Department of Economics Finance & Accounting

Working Paper N290-18

Attracting Foreign Direct Investment in Infrastructure

Gerda Dewit and Dermot Leahy
National University of Ireland, Maynooth

July 2018

Abstract: We examine optimal policy of a host developing country towards a foreign firm that can provide local infrastructure. In the main model, two types of infrastructural goods, one provided by the foreign firm and the other by a publicly owned firm, are complementary inputs for a domestic competitive final goods sector. We show that, due to strategic interaction between the infrastructure providers, average-cost pricing, though inferior for the consumer, is superior to marginal-cost pricing from an overall welfare perspective. In addition, when the home firm maximises profit, domestic surplus is maximised, but the domestic consumer loses from this.

JEL Codes: F23, L13; O24; P41.

Key words: Developing Countries; Infrastructure; Foreign Direct Investment; Complementarities; Pricing Game; Regulatory Policies.

Correspondence: Gerda Dewit; National University of Ireland, Maynooth; Department of Economics, Finance and Accounting; Maynooth; Ireland, *tel.:* (+)353-(0)1-7083776; *fax:* (+)353-(0)1-7083934; *e-mail:* Gerda.Dewit@mu.ie . Dermot Leahy; National University of Ireland, Maynooth; Department of Economics, Finance and Accounting; Maynooth; Ireland; *tel.:* (+)353-(0)1-7083776; *fax:* (+)353-(0)1-7083934; *e-mail:* Dermot.Leahy@mu.ie .

1. Introduction

In the last few decades, foreign direct investment (FDI) in infrastructure has become more important, particularly from developed to emerging and less developed economies (e.g., OECD, 2015). Less developed countries (LDCs) often suffer from an infrastructure gap: the need for investment in infrastructure exceeds the actual investment (Inderst and Stewart (2014)). Typically, governments in LDCs, facing an increasing demand for infrastructure, cannot finance the costs associated with investment in infrastructure. Since infrastructure is critically important for economic growth[1], several LDCs have decided to liberalise investment in infrastructure and have welcomed private foreign investment to narrow the infrastructure gap. As a result, FDI in some types of infrastructure such as transport, energy and telecommunications has increased rapidly, while other sectors dealing with essential infrastructure, such as water supply, typically remain within the remit of the government.[2]

Inward FDI in infrastructure differs from inward FDI in most goods and services. Unlike the latter, infrastructure has many public good characteristics. Furthermore, infrastructure projects often involve very high fixed costs and take a considerable time to complete. Infrastructural development tends to lower the costs for the productive capital in the economy as a whole. For instance, the development of a well-functioning, wide-ranging telecommunications network lowers the cost for most businesses.

This paper focuses on the complementarities between different types of infrastructure investment.[3] For instance, the public provision of a reliable electricity grid is likely to increase production of private businesses, which result in an increased need for better transport and even telecommunication facilities. Without the establishment of the electricity grid, there would be no need to enhance transport or telecommunication. In view of such complementarities,

---

[1] There is a huge literature arguing that there is a positive relationship between a country's infrastructure and its economic growth. Examples are Romp and de Haan (2005), Agenor and Moreno-Dodson (2006) and Estache and Fay (2009).

[2] These issues are illustrated at length in a recent report by the International Finance Cooperation (December, 2016), a member of the World Bank Group.

[3] In a report on infrastructure and growth for the UK, Aghion *et al.* (2017) mention the importance of complementarities for infrastructure. Examples of empirical evidence of infrastructural complementarities in a developing country context are Bouet and Roy (2008), who found evidence of complementarity across transport and communication infrastructure, and Urrunaga and Wong (2016), who found evidence of complementarities between different types of infrastructure for Peru.

government investment in and pricing of one type of infrastructure will affect the demands for complementary types of infrastructure.

Our analysis addresses two specific questions. First, we examine how liberalisation of a particular infrastructure sector affects the host economy, taking into account any complementarities between the liberalised infrastructure sector and the one controlled by the country's government. Second, we explore policies the government can put in place to maximise the country's benefits from FDI in infrastructure. In other words, we look at "commitment mechanisms" the government can adopt to maximise welfare when there are complementarities between the liberalised and government-controlled infrastructure sector.

Since most infrastructure sectors tend to be monopolistic, we focus on the interaction between a public and a single private investor in infrastructure, each of which operating in a different infrastructure sector. Both types of infrastructure are used as complementary inputs by downstream firms. We look at different pricing policies the government may adopt and assess specific regulatory policies. A welfare analysis is also provided. The model we construct is game-theoretic in nature as we focus on the strategic interdependence between the public and private firms. To do this as cleanly as possible we use a partial equilibrium approach.[4]

Our paper relates and contributes to several strands in the literature. First, it relates to the work on the developmental state, a concept referring to a "hard", interventionist state.[5] The central claim in this literature is that a LDC, which is typically trapped in a "low-growth" equilibrium, can instead reach a better equilibrium when its government takes an active policy stance by investing heavily in targeted industries. We discuss a different path towards a better outcome for a developing economy. Given the positive link between a well-developed infrastructure and a high income per capita, we argue here that, given the extremely tight public finances in most LDCs, breaking out of a low-growth equilibrium may –probably more realistically− be achieved by liberalising investment in infrastructure sectors that foster downstream industries and also have significant complementarities with other forms of infrastructure. Our claim is in line with the recommendations made by international organisations such as the OECD and the

[4] As such, we abstract from any general equilibrium effects. These would seriously overburden the analysis and blur its policy implications.

[5] The idea was first developed by Johnson (1982) to characterise the policy stance adopted by MITI in Japan. Some examples of work on the development state are Leftwich (1995), Woo-Cumings (1999) and Vivek (2014).

