The Political Economy of Patent Buyouts*

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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, whereas taxpayers within 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

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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 particularly severe (Chaudhuri et al., 2006).

This article 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. 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 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). As perfectly calculated and executed buyouts eliminate underproduction

[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 article.

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 article, we depart from the focus on government-firm frictions and explore previously unstudied distributional implications of buyouts which 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. 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 issues requires moving away from the literature's assumptions of a closed economy and of a benevolent government. We present a model which departs from both assumptions and solve it sequentially, in two steps.

We begin by tackling the question of buyouts from an international perspective, modelling two countries with different innovation and financing capacities, while maintaining the assumption of (national) welfare maximizing governments. We show that buyouts are no longer necessarily welfare-maximizing for the innovating country, as they reduce domestic monopoly distortion but also result in loss of profits in international markets. Furthermore, arrangements which can mute this tradeoff, such as subsidies to facilitate competitive production domestically while patent rights are maintained for use in international markets (akin to a national buyout), become preferred.[2] We also outline how intersovereign transfers, if they are possible and credible, can internalize the externality and result in globally optimal buyouts.

[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 monopoly power intact (Roin, 2014).

We then add the possibility of domestic distributional concerns, by relaxing the assumption of a benevolent government, and presenting a setting where parties in the innovating country choose policy to maximize their electoral victory probability. With different voter groups and varying preferences over the extent of the tax-financing burden, government involvement in innovation financing becomes additionally informed by these considerations, and therefore generally by the intersection of international and domestic distributional concerns. We show that the likelihood that buyouts or subsidies can replace patents becomes even smaller if groups which bear a higher tax-financing burden are more politically powerful. In addition, 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, patent buyouts 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. Because 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.

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, and particularly on information frictions that arise between the government and innovating firms when the government lacks information on the benefits and costs of innovations (Wright, 1983; Scotchmer, 1999; Shavell and van Ypersele, 2001). Studies have outlined a variety of institutional mechanisms that can mitigate the information problem and improve the optimality of buyouts, depending on assumptions about the nature of the problem (Kremer, 1998; Chari et al., 2012; Weyl and Tirole, 2012; Galasso et al., 2016, 2018). In 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.[3]

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.[4] In a simple North-South model where a Northern firm can innovate

[3]This occurs if the government, facing a relatively small budget, is subject to stochastic shocks that may require it to divert resources to an alternative unforeseen investment.

[4]An exception is Scotchmer (2004), in which innovators from both South and North compete on innovations in each country. However, this article simply assumes that buyouts are less efficient in financing innovation than patents, i.e. that global buyouts are not Pareto optimal. The key political

while a Southern firm can imitate 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 North can choose the extent of protection in the South (Deardorff, 1992), where the decision to invest in innovation in the North is not one-off but dynamic (Helpman, 1993), and where both Northern and Southern firms can innovate to different degrees and patent protections are decided simultaneously as they trade (Grossman and Lai, 2004).[5]

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. The aforementioned literatures generally assume governments are driven by national welfare maximization, and do not consider other objectives which may be salient in driving policy choices. In contrast, we take into account that many economies at the frontier of innovation *also* tend to be democracies, and show how this has nontrivial implications for the state's involvement in innovation financing via buyouts or subsidies.

In sum, our article augments the literature on buyouts with insight from trade and from political economy, to show how international and domestic redistributive concerns can obstruct globally optimal buyouts even in the absence of any government-firm frictions. To demonstrate concretely the complementarities with and contributions to the extant literature, we also present extensions of our model which combine our political economy lens with imperfect information and commitment issues.

The article proceeds as follows. Section 2 models patent buyouts in an international setting with benevolent governments and, alternatively, with governments oriented toward electoral concerns. Section 3 solves the model for optimal investment levels and innovation regime choice and demonstrates that both international and domestic redistributive considerations can limit the feasibility and pursuit of buyouts. Section 4 shows the robustness of the findings to extensions that involve information and commitment frictions, linking the model to prior research on these challenges. Section 5 discusses the scope and possible limitations of our theoretical design, and the last section concludes.

economy problem thus becomes too little patent protection in the world (due to national treatment of inventors). The distributive concerns are therefore very different from those we consider. Scotchmer also does not consider domestic conflict and how the public financing of buyouts may impact regime choice.

[5] Careful empirical measurement of welfare effects on the South of patent protection is limited. Notable exceptions are Chaudhuri et al. (2006), who construct demand curves to estimate large negative effects in India of TRIPS-triggered protection of antibacterial medicines, and Kyle and McGahan (2012) who use variation across countries in the timing of patent laws and in the severity of disease to show that patent protection is associated with increases in R&D in wealthy countries but not in developing countries.

2 Model

We model two countries (or regions), the industrialized North (N) and the less developed South (S). Innovation consists of the development of new products, and all capacity to innovate is concentrated among firms in the North. Once a product has been invented, it can be produced by firms in all countries, possibly subject to intellectual property rights such as patents. The products are consumed by n consumers in the world, of which the fraction $\gamma \in (0, 1)$ live in the North and the rest live in the South. In this section, we outline the integrated model of innovation and production, of the different possible innovation financing regimes, and of consumers' relevant electoral preferences around innovation financing. This sets the ground for solving the model for innovation regime choices in Section 3.

2.1 Innovation and production

A key feature of our model is that we express surplus in the product market, as well as its constituent parts (such as consumer surplus, profit, and deadweight loss), as reduced form functions of the total research costs invested for innovation. To arrive at these reduced form functions, we begin by assuming a continuum of products indexed by $z \in \mathbb{R}^{\geq 0}$. To invent a product, firms must incur a research cost $R(z) > 0$. The level of total innovation can be measured by a cutoff value $\hat{z}$, so that if the products $z \in [0, \hat{z}]$ are invented, the *total* research cost incurred by firms in the North is given by

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

Once a product z_i is innovated at cost $R(z_i)$, it can be produced at a given production cost, and we assume only that the inverse demand function in the market is continuous, differentiable, and monotonically decreasing in quantity. 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 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 $s(z)$. It is now possible to re-express $s(z)$ as a function of the total research cost I, so that $s(I)$ represents the optimal per-capita surplus per unit of research cost of the last (marginal) invention. Due to the ordering, s is a weakly decreasing step function of I, implying diminishing marginal returns to investment in research. If the number of inventions is large, then $s(I)$ can be approximated with a continuous function:

$$s = s(I); \qquad s' < 0 \tag{2}$$

Integrating over the area under the curve until $I(\hat{z})$, and multiplying by n, thus yields total optimal surplus over all products in the market. Therefore, for any given investment level $\hat{I} = I(\hat{z})$, the associated optimal surplus over all products in the market will be:

$$S^o(I) = n \int_0^{\hat{I}} s(I) dI \tag{3}$$

Another variable of interest is the profit share of surplus. Given our assumption of competitive markets for production 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 from production. Coupled with costly innovation expenses, this results in a net loss for an innovating firm so that no firm chooses to innovate without additional rewards. Under monopoly production enabled by patents, however, profits will be strictly positive. In line with the above, we denote with π the per-capita profit that producing firms make *before* netting out any innovation costs I. Since this is a share of surplus, it can be expressed as:

$$\pi = \pi(I); \qquad \pi' < 0, \qquad \pi(I) < s(I) \tag{4}$$

Aggregating over consumers and innovated products yields:

$$\Pi(I) = n \int_0^{\hat{I}} \pi(I) dI \tag{5}$$

With monopoly production, we denote the *remaining* per-capita consumer surplus and deadweight loss as $\zeta(I)$ and $l(I)$, respectively, both weakly declining functions of I. The subsequent equality between total surplus and the sum of its possible parts implies

$$\pi(I) + \zeta(I) + l(I) = s(I). \tag{6}$$

In contrast, in a publicly financed regime $\pi(I) = l(I) = 0$ and so $\zeta(I) = s(I)$.

2.2 Consumption and domestic preferences

We assume that consumers feature identical preferences for the innovated products but are heterogeneous in income. 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.

For consumers, welfare depends on the level of innovation I and the way it is financed, as the latter will determine whether, for example, consumers face any deadweight loss from the total surplus ($l > 0$ and $\zeta < s$) or not, have a tax-financing burden ($\tau > 0$) or not, etc. In the next subsection, we define how the welfare of a consumer in group J, denoted by ω^J, depends on the level of I and innovation regime. For now, we treat the constituent parts of $\omega^J(I)$ as a blackbox and explore how $\omega^J(I)$ may be relevant to domestic political considerations.

Let there be a simple democratic structure where consumers are also voters who take into account the effect of economic policy on themselves.[6] There are two political parties A and B, and $\sigma^{jJ} \gtreqless 0$ is a measure of the ideological bias toward party B of person j in group J. In addition, in a given electoral cycle, I_p is the public investment for innovation campaigned for by party $p \in \{A, B\}$. Therefore, voter j in group J prefers party A if $\omega^J(I_A) > \omega^J(I_B) + \sigma^{jJ}$ and prefers party B otherwise.[7]

Like Persson and Tabellini (2002), we let individual ideological bias σ^{jJ} have a group-specific distribution on the uniform support $\left[\delta - \frac{1}{2\phi^J}, \quad \delta + \frac{1}{2\phi^J}\right]$ 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. 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 also itself a random variable which has a uniform distribution on $\left[\delta^* - \frac{1}{2\psi}, \quad \delta^* + \frac{1}{2\psi}\right]$ 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 therefore less spread or uncertainty about which δ materializes in any given cycle.

