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Industrial Policy with Network Externalities: Race to the Bottom vs. Win-Win Outcome

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Abstract

Industrial policy has returned to the centre of economic governance, particularly in the high-tech sectors where positive network externalities in demand make market dominance self-reinforcing. This paper studies the welfare effects of an industrial policy targeting a sector with network externalities in a two-country model with strategic trade and R&D investment. We show how the welfare consequences of this policy are determined by the interaction between the strength of the externality, the type of R&D, and the degree of product differentiation between the home and the imported goods. When externalities are weak or the goods are close substitutes, the business-stealing effect produces a race to the bottom that dissipates more surplus than it creates. Under sufficiently strong externalities and weak substitutability or complementarity of the goods, industrial policy competition can make both countries simultaneously better off compared to the laissez-faire outcome because of the mutual business-enhancement effect. The case is stronger for the product innovation than for the process innovation, as the former directly affects the demand and triggers a stronger network effect than the latter which operates indirectly through the supply. Thus, network externalities create an opportunity for win-win industrial policies, but its realisation depends on the market structure and the nature of innovation.

JEL Classification: F13, H25, L13, O38

Keywords: Industrial policy, network externalities, R&D subsidies, strategic trade, Cournot competition

1 Introduction

The global resurgence of industrial strategy is increasingly focused on high-tech sectors often characterised by positive network externalities in demand, where the value of a product or a technology depends on the breadth of its adoption. Governments are simultaneously subsidising domestic firms and deterring foreign rivals using fiscal instrument, such as import tariffs or digital service taxes, and stringent regulations. The strategic-trade literature provides a well-established framework for analysing subsidies and taxes in oligopolistic settings, but that framework does not account for network externalities in demand. Whether the policy mix that governments are pursuing is welfare-improving or self-defeating in these sectors remains an open question. This paper establishes a theoretical framework delineating the conditions under which such strategies succeed or fail.

The status of industrial policy as a centrepiece of economic governance is not a new phenomenon, but rather a returning one. In the decades after the Second World War, governments in both advanced and developing economies routinely used tariffs, subsidies, public procurement, and directed credit to promote domestic industry and technological upgrading (Juhász et al., 2024; Aiginger and Rodrik, 2020). By the 1980s and 1990s, however, industrial strategy had fallen out of favour across much of the developed world. Globalisation, trade liberalisation, and growing scepticism about the state's ability to "pick winners" shifted the consensus toward market allocation and away from selective intervention (Pack and Saggi, 2006; Krueger, 1990). That consensus has been diluted by recent global shocks. The COVID-19 pandemic exposed the fragility of global supply chains, while geopolitical rivalry and concerns about technological sovereignty have made dependence on a small number of dominant foreign suppliers appear increasingly costly (Millot and Rawdanowicz, 2024). As a result, governments across the major economies have become willing to intervene directly in production, innovation, and market structure in sectors viewed as strategically important.

Semiconductors provide the clearest example. The US CHIPS and Science Act of 2022 committed approximately \$52 billion to domestic semiconductor manufacturing (United States Congress, 2022), while the EU Chips Act aims to mobilise more than €43 billion (European Commission, 2023). These initiatives combine support for domestic production with measures such as taxes and export restrictions, that erode the market share of foreign competitors. Moreover, electric vehicles, AI platforms, and renewable energy ecosystems all exhibit network externalities in demand, where the value of adoption depends on the breadth of the existing user base and complementary infrastructure (Li et al., 2017). The sectors where industrial policy is most actively deployed are precisely the sectors where network externalities are strongest.

In a standard strategic-trade setting, a government may wish to subsidise its domestic firm and tax the domestic sales of the foreign firm in order to shift oligopolistic rents toward home producers. When the demand is shaped by network externalities, however, policy affects not only static rents but also the self-reinforcing dynamics of adoption and market position, thus becoming a double-edged sword. A subsidy that increases the domestic firm's output strengthens the network externality associated with the domestic good, which in turn raises demand further. A tax on the foreign firm not only reduces its market share directly but weakens the network externality associated with the foreign good, compounding the competitive disadvantage. Each instrument reinforces the other through the network externality. On the other hand, if the foreign good benefits from a strong network externality, taxing that firm is particularly costly to home consumers, who lose access to the network externality associated with the foreign good. The optimal policy mix in such an environment can be qualitatively different from the standard case.

Despite the policy importance of this setting, no existing framework brings these elements together. The classical strategic-trade literature analyses how governments can use taxes or subsidies to alter the outcome of oligopolistic rivalry (Spencer and Brander, 1983; Brander and Spencer, 1985; Eaton and Grossman, 1986). Later extensions by Leahy and Neary (2001) and Haaland and Kind (2008) study R&D subsidies with spillovers and business-stealing motives, but none of these models incorporates network externalities in demand. Separately, building on the foundational contributions of Katz and Shapiro (1985, 1986), Farrell and Saloner (1985, 1986), and the consumption-side framework of Grilo et al. (2001), the network-externality literature explains how adoption feedback and compatibility shape market outcomes, but does not address optimal government policy in an international setting. Recent work by Naskar and Pal (2020) introduces network externalities into R&D competition but omits the government's policy choice entirely. The emerging literature on the new industrial policy (Juhász et al., 2024) has revived interest in the design of state intervention but lacks structural models of optimal policy design in sectors with network externalities. The interaction of strategic trade policy instruments with network externalities in demand remains unexplored. In our work we seek to fill this gap.

We develop a two-country, two-firm model in which the firms invest in R&D and sell differentiated goods that exhibit network externalities in demand. Governments support their producers by subsidising their R&D outlays. In addition, the government of the importing country taxes the sales of the foreign good. We derive the equilibrium under two R&D specifications, cost-reducing, or process R&D, and quality-enhancing, or product R&D, and use numerical exercises to illustrate the welfare consequences of policy interaction. A central question is whether the pursuit of industrial strategy is welfare-improving or leads to a self-defeating race to the bottom in the equilibrium.

Several results emerge. First, both government optimally choose to subsidise the R&D investment of their firms. This is consistent with the observed escalation of subsidy commitments in critical sectors across the US, EU, and China. Second, the sign of the optimal import tax and the welfare consequences of this policy interaction depend on both the strength of network externalities and the degree of product differentiation. Under the process R&D, the home country (the importer) gains at the expense of the foreign country (the exporter) regardless of the product differentiation. When the network externalities are weak, the policy competition destroys more surplus than it creates: the exporter's loss exceeds the importer's gain, so that collectively the countries would be better off without intervention. When the network externalities are strong enough, the importer's gain outweighs the exporter's loss, and policy competition raises aggregate welfare above laissez-faire. Under the product R&D, the pattern changes when the home and foreign goods are sufficiently differentiated. When the home and the foreign goods are weak substitutes or complements, the optimal tax turns negative when the network externality is sufficiently strong: rather than taxing the foreign rival, the home government finds it optimal to subsidise it. Import subsidy catalyses market-wide adoption through externality in demand. The gains from a larger, more valuable technological ecosystem outweigh the fiscal expenditure and the loss of domestic market share, turning a strategic rivalry into a win-win outcome, where both countries are simultaneously better off than under laissez-faire. Under relatively strong substitutability, the domestic firm's profit loss from reduced market share outweighs the gain in consumer surplus, and the home government choses to tax imports.