World Bank to foster development by encouraging FDI in infrastructure.[6] Second, our paper contributes to the wider literature on public investment that "*crowds in*" private sector investment.[7] It offers an example of how a carefully designed policy stance of the government can lead to a successful public-private provision of goods and services. Third, our analysis adds to the game theoretical body of work that focuses on complementarities between goods or activities. For instance, Gabszewicz *et al.* (2001) examine price competition with complementary goods. Another example of important complementarities occurs when there is strategic interaction between firms facing the decision of whether to enter a certain market (Matsuyama (2002)).[8]

The setup of the model with two different types of infrastructure is developed in section 2. Section 3 describes the pre-liberalisation benchmark case in which all infrastructure is provided domestically. The pricing game between the main domestic public firm and a foreign multinational is discussed in section 4. In that section we also consider different regulatory pricing strategies and the possible effects of privatisation of the previously publicly owned infrastructure provider. In section 5 we briefly discuss some extensions of the basic model. Section 6 concludes.

2. The Model

Consider a model in which two distinct types of infrastructural goods, the outputs of which are denoted by k and k^*, are used as inputs by a domestic competitive downstream final goods sector. The downstream firms use the inputs as perfect complements. For example, one could think of the infrastructural inputs as being water and electricity and the final good as bread. Without loss of generality we will choose units such that production of each unit of the

[6] Other work, e.g. Brook and Irwin (2003), also emphasises how policies centred on private provision of basic infrastructure may address some of the needs of the poor in LDCs. Starting from the fact that governments in LDCs have encouraged private sector investment to meet the growing demand for infrastructure, some authors examine what institutional framework is well suited to promoting private infrastructure investment (e.g., Banerjee *et al.* (2006)).

[7] See Makuyana and Odhiambo (2016) for a recent survey on the contributions of public and private capital to economic growth.

[8] Baland and Francois (1999), stress the importance of investment coordination in the context of demand complementarities. For a survey on complementarity and supermodularity, we refer to Amir (2005). Markard and Hoffmann (2016) is a recent example of work that focuses on the provision of specific types of infrastructure when there are complementarities.

downstream good requires one unit of each of the two inputs. Hence, the production function in the final goods sector, Q is:

$$Q = \min(k, k^*) \tag{1}$$

Thus, the marginal production cost of the downstream firms is c with:

$$c = r + r^*, \tag{2}$$

and r denotes the price of the infrastructural good k, whereas r^* stands for the price of the other input, k^*.

Preferences of the representative consumer are assumed to be quasi-linear and represented by the utility function:

$$u = aQ - \frac{b}{2}Q^2 + y, \tag{3}$$

where Q is consumption of the competitive good produced by downstream firms that use the two forms of infrastructure and y is consumption of the numeraire good by the representative consumer. For simplicity we assume no direct consumption of the infrastructural good by consumers or in the production of y. Relaxing this would add little of substance to the analysis. We can write the identity between national expenditure and national income Y as: $y + pQ = Y$, where p is the market price of the final good. Utility maximisation yields the inverse demand function for the final good Q:

$$p = a - bQ \tag{4}$$

Competitive pricing, $p = c$, implies $a - bQ = r + r^*$. Hence, the direct demand for infrastructure inputs from the downstream sector can be written as:

$$k = k^* = Q = S(a - r - r^*) \tag{5}$$

with $S \equiv 1/b$ a measure of the market size.

In the benchmark pre-liberalisation case, which is outlined in the next section, the country is exogenously endowed with an amount of infrastructural input k^*. In later sections this infrastructural input is provided by a foreign private firm at price r^* after the country has liberalised the provision of k^* .

However, infrastructural input k is always provided by the government or a government owned firm. There are economies of scale in the production of the infrastructural goods. These are captured by a specification that contains a fixed cost and a linear variable cost. The total cost of producing *k* is $\gamma k + F$, where γ is the marginal cost and *F* is the fixed cost. Thus, profit from producing *k* is:

$$\pi = (r - \gamma)k - F, \tag{6}$$

The government or the publicly owned company sets price *r* when providing its infrastructural input *k* to downstream firms. Unless otherwise stated, it operates under a break-even constraint.

Assumption 1: *We assume that the home firm's market size adjusted fixed cost does not exceed its maximised operating profit. This implies* $sF \leq k^2$.

If this condition did not hold break-even pricing would not be feasible.

National income is: $Y = \Pi + I = pQ + y$, where *I* is factor income and Π, represents any local profits or rents that accrue to domestic residents in providing infrastructural inputs. We will adopt the standard partial equilibrium approach and assume *I* is fixed and so total surplus is a valid measure of welfare. Letting *W* represent domestic welfare we can then write:

$$W = CS + \Pi, \tag{7}$$

where $CS = aQ - \frac{b}{2}Q^2 - pQ = \frac{b}{2}Q^2$ is consumer surplus.

3. The Benchmark: Public Infrastructure Investment only

To start with we assume the country is endowed with a fixed amount k_0^* of infrastructural units of k^*. We can perhaps, think of this as a situation in which the input, for instance water, is provided using a traditional technology. The fixed quantity of this infrastructure captures rather starkly the idea of a development constraint that limits the production of the final good. The shadow price for this infrastructural input, k_0^*, is given by r_0^*. The government provides *k* units of the other infrastructural unit at price *r*. The output of the perfectly competitive downstream industry is given by expression (5).