The relevant 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 policy is followed through on. To see how investment choice impacts voting, note that the swing voter in group J is the one indifferent between the two parties so that $\sigma^J =$

[6]We focus on the North. This is for simplification and as its strategic choices are most pertinent to innovation financing in the baseline model.

[7]We assume that under a patent regime individuals vote solely on the basis of ideological preferences as they do not consider innovation financing part of the political platform. In this case, voter j in group J votes for party A if $\sigma^{jJ} < 0$. Even if voters responded differently to a patent regime, the results of the model hold because, as we show below, parties act symmetrically, such that electoral victory probabilities are equalized.

$\omega^J(I_A) - \omega^J(I_B)$. As all voters in group J with preferences $\sigma^{jJ} < \sigma^J$ prefer party A, and given the distribution for σ, the overall vote share party A receives is

$$v_A = \sum_J \alpha^J \phi^J \Big[\sigma^J - \delta + \frac{1}{2\phi^J}\Big]. \tag{7}$$

Given Eq. (7), the probability that A wins the election is thus:[8]

$$Prob[v_A \geq 0.5] = \frac{1}{2} + \psi \left[\frac{\sum_J \alpha^J \phi^J [\omega^J(I_A) - \omega^J(I_B)]}{\sum_J \alpha^J \phi^J} - \delta^*\right]. \tag{8}$$

This shows A is more likely to win to the extent that its public innovation choices improve consumer (voter) welfare over and above the choices of its opponent, especially when it comes to voter groups with a high population share or a high swing density.

2.3 Innovation regimes

The level of innovation will depend on the amount that firms in the North invest in research, which is endogenously determined according to the regime used to incentivize innovation. We consider four regimes types: a global patent regime, a global buyout regime (financed entirely by the North), a national subsidy regime (akin to a national buyout), and a buyout regime with international transfers. In the first three cases, the North is the only strategic actor; in the fourth case, surplus transfers between countries are possible, introducing strategic interaction between the two countries.

Global patent protection In a regime of global patent protection, the innovating firms become monopoly producers in both countries.[9] The total research investment in this case is determined by Northern firms' profit maximization. At an aggregated level, the optimal value of I then solves

$$Max_I \quad \Pi(I) - I, \tag{9}$$

where $\Pi(I)$ is defined in Eq. (5) and derived from Northern and Southern markets.

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

[9] 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).

Domestically-financed global patent buyout Under a patent buyout, the Northern government 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. Given the assumed existence of competitive markets for production, this implies zero profit for all producers. 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.

In this case, $\zeta(I) = s(I)$, $\tau > 0$, and Northern consumers' welfare is equal to

$$\omega^{J,Buyout}(I) = \int_0^{\hat{I}} s(I)dI - \tau y^J. \tag{10}$$

Aggregating over all γn consumers results in total Northern welfare

$$W^{N,Buyout}(I) = \gamma n \sum_J \alpha^J \left[\omega^{J,Buyout}(I)\right] = S^N(I) - \gamma n \tau y, \tag{11}$$

where $y \equiv \sum \alpha^J y^J$ is average income.

If the government of the North maximizes national welfare, the targeted investment level under a buyout (and thereby τ) will be chosen as follows:

$$\begin{aligned} Max_I \quad & W^{N,Buyout}(I) \\ s.t. \quad & I \leq \gamma n \tau y \end{aligned} \tag{12}$$

The constraint requires that taxes cover innovation costs. The South plays no role for the chosen value of I because buyouts wipe out international profits, and any welfare effects on consumers in the South remain unconsidered by the Northern government.

If, in contrast, policy choices are electorally motivated, then I and the associated taxes are chosen by each party in the North to maximize the probability of election victory, subject to the taxation sufficiency constraint. The maximization problem then reads

$$\begin{aligned} Max_I \quad & Prob\Big[v_p\Big(\omega^{J,Buyout}(I)\Big) \geq 0.5\Big] \\ s.t. \quad & I \leq \tau \gamma n y \end{aligned} \tag{13}$$

Individual consumer welfare is again defined in Eq. (10), but the difference is in how welfare is now *aggregated* for optimization. In the objective function (12), individual welfare is simply aggregated into (11) so that each person's preferences factor equally, whereas in the objective function (13), it can be shown that individual welfare is weighed by swing densities for aggregation, with more swing groups weighing more heavily in the choice of taxation and innovation levels.

National subsidy (national buyout) Instead of a global buyout the North may also implement a national subsidy program which, in our model, is equivalent in implications to a *national* buyout; that is, a buyout which removes patent protection only in the North while keeping patents intact in the rest of the world. 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 monopoly powers, which in a multi-country world has the advantage for the North that firms can still sell as monopolists to consumers abroad.

In this case, $\zeta(I) = s(I)$ and $\tau > 0$ for Northern consumers, but in addition, there are profits from the South. Assuming each owns an equal fraction of the producing firms (and thus profits), consumer j's welfare in the North becomes

$$\omega^{J,Subsidy}(I) = \int_0^{\hat{I}} s(I)dI - \tau y^J + \frac{1-\gamma}{\gamma} \int_0^{\hat{I}} \pi(I)dI, \tag{14}$$

where the last part is the per-voter share of profits from the South.[10] Aggregated over γn, this results in Northern welfare

$$W^{N,Subsidy}(I) = \gamma n \sum \alpha^J \left[\omega^{J,Subsidy}(I)\right] = S^N(I) + \Pi^S(I) - \gamma n \tau y. \tag{15}$$

With a welfare maximizing government, the objective function is therefore

$$Max_I \quad W^{N,Subsidy}(I) \tag{16}$$

$$s.t. \quad I \leq \tau \gamma n y$$

With electoral concerns, on the other hand, the objective function once more revolves around electoral victory chances subject to the taxation constraint:

$$Max_I \quad Prob\Big[v_p\Big(\omega^{J,Subsidy}(I)\Big) \geq 0.5\Big] \tag{17}$$

$$s.t. \quad I \leq \tau \gamma n y$$

Global buyout with international transfer Finally, we allow for international

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

surplus transfers so that the governments of the North and the South can cooperate on financing a global patent buyout. The model then becomes strategic, involving a game between two actors. A contract specifies i) a lump-sum transfer amount $T^k \in \mathbb{R}$ from the South to the North, where $k \in \{N, S\}$ specifies the country with the bargaining power to set the contract, and ii) the level of innovation $I > 0$ that the government of the North must implement through a buyout if the contract is accepted.

Focusing on the scenario where the North has the bargaining power and offers the contract to the South, the action space and timing of the game are as follows.[11] First the government of the North offers a contract $\{I, T^N\}$. Second, the government of the South decides whether to accept the contract or not. If the contract is accepted, the South transfers T^N to the North and the North implements a buyout such that the specified level of innovation I is reached. If the contract is rejected, 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, and each country derives its respective welfare.

In the case that a transfer is accepted by the South, then $\zeta(I) = s(I)$ and $\tau > 0$ for Northern consumers but, in addition, the tax-paying burden is relieved to an extent by the transfer T^N. Therefore, while the Northern consumers' individual and collective welfare is still equal to Eqs. (10) and (11), respectively, T^N can create a wedge between I and the required tax financing, reducing the requisite τ for any I. More precisely, if it chooses to implement a buyout regime with transfers, a welfare maximizing government will generate a contract in $\{I, T^N\}$ that achieves

$$\begin{aligned} Max_{I,T^N} \quad & W^{N,Buyout}(I) \\ s.t. \quad & I \leq \tau\gamma ny + T^N \\ & \text{Participation constraint of South} \end{aligned} \tag{18}$$

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

[11] We show in the solutions that having the South set and offer the contract does not change outcomes about I or subsequent regime choice, only impacting the transfer amount associated with the contract.

transfers (which will be determined below). With electoral concerns, the contract satisfies

$$
\begin{aligned}
Max_{I,T^N} \quad & Prob\Big[v_p\Big(\omega^{J,Buyout}(I)\Big) \geq 0.5\Big] \\
s.t. \quad & I \leq \tau\gamma n y + T^N \\
& \text{Participation constraint of South}
\end{aligned}
\tag{19}
$$

3 Solution

The solution consists of specifying, for each innovation regime, the level of innovation and associated outcomes; we then determine which regime the North chooses when different innovation regimes are possible, and the implications for domestic and world welfare. We do this first for the international setting assuming welfare-maximizing governance, after which we summarize how findings are amended when electoral considerations, and therefore the domestic distributional setting, are taken into account.

3.1 Innovation regimes in an international setting

Let $W^W = W^N + W^S$ denote combined global (world) welfare. The following proposition compares a patent system to a global buyout.

