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Social efficiency of entry: Implications of network externalities

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Abstract

We examine the welfare effects of entry in the presence of network externalities. We show that if network goods are fully incompatible, entry is socially insufficient as long as the entry cost is high, the goods are sufficiently differentiated, and the degree of network externality is low. Further, we show that as the degree of compatibility between the network goods increases, insufficient entry becomes more likely. Our findings provide policy guidelines for anticompetitive and procompetitive entry regulations.

1 | INTRODUCTION

The literature on social efficiency of entry got its momentum with the influential work by Mankiw and Whinston (1986) who show that entry is socially excessive in oligopolistic industries with scale economies.[1] This is commonly known as "excess entry theorem" which provides a rationale for anticompetitive entry regulations. Since this seminal work, the topic of social desirability of entry has been analyzed and extended under various settings. Although Ghosh and Saha (2007) suggest that excessive entry may also arise due to marginal cost differences, a large body of the literature contradicts this view. For example, entry can be socially insufficient in the presence of technology licensing (Mukherjee & Mukherjee, 2008) and trade unions (De Pinto & Goerke, 2020). Entry can also be socially insufficient if the firms engage in cost reducing R&D (Chao et al., 2017), whether the firms enter the market sequentially or simultaneously (Cabral, 2004) and when the market is characterized by bilateral oligopoly where the input suppliers have market power (Ghosh & Morita, 2007a, 2007b). These findings encourage policy makers to adopt procompetitive policies under some circumstances.

Although these papers deepen our understanding in various directions, they have traditionally ignored the aspect of *network externalities*, which is an important feature in various industries in the contemporary world. One classic example of network market is online video game industry,[2] such as, Blizzard Entertainment's World of Warcraft that provides platforms upon which developers, such as Sony, Microsoft, Nintendo, launch new applications. Such applications are more useful and fun when used with friends, that is, the value of being part of the network rises as the network size increases. In 2006, Blizzard Entertainment's World of Warcraft reported that it had more than six million active users and generated $1 billion subscription revenue in 2006 (Schiesel & Richtel, 2006). It is, therefore, not surprising to interpret that network externalities play a pivotal role on firm's entry decision.

The literature examining the effects of entry in the presence of network externalities is relatively sparse. Economides (1996) showed that in a market with strong network externalities, if there exists an innovating quantity leader, it encourages entry of its rival firms. Fudenberg and Tirole (2000) developed a model of pricing where a sole supplier of network goods deters entry. Kliemnko and Saggi (2007) studied a foreign firm's choice of FDI as in de novo entry and acquisition in a market that is characterized by network goods.

In contrast to this literature, we study the welfare implications of free entry in an oligopolistic market in which firms produce horizontally differentiated goods that exhibit positive consumption externalities. In particular, we analyze how the social desirability to enter a market vary when the network goods are fully incompatible, fully compatible, and imperfectly compatible respectively. Therefore, this paper makes an attempt to uncover the role of network compatibility and its interplay with the degree of network externality in determining the market and social incentives of entry. This is the novelty of the paper, which to the best of our knowledge remained unexplored in the literature.

Our results show that if the network goods are fully incompatible, entry is socially insufficient if the entry cost is high, the goods are sufficiently differentiated, and the degree of network externalities is low. Otherwise, entry is socially excessive. However, when the network goods are fully compatible, entry is always socially insufficient for all degrees of network externality as long as the entry cost is high and the goods are sufficiently differentiated. Our findings provide guidelines to the policymakers whether to adopt an anticompetitive or a procompetitive policy to regulate an industry that produces network goods.