The win-win result is not observed in our model under the process R&D because the cost-reducing innovation shifts the supply curve and triggers the externality effect only indirectly, through the quantities demanded in the equilibrium. In contrast, the product R&D shifts the demand curve and triggers the externality directly. Hence, the combination of subsidies to R&D and imports creates a stronger mechanism for internalising the externality, especially when the goods are complements or sufficiently weak substitutes. The win-win result in our framework, therefore, requires a combination of three conditions: strong network externalities, demand-side innovation (product R&D), and sufficient product differentiation. Network externalities create the possibility; market structure determines whether it is realised.

The model admits a broader interpretation that connects these theoretical findings to the industrial realities of high-tech supply chains. The demand structure driven by network externalities in consumption is formally analogous to derived demand from a downstream sector of profit-maximising firms using the goods as intermediate inputs. Under this interpretation, network externalities correspond to agglomeration effects, where the value of an input increases as its adoption grows across the downstream sector through cross-firm compatibility, shared technical standards, and a deeper pool of specialised complementary services. The government's objective can then be read as maximisation of downstream industrial surplus. We maintain consumer-centric terminology throughout, but the results apply equally to competition for dominance in global intermediate-good markets.

The remainder of the paper is organised as follows. Section 2 reviews the related literature. Section 3 presents the model. Section 4 derives the equilibrium and states the analytical results for both process and product R&D. Section 5 uses numerical exercises to characterise the welfare effects of non-cooperative industrial policy under each R&D specification, and identifies the conditions under which intervention becomes self-defeating or mutually beneficial. Section 6 concludes. Supplementary Material[1] contains additional numerical examples and a discussion of the model limitations and potential extensions.

2 Related Literature

This paper bridges two distinct strands of research. The first is the strategic-trade and R&D-policy literature, which studies how governments use subsidies or trade instruments to alter the outcome of oligopolistic rivalry. The second is the literature on network externalities, compatibility, and network competition, which explains how network externalities in demand can make market leadership self-reinforcing. Existing work shows important parts of the problem, but there is still no integrated framework for analysing how a government should combine a tax on a foreign rival with domestic R&D subsidies when firms compete in a market with network externalities.

The strategic-trade literature provides the starting point. Spencer and Brander (1983) show that in an international duopoly with process R&D, a domestic government may wish to subsidise innovation in order to shift profits from the foreign to the home firm. Brander and Spencer (1985) extend the broader strategic-trade logic by showing how policy can shift oligopolistic rents in quantity competition, while Eaton and Grossman (1986) demonstrate that the direction of optimal intervention depends on the mode of competition. Together, these papers established the central insight that government policy can act as a strategic commitment device in imperfectly competitive international markets.

Later extensions of this framework that are directly relevant for the present paper include, for example, Leahy and Neary (2001), who study industrial policy with process and product R&D and innovation spillovers. This work shows that non-cooperative policy competition may generate over- or under-subsidisation and can leave both countries worse off. Lin and Saggi (2002) analyse the sequential choice of product and process R&D investments. They show that process R&D and product R&D can be complementary, since quality improvement raises the return to cost reduction and cost reduction supports larger output and hence greater returns to quality. Haaland and Kind (2006) analyse cooperative and non-cooperative R&D policy when governments can subsidise both process and product R&D, and show that the strength of the strategic subsidy motive depends on the degree of product differentiation. In a subsequent study, Haaland and Kind (2008) show, in a two-country framework, that the interaction between process R&D and trade policy does not always lead to excessively high subsidies, but, instead, can result in either symmetric or asymmetric equilibria, where only one firm survives and the other firm is inactive, depending on the degree of product differentiation. Symeonidis (2003); Ishii (2014); Hoefele (2016) further analyse product R&D in international oligopoly,

[1] https://arxiv.org/html/2603.29542v1#A1a

showing how product differentiation, competition mode, and trade exposure interact in shaping innovation incentives.

Other extensions of the strategic-trade and R&D framework address trade liberalisation with firm heterogeneity (Long et al., 2011), technology licensing and R&D incentives (Chang et al., 2013), leader-follower R&D subsidy dynamics in which an R&D subsidy can eliminate a foreign first-mover advantage through competitiveness-shifting rather than pure profit-shifting (Garcia Pires, 2009), R&D information disclosure (Baik and Kim, 2020), and product R&D under trade costs (Yang, 2018). These results highlight that the joint effect of tariffs and R&D incentives cannot be evaluated independently of market structure. However, this work does not incorporate network externalities in demand.

Closer to the present paper, Naskar and Pal (2020) bring network externalities into the analysis of process R&D. They show that stronger network effects raise firms' incentives to invest in cost-reducing innovation and can even overturn the standard Cournot-Bertrand ranking of R&D incentives. However, in their framework the two firms operate in a closed economy, and the government is inactive. More recently, Ghosh et al. (2024) study optimal trade policy in an export-rivalry model of differentiated network goods and show that network externalities can alter the sign of the optimal trade instrument. Their results demonstrate that network effects can change strategic-trade prescriptions qualitatively. At the same time, it does not study R&D investment and innovation policies that are central in this study.

The modern theory of network externalities and their role in competition is built on the classic contributions of Katz and Shapiro (1985, 1986) and Farrell and Saloner (1985, 1986). These papers show how compatibility choices, consumer expectations, and network externalities can generate self-reinforcing market positions and path dependence. A firm that gains an early lead may benefit not only from static demand but also from the expectation that more users, more complementary goods, and greater compatibility will attach to its product or service in the future. This is precisely the broad economic logic that motivates the network parameter in the present model.

Economides (1996) provides a general survey of network economics showing how network effects enter demand and pricing decisions. Our framework is close to that of Grilo et al. (2001) in modelling conformity effects directly on the demand side. Their framework provides a useful bridge between the classic literature on network goods and the reduced-form specification used in this paper, where willingness to pay depends positively on aggregate adoption.

A related public-finance literature studies the effect of network externalities on optimal taxation of platform-type markets; see Kind and Schjelderup (2025) for a recent review. Kind et al. (2008, 2009, 2010) show that in multi-sided markets standard tax-incidence results can fail and that taxes may affect welfare in ways that qualitatively differ from those for one-sided markets. This logic is extended to digital media markets in Kind and Koethenbuerger (2018). Cui and Hashimzade (2019) provide a useful conceptual foundation for the tax instrument by interpreting the digital services tax as a levy on location-specific rent. While this literature does not analyse the strategic-trade environment studied here, it demonstrates an analogous result: in the presence of network externalities the effects of taxation are no longer well captured by standard intuition.

Recent geoeconomic development renewed the interest in industrial policy among economists. Aiginger and Rodrik (2020) argue that industrial policy has re-emerged as a serious field of economic analysis after decades in which it was often treated with scepticism. Juhász et al. (2024) survey the new economics of industrial policy and show that the recent literature is more empirically disciplined and more attentive to market failures, coordination problems, and learning effects than earlier debates. Millot and Rawdanowicz (2024) place this revival in the current policy environment, emphasising national security, supply-chain resilience, decarbonisation, and technological sovereignty as key motives for renewed intervention.

