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# OFFSHORING AND PRODUCT INNOVATION

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# ABSTRACT

## Offshoring and Product Innovation*

We propose an endogenous growth model with offshoring to investigate its effects on product innovation and growth in the country of origin. Offshoring is associated with reduced feedback from offshored plants to domestic labs as well as coordination problems between the offshored and domestic divisions of firms. Production and transport cost parameters affect the static decision to relocate plants but not R&D. Hence, offshoring may be chosen by firms when it damages the growth rate of their countries of origin. In particular, if offshoring reduces the feedback from plants to labs, it is likely to bring dynamic losses when the countries of origin are large, especially in sectors in which R&D is cheap and product differentiation is strong. It is also likely to slow growth in sectors in which contractual incompleteness gives a strong bargaining power to offshored divisions in intra-firm transactions.

JEL Classification: F12 and F23
Keywords: growth, incomplete contracts, innovation and offshoring

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# 1 Introduction

Offshoring has sparked hot debates in the last few year that have mostly focused on its static effects on the product and labor markets. Offshoring to cheap labor countries is seen as directly benefiting consumers as firms pass on their savings in the form of lower prices. This effect may be stronger when associated with higher firm productivity.[1] At the same time, offshoring is frequently blamed by workers and trade unions for the slow pace of job growth in the United States and for the swelling wage differential between low and high skill workers (Feenstra and Hanson, 2001).

Much less attention has been devoted to the dynamic effects of offshoring on innovation and growth. First of all, offshoring may release domestic resources that can be reallocated to the creation of new products, new technologies and thus new and better jobs to replace those lost to cheaper foreign countries.[2] On the other hand, offshoring production to low income countries may reduce the feedback from plants to R&D labs, which typically remain located in the country of origin. For instance, in the case of optoelectronics Fuchs and Kirchain (2005) argue that decisions to offshore based on immediate cost pressures may be getting in the way of the critical innovations necessary for the development of the large-scale optoelectronic integrated circuits. These play a vital role in insuring continual advancement of microprocessor speed (Kimerling et al. 2004, p. 89-119). Yet, after the telecom bubble burst, most US optoelectronics firms moved upstream production to low-wage countries, mainly to China, Taiwan, Malaysia and Thailand. Once there, "a combination of non-transferable tacit knowledge in U.S. assembly line workers and implicit real-time on-the-line learning by design engineers is preventing firms from being able to cost-effectively manufacture the emerging design". This suggests that "the static economies of offshore manufacture ... lead to dynamic diseconomies - specifically, disincentives for innovation" (Fuchs and Kirkchain, 2005, p.3).

The effects of offshoring on R&D and growth are still largely neglected by international trade theory and they have also captured only very limited attention by the rapidly expanding empirical

[1] See, e.g., Barba Navaretti and Castellani (2006), Debeare, Lee and Lee (2006), and Hijzen, Jean and Mayer (2006) for evidence on Italy, Korea and France respectively.

[2] The issue is investigated by, e.g., Strauss-Kahn (2004) and Eckholm and Hakkala (2006) who study the effect of offshoring to low income countries on the demand for low and high skilled labor in France and Sweden respectively.

trade literature. The aim of the present paper is to start filling the theoretical gap, and possibly stimulate empirical research on the topic. In so doing, we concentrate on a specific question: *When is offshoring bad for growth?* The question is addressed in a set-up that abstracts from labor market issues but embeds all the other main pros and cons highlighted in the policy debate. There are two countries, North and South, and two sectors, production and R&D. Final products are horizontally differentiated and varieties are supplied according to blueprints that are invented and patented by R&D labs. Production takes place along a vertical chain consisting of two stages, intermediate supply ('upstream') and final assembly ('downstream'). Only North has the accumulated experience to perform R&D and a market for final products. Final assembly is interpreted as distribution and after-sale services. Hence, both R&D and final assembly take place in North and South is simply a potential production site for intermediates. Offshoring arises when these are indeed produced in South rather than North.

