures the existence of a closed-form solution and helps to keep the model tractable. However, it is not a critical feature for our results. What is needed is that monopoly pricing leads to a strictly positive loss in welfare, but this would also hold under many other types of demand functions (see also the corresponding discussion in Deardorff, 1992).

With respect to the assumption of identical consumers, if the quantity of some invented product demanded per consumer was different across countries, then the magnitudes of the tradeoffs facing the North in choosing between different innovation regimes would change. While sufficiently small derivations would leave our main qualitative findings intact, larger deviations would affect the results in Propositions 1 and 2. To see this, consider the two extreme cases of an innovation set A that generates products only demanded by consumers in the North, and an innovation set B that generates products only demanded in the South. In the case of B, moving from a patent system to a buyout without transfers would eliminate any research investment for this invention, as the North would not enjoy any of the surplus associated with B. In this case, and deviating from the results in Proposition 1, welfare of the South (and globally) would always be greater under a patent regime than under a buyout, and there would be no value of γ for which the North would implement a buyout. Similarly, for A the North would always implement a buyout (irrespective of the value of γ). At the same time, the key result in Proposition 3 would remain intact, as a Pareto-improving buyout with international transfer could be implemented both for A and for B (for A, the required transfer would be zero).

Symmetric production costs. The model moreover assumes that patent buyouts

[30]In addition, we might echo here Deardorff's argument that, in the absence of any information about the true functional form of $\tilde{s}(I)$, assuming linearity appears to be an appropriate choice.

lead to the same competitive pricing of invented products in all countries. This implies that the geographical organization of production is irrelevant; that is, it does not matter whether all production capacity is concentrated in the North and products are exported to the South, or the South also features some production capacity.[31] The model is therefore unable to capture important considerations in the context of industrial development and employment. At the same time, relaxing the assumed symmetry in production would keep most of our key qualitative insights intact. For example, suppose that consumers in the South would face higher prices under a buyout than consumers in the North because the cost of production is higher in the South than in the North (e.g., due to less productive technology and infrastructure) or because markets for production are not fully competitive in the South (and shipping products across countries entails transportation costs). The existence of such price differences will tend to reduce the benefits of a buyout to the South and thus affect the results of the model quantitatively (e.g., the derived cutoff values in Propositions 1 and 2 would change). At the same time, the qualitative insights obtained from Propositions 1 - 3 would largely remain the same. For instance, the North would still prefer a system with subsidies over a domestically-financed buyout (Proposition 2), and the globally efficient level of innovation will only be reached in the presence of international transfers (Proposition 3).

Market frictions. Innovations in the model are readily purchased and consumed by n individuals (distributed with share γ in the North) if their associated utility exceeds the cost. This feature abstracts from the fact that some consumers may face binding constraints in financing the consumption of new products, and that these constraints may systematically differ between countries. If there are individuals who are constrained from paying the equivalent of their marginal benefit obtained from consuming an innovation (e.g., due to credit market frictions) but these constraints are not considered in our model, then the model will tend to overestimate the value of innovation. Moreover, if these constraints were mostly concentrated in countries with less innovation capacity, this would

[31] This applies if producers make zero profits under a buyout (i.e., when production takes place in a competitive environment) and if all profits generated under a patent system flow to the North (e.g., through licensing; see also footnote 12).

reduce the benefits of a global buyout to those countries (as well as globally) relative to what our model implies.[32] The same applies to other constraints, including those related to institutions. For example, many health-based innovations are primarily delivered through national health systems. If the involved institutions are associated with a limited capacity to procure, distribute or maintain the respective products (e.g., due to organizational or human capital issues, even in the absence of financial constraints among consumers), then effective demand in these countries will be smaller than implied by our model.[33]

Static framework and partial equilibrium. Our theoretical insights are based on a static model which abstracts from dynamics over time. Of course, this does not mean that the model is unable to capture both the static and the dynamic losses associated with patents, as the latter are reflected in the size of I. However, the static nature of the model prevents us from studying some of the aspects that have been considered by previous work in the literature, such as the roles of patent length and the timing of buyouts (i.e., the possibility for governments to pursue a mixed strategy where innovators are allowed to enjoy monopoly power for a certain period of time until the government decides to implement a buyout, possibly depending on uncertain market conditions).

In addition, our model takes the volume and distribution of demand (captured by the parameters n and γ), the contribution of innovation to social surplus (captured by f and g), and the cost of innovation (R) as determined exogenously to the model and fixed with respect to the innovation regime in place. While this is in line with the approach taken by many other studies in the literature on patent protection and buyouts (e.g., most of the studies cited in Section 1), it is important to note that such an approach abstracts from general equilibrium effects that might determine those variables. For example, one

[32] To see this, consider a household in the South with a valuation of an innovation below the monopoly price but above the competitive price. When moving from a system of global patent protection to a buyout, the model assumes that the household will purchase the innovation, contributing to a rise in the South's consumer surplus. However, if market frictions such as credit constraints prevent the household from purchasing the product, then the increase in consumer surplus associated with a buyout will be lower than implied by the model.

[33] For instance, Marcus et al. (2022) find persistently low use of statins, which protect against cardiovascular disease, in low and middle-income countries even after prices for these drugs fell after patent expiry, due to poor diagnostics and lack of sufficient integration of statins into the primary health care systems of these countries. More generally, organizational problems in the healthcare institutions of developing countries can be severe even when financial constraints are not (Ahmad, 2021).

may be concerned that innovation regimes which increase total investment into research also reduce the research cost for subsequent innovations. Similarly, an innovation regime which lowers prices may (over time) affect the structure of demand, possibly differently in different countries. Modelling such processes would require a richer model in which demand and innovation regime are jointly determined, which is left for future research.

Voter heterogeneity. The model in Section 4 assumes that voters differ in their political importance due to groups' varying swing densities. It should be noted that, while it is convenient to frame the analysis in terms of swing densities, we could have alternatively assumed that groups have the same swing densities but, for instance, different campaign financing abilities (which increase with wealth), and that such lobbying powers impact party vote shares. In this case, it can be shown that a government with electoral concerns would also undertake investment decisions that deviate from those undertaken with pure (equal) aggregation of individual welfare, weighing more heavily instead the stronger lobbying groups. In equilibrium, parties would still act symmetrically, receive vote shares that reflect fundamentals, and be less likely to choose buyouts or subsidies over patent regimes, hence keeping the main qualitative insights in Propositions 7 - 9 intact. In essence, our findings rely critically on heterogeneity in voters' political importance, but the exact nature and source of that heterogeneity are not crucial.

5.3 Alleviating constraints: possibilities and challenges

If buyouts are constrained partly by conflict over the distribution of costs and benefits, what are the possibilities for—and challenges toward—alleviating such conflicts?

Transfers in practice. First and most directly, our model predicts that internationally-financed buyouts can lead to Pareto improvements relative to regimes based on global patent protection, even if they do not lead to full Pareto optimality (e.g., due to domestic distributional conflicts). While we have outlined in detail how transfers operate in theory, it remains to discuss why transfer-financed buyouts, if they are Pareto improving, are rarely observed in practice. Several factors can potentially account for this. First, our model implicitly assumes that international transfers are financed by government revenues (such as taxes) in the countries featuring less innovation capacity. In practice, however, there are often severe challenges toward the mobilization of domestic resources in low-income countries, including weak institutions and low taxation paying norms (Besley and Persson, 2014).

Second, even if governments in those countries can mobilize enough resources, the transfers agreed in exchange for implementing a buyout must be credible from the perspective of the innovating country, but credibility is compromised if the (here, Southern) government faces potentially unexpected shocks that may require diversion from a small budget (along the lines of Galasso (2020)). Without a supra-sovereign enforcer of agreements between sovereigns, it is difficult to see how such commitment problems, if they exist, can be overcome.

Third, our model abstracts from information constraints and assumes governments know the social value of innovations. In a single-economy model, it seems relatively harmless to assume that the government can observe market signals such as sales and prices (Shavell and van Ypersele, 2001). However, once we move to an international setting, the government of any country considering to implement a buyout would also need to observe such signals for foreign markets to choose the optimal buyout amount. If in practice obtaining such information from abroad is subject to transaction costs or other frictions, then a buyout agreement will tend to be less attractive than implied by the model.

Positive externalities. While intersovereign transfers help to directly offset negative externalities associated with free riding, another possibility (unmodeled) is that *positive* externalities from welfare in the less wealthy countries may improve the desirability of buyouts, even in the absence of transfers. For example, if governments of innovating countries are interested in aid to less advanced economies—as this may result in positive externalities to them from political stabilization or other reasons—then buyouts (without intersovereign transfers) may be viewed as one channel for aid. Concerns about loss of profits internationally would be reduced to the extent that they form part of the strategic resource transfer embedded in aid. Similarly, for certain technologies with positive externalities it might be in rich countries' own interest to facilitate their widespread use globally, even if doing so comes at a cost. For instance, this might be the case for health technologies that limit the spread of contagious diseases (such as vaccines or HIV antiretroviral therapy) and for climate technologies that help to reduce greenhouse gas emissions.

However, while the presence of positive externalities from resource transfer for buyouts can help offset negative externalities associated with freeriding, this would not necessarily alleviate domestic distributional concerns. Continuing with the above examples, justifying buyouts as aid would be subject to the same domestic conflict over how much foreign aid, which is tax-financed, is desirable, and there may also be considerable disagreement over how much to invest abroad in technologies that generate positive spillovers domestically.

International initiatives and philanthropy. Another policy implication of our paper relates to efforts to develop mechanisms that facilitate international *collaboration* on patent buyouts, and which feature into the agenda of recent initiatives such as the Health Impact Fund (Banerjee et al., 2010) and Advanced Market Commitment (Kremer et al., 2020, 2022). Such efforts would help overcome international distributional conflicts, but, as with aid, it is unclear if sufficient consensus can be reached domestically about how much to contribute to such programs. In contrast, our findings suggest that such initiatives are more likely to succeed if propelled by philanthropic seed funding where some degree of 'altruism' neutralizes the extent to which international and domestic distributional conflict arises. However, philanthropic funding (alone) may be limited in size; while it may be able to subsidize purchases of subsequent goods, it is unclear if it would be sufficient to fund patent-replacing buyouts.