These themes are directly relevant to sectors in which network effects or ecosystem effects matter. While large body of work has focussed on externalities in the use of digital platforms, network effects are also relevant well beyond purely digital markets, whenever compatibility, shared infrastructure, complementary software, and trained users or engineers increase the value of adoption. Semiconductor manufacturing policy is the clearest example. Recent work by Erten et al. (2025) provides early evidence on the employment effects of the US CHIPS Act and points to meaningful local spillovers from semiconductor investment. In the electric-vehicle market, for example, vehicle adoption and charging-station investment are linked by indirect network effects: more charging infrastructure raises the attractiveness of electric vehicles, and a larger fleet of electric vehicles raises the return to charging investment. Li et al. (2017) provide direct evidence of these feedback effects. On the theoretical side, Long and Cai (2023), motivated directly by CHIPS Act-style programmes, study why governments subsidise R&D-intensive foreign direct investment and show that when domestic absorptive capacity is high, R&D-targeted FDI subsidies can be welfare-superior to output subsidies or technology transfer mandates.

More broadly, current policies in semiconductors, EVs, and AI combine support for domestic production and innovation with measures that disadvantage foreign rivals through taxes, tariffs, export controls, procurement rules, or regulation. The exact instrument differs across sectors, but the common policy question is how governments should balance the support for domestic innovation against the intervention directed at foreign competitors. Our paper contributes to the literature by providing a theoretical structure for evaluation of the government intervention when industrial policy interacts with externalities and the market structure.

3 The Model

Consider two countries, home and foreign, each with one firm producing a differentiated good that exhibits network externalities in demand. Good 1 is produced by the foreign firm (Firm 1) and good 2 by the home firm (Firm 2). A third good, good 0, is produced by a perfectly competitive sector using one unit of labour per unit of output and is traded freely and costlessly; it serves as the numéraire. All goods are produced using labour as the only input.

For tractability, we model consumers (or, equivalently, downstream industry; see Remark 1 below) only in the home country. Thus, the home country is the importer and the foreign country is the exporter. Home consumers supply inelastically L units of labour, own equal shares in the home firm, and receive a lump-sum transfer from the government. Both goods exhibit network externalities in consumption and are imperfect substitutes. Both firms can invest in (cost-reducing) process innovation and (demand-enhancing) product innovation. Each government subsidises its own firm's R&D costs, and the home government levies a sales tax on the foreign firm's product. The interaction is modelled as a two-stage simultaneous-move game:

Stage 1. Both governments simultaneously announce their tax and subsidy policies.

Stage 2. Both firms simultaneously choose output quantities and R&D investments.

The equilibrium concept is sub-game perfect Nash equilibrium, obtained by backward induction.

3.1 Demand

The representative home-country consumer maximises the quasi-linear utility function (Singh and Vives, 1984):

$$\max_{q_0,\, q_1,\, q_2} \; U = A_1\, q_1 + A_2\, q_2 - \frac{1}{2}\Big(q_1^2 + q_2^2 + 2m\, q_1 q_2\Big) + q_0 \tag{1}$$

subject to the budget constraint

$$p_1 q_1 + p_2 q_2 + q_0 = M = L + \pi_2 + T, \tag{2}$$

where L is labour income, π_2 is the home firm's profit, and T is the lump-sum government transfer. The parameter $m \in [-1, 1]$ measures the degree of substitutability between goods 1 and 2: the goods are homogeneous when $m = 1$, substitutes when $m > 0$, complements when $m < 0$, and independent when $m = 0$.

Maximisation yields the inverse demand functions:

$$p_i = A_i - q_i - m\, q_j, \qquad i \neq j, \quad i, j \in \{1, 2\}. \tag{3}$$

Here A_i is the choke price, or the maximum willingness to pay when quantity demanded is zero. Two channels determine A_i. The first is the network externality effect, a_i, and the second is the product quality effect, r_i. We assume that these two effects are independent and additive,

$$A_i = a_i + r_i, \tag{4}$$

The quality of good i, measured by r_i, is determined by costly investment in product R&D by firm i.

Network externalities. Following Leibenstein (1950) and Grilo et al. (2001), and related work by Naskar and Pal (2020), we model positive network externalities as a positive effect of the aggregate consumption on the willingness to pay.[2] Specifically:

$$a_i = a + b_i Q_i, \tag{5}$$

where Q_i is the perceived aggregate demand for good i, $a > 0$ is a baseline demand parameter, and $b_i \in (0, 1)$ measures the strength of the network externality for good i.

Note that in our framework, unlike Grilo et al. (2001) where each consumer buys one unit, the representative consumer purchases q_i units. The network externality therefore enters through aggregate quantity rather than the number of consumers. In a fulfilled-expectations equilibrium, perceived and actual market demand coincide: $Q_i = q_i$.

Substituting (5) into (3), the demand system becomes:

$$p_1 = a + r_1 - (1 - b_1)\, q_1 - m\, q_2, \tag{6}$$

$$p_2 = a + r_2 - (1 - b_2)\, q_2 - m\, q_1. \tag{7}$$

The network externality reduces the effective slope of the demand curve from 1 to $(1-b_i)$. Stronger network effects make demand less responsive to own-quantity increases, because higher consumption reinforces willingness to pay.

3.2 Firms

Both firms are profit maximisers. The foreign firm (firm 1) faces a sales tax at rate $t \in (0, 1)$ levied by the home government on revenue from sales to home consumers.[3] The home firm (firm 2) faces no tax on domestic sales. There are no transport costs.

Each firm i can invest in two types of R&D:

[2] Naskar and Pal (2020) also assume that the individual willingness to pay is an increasing function of other buyers' demand, but use a different functional specification.

[3] This revenue-based tax structure captures a class of policy instruments that have proliferated internationally since the mid-2010s, including digital services taxes, equalisation levies, and withholding taxes on cross-border service payments. See Supplementary Material, Section **??** for a discussion and country-specific examples.

- *Process R&D* reduces marginal production cost from c_i to $(c_i - k_i)$, at a cost of $\frac{\varphi_i k_i^2}{2}$;

- *Product R&D* raises demand by r_i, at a cost of $\frac{\theta_i r_i^2}{2}$,

where φ_i and θ_i are (inverse) R&D efficiency parameters for process and product R&D respectively. Each government subsidises its own firm's R&D at rates s_i (process) and σ_i (product), so that the firm's net R&D cost is $(1-s_i)\frac{\varphi_i k_i^2}{2} + (1-\sigma_i)\frac{\theta_i r_i^2}{2}$.