The intuitions behind our results are as follows. The business stealing effect discussed in Mankiw and Whinston (1986) that promotes entry and the degree of product differentiation that discourages entry in the presence of scale economies, remain in our case. There is though an additional effect, *the net effect of network size*, that arises from network externality and network compatibility. The network size effect has contradicting implications on the social desirability of entry. First, if the degree of network externality is strong, it makes entry attractive by increasing the profit of each entrant via consumer's expectations. On the other hand, market entry incentives are not as strong since a rise in network size also increases consumers' welfare that in turn, increases the social welfare. This makes entry more socially desirable than what the market allows. Whether the network effect on an entrant's profit is more substantial than its impact on social welfare, that is, whether network externality incentivizes more (less) firms to enter the market than what is socially optimal depends on whether the network goods are fully incompatible (compatible). In summary, whether entry is socially excessive or insufficient largely depends on the relative strengths of these three effects.

The remainder of the paper unfolds as follows. Section 2 presents our model. Section 3 includes the analysis of the market competition stage. Section 4 presents an integer case example that illustrates our main findings. Section 5 analyses the entry stage for fully incompatible, fully compatible and partially compatible network goods and includes our main results. Section 6 concludes. All proofs are relegated to the Appendix.

2 | THE MODEL

Consider an economy with a large number of identical firms. If a firm decides to enter into the market, it incurs a fixed entry cost, $F > 0$, and a marginal production cost, $c \geq 0$. The firms that have entered into the market produce horizontally differentiated goods that exhibit positive network externalities. We assume that the representative consumer's preference is:[3,4]

$$U\left(q_i, q_j; y_i, y_j; m\right) = a\sum_i q_i - \frac{1}{2}\sum_i q_i^2 - \gamma\sum_{i\neq j} q_i q_j + n\left[\sum_i\left(y_i + \theta\sum_{i\neq j} y_j\right)q_i - \frac{1}{2}\sum_i y_i^2 - \theta\sum_{i\neq j} y_i y_j\right] + m, \quad (1)$$

where m is the numeraire good, q_i is the output of firm i and y_i is the consumer's expectation regarding firm i's total sales, with $i, j = 1,2, \ldots, i \neq j$. The degree of product substitutability is measured by $\gamma, 0 \leq \gamma \leq 1$, which ranges from zero (independent goods) to unity (perfect substitutes). The strength of network externality is measured by the parameter $n \in (0,1)$. A higher value of n implies stronger network externality, whereas $n = 0$ corresponds to the usual nonnetwork goods. Finally, the compatibility between the network goods is measured by $\theta \in [0,1]$, which ranges from zero (totally incompatible goods) to unity (perfectly compatible goods). Without loss of generality, we normalize the total mass of consumers to unity.

Utility maximization in (1) generates the consumers' inverse demand function:

$$P_i = a - q_i - \gamma \sum_{i \neq j} q_j + n\left(y_i + \theta \sum_{i \neq j} y_j\right), \tag{2}$$

with $i, j = 1,2, \ldots, \; i \neq j$. In line with Economides (1996) and Hoernig (2012), the network externalities enter additively in the inverse demand function. This implies that if $n > 0$, the consumers' marginal willingness to pay for the good increases with the increase in consumers' expectations regarding total sales of all firms, provided that the goods are compatible ($\theta > 0$). The extent of this increase depends both on the degree of network compatibility and the strength of network externality. However, when the goods are incompatible ($\theta = 0$), the consumers' marginal willingness to pay for a good depends exclusively on the sales of the firm producing that good.

We consider a two-stage game with observable actions. At stage 1 the firms decide simultaneously whether to enter or not into the market. At stage 2 consumers form expectations regarding the sales of all firms. At the same time, the firms simultaneously choose their quantities and then the respective profits are realized. We employ subgame perfectness to solve the game.

We assume that the following condition holds throughout our analysis:

Assumption 1. (i) $f < \frac{1}{2 - n}$ and (ii) $\gamma > n\theta$

Assumption 1 ensures that at least one firm will enter into the market. Note that Assumption 1(ii) is always satisfied as long as $\theta \leq \gamma$, that is, whenever the degree of network compatibility is lower or equal to the degree of product substitutability. For higher values of θ, it requires that the network externality is not too high, $n < \frac{\gamma}{\theta}$. To present our results in a more concise manner, we set $f = \frac{\sqrt{F}}{a - c}$, with $c < a$.