6 Conclusion

Innovators must be compensated for investing in innovation, but it has long been understood that doing so by granting monopoly power via patents is distortionary and inefficient. In contrast, a buyout in which the government directly transfers the requisite surplus to the innovator could in principle circumscribe the need for monopoly power. The previous literature has focused on patent buyouts in single-country models and under the assumption that governments maximize social welfare, and has shown that if the government can calculate and commit to transferring the social surplus to the innovator, then buyouts are clearly welfare enhancing.

In this paper, we consider two previously unstudied political economy tradeoffs that can arise due to how buyouts are financed and benefited from, and we explore how these can hinder the implementation of buyouts that would otherwise enhance global welfare. First, placing knowledge in the public domain in a multicountry world where not all countries can contribute equally to buyout financing would result in loss of profits for the financing country and in positive externalities for the rest of the world. Second, because buyouts are publicly financed, they may engender domestic conflict over the desired extent of tax financing, and such conflict will be influential if the government cares not simply about total welfare but about the welfare of politically important groups. In contrast, financing innovation through market sales of subsequent private goods (via patent power) circumscribes the global externality as well as the extent of dependence on public financing.

Our results demonstrate that these global and domestic distributional issues constrain the pursuit of buyouts, potentially to the detriment of the innovating country's and the world's welfare. Our findings also elaborate on the interaction between the two aspects, i.e. that domestic politics can interfere with the otherwise optimal and feasible solution of a buyout internationally financed through transfers. We also discuss possibilities for, and challenges toward, institutional responses that may alleviate—albeit not completely eliminate—these distributional constraints.

In light of these findings, buyouts of internationally useful innovations may be understood as *publicly financed goods with global externalities*, and which are very difficult to finance. Of course, the redistributive consequences of patented technologies and the potential toll on populations in the global South, as well as the question of alternative systems of incentivizing innovation, have taken on renewed importance in light of the COVID-19 pandemic. In fact, resistance by innovating countries to the placement of vaccine innovations in the public domain has often been framed in terms of concerns about international profit losses for innovating countries, and there has also been heterogeneity within countries about the desired extent of public financing for globally accessible vaccination. Although our paper is a general theoretical exploration which does not engage with the specifics of vaccine innovation and production nor with the welfare ramifications of contagious disease, we believe the framework presented here can help shed light on the primacy of such political economy concerns in the choice (and consequences) of patent regimes versus other innovation regimes more generally.

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APPENDIX

A Optimal consumer surplus and total research cost

Suppose per-capita demand for a single product z_i can be approximated by a linear inverse demand function

$$p_i = a_i - \frac{b_i}{n} q_i, \tag{A.1}$$

where p_i is the price, q_i is total market demand, n is the number of consumers with identical demand curves, and a_i and b_i are parameters. Assuming constant marginal production costs c_i for each product, equating price to marginal cost yields the optimal demand per capita

$$\frac{q_i^*}{n} = \frac{(a_i - c_i)}{b_i}. \tag{A.2}$$

If the product is sold at marginal cost, then its optimal per-capita consumer surplus is given by

$$\frac{S_i^o}{n} = \frac{\int_0^{q_i^*} (p_i - c_i) dq}{n} = \frac{(a_i - c_i)^2}{2b_i}. \tag{A.3}$$

Let the cost of *research* that went into inventing z_i be denoted by $R(z_i)$. Dividing the optimal per-capita consumer surplus by the research cost yields

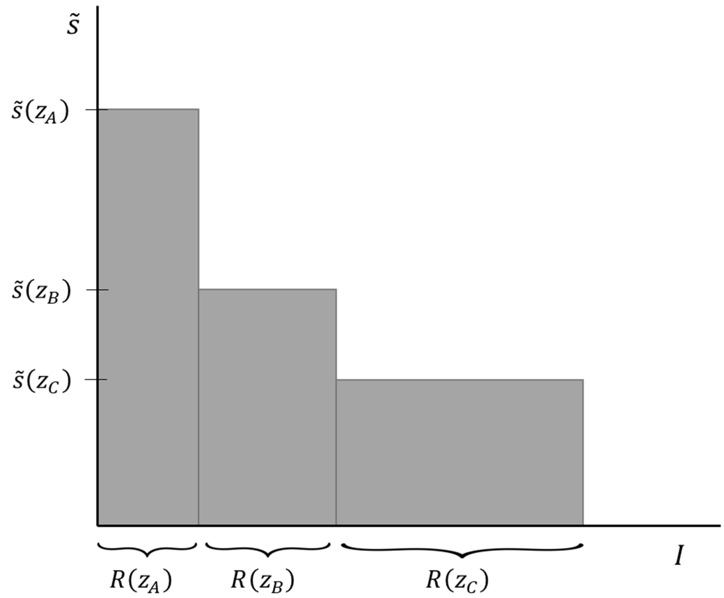
$$\tilde{s}(z_i) \equiv \frac{S_i^o}{nR(z_i)} = \frac{(a_i - c_i)^2}{2b_i R(z_i)}. \tag{A.4}$$

Ordering inventions in descending order of $\tilde{s}$ allows for $\tilde{s}$ to be expressed as a monotonically decreasing function of I, where $I = \int R(z) dz$ is the total research cost for all invented products. To see this, consider the following example with three products:

- z_A generates $S_A^o/n = 20$ and $R = 2$ is incurred in its invention.
- z_B generates $S_B^o/n = 15$ and $R = 3$ is incurred in its invention.
- z_C generates $S_C^o/n = 18$ and $R = 6$ is incurred in its invention.

The respective optimal per-capita consumer surplus per dollar of research cost ($\tilde{s}$) for these products is 10, 5, and 3. Descending order of $\tilde{s}$ therefore implies z_A, z_B, z_C. Plotting $\tilde{s}$ over I in this order yields the graph in Figure A1.

Figure A1: Optimal consumer surplus $\tilde{s}$ as a function of total research cost I



Source: Authors' illustration.

Due to the ordering, $\tilde{s}$ is a weakly decreasing step function of I. Moreover, it can be seen that the combined area shaded is equal to $20+15+18$, which is the sum of per-capita optimal consumer surplus across all products.

When there are many inventions, this can be calculated by taking the integral of $\tilde{s}$ from zero to I

$$\frac{S^o}{n} = \sum_i \frac{S_i^o}{n} = \int_0^I \tilde{s}(I)dI. \tag{A.5}$$

Multiplying this equation through by n provides the total optimal consumer surplus across all products

$$S^o(I) = \int_0^I n\tilde{s}(I)dI. \tag{A.6}$$

B Proofs for the baseline model

This appendix derives the solution to the model described in Section 2 and 3 along the following steps. First, we calculate the optimal behavior and associated welfare of the North and the South as functions of the model's primitives separately for each innovation regime. We then compare the resulting expressions with each other to determine the regime that emerges in equilibrium for any given parameter value combination. The proof of Proposition 1 is derived in Appendix B.4 by comparing the outcomes under global patent protection and a domestically-financed global buyout. The proof of Proposition 2 is derived in Appendix B.5 by considering the additional possibility of a national subsidy program in the North. Finally, the proof of Proposition 3 is derived in Appendix B.6 by obtaining the solution across all possible regimes when international surplus transfers are possible.

B.1 Global patent protection

Under a regime of global patent protection, the optimal level of research investment, I^{Patent}, chosen by the firms in the North is determined by the maximization problem in equation (6). With the made assumptions that demand is linear and the marginal cost of production is constant, it is well known that the monopoly profit amounts to one half of the optimal consumer surplus (obtained under competitive pricing) in a given country, so that

$$\Pi^i(I) = \frac{1}{2}S^{o,i}(I), \ i \in \{N, S\}. \tag{B.1}$$

The remaining surplus is split equally between consumers and deadweight loss, so that the consumer surplus under monopoly pricing can be expressed as a fixed share of the optimal surplus

$$S^{\pi,i}(I) = \frac{1}{4}S^{o,i}(I), \ i \in \{N, S\}. \tag{B.2}$$

Using the expression of $S^{o,N} = \gamma n \int_0^I (f - gI)dI$ (see equation 4) and noting that $S^{o,S}(I)$ is given by an analogous expression with $(1-\gamma)$ instead of γ, the maximization problem from equation (6) can be written as

$$Max_{I^{Patent}} \quad \hat{\Pi}(I) = \quad \frac{1}{2}\gamma n \int_0^I (f - gI)dI + \frac{1}{2}(1-\gamma)n \int_0^I (f - gI)dI - I^{Patent}. \quad \text{(B.3)}$$

Solving for I shows that the optimal level of research investment under a global patent regime is given by

$$I^{Patent} = \frac{nf - 2}{ng}. \quad \text{(B.4)}$$

The associated welfare of the North is given by equation (7). Plugging into this the expression for I^{Patent} from equation (B.4) leads to

$$\begin{aligned} W^{N,Patent} &= \frac{1}{4}\gamma n \int_0^I (f - gI)dI + \frac{1}{2}\gamma n \int_0^I (f - gI)dI + \frac{1}{2}(1-\gamma)n \int_0^I (f - gI)dI - \frac{nf-2}{ng} \\ &= \frac{nf-2}{8ng}\Big[(2+\gamma)(nf+2) - 8\Big]. \quad \text{(B.5)} \end{aligned}$$

The welfare of the South under a global patent regime consists of the consumer surplus obtained under monopoly pricing. This can be calculated as

$$\begin{aligned} W^{S,Patent} &= S^{\pi,S}(I^{Patent}) \\ &= \frac{1}{4}(1-\gamma)n \int_0^I (f - gI)dI \\ &= \frac{(1-\gamma)(n^2f^2 - 4)}{8ng}. \quad \text{(B.6)} \end{aligned}$$

B.2 Domestically-financed patent buyout

If the government of the North implements a buyout without receiving any surplus transfer from the South, then the level of innovation is determined by the maximization problem in equation (8). Assuming the taxation constraint is binding, solving for I^{Buyout} shows that the optimal level of research investment under a domestically-financed buyout is given by

$$I^{Buyout} = \frac{\gamma nf - 1}{\gamma ng}. \quad \text{(B.7)}$$

Notice that $I^{Buyout} > I^{Patent}$ whenever $\gamma > 0.5$; that is, whenever the market (population) size of the North is larger than that of the South.