Given the technology, we have $k = k_0^*$ in equilibrium. Due to the public company's break-even constraint, we have average-cost pricing (AC pricing) for *k*, which implies $(r - \gamma)k = F$. Since $k = k^*$ because infrastructural inputs are perfect complements, the price for the publicly provided infrastructure k, is equal to:

$$r_0 = \gamma + \frac{F}{k_0^*} \tag{8}$$

where r_0 denotes the price of the infrastructure provided by the government before liberalisation of the provision of the k^*-sector. Using (8) in (5) and making use of the fact that there is a fixed level of $k^* = k_0^*$, we can obtain an expression for r_0^*:

$$r_0^* = a - \gamma - \frac{F}{k_0^*} - \frac{k_0^*}{S} \tag{9}$$

Output and price of the competitive downstream good are given by:

$$Q_0 = k_0^* \tag{10a}$$

and

$$p_0 = a - bk_0^*, \tag{10b}$$

respectively.

Consumer surplus in the benchmark case is then:

$$CS_0 = \frac{b}{2}Q_0 = \frac{b}{2}k_0^* \tag{11}$$

If liberalisation raises output Q, then it will benefit the consumer. However, this is not sufficient to raise welfare if profits or rents of domestic input suppliers are adversely affected. Since k is priced at average costs, profits of the publicly provided infrastructural input remain zero before and after liberalisation. However, there may be some pre-liberalisation rents to suppliers of the other input. Suppose, for instance, that marginal costs are γ_0^* for $k^* \leq k_0^*$ but infinite for $k^* > k_0^*$, then there are rents of $(r_0^* - \gamma_0^*)k_0^*$ which will be lost if the local producers are replaced by a foreign supplier.

4. Liberalisation of Infrastructure Investment

In this section, the government has decided to liberalise investment in the provision of k^* and invited a foreign firm to supply this infrastructural input. The foreign multinational firm operates with superior technology and hence supplies the input much more efficiently than the traditional sector. The multinational must pay a fixed setup cost, F^*, and it then supplies the input at a marginal cost of γ^*. We assume that the foreign firm's marginal cost of investing k^* is significantly smaller than r_0^* and its fixed cost of doing so is not prohibitively high. The foreign firm's profits from supplying the local market with the input are:

$$\pi^* = (r^* - \gamma^*)k^* - F^* \tag{12}$$

Setting their prices simultaneously, the foreign firm maximises its profits (see expression (12)) and the home publicly-owned firm charges a price to break-even (with its profits specified in expression (7)). Using the demand for infrastructural inputs from the downstream sector in expression (5), the foreign firm's reaction function is:

$$r^* = \frac{a+\gamma^*-r}{2}, \tag{13}$$

with a slope $\partial r^*/\partial r = -1/2$. The home firm's reaction function is:

$$r = \gamma + \frac{F}{k} = \gamma + \frac{F}{S(a-r-r^*)}. \tag{14}$$

This reply function is non-negatively sloped, $\frac{\partial r}{\partial r^*} = \frac{sF}{k^2-sF} \geq 0$, from assumption 1 with $\frac{\partial r}{\partial r^*} = 0$ for $F = 0$.

We can rewrite (14) in reduced form as:

$$r = \gamma + \frac{a-\gamma-r^*-\sqrt{(a-\gamma-r^*)^2-4^F/_S}}{2} \tag{15}$$

The price reaction functions are depicted in Figure 1; the Nash equilibrium in prices occurs at point A.

[*Figure 1 about here*]

4.1. Liberalisation versus Benchmark

Let us now compare the pre-liberalisation benchmark with the outcome in which the foreign firm supplies the input k^*. A necessary condition for this to benefit home is that there is a fall in r^* from the price in the benchmark. Such a fall will see the government react by decreasing its own price *r*. This will lower marginal costs and thus raise output in the downstream industry. This in turn leads to an increase in consumer surplus compared to the benchmark. So, liberalisation of the provision of k^* benefits the country consumers of the downstream good. It also raises welfare, assuming that the consumer surplus gain dominates any lost rents from (pre-liberalisation) local production of the input that is now produced by the foreign firm.

We will now consider some alternative pricing strategies that the home authorities might adopt.

4.2. Average-cost pricing versus marginal-cost pricing

Suppose that the local publicly-owned firm was to price at marginal cost rather than average cost. Marginal cost pricing is often claimed to be a more efficient pricing practice. With marginal-cost (MC) pricing the firm sets $r = \gamma$, which is independent of the foreign price. In

Figure 2 the "reaction function" for this case is represented by the vertical line. It is everywhere to the left of the AC-pricing reaction function. A switch to marginal cost pricing increases the equilibrium price of the foreign firm ($r^{*M} > r^{*A}$) and reduces the equilibrium price of the public home firm ($r^M < r^A$) as well as the price for the final product of the downstream firms ($p^M < p^A$). This leads to an increase in output of the downstream firms and hence to an increase in consumer surplus. The downward sloping dashed lines in the figure are iso-price lines for the downstream final good. The lines closer to the origin are associated with a lower downstream price and hence a higher downstream output. Profits of the domestic firm under MC-pricing are now negative and, despite the gains to domestic consumers, the overall effect on welfare of moving to marginal cost pricing is negative. This is clear from Figure 2 by a comparison of iso-welfare contours. Geometrically lower contours are associated with higher levels of welfare. Moving from AC-pricing to MC-pricing implies moving from iso-welfare contour W^N to iso-welfare contour W^M, with $W^M < W^A$. The negative profits due to MC-pricing outweigh the consumer surplus gain. The reason why this happens is that MC-pricing means committing to a lower input price. The home country thus induces the foreign firm to raise its price, thereby extracting more rent from the home country. So, from a welfare perspective, AC- pricing by committing to a higher *r* works to improve the country's strategic position vis-à-vis the foreign firm. With AC- pricing, some of the profit of the foreign firm has been transferred to the government as welfare.