The main features of the policy debate are embedded as follows. First of all, South is blessed by a Ricardian advantage in intermediate supply, which maps into lower production costs and hence lower prices of intermediates. Southern intermediates, however, have to be shipped to North for final assembly. Shipments are costly and this generates a trade-off between production costs and transport costs. Second, coordination along the production chain is perfect if both stages take place in North whereas the geographical separation of upstream and downstream plants generates coordination problems that are not perfectly solvable through contracting. Contractual incompleteness generates additional costs that work against offshoring. Third, locating the upstream stage in South weakens the feedback from plants to labs due to imperfect knowledge spillovers.

In our set-up production and transport cost parameters affect the static decision to relocate plants but not R&D. Hence, offshoring may be selected by firms when it ends up damaging the growth rate of their country of origin. Particularly, when offshoring reduces the feedback from plants to labs, it is likely to bring dynamic losses if countries of origin are large, especially in sectors in which R&D is cheap and product differentiation is strong. It is also likely to slow down growth in sectors in which contractual incompleteness leaves a strong bargaining power to offshored divisions.

**Related literature**

The trade-off between production cost and transport cost embedded in our production chain is typical of the multinational models with vertical FDI (Markusen, 2002; Barba Navaretti and Venables, 2004). Its enrichment with additional contractual costs follows recent contributions that study firms' ownership and location choices in environments in which the contracts between the various stakeholders in the production process are incomplete and thus their interactions suffer from hold-up problems (Helpman, 2006). The key idea is that the quality of deliverables in a bilateral transaction is unobservable by third parties and therefore, after the deliverables have been produced, the stakeholders involved in the transaction have to bargain on some division of the surplus it would generate. Different degrees of contractual incompleteness are associated with different choices on ownership (Grossman and Helpman, 2002) or location (Antras, 2005). Their interactions with the characteristics of sectors and countries is able to generate the rich taxonomy of organizational forms observed in reality (Antras and Helpman, 2004). The foregoing contributions highlight the static effects of the organizational choice while neglecting its effects on innovation and growth. An exception is Naghavi and Ottaviano (2006) who introduce endogenous growth à la Grossman and Helpman (1991) in the static framework that Grossman and Helpman (2002) use to model the choice between vertical integration and outsourcing. When R&D is performed by independent labs, the dynamic perspective of Naghavi and Ottaviano (2006) reveals a tension between the static and dynamic implications of outsourcing as producers make their organizational choices neglecting their effects on innovation and growth. Hence, when outsourcing is selected, the static gains from specialized production may at times be associated with relevant dynamic losses for consumers due to slower innovation. Whether this happens or not depends on sector characteristics. In the present paper we investigate how the above tension between static gains and dynamic losses may arise in the case of offshoring.

In terms of ownership, ours is not a model of the boundaries of the firm. Hence, it is open to two alternative interpretations depending on whether transactions are assumed to take place within or across firms' boundaries. A first interpretation is that Southern contractual incompleteness stems from the lack of ex-post verifiability by third parties: input quality is too costly to be assessed by courts, due to inefficiency in the case of southern courts and prohibitive informational or jurisdictional barriers in the case of northern courts.[3] Alternatively, when transactions are assumed to take place within firms' boundaries, our assumption of incomplete contracts is reminiscent of Aghion and Tirole (1997), Antras (2003), Marin and Verdier (2003) as well as Hart and Moore (2005). These authors study the decentralization of decision making inside corporations. In addition Hart and Moore (2005) differentiate between coordination and specialization tasks within a firm. In this perspective, offshoring can be interpreted as a more decentralized organization, where real authority is granted to specialized divisions.[4] In other words, the geographical division of labor reallocates the decision making power from the CEO to specialized divisions. This gives rise to coordination problems among agents, who are only interested in their own stake in profits. The lack of authority by the CEO to enforce agreements between the two divisions gives rise to hold-up problems. When firms choose to produce only in North, they avoid coordination problems but must then bear higher costs of production.

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 investigates the decision of firms with regards to offshoring intermediate production. In section 4, we study how offshoring feeds back to R&D activities and innovation. We then show how the latter determines economic growth. Section 5 concludes.