Using the derived expression of I^{Buyout}, the welfare of the North under a buyout can be calculated as the value of the maximand in equation (8). With a binding taxation constraint, $\gamma n \tau y = I^{Buyout}$, this leads to

$$\begin{aligned} W^{N,Buyout} &= S^{o,N} - I^{Buyout} \\ &= \gamma n \int_0^I (f - gI) dI - \frac{\gamma n f - 1}{\gamma n g} \\ &= \frac{(\gamma n f - 1)^2}{2\gamma n g}. \end{aligned} \tag{B.8}$$

The associated welfare of the South can be calculated as

$$\begin{aligned} W^{S,Buyout} &= S^{o,S}(I^{Buyout}) \\ &= (1-\gamma) n \int_0^I (f - gI) dI \\ &= \frac{(1-\gamma)(\gamma^2 n^2 f^2 - 1)}{2\gamma^2 n g}. \end{aligned} \tag{B.9}$$

B.3 National subsidy

If the government of the North implements a national subsidy, then the level of innovation is determined by the maximization problem in equation (9). Assuming the taxation constraint is binding, solving for $I^{Subsidy}$ shows that the optimal level of research investment under a subsidy in the North is given by

$$I^{Subsidy} = \frac{nf(1+\gamma) - 2}{ng(1+\gamma)}. \tag{B.10}$$

Notice that for all feasible parameter values of $\gamma \in (0,1)$ it holds that $I^{Subsidy} > I^{Patent}$ and $I^{Subsidy} > I^{Buyout}$.

Using the derived expression of $I^{Subsidy}$, the welfare of the North under a national subsidy can be calculated from the maximand in equation (9) as

$$\begin{aligned}
W^{N,Subsidy} &= S^{o,N}(I^{Subsidy}) - I^{Subsidy} + \Pi^{S}(I^{Subsidy}) \\
&= \gamma n \int_0^I (f - gI)dI - \frac{nf(1+\gamma)-2}{ng(1+\gamma)} + \frac{1}{2}(1-\gamma)n \int_0^I (f-gI)dI \\
&= \frac{[nf(1+\gamma)-2]^2}{4ng(1+\gamma)}. \qquad \text{(B.11)}
\end{aligned}$$

The associated welfare of the South can be calculated as

$$\begin{aligned}
W^{S,Subsidy} &= S^{\pi,S}(I) \\
&= \frac{1}{4}(1-\gamma)n \int_0^I (f-gI)dI \\
&= \frac{(1-\gamma)\left[n^2 f^2 (1+\gamma)^2 - 4\right]}{8ng(1+\gamma)^2}. \qquad \text{(B.12)}
\end{aligned}$$

B.4 Proof of Proposition 1

The proof of Proposition 1 is obtained by comparing the total welfare of the North under a domestically-financed buyout (equation B.8) with the welfare obtained under a system of global patent protection (equation B.5). Taking the difference of the two expressions and simplifying the result leads to

$$\begin{aligned}
W^{N,Buyout} - W^{N,Patent} &= \frac{(\gamma nf-1)^2}{2\gamma ng} - \frac{nf-2}{8ng}\Big[(2+\gamma)(nf+2)-8\Big] \\
&= \frac{\gamma n^2 f^2 (3\gamma - 2) + 4(\gamma-1)^2}{8\gamma ng}. \qquad \text{(B.13)}
\end{aligned}$$

The numerator in expression (B.13), on which the sign depends, is a quadratic function of γ, and may be positive or negative, depending on the parameter values. The existence of a unique cutoff value $\overline{\gamma}_1$ (as described in Proposition 1), which determines whether the North prefers a buyout or a patent system, can be derived as follows. Setting the numerator in equation (B.13) equal to zero, and transforming it into the standard quadratic form gives

$$\gamma^2 - \frac{2n^2f^2+8}{3n^2f^2+4}\gamma + \frac{4}{3n^2f^2+4} = 0. \qquad \text{(B.14)}$$

Since the leading coefficient is positive, the parabola opens upward. Moreover, the two roots are given by

$$\overline{\gamma}^{-,+} = \frac{n^2 f^2 + 4 \mp nf\sqrt{n^2 f^2 - 4}}{3n^2 f^2 + 4}. \tag{B.15}$$

This implies that the difference $W^{N,Buyout} - W^{N,Patent}$ in equation (B.13) is negative for all values $\gamma \in (\overline{\gamma}^-, \overline{\gamma}^+)$ and is positive for $\gamma > \overline{\gamma}^+$ and $\gamma < \overline{\gamma}^-$. In addition, it can be shown (see below) that all feasible values of γ are greater than $\overline{\gamma}^-$. Hence, whether $W^{N,Buyout}$ is greater or smaller than $W^{N,Patent}$ is determined by the single cutoff value $\overline{\gamma}^+$. Setting $\overline{\gamma}_1 = \overline{\gamma}^+$ then provides the proof of Proposition 1.

To complete the proof, we now show that all feasible values of γ must be greater than $\overline{\gamma}^-$. This follows from two parameter value restrictions that arise endogenously in the model from the fact that the investment level can never be negative. From $I^{Patent} > 0$ it follows that $nf > 2$ (see equation B.4). And from $I^{Buyout} > 0$ it follows that $\gamma > \frac{1}{nf}$ (see equation B.7). Using these two restrictions, it is possible to verify that the first root, $\overline{\gamma}^-$, is always smaller than $\frac{1}{nf}$, and thus smaller than the feasible range of values of γ. Starting with

$$\frac{n^2 f^2 + 4 - nf\sqrt{n^2 f^2 - 4}}{3n^2 f^2 + 4} < \frac{1}{nf}, \tag{B.16}$$

simplifying the expression leads to

$$n^3 f^3 + 4nf - n^2 f^2\sqrt{n^2 f^2 - 4} - 3n^2 f^2 - 4 < 0. \tag{B.17}$$

The expression on the left-hand side of this inequality equals zero if $nf = 2$ and is strictly smaller than zero if $nf > 2$.[34] Together with the fact that $\gamma > \frac{1}{nf}$, it thus holds that $\gamma > \frac{1}{nf} > \overline{\gamma}^-$ so that there are no feasible values of γ that are smaller than $\overline{\gamma}^-$. Whether $W^{N,Buyout}$ is greater or smaller than $W^{N,Patent}$ is therefore determined by the single cutoff value $\overline{\gamma}_1 = \overline{\gamma}^+$.

Notice also that equation (B.15) together with the parameter restriction $nf > 2$ implies

[34] This can easily be verified (e.g., numerically) by rewriting the expression as a function of a single variable $x = nf$.

that $\overline{\gamma}^+ \in (\frac{1}{2}, \frac{2}{3})$.[35] Given that $I^{Buyout} > I^{Patent}$ whenever $\gamma > 0.5$ (see Section B.2), this implies that $I^{Buyout} > I^{Patent}$ always holds when the North prefers a buyout over patents (i.e., when $\gamma > \overline{\gamma}_1$).

In addition, we also show here that, for $\gamma < \overline{\gamma}_1$, global welfare is higher under a buyout than under a patent system. The change in the North's welfare when moving from a patent system to a buyout is given by equation (B.13). The corresponding change in the South's welfare can be calculated as

$$\begin{aligned} W^{S,Buyout} - W^{S,Patent} &= \frac{(1-\gamma)(\gamma^2 n^2 f^2 - 1)}{2\gamma^2 ng} - \frac{(1-\gamma)(n^2 f^2 - 4)}{8ng} \\ &= (1-\gamma)\frac{3\gamma^2 n^2 f^2 + 4\gamma^2 - 4}{8\gamma^2 ng}. \end{aligned} \tag{B.18}$$

Adding up the expressions in equations (B.13) and (B.18) shows that the change in global welfare when moving from a patent system to a buyout is given by

$$\begin{aligned} W^{W,Buyout} - W^{W,Patent} &= \frac{\gamma n^2 f^2 (3\gamma - 2) + 4(\gamma - 1)^2}{8\gamma ng} + (1-\gamma)\frac{3\gamma^2 n^2 f^2 + 4\gamma^2 - 4}{8\gamma^2 ng} \\ &= \frac{\gamma^2(n^2 f^2 - 4) + 4(2\gamma - 1)}{8\gamma^2 ng}. \end{aligned} \tag{B.19}$$

This expression is positive if $\gamma > \frac{1}{2}$ (recall that $nf > 2$ because $I^{Patent} > 0$). As derived above, it also holds that $\overline{\gamma}^+ \in (\frac{1}{2}, \frac{2}{3})$. Thus, for every cutoff value $\overline{\gamma}_1 = \overline{\gamma}^+$ there exists a range of values $\gamma \in (\frac{1}{2}, \overline{\gamma}_1)$ for which the North prefers a patent system over a buyout although a buyout would increase global welfare relative to a patent system. This completes the proof of Proposition 1. $\square$

B.5 Proof of Proposition 2

The proof of Proposition 2 is obtained by comparing the total welfare of the North under a national subsidy with the welfare obtained under global patent protection or under a domestically-financed buyout.

[35]The lower bound, $\overline{\gamma}^+ > \frac{1}{2}$ follows directly from applying the restriction $nf > 2$ to equation (B.15). The upper bound follows from the fact that $\lim_{nf \to \infty} \overline{\gamma}^+ = \frac{2}{3}$.

Taking the difference of the expressions in equation (B.11) and equation (B.5) shows that the welfare gain to the North when moving from a patent system to a national subsidy is given by

$$\begin{aligned} W^{N,Subsidy} - W^{N,Patent} &= \frac{[nf(1+\gamma)-2]^2}{4ng(1+\gamma)} - \frac{nf-2}{8ng}\Big[(2+\gamma)(nf+2)-8\Big] \\ &= \frac{\gamma(n^2f^2-4)+\gamma^2(n^2f^2+4)}{8ng(1+\gamma)}. \end{aligned} \tag{B.20}$$

This expression is positive given that $nf > 2$ (recall that this parameter restriction follows from $I^{Patent} > 0$). Thus, the North always prefers a national subsidy to a patent system.

Taking the difference of the expressions in equation (B.11) and equation (B.8) shows that the welfare gain to the North when implementing a subsidy rather than a domestically-financed buyout is given by

$$\begin{aligned} W^{N,Subsidy} - W^{N,Buyout} &= \frac{[nf(1+\gamma)-2]^2}{4ng(1+\gamma)} - \frac{\gamma nf(\gamma nf-2)+1}{2\gamma ng} \\ &= (1-\gamma)\frac{n^2f^2\gamma(1+\gamma)-2}{4\gamma ng(1+\gamma)}. \end{aligned} \tag{B.21}$$

This expression is positive if it holds that

$$n^2f^2\gamma(1+\gamma) > 2. \tag{B.22}$$

Using the two parameter restrictions, $\gamma > \frac{1}{nf}$ and $nf > 2$, derived above, it holds that

$$n^2f^2\gamma(1+\gamma) > nf+1 > 2. \tag{B.23}$$

Thus, the expression in equation (B.21) is always positive and the North prefers a subsidy to a domestically-financed buyout.