[*Figure 2 about here*]

4.3. Average Cost Pricing versus Privatisation

As an alternative, to AC- or MC-pricing, the government could let the domestic firm set a price that maximises its profits. From a pricing perspective this would be equivalent to privatising the provider of *k*. The two would also be equivalent from a welfare perspective if the privatised firm is wholly owned by domestic residents. Assuming this, we refer to this scenario as the privatisation case. The objective of the domestic private company would be to maximise its profits, π (see expression (6)).

with respect to *r*. The first-order condition is:

$$k - S(r - \gamma) = 0, \tag{16}$$

which can be rewritten, using expression (5) as the privatised home firm's reaction function:

$$r = \frac{1}{2}(a + \gamma - r^*). \tag{17}$$

Figure 3 depicts the price reaction functions of both firms after the home firm has been privatised. The home firm's reaction function is now, like the foreign firm's, negatively sloped. Combining expression (17) with expression (13) allows us to write the respective Nash equilibrium prices for infrastructure provided by the private domestic firm and the foreign multinational firm:

$$r = \frac{1}{3}(a + 2\gamma - \gamma^*) \tag{18}$$

and

$$r^* = \frac{1}{3}(a + 2\gamma^* - \gamma) \tag{19}$$

In Figure 3, the new Nash equilibrium occurs at point L; it implies a higher price for the home firm's infrastructure provision, but a lower one for the infrastructure provided by the foreign firm. Perhaps surprisingly, this privatisation outcome is also the outcome that maximises home welfare subject to the foreign reaction function. In other words, it coincides with the outcome in which the home firm chooses and commits to r to maximise home welfare before r^* is set. In fact, this becomes clear when considering the following price leadership optimisation problem:

$$max_r\ W = \frac{b}{2}[Q(r,r^*)]^2 + (r-\gamma)k(r,r^*) - F \qquad s.t\ \ r^*(r) = \frac{a+\gamma^*-r}{2} \tag{20}$$

The first-order condition for maximising expression (20) is:

$$k - [Q + S(r-\gamma)]\frac{\partial r^*}{\partial r} = 0 \qquad \text{where} \qquad \frac{\partial r^*}{\partial r} = -\frac{1}{2} \quad . \tag{21}$$

When we make use of the fact that $k = Q$, expression (21) reduces to expression (17).

Although the privatisation/profit maximisation outcome results in higher domestic welfare than AC-pricing by the home firm, it does result in a fall in consumer surplus as the downstream marginal costs rise and output falls.

[*Figure 3 about here*]

4.4. Regulation of the foreign firm

We have seen how the government can increase national welfare through privatisation of the publicly owned infrastructure provider. However, it may not wish to go down the road of privatization of its domestic public infrastructure. The government may instead consider regulating the pricing of the infrastructure that is provided by the foreign firm. In fact, it may wish to impose a price ceiling on privately provided infrastructure such that the price charged by the foreign firm cannot exceed level $\bar{r}^*$. Obviously, there are many different price ceilings that one could consider. In Figure 4 the price ceiling would yield the same welfare level as with privatization of the domestic public firm. It also would, through the public firm's reaction function, reduce the price charged by the public firm; the equilibrium with the price ceiling is at point C in Figure 4. Intuitively, the foreign firm's price reduction, enforced by the price ceiling, increases demand for the infrastructure it provides and, since public and private infrastructure are used as perfect complementary inputs by firms in the downstream industry, also increases demand for the publicly provided infrastructure. This lowers average fixed cost for the public domestic firm and hence its break-even price falls. As both the private and public infrastructural inputs are cheaper, the overall production of the downstream sector increases and so does consumer surplus. So, a price ceiling on the privately provided infrastructure does not only raise overall welfare but, in addition, increases consumer surplus. In Figure 4, the iso-output line for the downstream industry is closer to the origin, indicating that downstream production at C, and therefore consumer surplus, is higher in that point than in either point L or point N.

Note that the government needs to be cautious when imposing the price ceiling. If set too low, the foreign firm may no longer make positive profits and hence would simply not enter the market, in which case welfare will stay at the pre-liberalisation level.

[*Figure 4 about here*]

5. Extensions

In this section we first extend the model to include more downstream industries (subsection 5.1), and subsequently examine the effects of cost complementarities (subsection 5.2).

5.1. More downstream industries

Instead of one downstream industry that uses infrastructure from both sectors as perfect complements, the model can easily be extended to incorporate multiple downstream industries. Here, we assume that there are three downstream industries, all of which are perfectly competitive. Like in the basic model, industry 1 uses the publicly and the privately provided infrastructure as perfectly complementary inputs. As before we will choose units such that production of each unit of the downstream good requires one unit of each of the two inputs. So, a firm's marginal cost of production in this industry is given by $c_1 = r + r^*$, Since we want to illustrate that it is not necessary that all downstream industries use the two types of infrastructure as perfect complements, we assume that downstream industry 2 only uses the publicly provided infrastructural input, while downstream industry 3 exclusively uses the foreign privately provided infrastructure as an input. The input-output technology in industry

2 is given by $Q_2 = k_2/\lambda_2$; similarly, we have $Q_3 = k_3^*/\lambda_3$ in industry 3. The marginal production costs for a firm in industry 2 and 3 are thus equal to $c_2 = \lambda_2 r$ and $c_3 = \lambda_3 r^*$, respectively.