3 | THE MARKET COMPETITION STAGE

At Stage 2, firms simultaneously choose their quantities, each to maximize its gross (from the entry cost F) profits. If $k > 1$ firms have entered into the market, firm i solves:

$$\underset{q_i}{\text{Max}}\pi_i = (P_i - c)q_i = \left[a - q_i - \gamma \sum_{\substack{i=1 \\ i \neq j}}^{k} q_j + n\left(y_i + \theta \sum_{\substack{i=1 \\ i \neq j}}^{k} y_j\right) - c\right] q_i \tag{3}$$

with $i, j = 1,2, \ldots, \; k$ and $i \neq j$. From the first order condition we derive firm i's best response function:

$$q_i = \frac{1}{2}\left[a - c - \gamma \sum_{\substack{i=1 \\ i \neq j}}^{k} q_j + n\left(y_i + \theta \sum_{\substack{i=1 \\ i \neq j}}^{k} y_j\right)\right].$$

The best response function of firm i shifts out with an increase in consumers' expectations about its own output. Moreover, whenever $\theta > 0$, it also shifts out with an increase in consumers' expectations about its rivals' output, with this shift being larger, the higher is the degree of network compatibility. Notice also that whenever the goods are not perfectly compatible ($\theta < 1$), consumers' expectations about firm i's output result in a larger shift in its best response function than their expectations about its rivals' total output.

Solving the system of best response functions, and assuming, as in Katz and Shapiro (1985), that the consumers' expectations satisfy "rational expectations" in equilibrium, that is, $y_i = q_i$, $i = 1,2, \ldots, k$, we get each firm's equilibrium output and price for a given number of firms entering the market:

$$q^*(k) = \frac{a - c}{(2 - n) + (k - 1)(\gamma - n\theta)}, \tag{4}$$

$$p^*(k) = c + \frac{a-c}{(2-n)+(k-1)(\gamma - n\theta)}. \tag{5}$$

From (4) the equilibrium net profit of a firm that has entered into the market as a function of k is

$$\pi^*(k) = [q^*(k)]^2 - F = \left[\frac{a-c}{(2-n)+(k-1)(\gamma - n\theta)}\right]^2 - F. \tag{6}$$

Note that the firm's equilibrium output, price and net profit are decreasing in γ, and increasing in n and θ. By Assumption 1(ii), they are also decreasing in k.

We now determine social welfare for a given number of entering firms. Social welfare *(W)* constitutes of producer surplus (*PS*) and consumer surplus (*CS*). If k firms have entered into the market, it follows from (6) that their total net profit—the producer surplus—is

$$k\pi^*(k) = k\left[\frac{a-c}{(2-n)+(k-1)(\gamma - n\theta)}\right]^2 - kF. \tag{7}$$

The consumer surplus after some algebraic manipulations is

$$\begin{aligned} CS(k) &= \tfrac{k}{2}\Big[1-n+(\gamma-n\theta)(k-1)\Big](q^*)^2 \\ &= \tfrac{k}{2}\Big[1-n+(\gamma-n\theta)(k-1)\Big]\left[\tfrac{a-c}{(2-n)+(k-1)(\gamma-n\theta)}\right]^2. \end{aligned} \tag{8}$$

Then social welfare for a given number of entering firms k is

$$W(k) = \frac{k(a-c)^2[3-n+(\gamma-n\theta)(k-1)]}{2[(2-n)+(k-1)(\gamma-n\theta)]^2} - kF. \tag{9}$$

Note that, similar to the firms' equilibrium profit, social welfare is decreasing in γ, and increasing in n and θ.

4 | AN ILLUSTRATION: THE INTEGER CASE

In markets with network externalities, there is often one dominant or a few dominant firms. This may be due to high entry costs. It is then natural to ask whether there is socially insufficient or excessive entry in such markets. To illustrate our main findings, we consider an example with a few firms operating in the free entry market equilibrium and examine whether this market structure is preferable from the point of view of social welfare.