## 2 The Model

The economy consists of two countries, North and South. All workers and consumers belong to North but can be employed in South as expatriates.[5] Hence the South is simply a potential production site.

[3] In Grossman and Helpman (2002, 2003 and 2005), unobservable input quality is an issue insofar as only high quality inputs can be processed whereas low quality inputs are useless even though supplied at zero cost.

[4] As emphasized by Aghion and Tirole (1997) real authority translates into effective control over decisions, while formal authority is simply the right to decide.

[5] The assumption that there is no labor in South removes the main shortcoming of offshoring stressed in the popular debate, namely the substitution of northern jobs with southern ones. The purpose of the assumption is to abstract from that issue and single out instead the additional impact of offshoring on innovation as filtered through partial

## 2.1 Demand

There are $L$ infinitely-lived households with identical preferences defined over the consumption of a horizontally differentiated good $C$. The utility function is assumed to be instantaneously Cobb-Douglas and intertemporally CES with unit elasticity of intertemporal substitution:

$$U = \int_0^{\infty} e^{-\rho t} \ln C(t) dt, \tag{1}$$

where $\rho > 0$ is the rate of time preference and

$$C(t) = \left[ \int_0^{n(t)} c(i,t)^{\alpha} di \right]^{1/\alpha}$$

is a CES quantity index in which $c(i,t)$ is the consumption of variety $i$, $n(t)$ is the number of available varieties of good $C$, and $\alpha$ is an inverse measure of the degree of product differentiation between varieties. Households have perfect foresight and they can borrow and lend freely in a perfect capital market at instantaneous interest rate $R(t)$.

Using multi-stage budgeting to solve their utility maximization problem, households first allocate their income flow between savings and expenditures. This yields a time path of total expenditures $E(t)$ that obeys the Euler equation of a standard Ramsey problem:

$$\frac{\dot{E}(t)}{E(t)} = R(t) - \rho, \tag{2}$$

where we have used the fact that the intertemporal elasticity of substitution equals unity. By definition, $E(t) = P(t)C(t)$ where $P(t)$ is the exact price index associated with the quantity index $C(t)$:

$$P(t) \equiv \left[ \int_0^{n(t)} p(i,t)^{\alpha/(1-\alpha)} di \right]^{(1-\alpha)/\alpha}. \tag{3}$$

Households then allocate their expenditures across all varieties, which yields the instantaneous demand function

$$c(i,t) = A(t) p(i,t)^{-1/(1-\alpha)} \quad i \in [0, n(t)] \tag{4}$$

for each variety. In (4) $p(i,t)$ is the price of variety $i$ and

R&D spillovers and incomplete contracts.

$$A(t) = \frac{E(t)}{P(t)^{-\alpha/(1-\alpha)}} \tag{5}$$

is aggregate demand. Hence, $\sigma = 1/(1-\alpha)$ is the own and cross price elasticity of demand. Throughout the rest of the paper, we leave the time dependence of variables implicit when this does not generate confusion.

## 2.2 Supply

There are two factors of production in the economy. Labor is inelastically supplied by households and each household supplies one unit of labor so that we can use $L$ to refer both to the number of households and the total endowment of labor. Labor is freely mobile between countries and it is chosen as numeraire. The other factor is knowledge capital in the form of blueprints for the production of differentiated varieties. Blueprints are protected by infinitely lived patents and depreciate at a constant rate $\delta$.

There are two sectors, innovation (R&D) and production. Perfectly competitive labs invent blueprints for the production of the differentiated varieties. Varieties are freely traded and the production of each variety requires a single blueprint and consists of an upstream and a downstream stage. Producers enter by buying the rights to use the blueprints and split their activities between an upstream division supplying intermediates and a downstream division assembling them. Assembly takes place only in North whereas intermediates can be produced also in South. This country has a Ricardian advantage in intermediate production. In particular, $\lambda \geq 1$ units of labor are required to produce a unit of intermediate in North, whereas intermediate production in the South only requires 1 unit of labor per unit of output. Final assembly in turn needs one unit of the intermediate component for each unit of the final good. Accordingly, offshoring leads to productivity gains.