Demand in downstream industry (i=1, 2, 3) is given by $p_i = a_i - b_i Q_i$. Perfect competition in all downstream industries implies $p_i = c_i$ $(\forall i)$. Hence the direct demand for infrastructure inputs from downstream sector 1 can be written as:

$$k_1 = k_1^* = Q_1 = S_1(a_1 - r - r^*) \tag{22}$$

while the direct demand for infrastructure inputs from downstream sector 2 and 3 are, respectively:

$$k_2 = \lambda_2 Q_2 \tag{23}$$

and

$$k_3^* = \lambda_3^* Q_3 \tag{24}$$

with $Q_2 = S_2(a_2 - \lambda_2 r)$, $Q_3 = S_3(a_3 - \lambda_3^* r^*)$ and $S_i = 1/b_i$ $(\forall i)$. Total demand from downstream sectors for the public infrastructure input therefore is $K = k_1 + k_2$, while the demand from downstream firms for the infrastructure provided by the foreign firm is $K^* = k_1^* + k_3^*$. Together with expression (22), we then have $K - k_2 = k_1 = k_1^* = K^* - k_3^*$.

Given that the government and the foreign firm have the same objective functions as they did in the basic model, we find that the addition of other downstream industries does not affect the qualitative nature of the pricing game between the government and the foreign firm: the reaction function of the foreign firm preserves its negative slope, while the positive slope of the average-cost pricing government's reaction function is also maintained. Consequently, our qualitative results remain true in this extension of the model.

There is another way in which more downstream firms can be added to the model. Note that, so far, we have assumed that the downstream sectors are purely domestic and perfectly competitive. It is of course plausible that, as a result of the increased investment in infrastructure, the developing host country becomes attractive to FDI in new downstream industries. So, foreign firm activity in novel downstream markets may emerge, which may in turn contribute to the long-term growth of the economy.

5.2. Cost complementarities

Instead of (or as well as) demand complementarities between infrastructure inputs, there may exist cost complementarities between different types of infrastructure. Illustrating this in the simplest way, we eliminate the downstream sector for now and assume that the inverse demand functions for each type of infrastructure are given by:

$$r = a - bk \tag{25}$$

in the public infrastructure sector, and by

$$r^* = a^* - b^*k^* \tag{26}$$

in the private infrastructure sector. Marginal production costs are given by:

$$\gamma = \gamma_0 - \theta k^* \tag{27}$$

and

$$\gamma^* = \gamma_0^* - \theta^* k \tag{28}$$

where γ_0 and γ_0^* stand for the marginal production cost for the respective infrastructure investors if the other infrastructure provider's investment is zero. For each firm, the marginal production cost of infrastructure is lower the more the other type of infrastructure investor invests in its own infrastructure sector ($\theta > 0$ and $\theta^* > 0$). A similar complementarity may also exist for fixed costs, with $F = F_0 - \lambda k^*$ and $F^* = F_0^* - \lambda^* k$ (so, infrastructure investment in the other infrastructure sector possibly lowers fixed costs in the own infrastructure sector, F_0 and F_0^*, with $\lambda \geq 0$ and $\lambda^* \geq 0$).

The government sets the price of the public infrastructure, *r*, to break even. Welfare is now given by:

$$W = CS + rk - \gamma k - F \tag{29}$$

where consumer surplus is denoted by *CS*, with $CS = \frac{1}{2}(bk^2 + b^*k^{*2})$. The foreign firm simply maximises its profit given by expression (12).

Without deriving all the results in detail, we briefly discuss the qualitative similarities and differences of the pricing game with these assumptions. It remains true that the government's price reaction function is positively sloped. As the price of the foreign firm's infrastructure increases, infrastructure investment by the foreign firm will fall, which will increase the public firm's marginal cost (and possibly even its fixed cost). This results in a higher average cost for the public firm, which will be reflected in a higher price for its infrastructure. However, the foreign firm's price reaction function will now be positively sloped (given that the different types of infrastructure are no longer assumed to be infrastructural inputs). The equilibrium of the pricing game is shown in Figure 5 at point A. Privatisation of the public firm will now lead to lower consumer surplus and overall welfare as both firms will charge higher prices (see point L in Figure 5). However, as the government reaction function remains positively sloped, a price ceiling imposed on the foreign firm's infrastructure provision is, just like in our basic model, not only welfare improving but also beneficial for consumers of the host country as it brings prices in all infrastructure provision down (point C in Figure 5).

[*Figure 5 about here*]

6. Conclusion

In this paper we have used a simple model to examine the welfare effects of the liberalisation of foreign investment in infrastructure on a host country and to explore different host country post-liberalisation policies. Our analysis is inspired by the stylised fact that there often are important complementarities between different types of infrastructure. In our model both domestically produced infrastructural inputs and those provided by a foreign multinational firm are used as complementary inputs by a perfectly competitive downstream sector. Due to this complementarity in infrastructural input demand, the host country's welfare typically rises discretely as a result of the multinational firm entering the market. We have compared the equilibrium of the pricing game between the multinational firm and the public host-country firm, assuming that the latter has adopted average-cost pricing and compared it to those that which would prevail when the public host-country firm uses alternative pricing schemes. We found that marginal-cost pricing, often claimed to be a more efficient pricing practice, while being better for the consumer is inferior from an overall welfare perspective. This result arises due to strategic interaction between the home and foreign firms. Although marginal-cost pricing implies that the publicly provided infrastructural input is cheaper than under average-cost pricing, it allows the multinational to set a higher price for the type of infrastructure it provides. This leads us to explore, other pricing mechanisms the government of the host country could commit to strategically reduce the price charged by the foreign firm. We discuss the option of privatisation and a price ceiling on the infrastructural input provided by the multinational firm. Both raise the host country's overall welfare, but while the former lowers domestic consumer surplus, the latter has the advantage of raising it.