Profits are:

$$\pi_1 = (1-t)\, p_1\, q_1 - (c_1 - k_1)\, q_1 - (1-s_1)\,\frac{\varphi_1 k_1^2}{2} - (1-\sigma_1)\,\frac{\theta_1 r_1^2}{2}, \tag{8}$$

$$\pi_2 = p_2\, q_2 - (c_2 - k_2)\, q_2 - (1-s_2)\,\frac{\varphi_2 k_2^2}{2} - (1-\sigma_2)\,\frac{\theta_2 r_2^2}{2}. \tag{9}$$

3.3 Governments

The foreign government maximises its firm's profit net of subsidy expenditure:

$$W_1 = \pi_1 - s_1\,\frac{\varphi_1 k_1^2}{2} - \sigma_1\,\frac{\theta_1 r_1^2}{2}. \tag{10}$$

The home government maximises the welfare of its representative consumer, which includes consumer surplus, the home firm's profit, and net tax revenue (tax collected minus subsidies paid), all returned as a lump-sum transfer:

$$W_2 = U + \pi_2 - s_2\,\frac{\varphi_2 k_2^2}{2} - \sigma_2\,\frac{\theta_2 r_2^2}{2} + t\, p_1\, q_1. \tag{11}$$

Remark 1 (Supply-Chain Isomorphism)**.** While derived from a representative consumer's utility, the demand system in (6)–(7) is mathematically isomorphic to the derived demand of a downstream industry using intermediate inputs. Specifically, if a downstream sector employs a quadratic production technology, the profit-maximisation conditions for these firms yield an identical linear mapping between input prices and quantities. In this context, the network externality captures productive spillovers, such as technical compatibility, shared infrastructure, or ecosystem-specific human capital, which increase an input's value as its adoption grows. Under this reinterpretation, the consumer surplus in the home government's objective function is replaced by the downstream industrial rents. The strategic equilibrium between upstream producers remains invariant to this change in narrative, ensuring that the welfare results extend to competition for dominance in intermediate-good markets.

3.4 Stage 2: Profit Maximisation

We solve the game by backward induction, beginning with Stage 2. Taking government policies $(t, s_1, \sigma_1, s_2, \sigma_2)$ as given, each firm simultaneously chooses output and R&D outlays to maximise profit.

Substituting the demand functions (6)–(7) into the profit functions and differentiating, the first-order conditions for the foreign firm are:

$$\frac{\partial \pi_1}{\partial q_1} = (1-t)\left[a + r_1 - 2(1-b_1)\, q_1 - m\, q_2\right] - (c_1 - k_1) = 0, \tag{12}$$

$$\frac{\partial \pi_1}{\partial k_1} = q_1 - (1-s_1)\, \varphi_1\, k_1 = 0, \tag{13}$$

$$\frac{\partial \pi_1}{\partial r_1} = (1-t)\, q_1 - (1-\sigma_1)\, \theta_1\, r_1 = 0. \tag{14}$$

These yield:

$$q_1 = \frac{1}{2(1-b_1)}\left[a + r_1 - m\, q_2 - \frac{c_1 - k_1}{1-t}\right], \quad k_1 = \frac{q_1}{(1-s_1)\, \varphi_1}, \quad r_1 = \frac{(1-t)\, q_1}{(1-\sigma_1)\, \theta_1}. \tag{15}$$

Similarly, the home firm's optimal choices satisfy:

$$q_2 = \frac{1}{2(1-b_2)}\left[a + r_2 - m\, q_1 - (c_2 - k_2)\right], \quad k_2 = \frac{q_2}{(1-s_2)\, \varphi_2}, \quad r_2 = \frac{q_2}{(1-\sigma_2)\, \theta_2}. \tag{16}$$

In the choice of R&D investment, each firm equates the marginal benefit of R&D (additional output, or additional revenue for product R&D) to its marginal cost (net of subsidy). Higher subsidies and lower R&D cost parameters increase R&D intensity for any given level of output.

The equilibrium with both R&D channels active is derived in Section 4.1. The analysis then proceeds for two separate cases, process R&D only and product R&D only.

4 Equilibrium Analysis

We solve the Stage 2 equilibrium by backward induction. This section first considers the general case in which both process and product R&D are active, then analyses two separate cases that isolate the mechanism: process R&D only (Section 4.2) and product R&D only (Section 4.3). Throughout, we focus on the substitute-goods case ($m > 0$) as the primary setting; this is arguably the empirically most relevant case for competing strategic goods such as rival chip architectures or EV ecosystems. The analysis of the complements case ($m < 0$) is straightforward; the details and discussion are provided in the Supplementary Material (Section S3).[4]

4.1 Equilibrium with Both R&D Channels

Substituting the R&D conditions $k_i = q_i/[(1-s_i)\varphi_i]$ and r_i from (15)–(16) back into the output equations yields a linear system in (q_1, q_2). For the foreign firm:

$$\Gamma_1\, q_1 = a - \frac{c_1}{1-t} - m\, q_2, \tag{17}$$

where

$$\Gamma_1 \;\equiv\; 2(1-b_1) - \frac{1-t}{(1-\sigma_1)\theta_1} - \frac{1}{(1-t)(1-s_1)\varphi_1} \tag{18}$$

captures the effective slope of the foreign firm's best-response function, inclusive of both R&D feedbacks. The first subtracted term reflects product R&D. Investment in quality raises willingness to pay for the foreign good, flattening the residual demand curve. The second reflects process R&D. Cost reduction raises the effective intercept by the same mechanism as in the standard Brander–Spencer model.

For the home firm:

$$\Gamma_2\, q_2 = a - c_2 - m\, q_1, \tag{19}$$

where

$$\Gamma_2 \;\equiv\; 2(1-b_2) - \frac{1}{(1-\sigma_2)\theta_2} - \frac{1}{(1-s_2)\varphi_2}. \tag{20}$$

Solving the system of two best responses gives for the quantities in an interior equilibrium:

$$q_1 = \frac{\dfrac{1}{\Gamma_1}\left[a - \dfrac{c_1}{1-t}\right] - \dfrac{m}{\Gamma_1\,\Gamma_2}\left[a - c_2\right]}{\Delta^{kr}}, \tag{21}$$

$$q_2 = \frac{\dfrac{1}{\Gamma_2}\left[a - c_2\right] - \dfrac{m}{\Gamma_1\,\Gamma_2}\left[a - \dfrac{c_1}{1-t}\right]}{\Delta^{kr}}. \tag{22}$$

where

$$\Delta^{kr} \;\equiv\; 1 - \frac{m^2}{\Gamma_1\,\Gamma_2}, \tag{23}$$

Once q_1 and q_2 are determined, all four R&D investment levels follow immediately: $k_i = q_i/[(1-s_i)\varphi_i]$, $r_1 = (1-t)q_1/[(1-\sigma_1)\theta_1]$, and $r_2 = q_2/[(1-\sigma_2)\theta_2]$.

An interior equilibrium requires $\Gamma_i > 0$ and $\Delta^{kr} > 0$. We focus on the set of parameters for which both conditions are satisfied.

[4] https://arxiv.org/html/2603.29542v1#A3

The two R&D channels enter Γ_i additively, each reducing the effective slope of the firm's best-response function and thereby strengthening the equilibrium response to any policy change. We now proceed to the analysis of each type of innovation separately.