Offshoring is also associated with additional costs. First, if produced in South, intermediates have to be shipped to North and this incurs iceberg trade costs: $\tau > 1$ units have to be shipped for one unit to reach destination. Second, intermediates are variety-specific: once produced for a certain assembly line, they have no alternative use. Only high quality intermediates can be processed whereas low quality inputs are useless even though supplied at zero cost. Contracts between the upstream and downstream divisions are complete when both are located in North, but incomplete when the upstream division is offshored to South. In this case the quality of intermediates can not be assessed by third parties. That generates a hold-up problem: after the upstream division has supplied its specific input, it has to reach an agreement with the downstream division on how to share the joint surplus (revenues) from final sales. We denote the bargaining weight of intermediate input producer by $\omega$.

Finally, offshoring affects the marginal cost of innovation. We adopt an endogenous growth setting and assume that R&D faces a learning curve so that the marginal R&D cost of blueprints decreases with the number of blueprints that have been successfully introduced in the past. Specifically, the invention of a new blueprint requires $k/(v + \gamma f)$ units of labor where $k > 0$ is a parameter, $v$ is the number of blueprints used by producers keeping both divisions in North and $f$ the number of blueprints adopted by producers offshoring their upstream divisions.[6] Hence we have $v + f = n$. Given the chosen functional form, some initial stocks of implemented blueprints $n_0 > 0$ is needed to have finite costs of innovation at all times. We assume that this stock belongs to North. The parameter $\gamma \in (0, 1)$ captures the facts that offshoring reduces the feedback from production to labs in the home country as in the optoelectronics example discussed in the introduction.[7]

## 2.3 Timing

In each period $t$ the following sequence of actions take place. Independent labs engage in R&D to innovate new patents. Producers enter by purchasing the corresponding blueprints and choose the location of intermediate production. Upstream divisions manufacture the inputs needed by their downstream divisions. Once input production is completed, the offshoring divisions bargain over the

[6] The assumed shape of the learning curve serves analytical solvability and the comparison with Grossman and Helpman (1991). In equilibrium it yields a 'size effect', meaning that larger countries grow faster. As this prediction runs against the empirical evidence, the size effect could be removed by assuming that the intensity of the learning spillover is lower, i.e. $k/(v + \gamma f)^{\xi}$ with $0 < \xi < 1$ (Jones, 1995).

[7] See, e.g., Adams and Jaffe (1996) as well as Love and Roper (1999) for empirical evidence on the importance of the feedback from plants to labs.

share of total revenues from final sales and inputs are handed over to downstream divisions. Final assembly then takes place and the final products are sold to households together with those supplied by non-offshoring producers.

# 3 Industry Equilibrium

## 3.1 Production

At time $t$ the instantaneous equilibrium is found by solving the model backwards from final production to R&D. Varieties can be sold to final customers by two types of producers: offshoring and non-offshoring firms. A typical non-offshoring firm faces a demand curve derived from (4) and a marginal cost equal to $\lambda$. It chooses its scale by maximizing its operating profit

$$\pi_v = p_v y_v - \lambda x_v, \tag{6}$$

where $x_v$ is the amount of the intermediate input produced and $y_v = x_v$ is the final output. Optimal output and price are then given by:

$$x_v = y_v = A\left(\frac{\alpha}{\lambda}\right)^{\frac{1}{1-\alpha}} \tag{7}$$

and

$$p_v = \frac{\lambda}{\alpha}. \tag{8}$$

Replacing these values in (6) results in operating profit equal to

$$\pi_v = (1-\alpha)\, A\left(\frac{\alpha}{\lambda}\right)^{\frac{\alpha}{1-\alpha}}, \tag{9}$$

which is an increasing function of product differentiation $(1-\alpha)$ and a decreasing function of the marginal cost $(\lambda)$.