The number of firms in the free entry market equilibrium is characterized by the following conditions: (i) when k firms have entered into the market, each makes nonnegative profits: $\pi^*(k) \geq F$ and (ii) when k+1 firms have entered into the market, each makes strictly negative profits: $\pi^*(k+1) < F$. It is easy to check that k^* firms enter into the market if and only if, $\frac{1}{2-n+k^*(\gamma-n\theta)} < f \leq \frac{1}{2-n+(k^*-1)(\gamma-n\theta)}$. Further, using (9) we can get the respective lower and upper bound values of f for which k^W is the socially optimal number of firms.[5]

First, assume that there is full incompatibility between the network goods ($\theta = 0$). Let $\gamma = 0.5$ and $n = 0.1$. Figure 1a shows the free entry market equilibrium and the socially optimal number of firms for various values of the (normalized) entry cost f. There is insufficient entry for all $0.417 < f \leq 0.434$, while there is excessive entry for all $0.325 < f \leq 0.345$. Moreover, it can be checked that for $n = 0.2$, the region of insufficient entry shrinks ($0.435 < f \leq 0.438$), while that of excessive entry expands ($0.321 < f \leq 0.357$). Finally, for $n = 0.3$, there is never insufficient entry. The above indicates that for a lower degree of network externality, insufficient (excessive) entry occurs in a larger (smaller) interval of values of the entry cost.

Next, assume that there is full compatibility between the network goods ($\theta = 1$). Let again $\gamma = 0.5$ and $n = 0.1$. Figure 1b shows the free entry market equilibrium and the socially optimal number of firms for various values of f. There is insufficient entry for all $0.435 < f \leq 0.471$ as well as for all $0.370 < f \leq 0.371$, while there is excessive

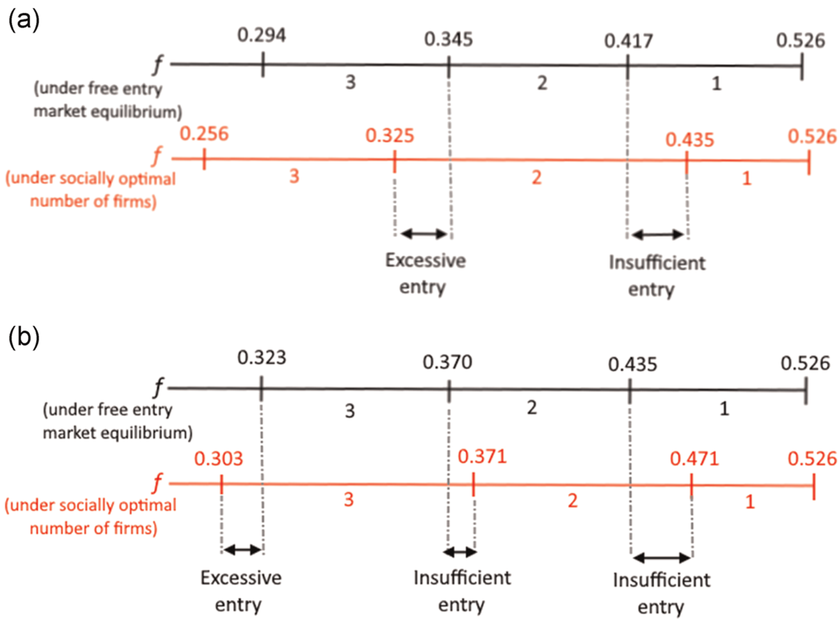

FIGURE 1 (a) Social efficiency of entry under $\theta = 0$, $\gamma = 0.5$, $n = 0.1$ and (b) social efficiency of entry under $\theta = 1$, $\gamma = 0.5$, and $n = 0.1$ [Color figure can be viewed at wileyonlinelibrary.com]

entry for all $0.303 < f \leq 0.323$. Moreover, it can be checked that for $n = 0.2$, the region of insufficient entry expands ($0.476 < f \leq 0.520$ and $0.417 < f \leq 0.427$), while that of excessive entry shrinks ($0.360 < f \leq 0.370$). A similar pattern occurs when we compare the $n = 0.3$ with the $n = 0.2$ case. The above indicates that network compatibility plays a crucial role for the likelihood of insufficient or excessive entry as the network externality becomes more prominent. In particular, when $\theta = 0$ as n increases, insufficient entry is less likely to occur, while for $\theta = 1$ the opposite is true.