Finally, we like to suggest another avenue for fostering infrastructure. One increasingly popular way of lightening the burden of infrastructure investment in OECD countries is the creation of public private partnerships (PPPs). While these are also emerging in LDCs, they are still in their infancy. An in-depth analysis of these and their potential welfare effects possibly is an avenue for future research.

References

Agenor P.-R. and B. Moreno-Dodson (2006), *Public infrastructure and growth: New channels and policy implications*, World Bank Policy Research Working Paper 4064, Washington, DC.

Aghion, P., T. Besley, J. Browne, F, Caselli, R. Lambert, R. Lomax, C. Pissarides, N. Stern and J. Van Reenen (2017), *Investing for Prosperity. Skills, Infrastructure and Innovation,* Report of the LSE Growth Commission.

Amir, R. (2005), "Supermodularity and complementarity in economics: An elementary survey", *Southern Economic Journal*, 71, 636-660.

Baland, J.M. and P. Francois (1999), "Investment coordination and demand complementarities", *Economic Theory*, 13, 495-505.

Banerjee, S.G. and J.M. Oetzel (2006), "Private Provision of Infrastructure in Emerging Markets: Do Institutions Matter?*", Development Policy Review,* 24, 175-202.

Bouet, A. and D. Roy (2008). *"Does Africa Trade Less than it Should, and If So, Why?: The Role of Market Access and Domestic Factors".* Washington DC: IFPRI.

Brook, P.J. and T.C. Irwin (2003), *Infrastructure for Poor People: Public Policy for Private Provision*, Washington, DC: World Bank.

Chibber, V. (2014), *"The Developmental State in Retrospect and Prospect: Lessons from India and South Korea"* in Williams, M. (ed.), New York: Routledge: 30–54.

Estache A. and M. Fay (2009), *Current debates on infrastructure policies*, Commission on Growth and Development, Working paper no 49.

International Finance Corporation (2016), *The Private Provision of Infrastructure: Opportunities for Emerging Markets*, World Bank Group, December 2016.

Johnson, C. (1982), *MITI and the Japanese Miracle. The Growth of Industrial Policy, 1925-1975*, Stanford University Press: Stanford, CA.

Gabszewicz, J., N. Sonnac and X. Wauthy (2001), "On price competition with complementary goods", *Economics Letters*, 70, 431-437.

Leftwich, A. (1995), "Bringing politics back in: Towards a model of the developmental state", *Journal of Development Studies*, 31, 400-427.

Makuyama, G. and N. Odhiambo (2016), "Public and private investment and economic growth: A review", *Journal of Accounting and Management*, 6, 25-42.

Markard, J. and V.H. Hoffmann (2016), "Analysis of complementarities: Framework and examples from the energy transition", *Technol. Forecast. Soc. Change,* http://dx.doi.org/10.1016/j.techfore.2016.06.008 .

Matsuyama, K. (2002), "Explaining diversity: Symmetry-breaking in complementarity games", *American Economic Review*, 92, 241-246.

OECD (2015), *Fostering Investment in Infrastructure. Lessons Learned from OECD Policy Reviews*, January 2015.

Romp, W. and J. de Haan (2005), *Public capital and economic growth: A critical survey*, European Investment Bank, Luxemburg, EIB papers 10.

Urrunaga, R. and S. Wong (2016), *"When the total is more than the sum of parts: Infrastructure complementarities"*, Peruvian Economic Association, Working Paper No. 64.

Woo-Cumings, M. (1999), *The Developmental State*, Cornell University Press: Ithaca, New York.