Turning to offshoring firms, the joint surplus of their divisions is given by the revenues from the final sales of the corresponding variety $p_f y_f$. This is divided according to the bargaining weights of the two parties. Accordingly, a share $(1-\omega)$ goes to the downstream division. With iceberg costs on intermediates $\tau > 1$, that gives downstream operating profits

$$\pi_f = (1-\omega)p_f y_f = (1-\omega)p_f \frac{x_m}{\tau}, \tag{10}$$

and the remaining share $\omega$ goes to the upstream division. This must decide in the previous stage how much input $x_m$ to produce incurring a cost of $x_m$ units of labor. Therefore, it maximizes

$$\pi_m = \omega p_f y_f - x_m, \tag{11}$$

which implies intermediate and final output equal to

$$\frac{x_m}{\tau} = y_f = A \left( \frac{\alpha\omega}{\tau} \right)^{\frac{1}{1-\alpha}} \tag{12}$$

with associated final price

$$p_f = \frac{\tau}{\alpha\omega}. \tag{13}$$

The presence of $\omega$ in (12) and (13) shows that the hold up problem materializes in a reduction of the amount of intermediate input supplied. This maps into a reduction of final output and an increase in its price. The more so the smaller the bargaining weight of the intermediate supplier.

Using these results in (10) and (11), the shares of the downstream and upstream divisions are respectively:

$$\pi_f = (1-\omega)\, A \left( \frac{\alpha\omega}{\tau} \right)^{\frac{\alpha}{1-\alpha}} \tag{14}$$

and

$$\pi_m = (1-\alpha)\, \omega A \left( \frac{\alpha\omega}{\tau} \right)^{\frac{\alpha}{1-\alpha}}. \tag{15}$$

Therefore the total operating profits of an offshoring firm, $\pi_o = \pi_f + \pi_m$, evaluate to

$$\pi_o = (1-\omega\alpha)\, A \left( \frac{\alpha\omega}{\tau} \right)^{\frac{\alpha}{1-\alpha}}. \tag{16}$$

Substituting (8) and (13) into (3) and (5) allows us to write aggregate demand as

$$A = \frac{E}{v \left( \frac{\alpha}{\lambda} \right)^{\frac{\alpha}{1-\alpha}} + f \left( \frac{\alpha\omega}{\tau} \right)^{\frac{\alpha}{1-\alpha}}}, \tag{17}$$

where $v$ and $f$ are the number of integrated and offshoring firms that are active at time $t$. As entrants can freely choose between offshoring and entirely domestic production in North, the operating profits producers earn are equal to $\pi \equiv \max(\pi_v, \pi_o)$.

Comparing (9) with (16) shows that profits with and without offshoring coincide when $\lambda = \tau$ and $\omega = 1$. The reason is that when $\lambda = \tau$ the saving by offshored production are exactly offset by the additional transport costs, and when $\omega = 1$ the upstream division appropriates all joint surplus and thus has the incentive to supply the optimal (i.e. surplus-maximizing) amount of intermediate.

## 3.2 Innovation

In the entry stage, labs invent new blueprints at a marginal cost that depends on acquired experience $k/(v + \gamma f)$ and their output determines the laws of motion of $n$. We then have

$$\dot{n} = \frac{(v + \gamma f)L^I}{k} - \delta n, \tag{18}$$

where $n = v + f$, $\dot{n} \equiv dn/dt$, $L^I$ is labor employed in inventing new blueprints, $(v + \gamma f)/k$ is its productivity and $\delta$ is the rate of depreciation.

Due to learning, as innovation cumulates, it becomes increasingly cheaper to create new patents and, being priced at marginal cost, their values fall through time. Specifically, if we call $J$ the asset value of a patent, marginal cost pricing gives $J = k/(v + \gamma f)$, which implies

$$\frac{\dot{J}}{J} = -\frac{\dot{v} + \gamma \dot{f}}{v + \gamma f}. \tag{19}$$

Labs pay their researchers by borrowing at the interest rate $R$ and know that the resulting patents will generate instantaneous dividends equal to the expected profits of the corresponding firms. Arbitrage in the capital market then yields

$$R + \delta = \frac{\pi}{J} + \frac{\dot{J}}{J} = \frac{\pi(v + \gamma f)}{k} - \frac{\dot{v} + \gamma \dot{f}}{v + \gamma f}, \tag{20}$$

where the second equality is granted by (19). This pins down the interest rate in the Euler equation (2).