Proposition 1. *For given primitives n, $s(I)$, $\pi(I)$, there exists a cutoff value γ^* of γ that determines whether the North fares better under global patent protection or under a domestically-financed global buyout. If $\gamma < \gamma^*$, then $W^{N,Patent} > W^{N,Buyout}$, and vice versa. Moreover, there exist combinations of model primitives such that, under the optimal levels of I chosen by the North in each innovation regime, it holds that $W^{N,Patent} > W^{N,Buyout}$ and $W^{W,Patent} < W^{W,Buyout}$; that is, the North's welfare is greater under global patent protection although the world as a whole would be better off with a global buyout.*

Proof. The proof is obtained by first comparing the North's maximum welfare under a system of global patent protection, obtained through maximizing the problem in Eq. (9), with the maximum welfare obtained under a domestically-financed global buyout, from maximizing Eq. (12). Let I^P and I^B be the investment choices under a patent regime and buyout regime, respectively. Solving the maximization problem in Eq. (9) generates the first-order condition $\pi(I^P) = \frac{1}{n}$, while solving Eq. (12) generates the first-order condition $s(I^B) = \frac{1}{\gamma n}$. Given that (i) the π and s curves are downward sloping, (ii) $\pi(I) < s(I)$ for all I, and (iii) $\gamma \in (0, 1)$, it follows that there is a cutoff value of γ below which $I^B < I^P$, and above which $I^B > I^P$. Denote this cutoff as $\overline{\gamma}$; that is, $s^{-1}(\frac{1}{\overline{\gamma}n}) = \pi^{-1}(\frac{1}{n})$, generating $I^B = I^P$ at $\gamma = \overline{\gamma}$.

Using the expressions for Northern welfare under the two regimes and subtracting $W^{N,Patent}(I^P)$ from $W^{N,Buyout}(I^B)$ yields:

$$\begin{aligned}W^{N,Buyout} - W^{N,Patent} =& \big[\gamma n \int^{I^B} s(I)dI - I^B\big] - \big[n\int^{I^P} \pi(I)dI + \gamma n \int^{I^P} \zeta(I)dI - I^P\big] \\ =& n\left[\gamma \int_{I^P}^{I^B} s(I)dI + \gamma \int^{I^P} l(I)dI - (1-\gamma)\int^{I^P} \pi(I)dI\right] \\ & - (I^B - I^P) \gtreqless 0\end{aligned} \tag{20}$$

where the second line arises from $\zeta(I) = s(I) - \pi(I) - l(I)$.

Eq. (20) permits the possibility that $W^{N,Buyout} - W^{N,Patent} < 0$, in which case the North prefers patents over a buyout. To see this, note that, as $\gamma \to 1$, I^B approaches the first-best investment level, so that Eq. (20) approaches $W^{N,FirstBest} - W^{N,Patent} > 0$. As $\gamma \to 0$, $I^B \to 0$ so that Eq. (20) approaches $-W^{N,Patent} < 0$.

In intermediate ranges of γ, note first that in a neighborhood $\gamma = \overline{\gamma} + \epsilon$ ($\epsilon > 0$ arbitrary small) around the cutoff, $I^B \to I^P$ so that $W^{N,Buyout} - W^{N,Patent}$ approaches $n\Big[\overline{\gamma}\int^{I^P} l(I)dI - (1-\overline{\gamma})\int^{I^P}\pi(I)dI\Big]$. This expression is negative if $\frac{\overline{\gamma}}{1-\overline{\gamma}}\int l(I)dI < \int \pi(I)dI$; in other words, if (under a patent) profit is a large share of the surplus relative to deadweight loss, then $W^{N,Buyout} - W^{N,Patent} < 0$ in the neighborhood around $\overline{\gamma}$. Furthermore, letting γ^* be that which fulfills $W^{N,Buyout}(I^B(\gamma^*)) - W^{N,Patent}(I^P) = 0$, then in this case $\gamma^* > \overline{\gamma}$, and $W^{N,Buyout} - W^{N,Patent} < 0$ for all $\gamma \in (0, \gamma^*)$ and positive otherwise. Conversely, if $\frac{\overline{\gamma}}{1-\overline{\gamma}}\int l(I)dI > \int \pi(I)dI$, then $W^{N,Buyout} - W^{N,Patent} > 0$ around the cutoff $\overline{\gamma}$; it is negative for $\gamma \in (0, \gamma^*)$ where now $\gamma^* < \overline{\gamma}$ and positive otherwise.

In contrast, the difference in world welfare under the two regimes is:

$$\begin{aligned}W^{W,Buyout} - W^{W,Patent} =& \big[\gamma n \int^{I^B} s(I)dI - I^B + (1-\gamma)n\int^{I^B} s(I)dI\big] \\ & - \big[n\int^{I^P} \pi(I)dI + \gamma n\int^{I^P}\zeta(I)dI - I^P + (1-\gamma)n\int^{I^P}\zeta(I)dI\big] \\ =& n\big[\int^{I^B} s(I)dI - \big(\int^{I^P}\pi(I)dI + \int^{I^P}\zeta(I)dI\big)\big] - (I^B - I^P) \\ =& n\left[\int_{I^P}^{I^B} s(I)dI + \int^{I^P} l(I)dI\right] - (I^B - I^P) \gtreqless 0\end{aligned} \tag{21}$$

Similar to the above, Eq. (21) will be positive as $\gamma \to 1$ and negative as $\gamma \to 0$. In intermediate ranges, then in an arbitrarily small neighborhood around the cutoff $\gamma = \overline{\gamma} + \epsilon$, $I^B \to I^P$ so that $W^{W,Buyout} - W^{W,Patent}$ approaches $n\int^{I^P} l(I)dI$. This is always positive. Furthermore, letting γ^{**} be that which fulfills $W^{W,Buyout}(I^B(\gamma^{**})) - W^{W,Patent}(I^P) = 0$, then $\gamma^{**} < \overline{\gamma}$, and $W^{W,Buyout} - W^{W,Patent} < 0$ for all $\gamma \in (0, \gamma^{**})$ and positive otherwise.

Combining the above, it follows that, for given values of n and sufficiently large shares of profit in the surplus, there is a range $\gamma \in (\gamma^{**}, \gamma^{*})$ in which $\gamma^{**} < \overline{\gamma} < \gamma^{*}$ and $W^{N,Buyout} - W^{N,Patent} < 0$ but $W^{W,Buyout} - W^{W,Patent} > 0$. □

This result is in stark contrast to the findings in the closed-economy literature on buyouts, in which buyouts are pursued over patents if the government is able to pay the innovator the 'correct' amount. In contrast, Proposition 1 shows that, once we move to a world of multiple countries, this is not necessarily the case anymore. It can be rational for the North to abstain from implementing a patent buyout, despite the government knowing the social value of each invention and the absence of commitment issues or other frictions. The intuition behind this result is based on the following considerations, explicit in the proof. First, the choice of regime affects firms' incentives to invest in research. As shown above, for sufficiently small values of γ it holds that $I^B < I^P$. Although this implies lower costs of innovation, it also reduces consumer surplus in the North as each additional product that is invented generates surplus. Second, a buyout eliminates the static deadweight loss associated with monopoly pricing, but it also eliminates the monopoly profit obtained from the South. Note that smaller values of γ further reduce the gain to the North from eliminating deadweight loss in the (small) domestic market while increasing the costs of foregoing profit from the (large) Southern market.

The implications for the world of moving from a patent to a buyout is also indeterminate, with a buyout having two opposing effects on consumer surplus in the South. The elimination of monopoly pricing tends to increase consumer surplus in the South but if a buyout leads to a lower level of innovation than the one achieved under a patent system, this hurts all consumers, including those in the South. Accordingly, the proof of Proposition 1 shows that the effect on world welfare can be positive or negative. Especially if monopoly profits are large, patents may be 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. *Under the optimal level of I chosen by the North in a given innovation regime, it holds that $W^{N,Subsidy} > W^{N,Patent}$ and $W^{N,Subsidy} > W^{N,Buyout}$; that is, the North chooses a national subsidy regime over patents and domestically-financed global buyouts. Moreover, $W^{W,Subsidy} > W^{W,Patent}$, while $W^{W,Subsidy}$ may be greater or smaller than $W^{W,Buyout}$ depending on the model's primitives.*

Proof. Let I^S be the investment choice under a subsidy regime. Solving the maximization problem in Eq. (16) generates the first-order condition $s(I^S) + \frac{1-\gamma}{\gamma}\pi(I^S) = \frac{1}{n}$. Compared to the first-order conditions for I^P and I^B shown in the proof of Proposition 1, and given that (i) the curves are downward sloping, (ii) $\pi(I) < s(I)$ for all I, and (iii) $\gamma \in (0,1)$, it holds that $I^S > I^P$ and $I^S > I^B$.

Northern welfare from subsidies $W^{N,Subsidy}(I^S)$ relative to patents $W^{N,Patent}(I^P)$ is:

$$\begin{aligned} W^{N,Subsidy} - W^{N,Patent} =& \left[\gamma n \int^{I^S} s(I)dI + (1-\gamma)n \int^{I^S} \pi(I)dI - I^S\right] \\ &- \left[n \int^{I^P} \pi(I)dI + \gamma n \int^{I^P} \zeta(I)dI - I^P\right] \\ =& n\left[\gamma \int_{I^P}^{I^S} s(I)dI + \gamma \int^{I^P} l(I)dI + (1-\gamma)\int_{I^P}^{I^S} \pi(I)dI\right] \\ &- (I^S - I^P) > 0 \end{aligned} \tag{22}$$

Eq. (22) is positive since the welfare difference effects (i.e., the terms in square brackets which are multiplied by n) are greater than the investment differentials. To see this, note that, if this were not the case, then the Northern government could choose a smaller value of I^S to obtain an even higher welfare under a subsidy. For instance, it could set I^S equal to I^P so that the expression in Eq. (22) will be unambiguously positive. Thus, for the optimally chosen investment level $I^S > I^P$, Eq. (22) is always positive.