Figure 1: The pricing game in infrastructure provision

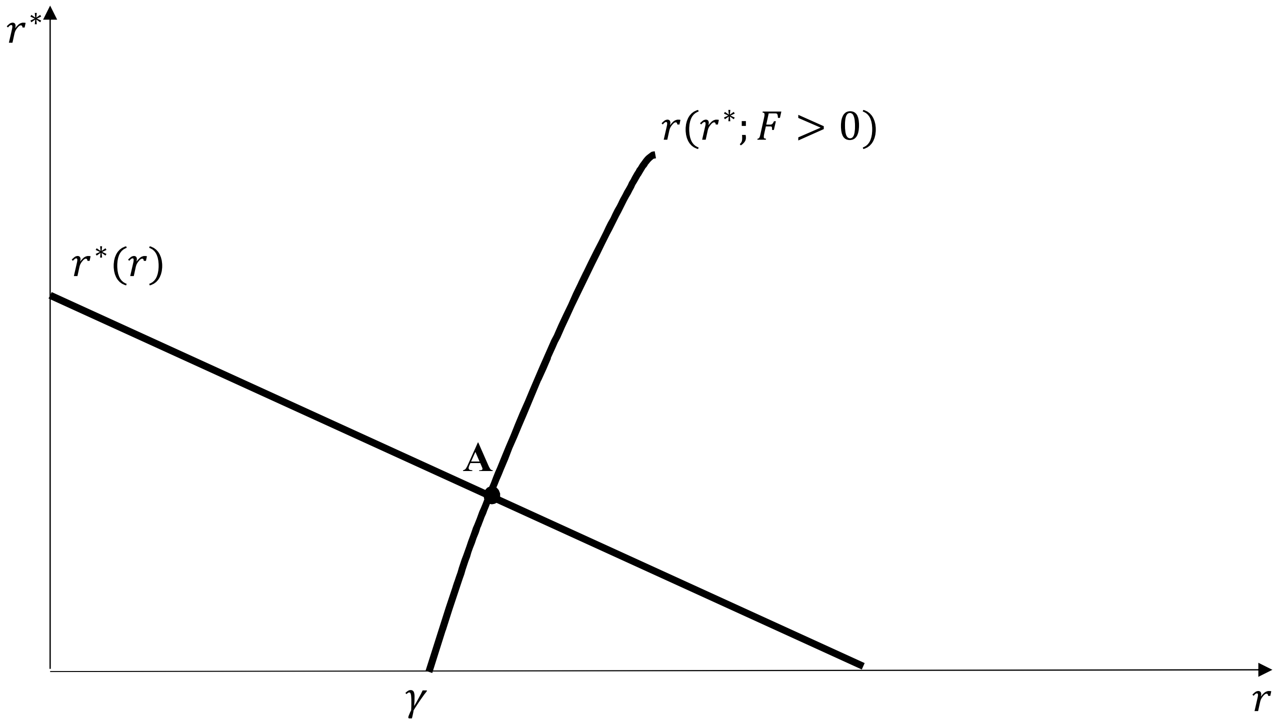

Figure 2: Comparing average-cost and marginal-cost pricing

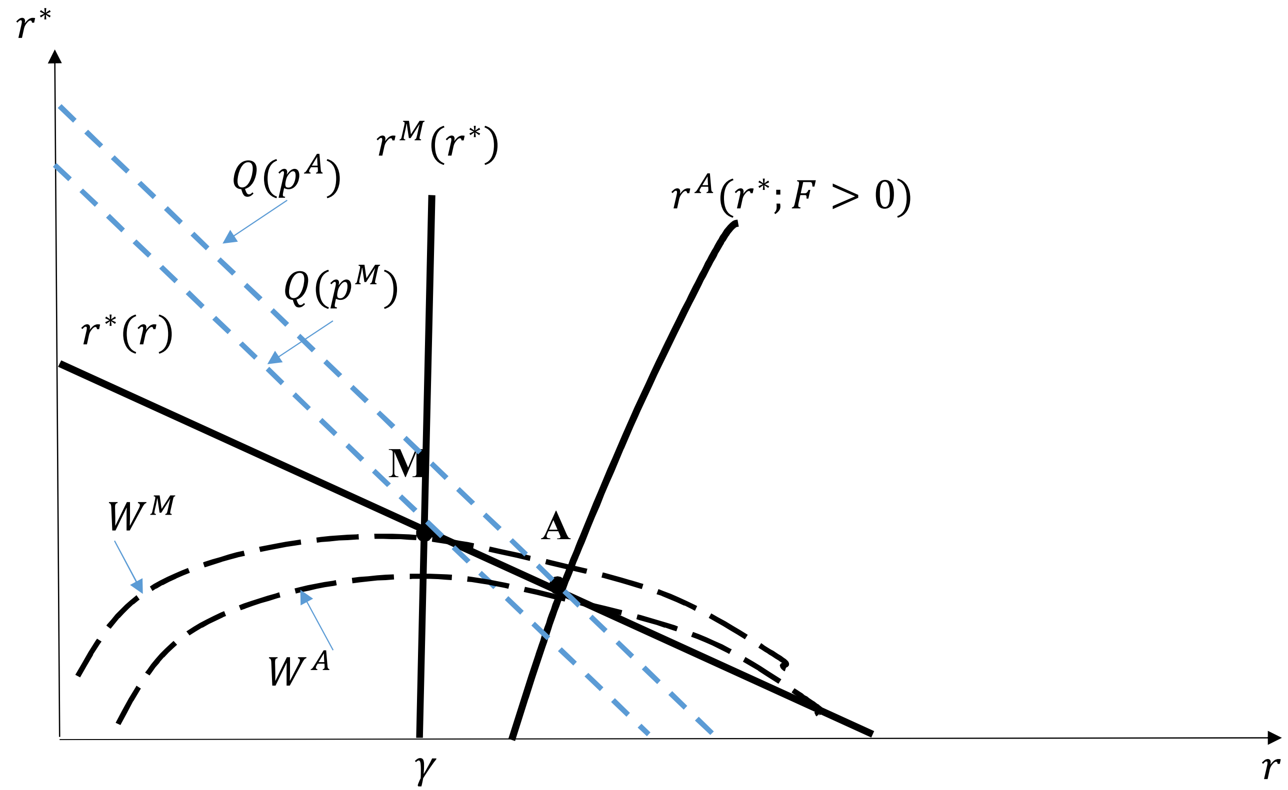

Figure 3: The effects of privatising the home firm