For the South, taking the difference of the expressions in equation (B.12) and equation

(B.6) leads to

$$W^{S,Subsidy} - W^{S,Patent} = \frac{(1-\gamma)[n^2 f^2(1+\gamma)^2 - 4]}{8ng(1+\gamma)^2} - \frac{(1-\gamma)(n^2 f^2 - 4)}{8ng}$$
$$= \frac{\gamma(1-\gamma)(2+\gamma)}{2ng(1+\gamma)^2}. \tag{B.24}$$

Since this expression is positive for all feasible values of γ (recall that $\gamma < 1$), the welfare of the South is always higher under a subsidy in the North than under a global patent regime. Moreover, given that a national subsidy in the North increases welfare both in the North and the South compared to a patent system, it also follows that global welfare is higher under the subsidy than under a global patent regime.

The global welfare comparison between a subsidy in the North and a domestically-financed buyout is less straightforward as the outcome depends on the parameter values. Taking the difference of the expressions in equation (B.12) and equation (B.9) shows that the welfare gain to the South when the North moves from a buyout to a national subsidy is given by

$$W^{S,Subsidy} - W^{S,Buyout} = \frac{(1-\gamma)[n^2 f^2(1+\gamma)^2 - 4]}{8(1+\gamma)^2 ng} - \frac{(1-\gamma)(\gamma^2 n^2 f^2 - 1)}{2\gamma^2 ng}$$
$$= (1-\gamma)\frac{4(1+2\gamma) - 3n^2 f^2 \gamma^2 (1+\gamma)^2}{8ng\gamma^2(1+\gamma)^2}. \tag{B.25}$$

Adding up the expressions in equations (B.21) and (B.25) shows that the change in global welfare when the North moves from a domestically-financed buyout to a subsidy is given by

$$W^{W,Subsidy} - W^{W,Buyout} = (1-\gamma)\frac{n^2 f^2 \gamma(1+\gamma) - 2}{4\gamma ng(1+\gamma)} + (1-\gamma)\frac{4(1+2\gamma) - 3n^2 f^2 \gamma^2(1+\gamma)^2}{8ng\gamma^2(1+\gamma)^2}$$
$$= (1-\gamma)\frac{4(1+\gamma-\gamma^2) - n^2 f^2 \gamma^2 (1+\gamma)^2}{8ng\gamma^2(1+\gamma)^2}. \tag{B.26}$$

This expression is negative if it holds that

$$4(1+\gamma-\gamma^2) - n^2 f^2 \gamma^2 (1+\gamma)^2 < 0. \tag{B.27}$$

Using the parameter restriction $nf > 2$ derived above, inequality (B.27) is fulfilled for all feasible values of n and f if

$$4(1+\gamma-\gamma^2) - 4\gamma^2(1+2\gamma+\gamma^2) < 0. \tag{B.28}$$

Dividing both sides of the inequality by 4 and simplifying the expression on the left-hand side leads to

$$1+\gamma-2\gamma^2-2\gamma^3-\gamma^4. \tag{B.29}$$

It is easy to verify (e.g., numerically) that this function has a single root on the interval $(0,1)$. Let this root be denoted by $\overline{\gamma}_2$. The function (B.29) is positive for $\gamma \in (0, \overline{\gamma}_2)$ and is negative for $\gamma \in (\overline{\gamma}_2, 1)$. Thus, if $\gamma > \overline{\gamma}_2$, the expression in equation (B.26) is negative so that global welfare is higher under a buyout than under a national subsidy. Conversely, if $\gamma < \overline{\gamma}_2$, then global welfare is higher under a national subsidy than under a buyout. This completes the proof of Proposition 2. $\square$

B.6 Proof of Proposition 3

As established by Proposition 2, the equilibrium outcome if international surplus transfers are not possible always consists of a national subsidy in the North. For the proof of Proposition 3 it is thus sufficient to compare each country's welfare obtained under a buyout with international transfer with the respective welfare obtained under the national subsidy. As described in Subsection 2.2.4, we consider two cases of a buyout with transfer, one where the North acts as the principal and offers a contract to the South, and one where the South is the principal and offers a contract to the North.

If the North sets up the contract, then the size of the transfer T and the achieved level of innovation $I^{Transfer}$ are determined by the North's optimization problem in equation (10). For ease of notation, let $\hat{T}_N$ and $\hat{I}_N$ denote the values of T and $I^{Transfer}$ if the contract is offered by the North.

Examining the optimization problem in equation (10), note first that a binding taxation constraint implies $\tau\gamma ny = \hat{I}_N - \hat{T}_N$. Therefore, the maximand in equation (10) becomes

$$W^{N,Transfer} = S^{o,N}(\hat{I}_N) - (\hat{I}_N - \hat{T}_N). \tag{B.30}$$

Second, the South's outside option is a subsidy regime, so that its participation constraint is given by

$$\int_0^{\hat{I}_N} (1-\gamma)n(f-gI)dI - \hat{T}_N \geq W^{S,Subsidy}. \tag{B.31}$$

Assuming that the South agrees to a transfer at its point of indifference between a buyout with transfer and the alternative of a national subsidy, and using the expression of $W^{S,Subsidy}$ from equation (B.12), the relevant Lagrangian is

$$\begin{aligned}\mathcal{L} &= S^{o,N}(I) + \hat{T}_N - \hat{I}_N - \lambda\left[(1-\gamma)n\int_0^{\hat{I}_N}(f-gI)dI - \hat{T}_N - W^{S,Subsidy}\right] \\ &= \gamma n\int_0^{\hat{I}_N}(f-gI)dI + \hat{T}_N - \hat{I}_N - \lambda\left[(1-\gamma)n\int_0^{\hat{I}_N}(f-gI)dI - \hat{T}_N - \frac{(1-\gamma)\left[n^2f^2(1+\gamma)^2-4\right]}{8ng(1+\gamma)^2}\right].\end{aligned}$$

Taking the first order conditions with respect to $\hat{T}_N$ and $\hat{I}_N$ leads to

$$\hat{T}_N = (1-\gamma)\frac{(3n^2f^2-4)(1+\gamma)^2+4}{8ng(1+\gamma)^2}, \tag{B.32}$$

$$\hat{I}_N = \frac{nf-1}{ng}. \tag{B.33}$$

Note that $\hat{T}_N$ is strictly positive (recall that $nf > 2$ because $I^{Patent} > 0$). The level of investment $\hat{I}_N$ corresponds to the world optimum (i.e., the investment level chosen by a government maximizing global welfare).

The resulting welfare of each country is given by

$$W^{N,Transfer} = \frac{(1+\gamma)^2\left[3n^2f^2(1+\gamma)-8nf+4\right]+4(1-\gamma)}{8ng(1+\gamma)^2}, \tag{B.34}$$

$$W^{S,Transfer} = W^{S,Subsidy}. \tag{B.35}$$

It is easy to verify that $W^{N,Transfer} > W^{N,Subsidy}$, so the North will always choose to implement a buyout if transfers are possible. Moreover, adding up $W^{N,Transfer}$ and $W^{S,Transfer}$

shows that the global welfare in this case is given by

$$W^{W,Transfer} = \frac{(nf-1)^2}{2ng}, \tag{B.36}$$

which equals the first-best global welfare that would also be achieved by a benevolent world social planner.

If the contract is instead set up by the South, then T and $I^{Transfer}$ are determined by the South's optimization problem:

$$\begin{aligned} \max_{\hat{T}_S,\hat{I}_S} \quad W^{S,Transfer} &= S^{o,S}(I) - \hat{T}_S = (1-\gamma)n\int_0^{\hat{I}_S}(f-gI)dI - \hat{T}_S \\ s.t. \quad \gamma n &\int_0^{\hat{I}_S}(f-gI)dI + \hat{T}_S - \hat{I}_S \geq W^{N,Subsidy}, \end{aligned} \tag{B.37}$$

where the subscript S indicates that the contract is offered by the South, and the inequality is the participation constraint of the North. Using the expression of $W^{N,Subsidy}$ from equation (B.11), the corresponding Lagrangian is

$$\mathcal{L} = (1-\gamma)n\int_0^{\hat{I}_S}(f-gI)dI - \hat{T}_S - \lambda\left[\gamma n\int_0^{\hat{I}_S}(f-gI)dI + \hat{T}_S - \hat{I}_S - \frac{[nf(1+\gamma)-2]^2}{4ng(1+\gamma)}\right].$$

Taking the first order conditions with respect to $\hat{T}_S$ and $\hat{I}_S$ leads to

$$\hat{T}_S = (1-\gamma)\frac{n^2f^2(1+\gamma)-2\gamma}{4ng(1+\gamma)}, \tag{B.38}$$

$$\hat{I}_S = \frac{nf-1}{ng}. \tag{B.39}$$

The level of investment $\hat{I}_S$ is the same as $\hat{I}_N$. For the transfer, using once more the fact that $nf > 2$ shows that $\hat{T}_S < \hat{T}_N$.

The resulting welfare of each country is given by

$$W^{N,Transfer} = W^{N,Subsidy}, \tag{B.40}$$

$$W^{S,Transfer} = (1-\gamma)\frac{n^2f^2(1+\gamma)-2}{4ng(1+\gamma)}. \tag{B.41}$$

It is easy to verify that $W^{S,Transfer} > W^{S,Subsidy}$, so the South will always choose to implement a buyout with transfers if it has the chance to do so. Moreover, adding up $W^{N,Transfer}$ and $W^{S,Transfer}$ shows that the global welfare again equals the first-best welfare from equation (B.36). This completes the proof of Proposition 3. □

B.7 Proof of Proposition 4

With resale, the North only obtains a fraction $r \in (0, 1)$ of the monopoly profit associated with each innovation from the Southern market. The achieved level of innovation, I^{Resale}, with a subsidy regime in this case is determined by

$$\begin{aligned} Max_{I^{Resale}} \quad & W^{N,Resale} = S^{o,N}(I^{Resale}) - I^{Resale} + (1-r)\Pi^S(I^{Resale}) \\ s.t. \quad & I^{Resale} \leq \tau\gamma ny \end{aligned}$$

Solving for I shows that the optimal level of research investment under a subsidy with resale is given by

$$I^{Resale} = \frac{nf[1+\gamma+r(\gamma-1)]-2}{ng[1+\gamma+r(\gamma-1)]}. \tag{B.42}$$

Given that $r(\gamma - 1) \in (-1, 0)$, it follows that $I^{Resale} < I^{Subsidy}$ for all $r \in (0, 1)$.