4.2 Process R&D

Setting $r_1 = r_2 = 0$ simplifies Γ_i, leading to the equilibrium described by

$$q_1 = \frac{1}{2(1-b_1)}\left[a - mq_2 - \frac{c_1 - k_1}{1-t}\right], \qquad k_1 = \frac{q_1}{(1-s_1)\varphi_1}, \tag{24}$$

$$q_2 = \frac{1}{2(1-b_2)}\left[a - mq_1 - (c_2 - k_2)\right], \qquad k_2 = \frac{q_2}{(1-s_2)\varphi_2}. \tag{25}$$

Substituting the R&D equations into the output equations and solving for outputs gives

$$q_1 = \frac{\frac{1}{2(1-b_1)}\left[a - \frac{c_1}{1-t}\right]\left[1 - \frac{1}{2(1-b_2)(1-s_2)\varphi_2}\right] - \frac{m(a-c_2)}{2(1-b_2)}}{\Delta^k}, \tag{26}$$

$$q_2 = \frac{\frac{1}{2(1-b_2)}\left[a - c_2\right]\left[1 - \frac{1}{2(1-b_1)(1-t)(1-s_1)\varphi_1}\right] - \frac{m}{2(1-b_1)}\left[a - \frac{c_1}{1-t}\right]}{\Delta^k}. \tag{27}$$

Investment levels then follow from $k_i = q_i/[(1-s_i)\varphi_i]$.

Here,

$$\Delta^k \equiv \left[1 - \frac{1}{2(1-b_1)(1-t)(1-s_1)\varphi_1}\right]\left[1 - \frac{1}{2(1-b_2)(1-s_2)\varphi_2}\right] - \frac{m^2}{4(1-b_1)(1-b_2)}. \tag{28}$$

An interior equilibrium with strictly positive quantities requires $\Delta^k > 0$, which is guaranteed for $0 < b_i < 1$, $0 < s_i < 1$, and m not too large.[5] The equilibrium quantities are:

Proposition 1 (Policy effects on output under process R&D)**.** *Under the maintained assumptions ($\Delta^k > 0$, $b_i \in (0,1)$, $s_i \in (0,1)$), the following comparative statics hold:*

Foreign firm:

(i) $\frac{\partial q_1}{\partial t} < 0$, $\frac{\partial k_1}{\partial t} < 0$: *the home tax reduces foreign output and process R&D.*

(ii) $\frac{\partial q_1}{\partial s_1} > 0$, $\frac{\partial k_1}{\partial s_1} > 0$: *the foreign subsidy increases foreign output and process R&D.*

[5] The second-order conditions for each firm's profit maximisation also require $1 - \frac{1}{2(1-b_1)(1-t)(1-s_1)\varphi_1} > 0$ and $1 - \frac{1}{2(1-b_2)(1-s_2)\varphi_2} > 0$, which hold under the maintained parameter restrictions. See Appendix B for details.

(iii) $\dfrac{\partial q_1}{\partial s_2} \leq 0$ *for* $m \geq 0$*: the home subsidy reduces foreign output when goods are substitutes, with equality when* $m = 0$*.*

Home firm:

(iv) $\dfrac{\partial q_2}{\partial t} \geq 0$, $\dfrac{\partial k_2}{\partial t} \geq 0$ *for* $m \geq 0$*: the home tax on the foreign rival increases home output and R&D when goods are substitutes.*

(v) $\dfrac{\partial q_2}{\partial s_2} > 0$, $\dfrac{\partial k_2}{\partial s_2} > 0$*: the home subsidy always increases home output and R&D.*

(vi) $\dfrac{\partial q_2}{\partial s_1} \leq 0$ *for* $m \geq 0$*: the foreign subsidy reduces home output when goods are substitutes.*

Proof. See Appendix A.[6] □

The home tax t reduces the foreign firm's net revenue per unit, directly discouraging its output and R&D. When goods are substitutes, this contraction benefits the home firm through reduced competitive pressure, or the "business-stealing" effect. Each firm's own-government subsidy unambiguously increases its output and R&D outlays by reducing the effective cost of innovation. Cross-subsidy effects depend on the degree of substitutability: when $m > 0$, a rival's subsidy intensifies competition and reduces the other firm's equilibrium output.

Proposition 2 (Network externality effects on output under process R&D)**.** *Under the same maintained assumptions:*

(i) $\dfrac{\partial q_i}{\partial b_i} > 0$, $\dfrac{\partial k_i}{\partial b_i} > 0$*: a stronger network externality on own good consumption increases own output and process R&D.*

(ii) $\dfrac{\partial q_i}{\partial b_j} \leq 0$, $\dfrac{\partial k_i}{\partial b_j} \leq 0$ *for* $m \geq 0$ $(i \neq j)$*: a stronger network externality in the rival's good consumption reduces own output and R&D when goods are substitutes.*

Proof. See Appendix A.[7] □

The network externality acts as an amplifier on the demand side. Stronger network externalities make the demand curve less steep (the effective slope is $1 - b_i$), so each unit of output generates greater willingness to pay. Under substitutability, this amplification

[6] https://arxiv.org/html/2603.29542v1#A1
[7] https://arxiv.org/html/2603.29542v1#A1

spills over negatively to the rival. In other words, a stronger network externality for one firm's good crowds out the other. This mechanism is central to the policy analysis. It implies that the stakes of industrial policy are higher when network externalities are strong, because falling behind becomes self-reinforcing.

Proposition 3 (Foreign subsidy best response under process R&D)**.** *The foreign government's best response in the process R&D subsidy competition is:*

$$s_1^* = \frac{\dfrac{m^2}{4(1-b_1)(1-b_2)}}{1 - \dfrac{1}{2(1-b_2)(1-s_2)\varphi_2}}. \tag{29}$$

In particular,

(i) $s_1^* > 0$ *whenever* $m \neq 0$*: the foreign government subsidises its firm unless the goods are independent.*

(ii) s_1^* *is independent of the home tax* t*.*

(iii) s_1^* *is increasing in the home subsidy* s_2 *(i.e.* $ds_1^*/ds_2 > 0$ *for* $m \neq 0$*): subsidies are strategic complements.*

Proof. See Appendix A.[8] □

The independence of s_1^* from t arises because the foreign subsidy operates through the R&D channel, which affects the foreign firm's cost structure, while the home tax affects revenue. The strategic complementarity ($ds_1^*/ds_2 > 0$) implies that unilateral subsidies provoke retaliatory subsidies. This is consistent with the observation of the escalating competition in semiconductors and EVs.

Proposition 4 (Home subsidy best response under process R&D and independent goods)**.** *When goods are independent* ($m = 0$)*, the home government's best response in the process R&D subsidy is:*

$$s_2^* = \frac{1}{1 + 2(1-b_2)}, \tag{30}$$

In particular, the optimal home subsidy is strictly positive, is independent of the foreign subsidy, and is increasing in the network externality parameter b_2*. Stronger network externalities call for higher subsidies.*

Proof. See Appendix A.[9] □

[8] https://arxiv.org/html/2603.29542v1#A1
[9] https://arxiv.org/html/2603.29542v1#A1

For $m > 0$, the system of the first-order conditions for an interior solutions is non-linear and cannot be solved in closed form. The numerical exercises in Section 5 confirm that, for the admissible range of parameters in an interior equilibrium, the home government optimally sets both a positive subsidy $s_2 > 0$ and a positive tax $t > 0$ when goods are substitutes ($m > 0$).