The above observations that have been obtained with specific numerical examples are of a more general nature as the analysis below reveals.

5 | THE ENTRY STAGE

At Stage 1, firms decide whether to enter or not into the market. As common in the literature, we consider the number of firms as a continuous variable. Hence entry in the market occurs as long as the net profit of a firm is nonnegative. Given symmetry, the free entry equilibrium number of firms, k^*, is given by $\pi^*(k^*) = 0$ or

$$\left[\frac{a-c}{(2-n)+(k-1)(\gamma-n\theta)}\right]^2 = F. \tag{10}$$

By (10) we get the equilibrium number of firms under free entry:

$$k^* = 1 + \frac{1-f(2-n)}{f(\gamma-n\theta)}. \tag{11}$$

By Assumption 1, $k^* > 1$. As expected, if the entry cost falls or the degree of product differentiation rises, the free entry equilibrium number of firms k^* increases. Moreover, k^* increases with θ and n. Intuitively, the higher the degree of network compatibility or the degree of network externality, the more the market incentivises firms to enter.

From (11), we get each firm's equilibrium output and price, $q^* = f(a-c)$ and $p^* = c + f(a-c)$, which are both increasing in f. Further, the equilibrium aggregate industry output is

$$Q^* = q^*k^* = \left[f + \frac{1-f(2-n)}{\gamma-n\theta}\right](a-c). \tag{12}$$

As expected, aggregate industry output is decreasing in f and γ, and increasing in n and θ.

Next, we determine the welfare maximizing number of firms. In line with the existing literature, we consider the second-best problem of welfare maximization, that is, we determine the welfare maximizing number of firms conditional on Cournot market behavior. This means that the social planner may regulate the number of firms entering into the market, but is unable to control the firms' behavior in the product market.

The social planner chooses k to maximize social welfare as given in (9). The welfare maximizing k satisfies $\frac{\partial W}{\partial k} = 0$, where

$$\frac{\partial W}{\partial k} = \left(\frac{(3-n)(2-n) + (k-5-n(k-2))(\gamma - n\theta) - (k-1)(\gamma - n\theta)^2}{2[(2-n) + (k-1)(\gamma - n\theta)]^3} - f^2\right)(a-c)^2.$$

It follows that as the entry cost falls, the welfare maximizing number of firms increases. Evaluating $\frac{\partial W}{\partial k}$ at k^*, we obtain

$$\left.\frac{\partial W}{\partial k}\right|_{k=k^*} = \frac{f^2(a-c)^2}{2}[4f - 1 - (2f+1)(\gamma + n - n\theta)]. \tag{13}$$

Then if social welfare is strictly quasi-concave in k, entry is socially insufficient when $\left.\frac{\partial W}{\partial k}\right|_{k=k^*} > 0$, whereas entry is socially excessive when $\left.\frac{\partial W}{\partial k}\right|_{k=k^*} < 0$. To get better insights, we consider the two extreme cases of network compatibility among goods, that is, full incompatibility $(\theta = 0)$[6] and full compatibility $(\theta = 1)$.