Finally, the aggregate resource constraint (i.e. the labor market clearing condition) closes the characterization of the instantaneous equilibrium. Since labor is used either in innovation or in intermediate production, we have $L = L^I + v\lambda x_v + f x_m$. By (7), (12) and (18), the condition can be rewritten as

$$L = \frac{k}{v + \gamma f}\left[\dot{v} + \dot{f} + \delta(v + f)\right] + v\lambda A\left(\frac{\alpha}{\lambda}\right)^{\frac{1}{1-\alpha}} + fA\tau\left(\frac{\alpha\omega}{\tau}\right)^{\frac{1}{1-\alpha}}. \tag{21}$$

### 3.3 Organization

For both types of firms to exist in any instant $t$, producers have to be indifferent between offshoring and non-offshoring. This is the case if both organizational choices offer the same operating profits, i.e. $\pi_v = \pi_o = \pi$. By (9) and (16) that is the case if and only if

$$(1-\alpha)\left(\frac{1}{\lambda}\right)^{\frac{\alpha}{1-\alpha}} = (1-\omega\alpha)\left(\frac{\omega}{\tau}\right)^{\frac{\alpha}{1-\alpha}}$$

This is generally impossible except for a zero-measure set of parameter values, so there is never simultaneous presence of both offshoring and non-offshoring firms. Only offshoring takes place when

$$\frac{1-\omega\alpha}{1-\alpha} > \left(\frac{\tau}{\lambda\omega}\right)^{\frac{\alpha}{1-\alpha}} \tag{22}$$

and no firms offshore whenever the reverse is true. In other words, when (22) holds, offshoring generates *static gains* due to a more efficient organization of production.

Condition (22) shows that offshoring is chosen when there are large gains from more productive intermediate supply in South (large $\lambda$) and when the transport costs of importing the intermediates back to North are low (small $\tau$). Accordingly, trade liberalization (lower $\tau$) makes an offshoring equilibrium more likely and can eventually change the industry equilibrium from integration to offshoring. The convergence of production costs (lower $\lambda$) on the other hand discourages offshoring and makes it more likely for producers to keep both divisions in North. Finally, institutional convergence (higher $\omega$) eliminates the hold-up problem and could encourage offshoring.

A large supplier bargaining power (large $\omega$) has two effects. On the right hand side of (22), it is associated with little intermediate underproduction by the offshored upstream division. On the left hand side, it corresponds to lower returns to the downstream division and thus lower total profits for offshoring firms. The first effect makes offshoring more attractive, while the second discourages it. When $\omega = 1$, the upstream division produces the optimal amount of intermediate and the offshoring decision boils down to a straightforward comparison of production and trade costs.

# 4 Innovation and Growth

We now turn to the dynamic effects of firms' offshoring decision to study its consequences on innovation in North.

## 4.1 No Offshoring

When condition (22) does not hold, no labor is allocated to offshoring ($f = 0$, $n = v$). Along a balanced growth path, we have $\dot{v}/v = g_v$ and $\dot{E} = 0$. This allows us to write the labor market clearing condition (21) and the Euler condition (2) respectively as

$$L = k\left(g_v + \delta\right) + \alpha E$$

and

$$0 = \frac{\left(1-\alpha\right)E}{k} - g_v - \rho - \delta.$$

These generate a two-dimensional system of differential equations that does not exhibit any transitionary dynamics. The system can therefore be solved for the constant values of expenditures and growth rate that characterize the balanced growth path at any point in time:

$$E_v^* = L + \rho k,\; g_v^* = (1-\alpha)\frac{L}{k} - \alpha\rho - \delta. \tag{23}$$

Accordingly, when all production takes place in North, growth is boosted by weak time preference (small $\rho$), slow depreciation (small $\delta$), large size of the economy (large $L$), small R&D cost (small $k$), and pronounced product differentiation (small $\alpha$). While a large size of the economy also gives large expenditures, weak time preference and small R&D costs depress them as the annuity value of the initial stock of blueprints ($\rho k$) is small in this case.