The positive subsidy at $m \geq 0$ reflects the consumer-surplus motive. Subsidising home-firm R&D lowers production costs, which benefits home consumers through lower prices and higher utility. The fact that s_2^* is increasing in b_2 means the case for subsidising domestic R&D is stronger in sectors with more powerful network externalities.

4.3 Product R&D

When firms invest in quality-enhancing (product) R&D rather than cost-reducing (process) R&D, the equilibrium structure changes in an important way. Firstly, the R&D directly amplifies the network effect by expanding the individual demand function. Second, the tax rate enters the foreign firm's optimal innovation choice directly, making it a more potent policy instrument. Setting $k_1 = k_2 = 0$ gives for the Stage 2 equilibrium

$$q_1 = \frac{1}{2(1-b_1)}\left[a + r_1 - mq_2 - \frac{c_1}{1-t}\right], \qquad r_1 = \frac{(1-t)\,q_1}{(1-\sigma_1)\theta_1}, \tag{31}$$

$$q_2 = \frac{1}{2(1-b_2)}\left[a + r_2 - mq_1 - c_2\right], \qquad r_2 = \frac{q_2}{(1-\sigma_2)\theta_2}. \tag{32}$$

The key difference is visible in the foreign firm's R&D choice (31): the factor $(1-t)$ multiplies q_1 in r_1, so the home tax reduces the marginal revenue from quality improvement directly. Under process R&D, the tax discourages foreign innovation only indirectly, by shrinking output and thereby lowering the return to cost reduction. Under product R&D, the tax simultaneously reduces the foreign firm's output and its incentive to invest in quality per unit of output. This is why a smaller tax achieves a comparable strategic effect, and why the welfare implications of the two R&D specifications differ in the numerical analysis of Section 5.

Substituting the R&D conditions back into the output equations and solving yields the equilibrium quantities:

$$q_1 = \frac{\frac{1}{2(1-b_1)}\left[a - \frac{c_1}{1-t}\right]\left[1 - \frac{1}{2(1-b_2)(1-\sigma_2)\theta_2}\right] - \frac{m(a-c_2)}{2(1-b_2)}}{\Delta^r}, \tag{33}$$

$$q_2 = \frac{\frac{1}{2(1-b_2)}\left[a - c_2\right]\left[1 - \frac{1-t}{2(1-b_1)(1-\sigma_1)\theta_1}\right] - \frac{m}{2(1-b_1)}\left[a - \frac{c_1}{1-t}\right]}{\Delta^r}, \tag{34}$$

where

$$\Delta^r \equiv \left[1 - \frac{1-t}{2(1-b_1)(1-\sigma_1)\theta_1}\right]\left[1 - \frac{1}{2(1-b_2)(1-\sigma_2)\theta_2}\right] - \frac{m^2}{4(1-b_1)(1-b_2)}. \tag{35}$$

An interior equilibrium requires $\Delta^r > 0$, analogous to the condition on Δ^k in Section 4.2. The comparative statics mirror the process-R&D case.

Proposition 5 (Policy effects on output and product R&D)**.** *Under the maintained assumptions ($\Delta^r > 0$, $b_i \in (0,1)$, $\sigma_i \in (0,1)$):*

(i) *The home tax reduces foreign output and product R&D: $\partial q_1/\partial t < 0$, $\partial r_1/\partial t < 0$.*

(ii) *Each firm's own-government subsidy increases its output and product R&D.*

(iii) *When the goods are substitutes ($m > 0$), the rival's subsidy reduces own output and R&D; the home tax increases home output and R&D.*

(iv) *When the goods are independent ($m = 0$), cross-country policy effects vanish.*

Proof. See Appendix B.[10] □

Proposition 6 (Network externality effects under product R&D)**.** *A stronger own-network externality increases own output and product R&D, while a stronger rival's network externality reduces own output and R&D when goods are substitutes ($m > 0$).*

Proof. See Appendix B.[11] □

Proposition 7 (Foreign subsidy best response under product R&D)**.** *The foreign government's best response in the product R&D subsidy is:*

$$\sigma_1^* = \frac{\dfrac{m^2}{4(1-b_1)(1-b_2)}}{1 - \dfrac{1}{2(1-b_2)(1-\sigma_2)\theta_2}}. \tag{36}$$

Specifically, (i) $\sigma_1^* > 0$ when $m \neq 0$; (ii) σ_1^* is independent of t; and (iii) subsidies are strategic complements.

Proof. See Appendix B.[12] □

Proposition 8 (Home policy under product R&D and independent goods)**.** *When $m = 0$, the home government's optimal product R&D subsidy is:*

$$\sigma_2^* = \frac{1}{1 + 2(1-b_2)}, \tag{37}$$

which is increasing in b_2.

[10] https://arxiv.org/html/2603.29542v1#A2
[11] https://arxiv.org/html/2603.29542v1#A2
[12] https://arxiv.org/html/2603.29542v1#A2

Proof. See Appendix B.[13] □

The qualitative results are analogous to the process-R&D case.

For arbitrary $m > 0$, the home government's optimal policy has no closed-form solution. Some numerical examples are shown in Section 5. At low values of b, the numerical exercises confirm that the home government combines a positive subsidy with a positive tax, as in the process-R&D case. At high b, however, the optimal tax can turn negative under product R&D, a finding that is discussed in Section 5.3. The fact that Propositions 5–8 are qualitatively similar to their process-R&D counterparts means that any qualitative differences in welfare outcomes between the two specifications can be attributed to the direct tax channel on quality investment.

5 Welfare Effects of Industrial Policy

The analytical results in Section 4 establish the qualitative properties of the Nash equilibrium under both process and product R&D, but the home government's joint choice of the policy mix (the R&D subsidy and the tax on the foreign rival) does not admit a closed-form solution when goods are substitutes ($m > 0$). This section uses illustrative numerical exercises to compare welfare under the Nash equilibrium with laissez-faire, varying the strength of network externalities b as the main parameter.

Three findings emerge. First, under process R&D, the foreign country is always worse off under Nash policy competition than under laissez-faire, while the home country always gains. At sufficiently high b, the home country's gain outweighs the foreign country's loss, and aggregate welfare exceeds the laissez-faire level (Section 5.2). Second, under product R&D when goods are weak substitutes or complements, both countries are better off under Nash than under laissez-faire at high b. The mechanism is a sign reversal in the optimal tax, which turns negative and becomes an import subsidy, which together with the demand-side R&D subsidies helps to partially internalise the network externality. When goods are relatively stronger substitutes, this win-win outcome vanishes because the profit loss from displacing the domestic firm's market share outweighs the consumer-surplus gain from the network externality (Section 5.3).

The optimal policy instruments as functions of b are reported in Supplementary Material, Section S2.[14]

5.1 Parameterisation

The parameter values are chosen to satisfy the interior-equilibrium and second-order conditions while delivering economically meaningful solutions. Throughout, the demand

[13] https://arxiv.org/html/2603.29542v1#A2
[14] https://arxiv.org/html/2603.29542v1#A2a

intercept is $a = 1$ and the R&D efficiency parameters are set symmetrically at $\varphi_1 = \varphi_2 = \theta_1 = \theta_2 = 2.5$. Production costs are set to $c_1 = c_2 = 0.7$ and network externalities to $b_1 = b_2 = b$, where b is varied from zero to the upper bound of the admissible region. The aim is to illustrate the patterns, rather than to produce calibrated empirical predictions.