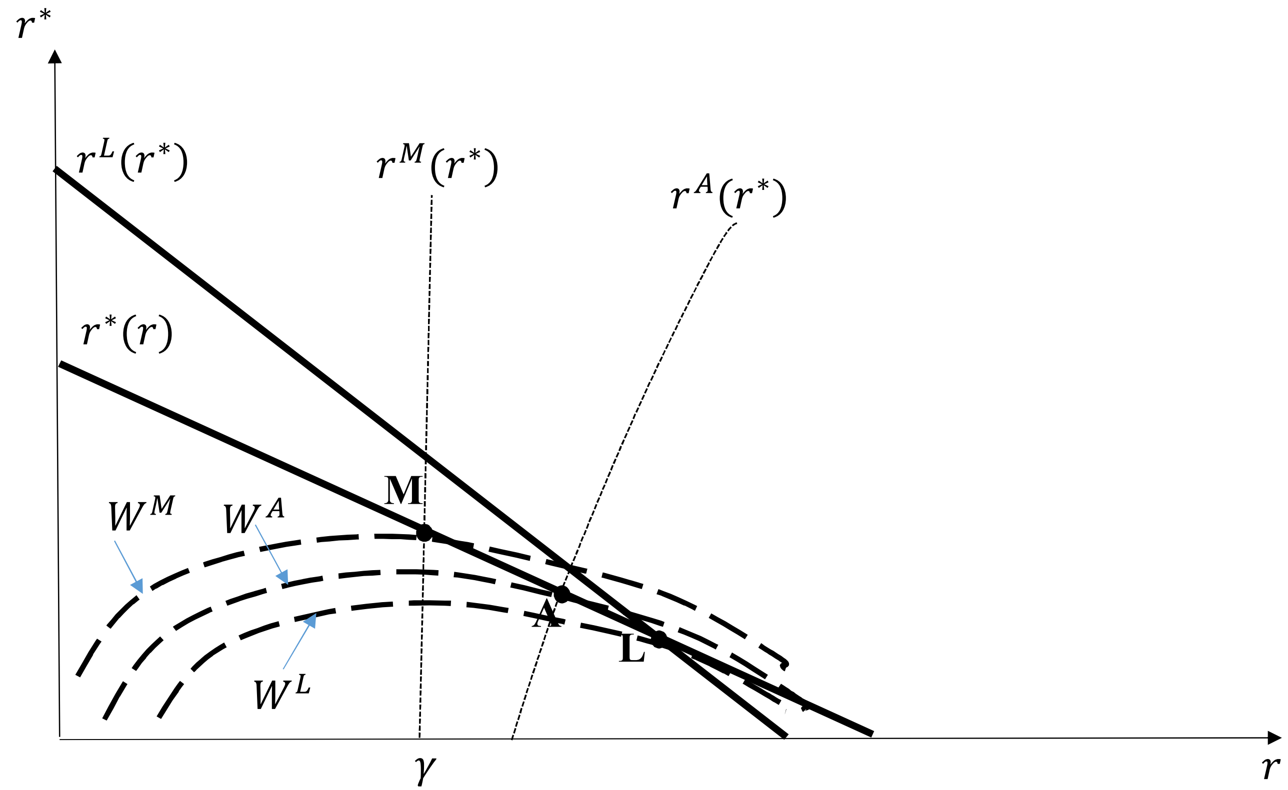

Figure 4: The effects of a price ceiling

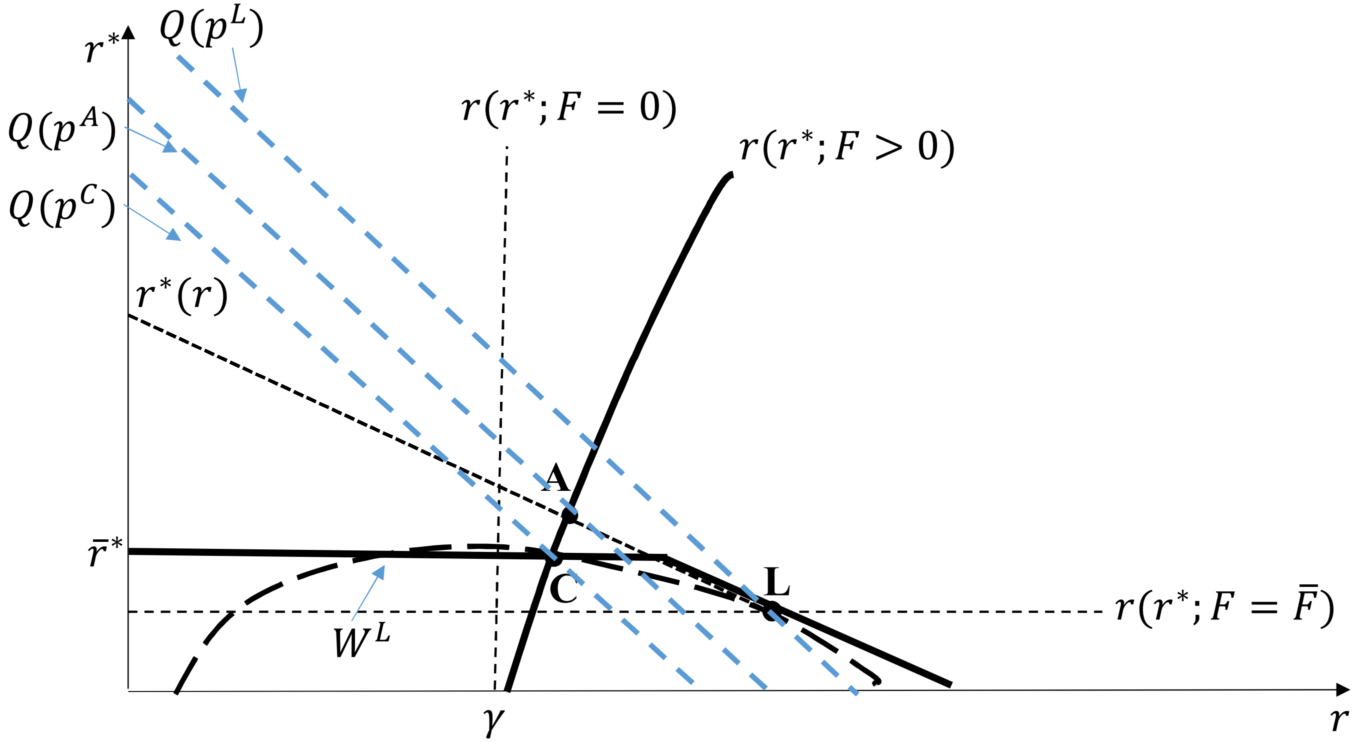

Figure 5: The pricing game and the effects of a price ceiling with cost complementarities