Northern welfare from subsidies $W^{N,Subsidy}(I^S)$ relative to buyouts $W^{N,Buyout}(I^B)$ is:

$$\begin{aligned} W^{N,Subsidy} - W^{N,Buyout} &= \left[\gamma n \int^{I^S} s(I)dI + (1-\gamma)n \int^{I^S} \pi(I)dI - I^S\right] - \left[\gamma n \int^{I^B} s(I)dI - I^B\right] \\ &= n\left[\gamma \int_{I^B}^{I^S} s(I)dI + (1-\gamma)\int^{I^S} \pi(I)dI\right] - (I^S - I^B) > 0 \end{aligned} \tag{23}$$

which is positive for an analogous reason as made above for Eq. (22).

World welfare from subsidies relative to patents is described by:

$$\begin{aligned} W^{W,Subsidy} - W^{W,Patent} =& \left[\gamma n \int^{I^S} s(I)dI + (1-\gamma)n \int^{I^S} \pi(I)dI - I^S + (1-\gamma)n \int^{I^S} \zeta(I)dI\right] \\ &- \left[n \int^{I^P} \pi(I)dI + \gamma n \int^{I^P} \zeta(I)dI - I^P + (1-\gamma)n \int^{I^P} \zeta(I)dI\right] \\ =& n\left[\gamma \int^{I^S} l(I)dI + \int_{I^P}^{I^S} \pi(I)dI + \int_{I^P}^{I^S} \zeta(I)dI\right] \\ &- (I^S - I^P) > 0 \end{aligned} \tag{24}$$

where Eq. (24) is positive, as it is unambiguously larger than Eq. (22) given that $I^S > I^P$. Relative to a buyout, we obtain:

$$\begin{aligned} W^{W,Subsidy} - W^{W,Buyout} =& \Big[\gamma n \int^{I^S} s(I)dI + (1-\gamma)n \int^{I^S} \pi(I)dI - I^S + (1-\gamma)n \int^{I^S} \zeta(I)dI\Big] \\ & - \Big[\gamma n \int^{I^B} s(I)dI - I^B + (1-\gamma)n \int^{I^B} s(I)dI\Big] \\ =& n\left[\int_{I^B}^{I^S} s(I)dI - (1-\gamma)\int^{I^S} l(I)dI\right] - (I^S - I^B) \gtreqless 0 \end{aligned} \tag{25}$$

Eq. (25) is indeterminate in sign, and can be negative for large $l(I)$. □

Subsidies as the preferred regime choice is an intuitive result, as this allows the North to eliminate the static deadweight loss associated with monopoly pricing at home (as a buyout would) while maintaining monopoly profits abroad (as a patent regime would). It is therefore preferable to both. As shown in the proof, a subsidy also increases welfare of the North by generating a higher level of innovation I than achieved under a buyout or a patent system. 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.

The implications for the world therefore depend on the effect on the South. Relative to a patent regime, Southern welfare is strictly greater under a (Northern) subsidy because the South is subject to static losses arising from monopoly pricing under both regimes, while dynamic losses are smaller under a subsidy program due to higher innovation. This is why a subsidy unambiguously raises global welfare relative to a mere patent system. In contrast, whether a subsidy also leads to higher welfare in the South (and globally) relative to a buyout is indeterminate and depends on the extent of deadweight loss from monopoly pricing in the South. With large deadweight losses, the benefit to the South from a subsidy regime with high innovation is attenuated by the cost of monopoly pricing; with a sufficiently large Southern market (low γ), global welfare is also lower, so that the North's choice of national subsidies is harmful to global welfare.

The results so far have compared the outcomes under a patent system, national subsidy program (akin to a national buyout), and domestically-financed global buyout. The next proposition clarifies the outcome when international surplus transfers to finance a global patent buyout are also considered.

Proposition 3. *If the North chooses between patents, a national subsidy program, domestically-financed global buyout, and a buyout with international transfer as specified above, then it chooses the latter. The outcome involves a global buyout with a positive transfer amount* *that stipulates the globally efficient level of innovation. The exact size of the transfer and resulting distribution of welfare depend on the relative bargaining power of the North and South (i.e., who offers the contract).*

Proof. Let I^T be the investment choice under a buyout regime with international transfer. In the maximization problem in (18), and given the results of Proposition 2, the participation constraint of the South is that its welfare under a transfer net of the transfer paid to the North be at least equal to its welfare under the alternative, subsidies, i.e. to $W^{S,Subsidy}$. The maximization problem for the North can thus be reformulated into the Lagrangian

$$\mathcal{L} = \gamma n \int^{I^T} s(I)dI + T^N - I^T - \lambda\big[(1-\gamma)n \int^{I^T} s(I)dI - T^N - W^{S,Subsidy}\big]. \tag{26}$$

Taking the derivative $\frac{\partial \mathcal{L}}{\partial I^T} = 0$ yields $\gamma n s(I^T) - \lambda(1-\gamma)ns(I^T) = 1$. Taking the derivative $\frac{\partial \mathcal{L}}{\partial T^N} = 0$ gives $\lambda = -1$. Substituting $\lambda = -1$ into the former first-order condition, we find that the investment amount chosen satisfies

$$s(I^T) = \frac{1}{n}. \tag{27}$$

Given the proofs of Propositions 1 and 2, Eq. (27) implies that I^T is greater than any of I^S,I^P, and I^B. To see that I^T is globally efficient, note that the world's first-best investment I^{FB} is chosen to maximize world optimal surplus net of investment:

$$W^{W,FirstBest}(I^{FB}) = n \int^{I^{FB}} s(I)dI - I^{FB}. \tag{28}$$

This generates the first-order condition

$$s(I^{FB}) = \frac{1}{n}. \tag{29}$$

From Eqs. (27) and (29), we conclude that $I^T = I^{FB}$.

To show that $T^N > 0$, taking the derivative $\frac{\partial \mathcal{L}}{\partial \lambda} = 0$ and substituting $W^{S,Subsidy} = (1-\gamma)n \int^{I^S} \zeta(I)dI$ yields $T^N = (1-\gamma)n\Big[\int^{I^T} s(I)dI - \int^{I^S} \zeta(I)dI\Big]$, which is positive.

The investment level I^T is independent of the transfer amount. To show that it is independent of bargaining structure more broadly, note that if the South had the bargaining power to set a contract, its corresponding Lagrangian would be $\mathcal{L} = (1-\gamma)n \int^{I^T} s(I)dI - T^S - \lambda\big[\gamma n \int^{I^T} s(I)dI - I^T + T^S - W^{N,Subsidy}\big]$. Taking the derivative $\frac{\partial \mathcal{L}}{\partial I^T}$ yields $(1-\gamma)ns(I^T) - \lambda\gamma n s(I^T) = 1$ while the derivative $\frac{\partial \mathcal{L}}{\partial T^S}$ again gives $\lambda = -1$. Substituting the latter into the former we obtain once more the first-order condition

$s(I^T) = \frac{1}{n}$. Only the transfer amount, which depends on the participation constraint, and the resulting welfare distribution among countries change – with the South now appropriating all the surplus from the transition to a transfer system. Solving for T^S in this case yields $T^S = [\gamma n \int^{I^S} s(I)dI + (1-\gamma)n \int^{I^s} \pi(I)dI - I^s] - [\gamma n \int^{I^T} s(I)dI - I^T)] > 0$, and comparing transfers shows that $T^S < T^N$. □

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 the globally efficient level of innovation in the model. Without transfers, the North chooses subsidies, which 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 transfers are possible, it is in the best interest of both countries to cooperate on financing a buyout which generates the globally efficient level of innovation; that is, all products z are invented for which the global optimal consumer surplus (achieved under competitive pricing) is greater than the research cost. Importantly, this result is independent of the model's parameter values, not depending, for example, on the relative size of the North or South or on $\pi(I)$ and $l(I)$ magnitudes.

3.2 Adding domestic distributional concerns

With electoral concerns, note first that, because in equilibrium both parties make symmetric choices, $I_A = I_B$, and given Eq. (8), the victory probabilities for A and B are:

$$Prob[v_A \geq 0.5] = \frac{1}{2} - \psi\delta^*, \tag{30}$$

$$Prob[v_B \geq 0.5] = \frac{1}{2} + \psi\delta^*. \tag{31}$$

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 a transfer-facilitated buyout regime.[12] Moreover, the probabilities of victory for A and B are those in Eqs. (30)-(31) also for a patent regime.[13] The main difference between regimes is therefore optimal investment level —by the government or firms— and subsequent welfare implications, while

[12]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.

[13]This can be seen with our assumption that voters vote only on ideological preference, so that $\omega(I_A) = \omega(I_B) = 0$. However, it would also hold more broadly as long as actions by the parties are symmetric, as $\omega(I_A)$ and $\omega(I_B)$ cancel out in the electoral victory probability in Eq. (8).

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

$$\Delta \equiv \frac{\left(\sum_J \alpha^J \phi^J y^J\right)}{\left(\sum_J \alpha^J \phi^J\right) y} \tag{32}$$

to denote an expression that recurs repeatedly in the solutions (see below) 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[14]

$$\Delta = \frac{\bar{\phi}\left(\sum_J \alpha^J y^J\right)}{\bar{\phi}\left(\sum_J \alpha^J\right) y} = 1. \tag{33}$$

In contrast, differential densities imply $\Delta \neq 1$. If the wealthier 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 in Propositions 4-6, which are structured to be parallel to Propositions 1-3.