Each pattern is illustrated for two values of the substitutability parameter, $m = 0.05$ (weakly substitutable goods) and $m = 0.25$ (moderately substitutable goods), to show how the welfare effects of network externalities depend on the degree of product differentiation. Network-goods sectors span a wide range of substitutability. A foreign AI platform and a domestic alternative may have very different ecosystems and developer communities, making them weak substitutes (m small), while competing chip architectures for the same application are closer substitutes (m moderate). We are interested in an interior equilibrium, with all equilibrium quantities, prices, and R&D outlays strictly positive. This determines the admissible range of b. Under the process-R&D specification this restricts b to approximately $[0, 0.46]$; under product R&D the admissible range extends to approximately $[0, 0.50]$.

Table 1: Parameter values used in the numerical exercises

Parameter	**Value**	**Interpretation**
a	1	Demand intercept
$c_1 = c_2$	0.7	Marginal cost (symmetric)
$\varphi_1 = \varphi_2$	2.5	Process R&D cost parameter
$\theta_1 = \theta_2$	2.5	Product R&D cost parameter
$b_1 = b_2 = b$	$[0, \bar{b}]$	Network externality (swept)
m	$\{0.05, 0.25\}$	Substitutability

5.2 Process R&D

Figure 1 shows the welfare differences between the industrial policy equilibrium ("Nash") and laissez-faire ("LF") as functions of the common network externality strength, b, for weak and moderate substitutability between home and imported good. Country 1 is the exporter (foreign country) and Country 2 is the importer (home country).

Several clear patterns emerge. First, the foreign country is always worse off under the industrial policy competition than under laissez-faire ($\Delta W_1 < 0$ throughout). At $m = 0.05$ the loss is relatively mild and flattens at high b. At $m = 0.25$ it deepens substantially as b increases. Second, the home country always gains ($\Delta W_2 > 0$ throughout). The gain is modest at low b and rises steeply as network effects strengthen, reaching considerably higher levels at lower substitutability. Third, the aggregate welfare difference ΔW changes sign. At low b, aggregate welfare under intervention is lower than under laissez-faire, so that industrial policy is self-defeating in aggregate. As b rises, the home

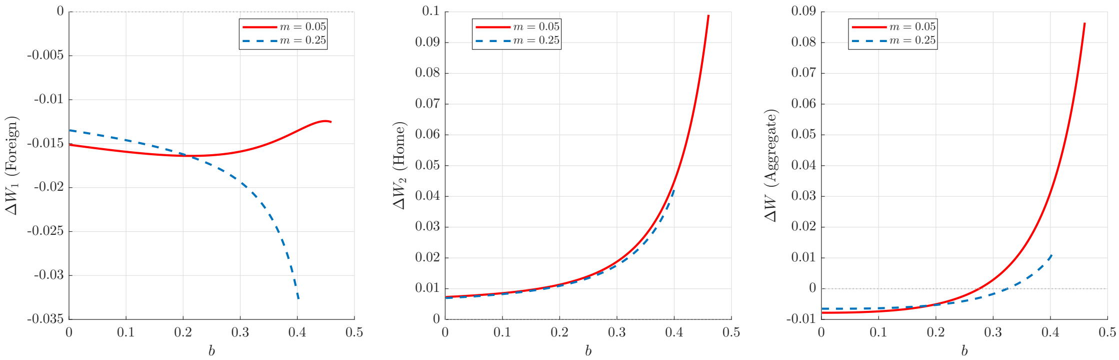

Figure 1: Process R&D: welfare differences ($\Delta W_i \equiv W_i^{\text{Nash}} - W_i^{\text{LF}}$) between the industrial policy equilibrium ("Nash") and laissez-faire ("LF") as functions of network externality strength b, for $m = 0.05$ (solid) and $m = 0.25$ (dashed). Left: foreign country always loses. Centre: home country always gains. Right: aggregate welfare under policy competition exceeds laissez-faire at high b, more strongly at lower substitutability.

country's gain grows faster than the foreign country's loss, and ΔW turns positive. This zero-crossing occurs at a substantially higher value of b under stronger substitutability ($m = 0.25$), reflecting the greater rent-dissipation cost that network effects must overcome. At $m = 0.05$, the aggregate welfare gain at high b is large. At $m = 0.25$ it barely turns positive before the admissible range ends.

The mechanism is the network externality in demand interacting with the product substitutability. The home government's R&D subsidy raises domestic output, which strengthens the domestic firm's network position, raising further the demand. When the network externality is weak (low b), the distortionary cost of the tax and subsidy dominates. Since subsidies are strategic complements (Propositions 3 and 7), each government's intervention provokes a retaliatory response, leading to a race to the bottom that dissipates surplus faster than network externalities can generate it. In contrast, when the externality is strong enough (high b), so that the subsidy effectively internalises part of the positive externality undersupplied by the market, the import tax reinforces this by shifting market share toward the domestic firm. However, at the same time, the tax always harms the foreign country. The aggregate gain at high b arises because the welfare gain from subsidising the network externality on the demand side is large enough to offset the foreign country's loss.

Stronger substitutability ($m = 0.25$) shifts the ΔW curve downward relative to $m = 0.05$, so that a substantially larger network externality is needed to make the industrial policy equilibrium welfare-improving. When goods are closer substitutes, competitive interaction is more intense, the subsidy generates more business-stealing, and a stronger network externality is needed to overcome the associated welfare cost.

Under the process R&D, in our model the industrial policy equilibrium is always redistributive in the interior equilibrium. The home country gains at the foreign country's expense. Whether the two countries collectively gain depends on the strength of network externalities. Additional investigation (see figures in Supplementary Material Section **??**) confirms that the optimal tax generally declines in b at low substitutability, while both subsidies rise, consistent with the model prediction that the case for subsidising domestic R&D is stronger in sectors with more powerful network externalities (Proposition 4). At higher substitutability, the optimal tax declines over most of the range and rises close to the upper boundary of the admissible region, reflecting the stronger business-stealing motive that sustains the tax when competitive interaction is intense.

The process-R&D results therefore suggest that in sectors where innovation is primarily cost-reducing, non-cooperative industrial policy is redistributive. The importing country benefits at the expense of the exporting country, and the aggregate gain from policy intervention depends on the strength of network externalities. When network externalities are weak, the distortionary cost of taxes and subsidies dominates, and the industrial policy reduces the aggregate welfare. When network externalities are strong, the innovation subsidy partially internalises the positive externality in demand, and industrial policy leads to the aggregate welfare gain.

5.3 Product R&D

Figure 2 reports the same welfare comparison for the product-R&D specification.