Using expression (B.42) in equation (11) and assuming a binding taxation constraint, the North's welfare under a national subsidy with resale can be calculated as

$$\begin{aligned} W^{N,Resale} &= S^{o,N}(I^{Resale}) - I^{Resale} + (1-r)\Pi^S(I^{Resale}) \\ &= \gamma n \int_0^I (f - gI)dI + (1-r)\frac{1}{2}(1-\gamma)n \int_0^I (f-gI)dI - \frac{nf[1+\gamma+r(\gamma-1)]-2}{ng[1+\gamma+r(\gamma-1)]} \\ &= \frac{[nf(1+\gamma+r\gamma-r)-2]^2}{4ng(1+\gamma+r\gamma-r)}. \end{aligned} \tag{B.43}$$

Taking the difference of the expressions in equation (B.43) and equation (B.11) shows that the welfare loss to the North resulting from resale in the case of a national subsidy is given by

$$W^{N,Resale} - W^{N,Subsidy} = r(1-\gamma)\left[4 - n^2f^2(1+\gamma)(1+\gamma+r\gamma-r)\right]. \tag{B.44}$$

Since the investment level cannot be negative, it follows from $I^{Resale} > 0$ that $(1 + \gamma + r\gamma - r) > \frac{2}{nf}$. Together with the parameter restriction $nf > 2$ (derived in Appendix B.4), this implies that the term in squared brackets in equation (B.44) is negative. It thus holds that $W^{N,Resale} < W^{N,Subsidy}$ for all $r \in (0, 1)$.

The result that $W^{N,Resale} > W^{N,Buyout}$ for all $r \in (0, 1)$ can be derived as follows. Taking the difference of the expressions in equation (B.43) and equation (B.8) gives

$$W^{N,Resale} - W^{N,Buyout} = (\gamma - 1)(r - 1)\left[\gamma n^2 f^2 (1 + \gamma + r\gamma - r) - 2\right]. \tag{B.45}$$

Using the parameter restrictions $(1+\gamma+r\gamma-r) > \frac{2}{nf}$ (derived above) and $\gamma > \frac{1}{nf}$ (derived in Appendix B.4), it follows that the term in squared brackets in equation (B.45) is positive. Given that $\gamma \in (0, 1)$ it thus holds that $W^{N,Resale} > W^{N,Buyout}$ for all $r \in (0, 1)$.

If $r = 1$ (i.e., perfect resale), then foreign profits to the North are fully eliminated. The optimal strategy of the North in this case mirrors the one under a domestically-financed patent buyout. To see this, note that North's optimization problem under $r = 1$ takes the same form as in equation (8), while the investment level in equation (B.42) reduces to the expression in (B.7). With perfect resale, the North is thus indifferent between a subsidy and a domestically-financed patent buyout.

Whether the North fares better under a subsidy with resale or under global patent protection depends on the parameter values. To see this, consider a switch from patent protection to a national subsidy with resale. Under a subsidy, resale reduces the North's profit extracted from the Southern market. This effect is less important, the larger γ is (i.e., the smaller the share of the South in the global market is). At the same time, moving from patents to a subsidy eliminates static deadweight loss in the North's home market. The associated increase in welfare is larger, the higher γ is. Thus, for given values f, g, n, and r, larger values of γ make a subsidy under resale more attractive to the North relative to patents (it is also possible to verify this result numerically, as we have done for different parameter value combinations).

The last part of Proposition 4 states that the presence of resale leaves intact the result that, if international surplus transfers are possible, the equilibrium outcome consists of a buyout which stipulates the globally efficient level of innovation. This follows directly from the fact that the first-order conditions that determine the level of innovation (i.e., the values of $\hat{I}_N$ and $\hat{I}_S$ in Appendix B.6) remain unaffected by the introduction of the parameter r to the North's objective function. At the same time, the presence of resale reduces the North's welfare under a subsidy, so that the restriction in (B.37) is relaxed, affecting the size of T and thus the distribution of welfare (analogously for the South's participation restriction if the North acts as the principal). This completes the proof of Proposition 4. $\square$

B.8 Proof of Proposition 5

Given that countries' welfare is additively separable in each sector, Proposition 2 is sufficient to establish that global patent protection paired with a national subsidy will be a dominant strategy for both countries. Specifically, recall that Proposition 2 establishes that a subsidy regime will always strongly (weakly) dominate a patent regime for the innovating (recipient) country. Therefore, we can safely exclude *Patent* from the strategy space, which leaves us with a 2-by-2 game in which each country chooses *Subsidy* or *Buyout* for its sector.

Let the simultaneous one-period game be between players N and S, which innovate in sectors k and l respectively. Moreover, let $W^r_{i\omega}$ denote the welfare obtained by player $i \in \{N, S\}$ from sector $\omega \in \{k, l\}$ under the innovation regime $r \in \{Subsidy, Buyout\}$. The payoff matrix is given as follows.

Table A1: Payoffs with two innovating countries

		S: *Subsidy*	S: *Buyout*
N	*Subsidy*	$(W^{Subsidy}_{N,k} + W^{Subsidy}_{N,l},\quad W^{Subsidy}_{S,k} + W^{Subsidy}_{S,l})$	$(W^{Subsidy}_{N,k} + W^{Buyout}_{N,l},\quad W^{Subsidy}_{S,k} + W^{Buyout}_{S,l})$
	Buyout	$(W^{Buyout}_{N,k} + W^{Subsidy}_{N,l},\quad W^{Buyout}_{S,k} + W^{Subsidy}_{S,l})$	$(W^{Buyout}_{N,k} + W^{Buyout}_{N,l},\quad W^{Buyout}_{S,k} + W^{Buyout}_{S,l})$

Proposition 2 establishes that, within the sector it innovates in, the North prefers a subsidy regime to a buyout (recall that sectors are non-overlapping and welfare is additively separable in sectors). It thus holds that $W_{N,k}^{Subsidy} > W_{N,k}^{Buyout}$. By symmetry, for the innovating South it holds that $W_{S,l}^{Subsidy} > W_{S,l}^{Buyout}$. From the payoff matrix (Table A1), it can be seen that this results in a unique $\{Subsidy, Subsidy\}$ equilibrium, as each country is better off subsidizing its own sector regardless of what the other chooses to do.

Proposition 2 can also be used to see that the implications for world welfare are indeterminate between $\{Subsidy, Subsidy\}$ and $\{Buyout, Buyout\}$ when a country uses buyouts to maximize only its own surplus. For innovation in the North's sector x (for which the South is a non-innovating player), it has been established that the sum of the two countries' welfares from a subsidy regime may be greater or smaller than the sum of their combined welfare from a buyout regime, depending on the parameter values of the model (see the proof of Proposition 2 in Appendix B.5). In terms of the above payoff matrix, this translates to

$$W_{N,k}^{Subsidy} + W_{S,k}^{Subsidy} \lesseqgtr W_{N,k}^{Buyout} + W_{S,k}^{Buyout}. \tag{B.46}$$

By symmetry, for the South's sector l we obtain

$$W_{N,l}^{Subsidy} + W_{S,l}^{Subsidy} \lesseqgtr W_{N,l}^{Buyout} + W_{S,l}^{Buyout}. \tag{B.47}$$

Notice that world welfare for $\{Subsidy, Subsidy\}$ is the sum of the left-hand sides of the two above inequalities, while world welfare for $\{Buyout, Buyout\}$ is the sum of the two right-hand sides. Therefore, it is in general indeterminate whether the $\{Subsidy, Subsidy\}$ equilibrium is Pareto superior or inferior to a mutual buyout where each country maximizes its own surplus.

The second part of Proposition 5 states that the game can devolve into a Prisoner's Dilemma if the two countries are cooperative in their buyout strategy, i.e. if each seeks to maximize total world welfare from their sector. By construction, $\{Buyout, Buyout\}$ now maximizes world welfare (note that, to keep notation simple, we still use the same notation for buyouts as above, although the rest of this section focuses on cooperative buyouts). However, for a Prisoner's Dilemma to hold, it is also necessary that (i) *Subsidy* remains a dominant strategy for each country, and (ii) each country would be better off by moving to $\{Buyout, Buyout\}$.

To see that *Subsidy* remains a dominant strategy we can compare (for the North, and then the South by symmetry) $W_{N,k}^{Subsidy}$ with $W_{N,k}^{Buyout}$ when the buyout is cooperative. To make the distinction between the sectors clear, let the parameters be f_ω, g_ω where $\omega \in \{k, l\}$ (although this does not affect within-sector welfare comparisons). Then, $W_{N,k}^{Subsidy}$ can be calculated in accordance with equation (B.11) as

$$W_{N,k}^{Subsidy} = \frac{[nf_k(1+\gamma)-2]^2}{4ng_k(1+\gamma)}. \tag{B.48}$$

To calculate $W_{N,k}^{Buyout}$, we note that the globally optimal level of innovation in sector k is $I_k^* = \frac{nf_k-1}{ng_k}$ (see equation B.33), so that

$$\begin{aligned} W_{N,k}^{Buyout} &= S_k^{o,N}(I_k^*) - I_k^* \\ &= \gamma n \int_0^{I_k^*} (f_k - g_k I) dI_k - \frac{nf_k - 1}{ng_k} \\ &= \frac{(nf_k-1)[\gamma(nf_k+1)-2]}{2ng_k}. \end{aligned} \tag{B.49}$$

Taking the difference of the last two equations gives

$$W_{N,k}^{Subsidy} - W_{N,k}^{Buyout} = \frac{(1-\gamma)\left[n^2 f_k^2(1+\gamma) - 2\gamma\right]}{4ng_k(1+\gamma)}. \tag{B.50}$$

The right-hand side of equation (B.50) is strictly positive because $n^2 f_k^2(1+\gamma) > 2\gamma$ given that $nf_k > 2$. By symmetry, for the South it holds that $W_{S,l}^{Subsidy} > W_{S,l}^{Buyout}$ when the buyout is cooperative (i.e., the South acts like a global welfare maximizer in sector l). Therefore, $\{Subsidy, Subsidy\}$ remains the unique equilibrium.