Proposition 4. *The presence of electoral concerns (i.e., when* $\Delta \neq 1$*) changes the scope for domestically-financed global buyouts relative to patents. Specifically, the set of parameter value combinations for which* $W^{N,Buyout} > W^{N,Patent}$ *increases when* $\Delta < 1$ *but decreases when* $\Delta > 1$*, and the magnitude of this divergence increases in* $|\Delta - 1|$*.*

Proof. Let $I^{\overline{P}}$ and $I^{\overline{B}}$ be the investment choices under a patent regime and a buyout regime with electoral considerations, respectively. As firms still operate on the basis of profit maximization, Eq. (9) yields the first-order condition $\pi(I^{\overline{P}}) = \frac{1}{n}$. Therefore, $I^{\overline{P}} = I^P$. With a buyout, the government's electoral considerations in Eq. (13) generate the first-order condition $s(I^{\overline{B}}) = \frac{\Delta}{\gamma n}$. Comparing with the proof of Proposition 1, this highlights that, if $\Delta > 1$, then investment under buyouts is lower than under welfare maximization ($I^{\overline{B}} < I^B$), and vice versa if $\Delta < 1$.

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

Given equalized victory probabilities, regime choice hinges on welfare outcomes for the North. Welfare functional forms by regime do not change; only the values of investment do (responding to different maximization objectives). Relying on the forms in Proposition 1 we can calculate the difference in welfare between a buyout and patent regime as

$$\begin{aligned} W^{N,Buyout} - W^{N,Patent} =& n\left[\gamma \int_{I^P}^{I^{\overline{B}}} s(I)dI + \gamma \int^{I^P} l(I)dI - (1-\gamma)\int^{I^P} \pi(I)dI\right] \\ & - (I^{\overline{B}} - I^P) \gtreqless 0 \end{aligned} \tag{34}$$

Comparing Eq. (34) with Eq. (20), if $\Delta > 1$ and therefore $I^{\overline{B}} < I^B$, then the expression in Eq. (34) is smaller, reducing the advantage of buyouts over patents, and thereby the range of values γ for which $W^{N,Buyout} > W^{N,Patent}$ (for given n, $\pi(I)$, $l(I)$). The magnitude of this reduction increases with a higher $\Delta - 1$. The opposite holds if $\Delta < 1$ and $I^{\overline{B}} > I^B$, in which case the relative advantage of buyouts rises with $-(\Delta - 1)$. □

Proposition 4 implies that it will be more likely that the North will abstain from implementing a buyout *if* wealthy groups are also more powerful politically (i.e. $\Delta > 1$). The intuition behind this is that the wealthier pay a higher absolute amount of their income under a flat-rate tax (and even more so under a progressive tax), so that they have lower relative benefit per unit of innovation and prefer less public financing. The government, extra-sensitive to the demands of these groups, would attenuate their public innovation spending under a buyout regime. By contrast, investment choices under a patent regime —driven by profit considerations— are unaffected by this dimension. As a result, the welfare advantage that accrues from buyouts potentially increasing innovation levels, will diminish. Given (second-order) welfare concerns, the North will therefore be less likely to replace a patent regime with a global buyout.

The implications for the South, and therefore the world, continue to be ambiguous. To the extent that the higher income group in the North is more politically important, implying $I^{\overline{B}} < I^B$, Southern consumer surplus gains from innovation are diminished relative to the solution in Section 3.1. The opposite holds if the lower income group is more politically important, with the South reaping greater benefits from the externality associated with buyouts. In this latter case, a choice in the North of patents over buyouts (which is still possible if, for example, profit margins under a patent regime are sufficiently large) would mean foregoing even larger global gains than previously calculated.

The next proposition describes how the results in Proposition 2 change in the presence of electoral concerns.

Proposition 5. *With electoral concerns, if $\Delta < 1$, then $W^{N,Subsidy} > W^{N,Patent}$ and $W^{N,Subsidy} > W^{N,Buyout}$. If $\Delta > 1$, then the welfare of the North under subsidies exceeds* *that under buyouts but does not necessarily exceed that under patents.*

Proof. Let $I^{\overline{S}}$ be the investment choice under a subsidy regime with electoral concerns. Solving the maximization problem in Eq. (17) generates the first-order condition $s(I^{\overline{S}}) + \frac{1-\gamma}{\gamma}\pi(I^{\overline{S}}) = \frac{\Delta}{n}$. Compared to the first-order condition for I^S in Proposition 2, and given that the left-hand side is downward sloping, then $\Delta > 1$ implies $I^{\overline{S}} < I^S$. Conversely, $\Delta < 1$ implies $I^{\overline{S}} > I^S$. Northern welfare from subsidies relative to patents is

$$\begin{aligned} W^{N,Subsidy} - W^{N,Patent} =& n\left(\gamma\Big[\int_{I^P}^{I^{\overline{S}}} s(I)dI + \gamma\int^{I^P} l(I)dI\Big] + (1-\gamma)\int_{I^P}^{I^{\overline{S}}} \pi(I)dI\right) \\ & - (I^{\overline{S}} - I^P) \gtrless 0 \end{aligned} \tag{35}$$

If $\Delta < 1$, so that $I^{\overline{S}} > I^S$, then along with the proof in Proposition 2 that $I^S > I^P$, this implies $I^{\overline{S}} > I^P$, making Eq. (35) positive. Otherwise, Eq. (35) may be negative, as sufficiently high $(\Delta - 1)$ renders $I^{\overline{S}} < I^P$.

Northern welfare from subsidies relative to buyouts is

$$W^{N,Subsidy} - W^{N,Buyout} = n\left[\gamma\int_{I^{\overline{B}}}^{I^{\overline{S}}} s(I)dI + (1-\gamma)\int^{I^{\overline{S}}} \pi(I)dI\right] - (I^{\overline{S}} - I^{\overline{B}}) > 0 \tag{36}$$

Eq. (36) is always positive by virtue of $I^{\overline{S}} > I^{\overline{B}}$, which can be seen by comparing the first-order condition for $I^{\overline{S}}$ with that in the proof of Proposition 4 for $I^{\overline{B}}$. $\square$

Proposition 5 implies that, unlike in the case without domestic distributional concerns (see Proposition 2), implementing a subsidy is not necessarily the North's optimal choice anymore. 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.

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 investment under subsidies is higher. 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 is sufficiently important for electoral victory, then investment under a subsidy may be *lower* than under a patent regime. 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.

Finally, the next proposition describes how the results in Proposition 3 change in the presence of electoral concerns.

Proposition 6. *With electoral concerns (i.e., $\Delta \neq 1$), a global buyout with a transfer contract (as specified in Section 2.3) does not generate the globally efficient level of innovation. Global welfare is lower than its optimal level, and the gap increases with* $|\Delta - 1|$.

Proof. Let $I^{\overline{T}}$ be the investment choice under a global buyout with international transfer in the presence of electoral concerns, and $\overline{T}^N$ be the corresponding transfer amount with the North offering the contract. It needs to be shown that $\Delta \neq 1$ implies $I^{\overline{T}} \neq I^{FB}$. To do this, note first that the maximization problem in Eq. (19) can be rewritten in the form of the ensuing constrained first-order condition:

$$\sum_J \alpha^J \phi^J \frac{\partial \omega^J}{\partial I^{\overline{T}}} = 0 \tag{37}$$

$$s.t. \quad I^{\overline{T}} \leq \tau\gamma n y + \overline{T}^N$$

$$\text{Participation constraint of South}$$

where now we can be agnostic about whether the fallback level of the South is its welfare under subsidy or patents; we denote it as $W^{S,fallback}$.

To clarify the components of ω^J and solve the above, we note that with both constraints in Eq. (37) being binding, consumer welfare in the North with a transfer is $\omega^J = \int^{I^{\overline{T}}} s(I)dI - \frac{I^{\overline{T}} - \overline{T}^N}{\gamma n y} y^J$, where $\overline{T}^N$ meets the South's participation constraint so that $\overline{T}^N = (1-\gamma)n \int^{I^{\overline{T}}} s(I)dI - W^{S,fallback}$. Substituting the expression for $\overline{T}^N$ into w^J, and then taking the derivative with respect to $I^{\overline{T}}$, we obtain

$$\frac{\partial \omega^J}{\partial I^{\overline{T}}} = s(I^{\overline{T}}) - \frac{y^J}{\gamma n y} + \frac{(1-\gamma)}{\gamma y} s(I^{\overline{T}}) y^J. \tag{38}$$

Substituting Eq. (38) into the first-order condition in Eq. (37) yields

$$\sum_J \alpha^J \phi^J \Big(s(I^{\overline{T}}) - \frac{y^J}{\gamma n y} + \frac{(1-\gamma)}{\gamma y} s(I^{\overline{T}}) y^J \Big) = 0, \tag{39}$$

which can be simplified to

$$s(I^{\overline{T}}) + \frac{\Delta}{\gamma}(1-\gamma)s(I^{\overline{T}}) = \frac{\Delta}{\gamma n}. \tag{40}$$

We can see immediately that if $\Delta = 1$, the above reduces to $s(I^{\overline{T}}) = \frac{1}{n}$, so that $I^{\overline{T}} = I^{FB}$. Otherwise, if $\Delta \neq 1$, then $s(I^{\overline{T}}) \neq \frac{1}{n}$, so that $I^{\overline{T}} \neq I^{FB}$. It follows that world welfare is lower than the first best and increasingly so as $|\Delta - 1|$ rises. $\square$

Proposition 6 implies that the presence of a technology for international surplus transfers is no longer sufficient to achieve the globally efficient level of innovation when investment decisions are affected by electoral concerns. In particular, a transfer contract $\{I^{\overline{T}}, \overline{T}^N\}$ designed by the Northern government and driven by domestic distributional considerations will lead to suboptimal investment and lower world welfare levels.