5.1 | Network incompatibility

First, consider the case in which the network goods are fully incompatible $(\theta = 0)$. It can be checked that social welfare is a strictly quasi-concave function of k. In particular, it is strictly concave in k if $n + \gamma \leq 1$. While if $n + \gamma > 1$, welfare is strictly concave for all $k < \frac{(4-n-\gamma)(2-n-\gamma)}{\gamma(n+\gamma-1)} \equiv k_c(\gamma, n)$. Nevertheless, it can be checked that for all $k \geq k_c(\gamma, n)$, $\frac{\partial W}{\partial k} < 0$, implying that social welfare is a strictly quasi-concave function for all $n + \gamma > 1$. Then (13) reduces to

$$\left.\frac{\partial W}{\partial k}\right|_{k=k^*, \theta=0} = \frac{f^2(a-c)^2}{2}[4f - 1 - (2f+1)(\gamma + n)]. \tag{14}$$

Entry is socially insufficient (excessive) if and only if the above derivative is positive (negative). Our findings are summarized in the following proposition.

Proposition 1.

(i) Entry is socially excessive for all n *if* $f < \frac{1}{4}$, *or* $f \geq \frac{1}{4}$ *and* $\gamma > \frac{4f-1}{2f+1}$.
(ii) Otherwise, it is socially excessive if $n^* < n < 1$ *and it is socially insufficient if* $0 < n < n^*$, *where* $n^* = \frac{4f-1-(2f+1)\gamma}{2f+1}$.

The intuition goes as follows. Entry creates three effects. First, in line with Mankiw and Whinston (1986), entry creates a *business stealing effect* by lowering the outputs and gross (from the entry cost) profits of the incumbent firms. This boosts entry. Second, horizontally differentiated goods create a *love-for-variety effect*. As consumers value variety, each marginal entrant increases social welfare more than the increase in its own profit. This leads to less entry than it is socially desirable. And third, a *net effect of network size* that as discussed below has an ambiguous effect on the social desirability of entry.

The network size (as reflected by both network externality and network compatibility), in our model, creates a conflicting effect on the marginal entrant's profit and social welfare. On one hand, as observed by Economides (1996), an increase in network externality widens the market of each firm via consumers' expectations. This encourages more firms to enter into the market to appropriate a higher profit by charging a higher price and selling larger quantities.

We call this a *positive network size effect*. On the other hand, a rise in network externality also increases consumers' welfare, which results in an increase in social welfare. This leads to less entry than what is socially desirable. We call this a *negative network size effect*. As we will see below, the net effect of network size on social desirability of entry is ambiguous and depends on both the degree of network externality and network compatibility.

Let us begin with the case where the entry cost is low ($f < \frac{1}{4}$), meaning that the product market is sufficiently competitive. Each new entrant creates a significant business stealing effect by reducing the profit of the incumbents. Under full network incompatibility, it also creates a small net effect of network size by widening the overall market size. These two effects dominate the love-for-variety effect, resulting in more entry than what is socially desirable. Moreover, when the entry cost is high ($f \geq \frac{1}{4}$) and the goods are close substitutes ($\gamma > \frac{4f-1}{2f+1}$), the love-for-variety effect is weak. The business stealing effect and the net effect of network size are still prominent, and entry is excessive in this case too.

Finally, let the goods be sufficiently differentiated ($\gamma > \frac{4f-1}{2f+1}$) and the entry cost be high ($f \geq \frac{1}{4}$). If the degree of network externality is sufficiently large ($n > n^*$), it strengthens both the positive and negative network size effects. However, as the network goods are fully incompatible ($\theta = 0$), the representative consumer's benefit and hence, the increase in social welfare (negative network size effect) arising from increased network size is small compared to the marginal entrant's benefit in profit (positive network size effect). Furthermore, when the network externality is strong, entry shifts out the demand functions for all firms, which indirectly intensifies the business stealing effect by increasing the market share of the incumbent firms. As a result, a socially excessive number of firms enter the market as the positive network size and the business-stealing effects dominate the love-for-variety and the negative network size effects. On the other hand, the lower the degree of network externality, relatively weaker is the business stealing effect and the less the entrants and the consumers benefit from the network size. Therefore, when $n < n^*$, the love-for-variety and the negative network size effects overshadow the positive network size and the business stealing effects. As a result, the free entry equilibrium number of firms becomes socially insufficient.