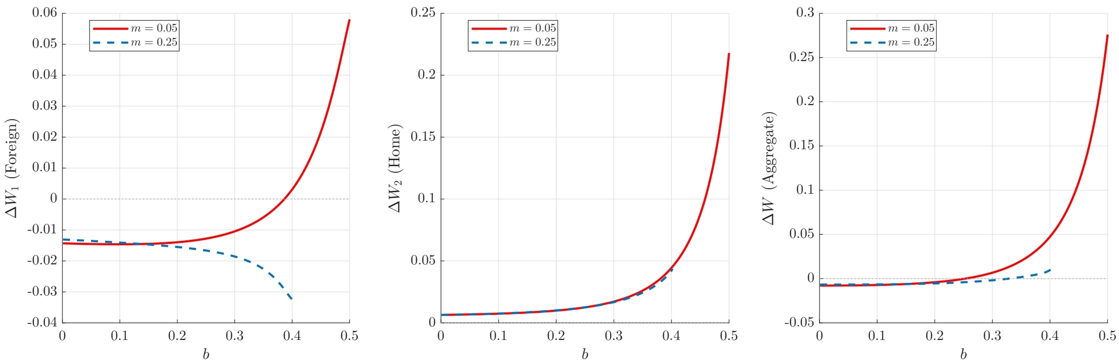

Figure 2: Product R&D: welfare differences ($\Delta W_i \equiv W_i^{\text{Nash}} - W_i^{\text{LF}}$) between the industrial policy equilibrium ("Nash") and laissez-faire ("LF") as functions of network externality strength b, for $m = 0.05$ (solid) and $m = 0.25$ (dashed). Left: at $m = 0.05$, the foreign country switches from losing to gaining at high b; at $m = 0.25$, the foreign country always loses. Centre: home country gains throughout. Right: aggregate welfare gain is substantially higher at lower and higher b.

At $m = 0.25$, the product-R&D welfare differences are qualitatively similar to the process-R&D case. The foreign country loses throughout, the home country gains, and the aggregate welfare difference turns positive only near the upper boundary of the admissible range. Stronger substitutability makes industrial policy redistributive under both R&D specifications in our model.

At $m = 0.05$, the pattern changes. The exporting (foreign) country's loss shrinks as b rises, eventually crosses zero and turns into gain. Above the threshold, the exporter is better off under industrial policy competition than under laissez-faire. Since the importing (home) country also gains over this range, both countries simultaneously benefit from the industrial policy competition compared to no intervention. The aggregate welfare difference ΔW turns positive at a lower value of b than ΔW_1 and rises steeply thereafter.

The win-win result is driven by a sign reversal in the optimal tax. As b rises, t^* declines and turns negative at approximately the same value of b at which ΔW_1 changes sign (Supplementary Material, Section S2).[15] The home government chooses to subsidise rather than tax the foreign good because, in the presence of strong network effects, the resulting quality improvement triggers a self-reinforcing expansion in demand. This feedback loop raises the aggregate willingness to pay and consumer surplus by more than the associated fiscal cost, effectively using both the trade policy and the innovation policy in internalising the positive consumption externality.

This sign reversal in our model is specific to the product-R&D specification and is absent from the process-R&D case when the goods are substitutes. As discussed in Section 4.3, the tax enters the foreign firm's product-R&D choice condition directly (equation 31), so a negative tax raises the foreign firm's return to quality investment, which in turn raises consumers' willingness to pay and triggers the network effect directly. Under process R&D, the tax affects only the output channel, and the indirect demand network effect is too weak to justify the fiscal cost of an import subsidy. The numerical exercises confirm that the sign reversal does not arise under process R&D in our specification.

The link between the product subsitutability and the win-win result reflects the interaction between network externalities and the business-stealing effect. When goods are close substitutes, an import subsidy that expands foreign output would displace domestic output, because consumers switch toward the now-cheaper foreign good. The profit loss to the home firm would outweigh the consumer-surplus gain from the network externality, and so an import subsidy would not be optimal from the home government viewpoint. When goods are weak substitutes, this business-stealing cost is small, and the network externality channel dominates. The win-win result therefore requires three conditions to hold simultaneously: strong network externalities (b high), quality-enhancing innovation (product R&D), and sufficient product differentiation (m low).

Since business-stealing effect disappears when the demands are independent and turn into business-augmenting effect when the goods are complements (for example, EVs and charging infrastructure, or, in the intermediate-input interpretation of Remark 1, the litography machines and the ultra-precise mirrors used jointly in semiconductor chip fabrication), it is natural to expect that R&D subsidy by each country will lead to the mutual market expansion, further boosting the network effect. As a result, the

[15] https://arxiv.org/html/2603.29542v1#A2a

win-win outcome will be more likely for complements even at relatively low network strength. Indeed, the numerical exercises support this reasoning. When the goods are complements ($m < 0$), the win-win region expands and appears under both R&D specifications, because subsidising the foreign firm raises rather than reduces demand for the domestic good. Under this corresponds to sectors where the competing goods. Numerical examples are reported in Supplementary Material, Section S3.[16]

6 Conclusion

This paper studies the welfare effects of industrial policy in sectors characterised by network externalities in demand using a two-country, two-good model. The central finding is that the welfare effects of the industrial policy that combines R&D subsidies and a tax on import depend on the interaction between the strength of the network externality strength and market structure. When the home and foreign goods are moderate or strong substitutes, the home (importing) country gains at the expense of the foreign (exporting) country regardless of the degree of substitutability. The aggregate welfare effect of policy competition turns from negative to positive only when the network externalities are sufficiently strong. When the goods are weak substitutes or complements, the win-win outcome is possible. The network externalities create the possibility of the mutually beneficial industrial policy, but its realisation depends on the market structure.

The case for industrial policy, thus, depends on the strength of the network externality, the extent of substitutability or complementarity between the home and foreign goods, and on the nature of innovation. When the goods are substitutes, R&D subsidies contribute to business-stealing effect: higher market share of one firm reduces the market share of another. Since the externality operates on the demand side of the market, the case is stronger when the innovation directly affects the demand by increasing willingness to pay: quality-enhancing, or product R&D. When the innovation is on the supply side, i.e. cost-reducing, or process R&D, the importing country benefits from taxing the foreign good, at the cost to the exporting country; the aggregate welfare also deteriorates unless the externalities are sufficiently strong.

However, when the goods are complements, R&D subsidies contribute to the market expansion for both firms and, thus, operate in the same direction as the network effects in terms of the welfare. As a result, the industrial policy helps internalise the externality and can lead to welfare gains for both countries. Here, again, the case is stronger for the product innovation; indeed, in our specification the win-win outcome can occur under product R&D even for sufficiently weak substitutes, whereas for the process R&D this only takes place under complementarity.

Ultimately, our findings suggest that the global return to industrial strategy need not be a zero-sum game. While the risk of a rent-dissipating race to the bottom is real, espe-

[16] https://arxiv.org/html/2603.29542v1#A3

cially in process-heavy manufacturing, the transition toward a modern economy defined by product innovation and deep technical complementarities offers a different path. By identifying the thresholds where network effects help the policy create mutual benefits, this paper provides a roadmap for a more sophisticated industrial policy, where the expansion of global technological ecosystems dominates the narrow pursuit of national market share. In this light, the "revival" of industrial policy is not about picking winners, but is rather about fostering the interconnected networks that drive economic value in the contemporary global landscape.

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