The key intuition for this result is as follows. Previously, in the baseline international model, 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.

3.3 Summary and simulation

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 distributional issues underestimates the challenges toward instituting buyout regimes even when buyouts are globally welfare enhancing.[15]

To conclude this section, we present a numerical simulation to illustrate the North's tradeoff between a patent regime and a domestically-financed global buyout (Proposition

[15] We note that, in solving the model, we focus on the case where a patent regime implies full intellectual property rights protection in both the North and South. Any deviation from this assumption (e.g., counterfeit products in the South) would tend to reduce the incentives of Northern firms to invest in innovation, thereby making a patent system relatively less attractive to the North with respect to the international welfare distribution. However, unless monopoly profits are reduced to zero, the presence of (some) counterfeit products does not critically affect our main (qualitative) findings. In addition, the domestic electoral considerations we study remain unaffected by counterfeit products.

1). This sheds light on how different parameter values in our model impact the patent-buyout binary that is often considered in the (closed-economy) literature, but similar exercises can be conducted for the other propositions. As simulation requires moving from general to a closed-form specifications, we introduce the following additional functional form assumptions. Following Deardorff (1992), we assume that the speed by which diminishing returns to innovation occur is constant, so that $s(I)$ can be represented by a linear function of the form

$$s(I) = f - gI. \tag{41}$$

The intercept $f > 0$ indicates how valuable inventions are in general; that is, how productive the innovation technology is.[16] The slope parameter $g > 0$ indicates the speed by which diminishing returns to innovation set in.

With this linearity assumption (and the implied linearity of demand), monopoly profit and consumer surplus under monopoly pricing are given as fixed shares of the optimal consumer surplus in each country.[17] Solving the model using the linear expression from equation (41) in place of the general term $s(I)$ used in Section 2 shows that Eq. (20), which compares total welfare of the North under patents versus under a domestically-financed buyout, now takes the form

$$W^{N,Buyout} - W^{N,Patent} = \frac{\gamma n^2 f^2 (3\gamma - 2) + 4(\gamma - 1)^2}{8\gamma n g}. \tag{42}$$

Similarly, the change in *global* welfare when moving from a patent system to a buyout, previously described by Eq. (21), is now given as

$$W^{W,Buyout} - W^{W,Patent} = \frac{\gamma^2 (n^2 f^2 - 4) + 4(2\gamma - 1)}{8\gamma^2 n g}. \tag{43}$$

We use these results to simulate the outcomes and associated welfare implications for different parameter value combinations.

The results are presented in Figure 1. Panel (a) shows the North's welfare gain under a domestically-financed buyout compared to patents (Eq. 42). Positive values imply that the North will implement a buyout whereas negative values imply a patent system. Panel (b) shows the corresponding values for global welfare (Eq. 43).

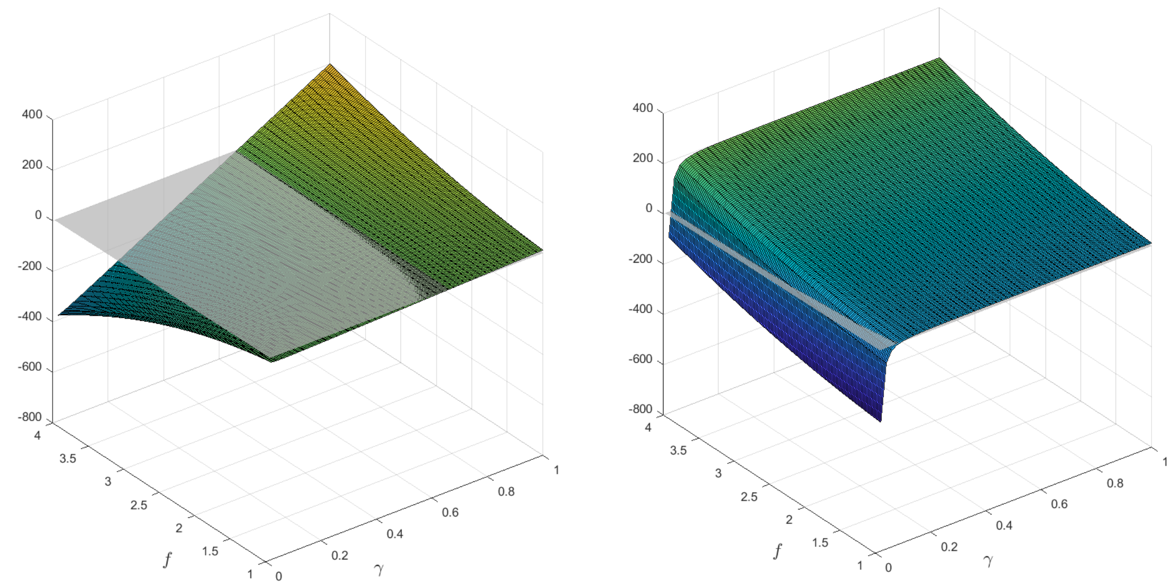
We observe that, in line with the results of Proposition 1, there are many parameter value combinations for which the North prefers a patent system although global welfare

[16]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 $s(z)$.

[17]Specifically, as is known for the linear case, the monopoly profit amounts to one half of the optimal consumer surplus while the remaining surplus is split equally between consumers and deadweight loss.

Figure 1: Simulations for different values of γ and f

(a) $W^{N,Buyout} - W^{N,Patent}$ (b) $W^{W,Buyout} - W^{W,Patent}$



Note: Simulations based on parameter values: $\gamma \in (0, 1)$, $f \in (1, 6)$, $n = 20$, $g = 0.2$.

would be greater with a buyout. These are all the combinations which fall below the white horizontal plane in Panel (a) but above it in Panel (b). We also observe, from Panel (a), that sufficiently large values of γ always lead to a buyout whereas small values of γ lead to patents. This illustrates the function of bigger Northern markets (higher γ), explained earlier, in (i) augmenting the gains from buyout elimination of domestic deadweight loss, (ii) limiting the cost from buyout elimination of international profit loss, and (iii) encouraging high innovation and subsequent Northern consumer surplus under a buyout.

Finally, we see that with the linear functional form assumptions made above, the cutoff value of γ, which determines whether the North chooses a buyout or not, lies in the interval $(\frac{1}{2}, \frac{2}{3})$; this also holds for any fixed values for n and g (omitted). In particular, this suggests that the results in Proposition 1 do not critically depend on γ taking extreme values close to zero or close to one.[18]

[18] To see how the results of the simulation are embedded within the general-form model more broadly, note that this implies $\gamma^* \in (\frac{1}{2}, \frac{2}{3})$ where γ^* is the cutoff value defined in the proof for Proposition 1. In addition, with the functional form assumption made above, profit under monopoly patents is half of the surplus share while deadweight loss is one-quarter of the surplus, so that the ratio of total profits to total deadweight loss is two. Finally, the population parameter which equates I^B and I^P here is $\bar{\gamma} = \frac{1}{2}$. Taken together, these imply that $\frac{\bar{\gamma}}{1-\bar{\gamma}} < \frac{\int \pi(I)dI}{\int l(I)dI}$, since $1 < 2$ (and that $\bar{\gamma} < \gamma^*$ for all possible γ^*). Recall from the proof of Proposition 1 that this is the condition for the existence of a range of γ in which the North is better off with patents although the world as a whole is worse off. This is why, with this linear functional form, then for any cutoff γ^* there will *always* be a range of γ for which the optimal choice of

4 Extensions

In the previous literature, the widespread absence of buyouts observed in practice has been mostly attributed to two main channels: information asymmetries regarding the appropriate size of buyouts, and commitment problems impeding the credibility of future transfers from the government to the innovating firms. So far, we have abstracted from information and commitment problems to show that, even in their absence, it can be rational for governments to prefer patents over buyouts, due to the global externalities and political economy considerations captured in our model. In this section, we link our insights back to this literature and discuss how information and commitment problems may affect countries' optimal behavior in our setting.

4.1 Information asymmetry

The standard information asymmetry explored in the literature is the one between the (financing) government and firms. To see how such an asymmetry amends our framework, suppose the Northern government does not know consumer's demand functions and does not observe market signals such as sold quantities, so that it faces uncertainty about $s(I)$. For publicly financed innovation regimes, the government therefore has to form expectations $E[s(I)]$ when choosing the targeted investment level I. For example, in a buyout, a welfare-maximizing government's first-order condition would be amended from $s(I) = \frac{1}{\gamma n}$ (Proposition 1) to

$$E[s(I)] = \frac{1}{\gamma n}. \tag{44}$$

Given that $s(I)$ is decreasing in I, it follows that the value of I chosen under imperfect information is larger than the value obtained under full information when $E[s(I)] > s(I)$, and is inadequately small when $E[s(I)] < s(I)$. In both cases, as Northern welfare is optimized under a buyout when I is set such that $s(I) = \frac{1}{\gamma n}$, there is a welfare loss for the North relative to the outcome under full information. Similar arguments apply to the choice of I under a subsidy regime. In contrast, and assuming (as the literature does) that firms have information about demand functions, then in a patent-based system I is determined under full information.