A straightforward implication of Proposition 1 is that when goods are homogenous ($\gamma = 1$), entry is always socially excessive. This is in line with Mankiw and Whinston (1986). When the firms produce homogenous goods, market competition is fierce, intensifying the business stealing effect that promotes entry. In contrast, the love-for-variety effect that discourages entry disappears. Firms also benefit through the net effect of network size and as a result, entry is socially excessive. Thus, the findings of Mankiw and Whinston (1986) are robust when there exists network externality.

5.2 | Full network compatibility

Next, assume that there is full compatibility between the network goods ($\theta = 1$). It can be checked that social welfare is a strictly concave function of k. Then (13) reduces to

$$\left.\frac{\partial W}{\partial k}\right|_{k=k^*,\theta=1} = \frac{f^2(a-c)^2}{2}[4f - 1 - (2f+1)\gamma]. \tag{15}$$

Our findings are summarized in the following Proposition.

Proposition 2.

(i) *Entry is socially excessive for all n if $f < \frac{1}{4}$, or $f \geq \frac{1}{4}$ and $\gamma > \frac{4f-1}{2f+1}$.*
(ii) *Otherwise, it is socially insufficient for all n.*

The intuition behind Proposition 2(i) is along the lines stated in Proposition 1. Interestingly, when the entry cost is high and the network goods are sufficiently differentiated, entry is socially insufficient for all degrees of network externalities (Proposition 2(ii)). The reasoning is as follows. When the network goods are perfectly compatible ($\theta = 1$), the effect of network externality on the marginal entrant's profit and social welfare becomes a lot stronger than that where the network goods are perfectly incompatible ($\theta = 0$). The goods being perfectly compatible, the consumers' utility, in this case, increases more than its expenditure followed by an increase in network size. As a result, the social welfare increases more than the entrant's profit. This implies that the negative network size effect, together with the love-for-variety effect, overshadow the business stealing and positive network size effects, resulting in socially insufficient entry. Therefore, as established in Section 4, an increase in network compatibility increases the likelihood of insufficient entry.

In this case too, entry is socially excessive whenever the network goods are perfect substitutes.

5.3 | The general network compatibility case

We now return to the general case in which network goods are imperfectly compatible $(0 < \theta < 1)$. Using similar arguments as in the full incompatibility case, it turns out that social welfare is a strictly quasi-concave function of k.[7] Then by (13), we get the following result:

Proposition 3.

(i) *Entry is socially excessive for all n and θ if $f < \frac{1}{4}$, or $f \geq \frac{1}{4}$ and $\gamma > \frac{4f-1}{2f+1}$.*

(ii) *Otherwise, entry is socially insufficient for all n if $\theta > \frac{(1+2f)\gamma}{4f-1}$ or if $\theta < \frac{(1+2f)\gamma}{4f-1}$ and $n < n^*(\theta)$, and socially excessive if $\theta < \frac{(1+2f)\gamma}{4f-1}$ and $n > n^*(\theta)$, where $n^*(\theta) = \frac{4f-1-(2f+1)\gamma}{(1-\theta)(1+2f)}$, with $\frac{\partial n^*}{\partial \theta} > 0$.*

Proposition 3 asserts our findings in Propositions 1 and 2 and highlights the role of network compatibility θ. When the entry cost is low, entry is always socially excessive. This also holds when the entry cost is higher and the network goods are not too differentiated (Proposition 3(i)). In contrast, as Proposition 3(ii) states, for high entry cost and sufficiently differentiated goods, entry is often socially insufficient. In particular, if the network compatibility is high, entry is always socially insufficient, while if it is low the degree of network externality should be low too.

The intuition is as follows. Recall that the free entry equilibrium number of firms k^* increases with the degree of network compatibility θ. An increase in the degree of network compatibility and hence, a rise in network size, clearly, encourages more firms to enter into the market to appropriate a higher profit by charging a higher price and selling larger quantities. On the other hand, the consumers' welfare rises as they value closely related network goods. This improves social welfare. As follows, each marginal entrant increases social welfare more than the increase in its own profit when the degree of network compatibility is high. As a result, it is more likely that entry becomes socially insufficient as the network compatibility increases.