It remains to be shown that both countries could gain from moving to (non-equilibrium) $\{Buyout, Buyout\}$. For the North, this would imply that its welfare under a mutual subsidy is lower than its welfare under a mutual buyout:

$$W_{N,k}^{Subsidy} + W_{N,l}^{Subsidy} < W_{N,k}^{Buyout} + W_{N,l}^{Buyout}, \tag{B.51}$$

and analogously for the South.

The welfare of the North from its own k sector under a subsidy and a buyout regime is given by the expressions in equations (B.48) and (B.49), respectively. To calculate the welfare of the North from sector l under each possible innovation regime implemented by the South, it is first necessary to calculate how much the South would innovate under each regime. Under a subsidy, the South would innovate by maximizing its welfare

$$W^{S,Subsidy} = S^{o,S}(I^{Subsidy}) + \Pi^N(I^{Subsidy}) - I^{Subsidy}, \tag{B.52}$$

where

$$S^{o,S}(I^{Subsidy}) = (1-\gamma)n \int_0^I (f_l - g_l I) dI \tag{B.53}$$

and

$$\Pi^N(I^{Subsidy}) = \frac{1}{2}\gamma n \int_0^I (f_l - g_l I) dI. \tag{B.54}$$

The result is

$$I_l^{Subsidy} = \frac{n f_l (2-\gamma) - 2}{n g_l (2-\gamma)}. \tag{B.55}$$

It can be checked that this is consistent with the level of innovation under a subsidy for the North (equation B.10) but with γ being replaced by $(1-\gamma)$ as the relevant market share of the innovating country. Subsequently, the welfare of the North under such a regime can be calculated as

$$\begin{aligned} W_{N,l}^{Subsidy} &= S^{\pi,N}(I^{Subsidy}) \\ &= \frac{1}{4}\gamma n \int_0^I (f_l - g_l I) dI \\ &= \frac{\gamma \left[n f_l (2-\gamma) - 2 \right]}{2 n g_l (2-\gamma)^2}. \end{aligned} \tag{B.56}$$

In contrast, under a cooperative buyout the South would innovate to the level $I_l^* =$

$\frac{nf_l-1}{ng_l}$. The welfare of the North under such a regime would be

$$\begin{aligned} W_{N,l}^{Buyout} &= S_l^{o,N}(I_l) \\ &= \gamma n \int_0^{I_l^*} (f_l - g_l I) dI_l \\ &= \frac{\gamma\left[n^2 f_l^2 - 1\right]}{2ng_l}. \end{aligned} \tag{B.57}$$

Taking the difference of the last two equations gives

$$W_{N,l}^{Subsidy} - W_{N,l}^{Buyout} = \gamma \frac{nf_l(2-\gamma) - 2 - (2-\gamma)^2(n^2 f_l^2 - 1)}{2ng_l(2-\gamma)^2}. \tag{B.58}$$

It can easily be verified that the numerator of the right-hand side of equation (B.58) is negative for all $nf > 2$, thereby confirming that each country prefers the other to institute a globally welfare maximizing buyout.

As a last step, the condition (B.51) for the Prisoner's Dilemma can be rewritten as

$$\left(W_{N,k}^{Subsidy} - W_{N,k}^{Buyout}\right) + \left(W_{N,l}^{Subsidy} - W_{N,l}^{Buyout}\right) < 0, \tag{B.59}$$

where plugging in the expressions from equations (B.50) and (B.58) gives

$$\frac{(1-\gamma)\left[n^2 f_k^2(1+\gamma) - 2\gamma\right]}{4ng_k(1+\gamma)} + \gamma \frac{nf_l(2-\gamma) - 2 - (2-\gamma)^2(n^2 f_l^2 - 1)}{2ng_l(2-\gamma)^2} < 0. \tag{B.60}$$

When $f_k = f_l$ and $g_k = g_l$, so that both sectors have the same relationship between the level of innovation and the consumer surplus function, the expression on the left-hand side of inquality (B.60) reduces to

$$\frac{-n^2 f^2(\gamma-2)^2(\gamma+1)(3\gamma-1) - 2\gamma nf(\gamma-2)(\gamma-1) - 4\gamma(1-3\gamma+4\gamma^2-\gamma^2)}{4nf(1+\gamma)(2-\gamma)^3}. \tag{B.61}$$

The denominator of expression (B.61) is positive. It can also be verified that the numerator is negative for all $\gamma \in (0,1)$, so that the overall expression is always negative. Thus, there exist parameter value combinations for which the North is worse off in the subsidy equilibrium than under a mutual cooperative buyout. By symmetry, the same can be established for the South. This completes the proof for the Prisoner's Dilemma.

Finally, the last part of Proposition 5 states that only transfers outside the game can move the world to the globally optimal buyout regime. This follows directly from $\{Subsidy, Subsidy\}$ being a unique but Pareto inferior equilibrium. This completes the proof of Proposition 5. $\square$

B.9 Proof of Proposition 6

First note that the optimal level of innovation under a global patent regime is independent of the number of countries and thus takes the same form as in equation (B.4). To see this, note that the innovating country's maximization problem (6) in the case of $N > 2$ countries is given by

$$Max_{I^{Patent}} \quad \hat{\Pi}(I^{Patent}) = \Pi^N(I^{Patent}) + \sum_{i=1}^{N-1} \Pi^i(I^{Patent}) - I^{Patent}. \tag{B.62}$$

Since all summands have the same form

$$\Pi^i(I^{Patent}) = \frac{1}{2}\gamma_i n \int_0^I (f - gI)dI, \tag{B.63}$$

equation (B.62) can be written as

$$Max_{I^{Patent}} \quad \hat{\Pi}(I^{Patent}) = \frac{1}{2} n \int_0^I (f - gI)dI \sum_{i=1}^{N} \gamma_i - I^{Patent}. \tag{B.64}$$

With $\sum_{i=1}^{N} \gamma_i = 1$, solving for I leads to the same expression as equation (B.4). The associated welfare of country N is given by

$$W^{N,Patent} = S^{\pi,N}(I^{Patent}) + \sum_{i=1}^{N} \Pi^i(I^{Patent}) - I^{Patent}, \tag{B.65}$$

which leads to an analogous expression as equation (B.5):

$$W^{N,Patent} = \frac{nf-2}{8ng}\Big[(2+\gamma_N)(nf+2) - 8\Big]. \tag{B.66}$$

In contrast, the optimal level of innovation under a targeted buyout will in general differ from the one under a domestically-financed global buyout considered in the two-country case (equation (B.7)). Starting with

$$Max_{I^{Buyout(N,m)}} \quad W^N = S^{o,N}(I^{Buyout(N,m)}) + \sum_{i=1}^{m-1} \Pi^i(I^{Buyout(N,m)}) - I^{Buyout(N,m)}, \quad \text{(B.67)}$$

inserting the respective expressions gives

$$Max_{I^{Buyout(N,m)}} \quad W^N = \gamma_N n \int_0^I (f-gI)dI + \frac{1}{2}\gamma_r n \int_0^I (f-gI)dI - I^{Buyout(N,m)}. \quad \text{(B.68)}$$

Solving for I yields

$$I^{Buyout(N,m)} = \frac{nf(\gamma_N + \frac{\gamma_r}{2}) - 1}{ng(\gamma_N + \frac{\gamma_r}{2})}. \quad \text{(B.69)}$$

Inserting the derived expression for investment in (B.69) into the maximand in (B.68), the welfare of country N obtained from a targeted buyout can be calculated as:

$$W^{N,Buyout(N,m)} = \frac{\left[nf(\gamma_N + \frac{\gamma_r}{2}) - 1\right]^2}{2ng(\gamma_N + \frac{\gamma_r}{2})}. \quad \text{(B.70)}$$

In case of a national buyout (i.e., $\gamma_m = 0$), replacing γ_r with $(1-\gamma_N)$ in equation (B.69) leads to

$$I^{Buyout(N)} = \frac{nf(1+\gamma_N) - 2}{ng(1+\gamma_N)}. \quad \text{(B.71)}$$

Notice that this is equivalent to the respective expression for a national subsidy in equation (B.10). Similarly, the welfare of country N under a national buyout can be derived from equation (B.70) as

$$W^{N,Buyout(N)} = \frac{[nf(1+\gamma_N) - 2]^2}{4ng(1+\gamma_N)}. \quad \text{(B.72)}$$

Taking the difference of $W^{N,Buyout(N)}$ and $W^{N,Patent}$ (from equations (B.72) and (B.66)) leads to an analogous expression as in equation (B.20) which is strictly positive. This proves the first part of Proposition 6.

To derive the second part of Proposition 6, one can take the derivatives of $W^{N,Buyout(N,m)}$ with respect to γ_N and γ_m. Notice that a rise in γ_N necessarily implies a reduction in γ_m

or γ_r. The overall change in $W^{N,Buyout(N,m)}$ is given by the total derivative

$$dW^{N,Buyout(N,m)} = \frac{\partial W^{N,Buyout(N,m)}}{\partial \gamma_N} d\gamma_N + \frac{\partial W^{N,Buyout(N,m)}}{\partial \gamma_m} d\gamma_m + \frac{\partial W^{N,Buyout(N,m)}}{\partial \gamma_r} d\gamma_r.$$

The partial derivatives are given by

$$\frac{\partial W^{N,Buyout(N,m)}}{\partial \gamma_N} = \frac{nf^2}{2g} - \frac{1}{2ng(\gamma_N + \frac{\gamma_r}{2})^2} > 0 \tag{B.73}$$

$$\frac{\partial W^{N,Buyout(N,m)}}{\partial \gamma_m} = -\frac{nf^2}{4g} + \frac{1}{4ng(\gamma_N + \frac{\gamma_r}{2})^2} < 0 \tag{B.74}$$

$$\frac{\partial W^{N,Buyout(N,m)}}{\partial \gamma_r} = \frac{nf^2}{4g} - \frac{1}{4ng(\gamma_N + \frac{\gamma_r}{2})^2} > 0, \tag{B.75}$$

where the indicated signs follow from the fact that $I^{Buyout(N,m)} > 0$ implies that $nf(\gamma_N + \frac{\gamma_r}{2}) > 1$ (see equation (B.69)).