Thus, the first result from introducing government-firm asymmetric information to our setup mirrors the core result of the single-economy setting (e.g. Shavell and van Ypersele, 2001): the asymmetry reduces the desirability of buyouts —and publicly financed

the North would be a patent which is nonetheless detrimental to world welfare relative to a buyout.

regimes in general— relative to patents.[19] This is precisely because the patent-based reward system is not affected by the information problem but buyouts are, giving a boost to patents over buyouts. The difference here is that information problems are not *necessary* for explaining low buyout feasibility; rather, they compound the existing political economy implications that we consider.

Second, while the above issue of regime choice involves assessing Northern welfare (and this is lower under imperfect as opposed to full information), our international setting gives rise to the distinct possibility that asymmetric information nonetheless may lead to improvements in *global* welfare. This is possible because, in our setting, global welfare is *not* equal to Northern welfare as it also encompasses the South. To see this, consider the case where the North (still) finds it optimal to implement a domestically-financed global buyout under imperfect information, but the chosen investment level I remains below the global optimum (see Proposition 1). In this case, if information asymmetries cause the government to expect $s(I)$ to be higher than it really is (but not too high), this generates a shift in I closer to the globally optimal investment level than under perfect information, increasing global welfare. Intuitively, asymmetric information leading to an overvaluation of Northern benefit from the government's point of view generates a positive externality to the South which benefits from the higher innovation, potentially improving world welfare (if the South's gain is greater than the North's loss) relative to full information. In sum, the implications globally will depend on the type of information problem and its interaction with the determinants of world welfare.

An additional insight from the international setup relates to the feasibility of using market signals to bridge potential information asymmetries. Previous studies highlight that governments can use market signals such as prices and sold quantities to inform the design of patent buyouts when *ex ante* information about the social value of innovations is lacking (Shavell and van Ypersele, 2001; Chari et al., 2012; Galasso et al., 2016). We note that, while in the single-economy models underlying these studies it seems relatively harmless to assume that governments can observe such market signals, moving to an international setting means that any national government considering to implement a buyout would also need to observe these signals on foreign markets to choose the optimal buyout amount. If in practice obtaining such information from abroad is subject to additional transaction costs or other frictions, then the feasibility of buyouts relative to patents will be further diminished in the international setting.

[19]The same result would emerge if the asymmetry would exist not in terms of access to information *per se*, but in higher costs of processing available information for governments than for firms, which is a common assumption in the literature on centralized planning or regulation under imperfect information (Feldman and Serrano, 2006, Ch. 5.5; Naeher, 2023).

4.2 Commitment problems

Commitment problems may arise between the (financing) government and its firms as is standard in the literature but also, in our international setup, between sovereigns. We focus on this latter possibility and its effect on transfer-financed buyouts.

Recall that our model in Section 2 implicitly assumes international transfers are financed by government revenues (such as taxes) in the countries with less innovation capacity. In practice, however, there are often severe challenges toward mobilizing domestic resources in low-income countries, including weak institutions and low taxation paying norms (Besley and Persson, 2014). Even if governments in those countries can in principle 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 South's) government faces shocks or alternative opportunities that can induce diversion from a small budget (along the lines of Galasso, 2020).

To explore the potential impact of these issues in our framework, we incorporate, for the Southern government, a budget that can be used for a combination of transfers as well as other lucrative (but costly) investment opportunities.[20] More concretely, let B be the South's budget, r the returns on the other investment opportunity if pursued, and ϖ the cost of funding this investment. Moreover, assume that $r - \varpi > 0$ and that $B > \varpi$, so that in the absence of other commitments this opportunity is pursued.[21]

Since the first-best outcome with transfers in the baseline model is obtained regardless of who offers the contract, our point of departure is the South setting the transfer contract, as this allows for a smaller transfer amount and thus maximum surplus extraction for the South (Proposition 3). The point is to show that even in this case, transfers may no longer generate the first-best innovation investment outcome. Let T^* be the transfer amount that generates the globally efficient level of innovation I^{FB} when the South sets the contract in the baseline model. The next proposition summarizes the results of introducing B, r, and ω to this setup.

Proposition 7. *An intersovereign transfer contract generates less than the globally efficient level of innovation if $B < T^*$, or if $B - \varpi < T^* < B$ but r is sufficiently high.*

[20] This modeling approach is inspired by Galasso (2020) who shows that, in the presence of a limited budget and potential shocks that require diversion of funds, it may no longer be feasible for a government to offer a reward schedule (akin to a buyout) to firms to induce them to place their knowledge in the public domain. Our model differs by studying transfers among sovereigns (from the South to the North), and we focus on non-stochastic investment opportunities which may or may not be pursued by the South depending on net payoffs.

[21] We abstract from government borrowing although B can be conceptualized as the total funds available including from borrowing. What matters for our purposes is that feasible government spending is capped at some amount B.

Furthermore, with sufficiently low B and high ϖ, the efficacy of transfers to increase innovation investment can break down entirely. Only if $B - \varpi > T^*$ do transfers guarantee an outcome with a globally efficient innovation level.

Proof. Let $\theta \in \{0, 1\}$ be the decision of the Southern government to forego ($\theta = 0$) or to pursue ($\theta = 1$) the opportunity that yields a payoff, net of funding, of $r - \varpi$. The constrained maximization problem for the South is now

$$\begin{aligned} Max_{I^T,T^S,\theta} \quad & (1-\gamma)n \int^{I^T} s(I)dI - T^S + \theta(r - \varpi) \\ s.t. \quad & T^S \leq B - \theta\varpi \\ & \text{Participation constraint of North} \\ & I^T \leq \tau\gamma n y + T^S \end{aligned} \tag{45}$$

The objective function shows that choosing to pursue the other investment opportunity generates a payoff $(r - \varpi)$ but, as shown in the second constraint, also restricts the scope for transfers out of the given budget to achieve a global patent buyout. The subsequent Lagrangian can be expressed as

$$\begin{aligned} \mathcal{L} = (1-\gamma)n \int^{I^T} s(I)dI - T^S + \theta(r-\varpi) - \lambda_1[\gamma n \int^{I^T} s(I)dI - I^T + T^S - W^{N,Subsidy}] \\ - \lambda_2[T^S - B + \theta\varpi], \end{aligned} \tag{46}$$

with the first order conditions for the continuous variables (including Kuhn-Tucker for the budget constraint) being $\frac{\partial\mathcal{L}}{\partial I^T} = \frac{\partial\mathcal{L}}{\partial T^S} = \frac{\partial\mathcal{L}}{\partial\lambda_1} = 0$, $\frac{\partial\mathcal{L}}{\partial\lambda_2} \geq 0$, $\lambda_2 \geq 0$, and $\lambda_2\frac{\partial\mathcal{L}}{\partial\lambda_2} = 0$.

Note that if there were no budget constraint, the government would always choose $\theta = 1$ and $T^S = T^*$, generating $I^T = I^{FB}$. The South's welfare would accordingly be $W^S = (1-\gamma)n\int^{I^{FB}} s(I)dI - T^* + r - \varpi$, while the North has the welfare of its outside option, $W^{N,Subsidy}$. With the budget constraint, however, the decision problem over θ is nontrivial. We solve for I^T and T^S under $\theta = 1$ and under $\theta = 0$ separately given the parameters γ, n, B, r, ϖ, calculate the South's maximized payoffs, and evaluate choice of θ (and T^S and I^T) under different parameter values.

Beginning with $\theta = 1$, solving the FOCs indicates that, when $B - \varpi > T^*$, then $\lambda_2 = 0$ while $\frac{\partial\mathcal{L}}{\partial\lambda_2} = B - T^S - \varpi > 0$. The chosen transfer amount is $T^S = T^*$ while $I^T = I^{FB}$. The South's welfare is $W^S|_{\theta=1,\quad B-\varpi>T^*} = (1-\gamma)n\int^{I^{FB}} s(I)dI - T^* + r - \varpi$, which is the same as with no budget constraint.

Alternatively, with $\theta = 1$ but $B - \varpi < T^*$, meeting all FOCs requires $\lambda_2 > 0$ while $\frac{\partial\mathcal{L}}{\partial\lambda_2} = B - T^S - \varpi = 0$. The transfer is what is left over from the budget after financing the other project, $T^S = B - \varpi < T^*$, and this generates $I^T < I^{FB}$; both transfer and innovation investment are thus less than the first-best. The South's welfare is now $W^S|_{\theta=1, \quad B-\varpi<T^*} = (1-\gamma)n\int^{I^T} s(I)dI - T^S + r - \varpi$ which, substituting for the value of T^S, equals $(1-\gamma)n\int^{I^T} s(I)dI - B + r$. Furthermore, working with the North's participation constraint shows that the *minimum* transfer needed to satisfy this constraint is $T_{min} = W^{N,Subsidy} - W^{N,Buyout} < T^*$, and this minimum transfer would generate $I^T = I^{Buyout}$. If $B - \varpi$ (the leftover transfer amount) is not just lower than T^* but also lower than T_{min}, then transfers as an option break down as the North's outside option of subsidy welfare cannot be met, leading the North to reject the transfer contract. In this case the South is left with its outside option of subsidy welfare plus $r - \varpi$.