6 | CONCLUDING REMARKS

We analyze the role of network externalities in determining the social desirability of free entry. We demonstrate that when the network goods are fully incompatible, entry is socially insufficient only if the entry cost is high, the goods are highly differentiated, and the degree of network externality is low. Otherwise, entry is socially excessive. We also show that when the network goods are fully compatible, entry is socially insufficient for all degrees of network externality as long as the entry cost is high and the goods are sufficiently differentiated. Finally, we confirm the Mankiw and Whinston (1986) socially excessive entry result in a homogenous good industry characterized by network externalities.

The present model can be seen as a building block for the analysis of more general and policy relevant cases. There are a few directions in which our work can be extended. A good starting point could be to consider standard regulatory policies, such as tax policies that are imposed by the governments to improve social welfare. It is well known that governments can use tax policies to improve a country's welfare by reducing the distortion created by imperfectly competitive product markets. It has also been well documented in the literature that tax revenue in one sector may help to reduce the tax burden in another sector. Hence, there can be a shadow cost of public funds. In this context, it would be interesting to explore the impacts of tax policy and associated shadow cost on the social desirability of entry. In addition, we are in an era of severe environmental concerns. One could, therefore, revisit the question of welfare implications of entry in a polluting industry that poses environmental damage to the society. Finally, to the best of our knowledge, there is no extension of the Dixit and Stiglitz model in the literature that incorporates network externalities. Developing such a model and using it for addressing the social desirability of entry is a promising avenue for future research.

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ENDNOTES

[1]For a representative sample, see Von Weizsäcker (1980), Suzumura and Kiyono (1987), Okuno-Fujiwara and Suzumura (1993), Anderson et al. (1995), Stähler and Upmann (2008), Mukherjee (2012a, 2012b), Amir et al. (2014), Basak and Mukherjee (2016), De Pinto and Goerke (2019), and Cao and Wang (2020).

[2]Other examples of network goods include computer hardware and software, Internet browsers, telephones, and so forth.

[3]The underlying utility function in the absence of network externality ($n = 0$) is an extension of Singh and Vives (1984) for any arbitrary number of goods. It has the love-for-variety property, that is, ceteris paribus, the representative consumer's utility increases with the number of varieties available in the market. The monopolistic competition model á la Dixit and Stiglitz (1977) also exhibits love-for-variety, yet it does not allow for strategic effects as each individual firm is assumed to be very small.

[4]Our preference function is a generalization of what has been widely used in several studies that assume $\theta = \gamma$ (see e.g., Chirco & Scrimitore, 2013; Hoernig, 2012; Pal 2014, 2015; Song & Wang 2017). Naskar and Pal (2020) study the effects of network externality in the presence of R&D investments by considering the cases of $\theta = 0$ and $\theta = \gamma$.

[5]These expressions are too long to be reported here. They are available from the authors upon request.

[6]Our assumption of $\theta = 0$ is in line with Naskar and Pal (2020) who discuss the effects of network externality in the context of R&D.

[7]In particular, it can be checked that social welfare is strictly concave in k for all $\theta \geq \gamma$, or $\theta < \gamma$ and $n(1-\theta) + \gamma \leq 1$. Otherwise, it is strictly concave for all $< \frac{[4 - n(1-\theta) - \gamma][2 - n(1-\theta) - \gamma]}{(\gamma - n\theta)[n(1-\theta) + \gamma - 1)]} \equiv k_c(\gamma, n, \theta)$. Nevertheless, it can be checked that for all $k \geq k_c(\gamma, n, \theta)$, $\frac{\partial W}{\partial k} < 0$, implying that welfare is a strictly quasi-concave function for all $\theta < \gamma$ and $n(1-\theta) + \gamma > 1$.

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