If γ_N increases and γ_m and γ_r decline (with $d\gamma_m + d\gamma_r = -d\gamma_N$), then the total change in $W^{N,Buyout(N,m)}$ amounts to

$$dW^{N,Buyout(N,m)} = \frac{nf^2}{2g} - \frac{1}{2ng(\gamma_N + \frac{\gamma_r}{2})^2} \left(\frac{3}{2} d\gamma_N + d\gamma_r \right), \tag{B.76}$$

which is strictly positive given the sign of expression (B.73) and the fact that $d\gamma_r \geq -d\gamma_N$. Notice that this result holds irrespective of whether the increase in γ_N happens at the full expense of γ_m (so that $d\gamma_r = 0$), at the full expense of γ_r (so that $d\gamma_m = 0$), or at the expense of both ($d\gamma_m, d\gamma_r < 0$). Analogously, it follows from equations (B.73) to (B.75) that an increase in γ_m causes $W^{N,Buyout(N,m)}$ to decline, irrespective of whether the increase in γ_m happens at the expense of γ_r or γ_N (or both).

The last part of Proposition 6 states that greater values of γ_N imply a larger range of values of γ_m for which $W^{N,Buyout(N,m)} > W^{N,Patent}$. To show this, one can take the difference of $W^{N,Buyout(N,m)}$ and $W^{N,Patent}$ and simplify the resulting expression to get

$$W^{N,Buyout(N,m)} - W^{N,Patent} = \frac{3n^2f^2 + 4}{8ng}\gamma_N + \frac{nf^2}{4g}\gamma_r + \frac{1}{2ng(\gamma_N + \frac{\gamma_r}{2})} - \frac{2nf^2}{8g} - \frac{1}{ng}. \tag{B.77}$$

If γ_N takes a larger value, then the total change in $(W^{N,Buyout(N,m)} - W^{N,Patent})$ is given by the total derivative of equation (B.77) with respect to γ_N, γ_m, and γ_r, which can be calculated as

$$\left[\frac{3n^2f^2+4}{8ng} - \frac{1}{2ng(\gamma_N+\frac{\gamma_r}{2})^2}\right] d\gamma_N + \left[\frac{nf^2}{4g} - \frac{1}{4ng(\gamma_N+\frac{\gamma_r}{2})^2}\right] d\gamma_r. \tag{B.78}$$

This expression is positive as long as

$$\left[\frac{n^2f^2+4}{2} - \frac{1}{(\gamma_N+\frac{\gamma_r}{2})^2}\right] d\gamma_N + \left[n^2f^2 - \frac{1}{(\gamma_N+\frac{\gamma_r}{2})^2}\right] (d\gamma_N + d\gamma_r) > 0. \tag{B.79}$$

For $d\gamma_N > 0$ it holds that $(d\gamma_N + d\gamma_r) \geq 0$ (with the equality applying if $d\gamma_m = 0$). The term in the second squared parentheses is positive because it holds that $nf(\gamma_N + \frac{\gamma_r}{2}) > 1$ (see above). For the term in the first squared parentheses to be positive, it must hold that

$$n^2f^2\left(\gamma_N + \frac{\gamma_r}{2}\right)^2 + 4\left(\gamma_N + \frac{\gamma_r}{2}\right)^2 > 2. \tag{B.80}$$

Since the first summand is greater than one, this is fulfilled as long as

$$2\left(\gamma_N + \frac{\gamma_r}{2}\right) > 1. \tag{B.81}$$

Replacing γ_r with $(1 - \gamma_N - \gamma_m)$ and simplifying the expression leads to $\gamma_m < \gamma_N$. The total derivative (B.78) is thus positive as long as $\gamma_m < \gamma_N$. Hence, greater values of γ_N permit γ_m to be larger and still $W^{N,Buyout(N,m)} > W^{N,Patent}$. This completes the proof of Proposition 6. $\square$

C Proofs for the model with electoral concerns

C.1 Domestically-financed patent buyout

If the government of the North implements a buyout under electoral concerns, then the optimal level of innovation satisfies equations (21) and (23) as well as the taxation constraint. Adding these together, we can calculate optimal investment as

$$I^{Buyout} = \frac{\gamma n f - \Delta}{\gamma n g}, \tag{C.1}$$

where $\Delta = \frac{\sum_j \alpha^J \phi^J y^J}{\phi y}$ and $\phi = \sum_j \alpha^J \phi^J$ is the average swing density in the population.

As noted in Section 4, if all groups have equal swing densities (i.e., they are all equally politically important), then $\sum_j \alpha^J \phi^J y^J = \phi y$ so that $\Delta = 1$. In this case, the expression in equation (C.1) becomes identical to investment in a buyout without electoral concerns (see equation (B.7)). In contrast, if $\Delta \neq 1$, then investment is either higher or lower in the presence of electoral concerns than before in the baseline model, depending on which income group is more important for electoral concerns. Specifically, the difference in investment levels in a buyout with electoral concerns (equation C.1) and without such concerns (equation B.7) is

$$\frac{\gamma n f - \Delta}{\gamma n g} - \frac{\gamma n f - 1}{\gamma n g} \begin{cases} < 0, & \text{for } \Delta > 1 \\ = 0, & \text{for } \Delta = 1 \\ > 0, & \text{for } \Delta < 1 \end{cases} \tag{C.2}$$

This implies that when wealthier groups are more important in the political calculus (i.e., $\Delta > 1$), there is too little investment in innovation financing because their preference is for less taxation, given that they pay more in absolute amount, and vice versa.

Using the expression for I^{Buyout} from equation (C.1), along with equation (23), the welfare of the North can be calculated as

$$W^{N,Buyout} = \gamma n \sum_j \alpha^J \left[\int_0^{I^{Buyout}} (f - gI)dI - \frac{I}{\gamma n y} y^J \right] \\ = \frac{(\gamma n f - 1)^2 - (\Delta - 1)^2}{2\gamma n g}. \tag{C.3}$$

The associated welfare of the South can be calculated as

$$W^{S,Buyout} = (1-\gamma) n \int_0^{I^{Buyout}} (f - gI)dI \\ = \frac{(1-\gamma)(\gamma^2 n^2 f^2 - \Delta^2)}{2\gamma^2 n g}. \tag{C.4}$$

It can be seen that if all groups are equally politically important (i.e., $\Delta = 1$), then the expressions for Northern and Southern welfare become identical to those in equations (B.8) and (B.9). If $\Delta \neq 1$, it holds that welfare in the North is distinctly lower under electoral concerns, as taking the difference of equations (C.3) and (B.8) shows that

$$\frac{(\gamma n f - 1)^2 - (\Delta - 1)^2}{2\gamma n g} - \frac{(\gamma n f - 1)^2}{2\gamma n g} < 0 \quad \text{if} \quad \Delta \neq 1. \tag{C.5}$$

Meanwhile, impacts on welfare in the South are ambiguous and depend on the value of Δ. Specifically, taking the difference of equations (C.4) and (B.9) yields

$$\frac{(1-\gamma)(\gamma^2 n^2 f^2 - \Delta^2)}{2\gamma^2 n g} - \frac{(1-\gamma)(\gamma^2 n^2 f^2 - 1)}{2\gamma^2 n g} \gtreqless 0 \quad \text{if} \quad \Delta \lesseqgtr 1. \tag{C.6}$$

C.2 National subsidy

If the government of the North implements a subsidy, then the optimal level of innovation satisfies equation (21), the taxation constraint, and the expression for consumer welfare in equation (25). Adding these together, optimal investment is given by

$$I^{Subsidy} = \frac{nf(1+\gamma) - 2\Delta}{ng(1+\gamma)} \tag{C.7}$$

Notice once more that if all groups are equally swing-dense, then the expression for $I^{Subsidy}$

becomes equivalent to one in equation (B.10). In contrast, if $\Delta \neq 1$, then investment is either higher or lower in the presence of electoral concerns than in the baseline model, depending on which income group is more important for electoral concerns. Specifically, taking the difference in investment levels with electoral concerns (equation C.7) and without (equation B.10) shows that

$$\frac{nf(1+\gamma)-2\Delta}{ng(1+\gamma)} - \frac{nf(1+\gamma)-2}{ng(1+\gamma)} \quad \begin{cases} < 0, & \text{for } \Delta > 1 \\ = 0, & \text{for } \Delta = 1 \\ > 0, & \text{for } \Delta < 1 \end{cases} \tag{C.8}$$

Note that, with electoral concerns, investment under a subsidy is still higher than investment under a domestically-financed buyout, since it holds that

$$\begin{aligned} I^{Subsidy} - I^{Buyout} &= \frac{ng(1+\gamma)-2\Delta}{ng(1+\gamma)} - \frac{\gamma nf - \Delta}{\gamma ng} \\ &= \Delta\frac{1-\gamma}{\gamma(1+\gamma)ng} > 0. \end{aligned} \tag{C.9}$$

However, it no longer holds that investment under a subsidy is necessarily higher than investment under patents. To see this, taking the difference of equations (C.7) and (B.4) yields

$$\begin{aligned} I^{Subsidy} - I^{Patent} &= \frac{ng(1+\gamma)-2\Delta}{ng(1+\gamma)} - \frac{nf-2}{ng} \\ &= 2\frac{1+\gamma-\Delta}{ng(1+\gamma)} \gtreqless 0, \end{aligned} \tag{C.10}$$

where the above expression is negative if $\Delta > \gamma + 1$.