Moving to $\theta = 0$, a similar exercise shows that when $B > T^*$, then $T^S = T^*$ and $I^T = I^{FB}$, leading to Southern welfare $W^S|_{\theta=0, \quad B>T^*} = (1-\gamma)n\int^{I^{FB}} s(I)dI - T^*$. Conversely, when $B < T^*$, then the transfer is the entirety of the (too-small) budget $T^S = B < T^*$, generating $I^T < I^{FB}$ and welfare $W^S|_{\theta=0, \quad B<T^*} = (1-\gamma)n\int^{I^T} s(I)dI - T^S = (1-\gamma)n\int^{I^T} s(I)dI - B$. Furthermore, if B (and thus the transfer amount) is even lower than T_{min}, then transfers can no longer meet the North's outside option of subsidy welfare. In this case the South is also left with its outside option of subsidy welfare.

Finally, suppose $B - \varpi > T_{min}$ (and hence also $B > T_{min}$) so that transfers are feasible under $\theta \in \{0, 1\}$. Comparing the welfare of the South under different parameter value combinations shows the following.

i. If $B - \varpi > T^*$ (and hence also $B > T^*$), the Southern government chooses $\theta = 1$, because $W^S|_{\theta=1, \quad B-\varpi>T^*} > W^S|_{\theta=0, \quad B>T^*}$. We obtain $T^S = T^*$ and $I^T = I^{FB}$.

ii. If $B - \varpi < T^* < B$, it compares (a) welfare from not diverting any funds and transferring the full amount T^*, resulting in $W^S|_{\theta=0, \quad B>T^*}$, with (b) welfare from funding the other opportunity and transferring less than the first-best amount for innovation, resulting in $W^S|_{\theta=1, \quad B-\varpi<T^*}$. Comparing the two shows that the former is higher only when $(1-\gamma)n\int_{I^T}^{I^{FB}} s(I)dI + (B - T^*) > r$. In this case it chooses $\theta = 0$, $T^S = T^*$, and $I^T = I^{FB}$. Otherwise, if r is sufficiently high such that $(1-\gamma)n\int_{I^T}^{I^{FB}} s(I)dI + (B - T^*) < r$, then it chooses $\theta = 1$, $T^S < T^*$ and $I^T < I^{FB}$.

iii. If $B < T^*$ (hence also $B - \varpi < T^*$), it compares (a) welfare from not diverting funds and transferring less than the first-best amount, resulting in $W^S|_{\theta=0, \quad B<T^*}$, with (b) welfare from funding the other opportunity and transferring even less than that to the North, resulting in $W^S|_{\theta=1, \quad B-\varpi<T^*}$. The choice will depend on the magnitude of the surplus from higher innovation compared to the foregone r (from the first relative to second option), but both choices yield $T^S < T^*$ and $I^T < I^{FB}$.

□

Proposition 7 shows that limited budgets and/or highly lucrative outside opportunities in the country with less innovation capacity can further reduce the feasibility of global buyouts relative to alternative regimes. They do this by sanding the wheels of the one mechanism identified earlier, intersovereign transfers, that can in theory bridge the international externality associated with global buyouts. Given that lesser innovation capacity is often an *outcome* itself of resource constraints, these problems, particularly of limited budgets, likely have non-trivial relevance in the real world. In turn, the potential difficulties of superseding the distributional problems we study in the paper (such as via transfers) further highlight the importance of understanding these distributional dimensions in any analysis of innovation financing.

5 Scope and limitations

This section discusses the assumptions underlying our model, focusing on robustness to alternative modelling choices. The discussion is mostly framed in terms of the results with welfare maximizing governments, but similar conclusions can be drawn about the variant with electoral concerns in the features it shares with the baseline model.

Identical demand functions The model follows the literature in assuming that consumers feature the same inverse demand functions (in all countries and across all goods). With respect to this assumption, 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 deviations would leave our main qualitative findings intact, larger deviations may affect the results in Propositions 1 and 2. To see this, consider the two extreme cases of an innovation set X that generates products only demanded by consumers in the North, and an innovation set Y that generates products only demanded in the South. In the case of Y, 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 Y. 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 the North would not in any case implement a buyout. Similarly, for X the North would always implement a buyout. At the same time, the key result in Proposition 3 would remain intact, as a globally efficient buyout with international transfer could be implemented both for X and for Y (where for X the required transfer would be zero).

Symmetric production costs The model moreover assumes that patent buyouts 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.[22] 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. At the same time, the qualitative insights obtained from Propositions 1 - 3 would largely remain the same. In particular, 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 reduce the benefits of a global buyout to those countries (as well as globally) relative to what our model implies.[23] The same applies to other constraints, including

[22]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 9).

[23]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.

those related to institutions. For example, many health-based innovations are primarily delivered through national health systems. If, on the supply side, 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.[24]

Static framework and partial equilibrium Our theoretical insights are based on a static model which abstracts from dynamics over time. 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 the general function s), 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 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.

Political heterogeneity The model assumes that voters differ in their political importance due to groups' varying swing densities. It should be noted that, while it is

[24]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).

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 and receive vote shares that reflect fundamentals. This would therefore keep the main qualitative insights in Propositions 4 - 6 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.

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. Prior 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 article, we consider two previously unstudied political economy tradeoffs that can arise from how buyouts are financed and benefited from, and explore how these can hinder the implementation of buyouts which would otherwise enhance global welfare. First, placing knowledge in the public domain in a multi-country 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. 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 analysis demonstrate how these global and domestic distributional concerns may constrain the pursuit of buyouts, potentially to the detriment of the innovating country's and the world's welfare. We also elaborate on the interaction between the two aspects, especially that domestic politics can interfere with the otherwise optimal and feasible solution of a buyout internationally financed through transfers.

In light of these findings, buyouts of globally useful innovations may be understood as *publicly financed goods with global externalities*, and hence acutely difficult to institute. At the same time, from a policy perspective, an appreciation of the political economy difficulties of instituting buyouts can facilitate an assessment of the possibilities for alleviating these constraints. Our exploration of transfer-financed buyouts is in this vein. In-depth exploration of other mechanisms is beyond the scope of this article, but here we briefly refer to possibilities for (i) sovereign initiative arising from strategic concerns and (ii) non-governmental initiative in the form of collaborative or philanthropic funding.

On the sovereign front, while transfers help to offset negative externalities from free riding, a distinct possibility (unmodelled) 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, governments of innovating countries may be interested in providing aid to less advanced economies, as this may result in positive externalities to them from political stabilization or other strategically motivated objectives (Olivie and Perez, 2020). If buyouts can be linked to such objectives, thereby viewed as one channel for aid, then concerns about loss of profits globally 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' interest to facilitate their widespread use globally, even if doing so comes at a cost. 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. For example, the debate over innovation financing and global access to technology took on renewed importance during COVID-19 not only because of the magnitude of human suffering, but also because of the externalities of innoculating against cross-border contagious disease, with the latter demonstrably boosting public support in the West for globally accessible vaccination (Klumpp et al., 2022).

However, while the presence of positive externalities from resource transfer for buyouts can help offset negative externalities associated with free riding, it 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. As shown in our analysis, these concerns stem primarily from the structure of domestic politics in the innovating countries themselves. One possible implication is that in more equal societies, and in those where political representation is *not* primarily driven by a small group of the wealthy electorate, publicly financed innovation regimes are less likely to be contentious, with positive repercussions for the rest of the world.

With respect to non-governmental initiatives, our analysis has policy implications for efforts to collaborate internationally on innovation financing, 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). These initiatives have largely focused on incentivizing innovation of drugs which cater to poor populations with limited purchasing power (e.g. neglected diseases), through advancing a design in which companies are compensated by the fund if they sell the end-products at competitive (cost) prices to the target population. Therefore, as opposed to a system like buyouts which supplants patents generally, they aim to *complement* patent financing in areas where monopoly power is an insufficient incentive due to limited market demand.

Despite the more limited scope of these initiatives (relative to buyouts), our political economy lens can shed light on their challenges and prospects. For example, the Health Impact Fund, which relies in its design on voluntary financing by wealthy states for the fund and which initially suggested a budget of 6 billion USD (later revised downward), has yet to gain traction to be implemented or even piloted. Our analysis can help explain the hesitancy of potential financiers, particularly since in this case the size of the global externality vis-a-vis domestic benefit is, by design, large. The Advanced Market Commitment initiative instead relies on philanthropic private donors and has been more successful, as evidenced by its key success to this date in pneumococcal drugs, funded by the Gates Foundation. Congruent with our framework, this is precisely because some degree of 'altruism' neutralizes the extent of international and domestic distributional conflict in the way. On the other hand, the limited aim and size of this project likely reflects limitations to altruistic funding, at least relative to the magnitude of social surplus which could motivate comprehensive non-patent systems such as buyouts.

In the renewed discourse after the COVID-19 pandemic on the consequences of patented technologies, potential toll on the global South, and alternative systems of incentivizing innovation, political economy and distributional considerations took center stage. Resistance by innovating countries to the placement of vaccine innovations in the public domain was often understood in terms of international profit loss concerns (APHA, 2022), with some evidence supporting this view in the press (Furlong et al., 2022), and with heterogeneity within countries about the desired extent of public financing for global accessibility (Clarke et al., 2021). The framework presented here, although general and not engaging with the specifics of particular innovations, emphasizes precisely these issues. We believe it can help to shed light on the primacy of political economy concerns in the choice (and consequences) of patent regimes versus other innovation regimes more generally, and to facilitate future research on feasible policy spaces in response.

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