Using the derived expression of $I^{Subsidy}$ and equation (25), the welfare of the North under a subsidy can now be calculated as

$$\begin{aligned} W^{N,Subsidy} &= \gamma n \sum_j \alpha^J \left[\int_0^{I^{Subsidy}} (f-gI)dI - \frac{I}{\gamma ny} y^J - \frac{1}{\gamma n}\Pi^S(I) \right] \\ &= \frac{\Big(nf(1+\gamma)-2\Big)^2 - 4(\Delta-1)^2}{4ng(1+\gamma)}. \end{aligned} \tag{C.11}$$

The associated welfare of the South is

$$\begin{aligned} W^{S,Subsidy} &= (1-\gamma)n\int_0^{I^{Subsidy}}(f-gI)dI \\ &= (1-\gamma)\frac{\left[n^2f^2(1+\gamma)^2-4\Delta^2\right]}{8ng(1+\gamma)^2}. \end{aligned} \tag{C.12}$$

If all groups are equally politically important (i.e., $\Delta = 1$), the expressions for investment, Northern welfare, and Southern welfare become identical to those in equations (B.10), (B.11) and (B.12). If $\Delta \neq 1$, then welfare in the North is distinctly lower under electoral concerns, as comparing eq. (C.11) to eq. (B.11) yields

$$\frac{\left(nf(1+\gamma)-2\right)^2-4(\Delta-1)^2}{4ng(1+\gamma)} - \frac{\left(nf(1+\gamma)-2\right)^2}{4ng(1+\gamma)} < 0 \quad \text{if} \quad \Delta \neq 1. \tag{C.13}$$

Meanwhile, impacts on welfare in the South are ambiguous, depending on the value of Δ. Specifically, taking the difference of equations (C.12) and (B.12) yields

$$(1-\gamma)\frac{\left[n^2f^2(1+\gamma)^2-4\Delta^2\right]}{8ng(1+\gamma)^2} - (1-\gamma)\frac{\left[n^2f^2(1+\gamma)^2-4\right]}{8ng(1+\gamma)^2} \gtreqless 0 \quad \text{if} \quad \Delta \lesseqgtr 1. \tag{C.14}$$

C.3 Proof of Proposition 7

The proof of Proposition 7 is obtained by comparing total welfare in the North under a domestically-financed buyout to that under patents, both with and without electoral concerns.

Since $W^{N,Buyout}$ declines under electoral concerns (see equation (C.5)) while $W^{N,Patent}$ remains unchanged, there is a greater range of parameter value combinations for which $W^{N,Buyout} < W^{N,Patent}$. To see this, taking the difference of the two expressions and simplifying leads to

$$
\begin{aligned}
W^{N,Buyout} - W^{N,Patent} &= \frac{(\gamma nf-1)^2-(\Delta-1)^2}{2\gamma ng} - \frac{nf-2}{8ng}\Big[(2+\gamma)(nf+2)-8\Big] \\
&= \frac{\gamma n^2f^2(3\gamma-2)+4\big[(\gamma-1)^2-(\Delta-1)^2\big]}{8\gamma ng}. \qquad \text{(C.15)}
\end{aligned}
$$

Setting the numerator in the equation above equal to zero, transforming it into the standard quadratic form, and calculating the roots gives

$$
\overline{\gamma}^{-,+} = \frac{n^2f^2+4 \mp nf\sqrt{n^2f^2-4+(\Delta-1)^2(\frac{3}{4}+\frac{1}{n^2f^2})}}{3n^2f^2+4}. \qquad \text{(C.16)}
$$

Since the parabola opens upward, this implies that the difference $W^{N,Buyout} - W^{N,Patent}$ is negative for all values $\gamma \in (\overline{\gamma}^-, \overline{\gamma}^+)$ and is positive for $\gamma > \overline{\gamma}^+$ and $\gamma < \overline{\gamma}^-$. Comparing the roots in equation (C.16) to those in equation (B.15) shows that now $\overline{\gamma}^-$ is smaller while $\overline{\gamma}^+$ is larger, for any $\Delta \neq 1$. Therefore, there is a greater range of values for which $W^{N,Buyout} < W^{N,Patent}$ than previously, and more so as Δ departs from 1 in either direction.

To complete the proof, consider global welfare. Adding up the expressions in equations (C.3) and (C.4), and subtracting from that world welfare under a patent regime, shows that the change in global welfare when moving from a patent system to a buyout is now given by

$$
W^{W,Buyout} - W^{W,Patent} = \frac{\gamma^2(n^2f^2-4)+4\Delta(2\gamma-\Delta)}{8\gamma^2 ng}. \qquad \text{(C.17)}
$$

The value of this expression depends on the combination of γ and Δ parameters. It can be shown that, compared to the previously calculated expression in equation (B.19), the expression in equation (C.17) is smaller if $\Delta > 1$. This is because the South is also less well off than previously with a buyout relative to a patent. In contrast, with $\Delta < 1$, then as long as γ is sufficiently small relative to Δ, there will be a *broader* range of values than previously for which $W^{W,Buyout} > W^{W,Patent}$, despite the fact that the North is now *less* likely to switch to a buyout regime. This completes the proof of Proposition 7. □

C.4 Proof of Proposition 8

The proof of Proposition 8 is obtained by comparing total welfare in the North under a subsidy to its welfare under other regimes, in the presence of electoral concerns.

Subtracting equation (C.3) from equation (C.11) yields

$$\begin{aligned} W^{N,Subsidy} - W^{N,Buyout} &= \frac{\Big(nf(1+\gamma)-2\Big)^2 - 4(\Delta-1)^2}{4ng(1+\gamma)} - \frac{(\gamma nf-1)^2-(\Delta-1)^2}{2\gamma ng} \\ &= \frac{1-\gamma}{4\gamma(1+\gamma)ng}\Big[n^2f^2\gamma(1+\gamma)-2+2(\Delta-1)^2\Big] > 0. \end{aligned} \tag{C.18}$$

Thus, under electoral concerns, subsidy still trumps buyouts in terms of welfare from the perspective of the North. Moreover, the presence of voter heterogeneity (i.e., $\Delta \neq 1$) increases the extent to which subsidies are preferred over domestically-financed buyouts.

However, subsidy no longer necessarily trumps patents in terms of welfare for the North. To see this, subtracting equation (B.5) from equation (C.11) yields

$$\begin{aligned} W^{N,Subsidy} - W^{N,Patent} &= \frac{\Big(nf(1+\gamma)-2\Big)^2 - 4(\Delta-1)^2}{4ng(1+\gamma)} - \frac{nf-2}{8ng}\Big[(2+\gamma)(nf+2)-8\Big] \\ &= \frac{\Big[\gamma(n^2f^2-4)+\gamma^2(n^2f^2+4)\Big]-8(\Delta-1)^2}{8ng(1+\gamma)}. \end{aligned} \tag{C.19}$$

This expression turns negative if the numerator is negative, which is the case when

$$\Delta > \sqrt{\frac{\gamma(n^2f^2-4)+\gamma^2(n^2f^2+4)}{8}} + 1. \tag{C.20}$$

Given the restriction $nf > 2$, the expression under the square root is positive, so that inequality (C.20) becomes

$$\Delta > x + 1 \quad \text{for some} \quad x(\gamma, n, f) > 0. \tag{C.21}$$

Therefore, for $\Delta > 1$ and which is sufficiently large to meet inequality (C.21), it holds that $W^{N,Subsidy} < W^{N,Patent}$. Moreover, the absolute value of the difference $W^{N,Subsidy} - W^{N,Patent}$ is increasing in Δ. This completes the proof of Proposition 8. □

C.5 Proof of Proposition 9

The proof of Proposition 9 is obtained by calculating the equilibrium under a transfer contract set by the North. As in the proof of Proposition 3, for ease of notation, let $\hat{T}_N$ and $\hat{I}_N$ denote the values of T and $I^{Transfer}$ if the contract is offered by the North. Letting $\tilde{W}^S$ be the welfare obtained from the outside option of the South, not yet specified (as it could be either welfare under a subsidy or under patents), the North's maximization problem is given by

$$Max_{\hat{I}_N,\hat{T}_N} \quad Prob[v(\hat{I}_N) \geq 0.5] \tag{C.22}$$

$$s.t. \quad \hat{I}_N \leq \tau\gamma ny + \hat{T}_N$$

$$s.t. \quad \int_0^{\hat{I}_N} (1-\gamma)n(f-gI)dI - \hat{T}_N \geq \tilde{W}^S$$

The last line is the participation constraint of the South and states that the South's welfare under transfers must be at least as good as its welfare under its outside option.

To calculate the chosen investment $\hat{I}_N$, note first that, under a binding taxation constraint, $\tau = \frac{\hat{I}_N - \hat{T}_N}{\gamma ny}$, consumer welfare in the North becomes

$$c^J = \int_0^I (f-gI)dI - \Big(\frac{\hat{I}_N - \hat{T}_N}{\gamma ny}\Big)y^J. \tag{C.23}$$

If the participation constraint of the South is binding, then the transfer amount is given by

$$\hat{T}_N = (1-\gamma)n\int_0^I (f-gI)dI - \tilde{W}^S. \tag{C.24}$$

Substituting equation (C.24) into equation (C.23) leads to

$$c^J = \int_0^I (f-gI)dI - \Big(\frac{\hat{I}_N - (1-\gamma)n\int_0^I (f-gI)dI + \tilde{W}^S}{\gamma ny}\Big)y^J. \tag{C.25}$$

Taking the derivative of this expression with respect to $\hat{I}_N$ gives

$$\frac{\partial c^J}{\partial I} = (f-gI) - \frac{y^J}{n\gamma y} + \frac{1-\gamma}{\gamma y}(f-gI)y^J. \tag{C.26}$$

Since the Northern government is maximizing the probability of winning, we plug this derivative into equation (21), which leads to

$$\hat{I}_N = \frac{nf - \frac{\Delta}{\gamma + (1-\gamma)\Delta}}{ng}. \tag{C.27}$$

This expression for investment holds regardless of the transfer amount $\hat{T}_N$ or of the South's outside option (on which $\hat{T}_N$ depends).

Note that *only* if $\Delta = 1$, then the above expression for investment reduces to $\frac{nf-1}{ng}$ which is the globally optimal level of investment. Otherwise, if $\Delta \neq 1$, the transfer does not bring about the global optimum. Correspondingly, global welfare will also not be at the optimal level. We can calculate global welfare as $W^W = n\int_0^I (f - gI)dI - \hat{I}_N$, where $\hat{T}_N$ cancels out since it is a lump sum transfer from one country to the other. Using the derived expression of $\hat{I}_N$, this yields

$$W^{W,Transfer} = \frac{(nf-1)^2 - \left(\frac{\Delta}{\gamma + (1-\gamma)\Delta} - 1\right)^2}{2ng}. \tag{C.28}$$

Notice that without voter heterogeneity (i.e., $\Delta = 1$), this expression reduces to the globally optimal value, $W^W = \frac{(nf-1)^2}{2ng}$, which was previously calculated (see equation B.36). However, if $\Delta \neq 1$, then world welfare with transfers is less than the globally optimal value. This completes the proof for Proposition 9. $\square$