## 4.2 Offshoring

When condition (22) holds, no labor is allocated to vertical integration ($v = 0$, $n = f$). Along a balanced growth path, we have $\dot{f}/f = g_f$ and $\dot{E} = 0$. This allows us to write the market clearing condition (21) and the Euler condition (2) respectively as

$$L = \frac{k}{\gamma}(g_f + \delta) + \alpha\omega E$$

and

$$0 = \frac{\gamma(1 - \omega\alpha) E}{k} - g_f - \rho - \delta.$$

Hence we have another two-dimensional system of differential equations that does not exhibit any transitionary dynamics. Its solution gives the constant values of expenditures and growth rate that characterize the balanced growth path of the model at any point in time:

$$E_f^* = L + \rho\frac{k}{\gamma},\ g_f^* = \gamma(1 - \omega\alpha)\frac{L}{k} - \omega\alpha\rho - \delta. \tag{24}$$

As before, growth is fostered by weak time preference (small $\rho$), slow depreciation (small $\delta$), large size of the economy (large $L$), small R&D cost (small $k$), and pronounced product differentiation (small $\alpha$). Weak feedback from production to innovation due to limited learning spillovers under offshoring (small $\gamma$) and strong upstream bargaining power (large $\omega$) both imply a small growth rate. The negative impact of $\omega$ on growth is due to the fact that an increase in upstream bargaining power reduces the joint profits of offshorers, thus discouraging the creation of new blueprints. Again, a large size of the economy also supports large expenditures whereas weak time preference as well as small R&D costs depress them. In addition, weaker knowledge spillovers increase expenditures in the offshoring equilibrium as the returns to R&D fall.

Comparing (23) with (24) shows that the two strategies coincide when $\gamma = \omega = 1$, that is, when the geographical separation between intermediate plants and labs does not weaken the knowledge spillovers to labs in the home country, and does not generate any incentive for upstream divisions abroad to underproduce.

## 4.3 Static Gains and Dynamic Losses

The presence of $\omega$ and $\gamma$ in (24) opens the gate to *dynamic losses* from offshoring in terms of slower innovation and growth. Indeed, offshoring only leads to faster growth than no offshoring when downstream bargaining power and learning spillovers are strong enough. Particularly, offshoring brings about a higher growth rate than no offshoring if and only if

$$\gamma > \frac{L(1-\alpha) - k\alpha\rho(1-\omega)}{L\,(1-\omega\alpha)} \tag{25}$$

The right hand side of (25) is smaller than unity. Hence, offshoring is always good for growth when it is not associated with weaker knowledge spillovers ($\gamma = 1$), the reason being that contractual incompleteness causes upstream under-production and thus releases labor to R&D. The right hand side of (25) is also an increasing function of $L$ and $\omega$ as well as a decreasing function of $\alpha$, $k$ and $\rho$. Accordingly, when offshoring impairs the feedback from plants to labs ($\gamma < 1$), it is more likely to bring dynamic losses in large patient countries (large $L$ and small $\rho$), and in sectors in which innovation is cheap (small $k$) and product differentiation substantial (small $\alpha$). It also slows growth in sectors in which contractual incompleteness leaves much bargaining power to offshored divisions (large $\omega$). The reason is that a large $\omega$ reduces the incentive of upstream divisions to under-produce. As this increases the size of their plants, they absorb labor that could have otherwise been engaged in R&D.

Comparing the growth rates in (23) and (24) with the offshoring break-even point (22) reveals that only the left hand side in the latter equation, i.e. the relative profit margin, is relevant for the growth rate. This is because the right hand side in (22) is simply the relative price of offshorers over non-offshorers'. It contains transport costs $\tau$, the hold-up impact $1/\omega$, and the marginal costs of production in the North $\lambda$. Components of price do not appear instead in the growth equations because once all firms have chosen whether or not to offshore, the price no longer affects their profits as they all enjoy the same market share ($E/n$). As the production and shipping cost parameters $\tau$ and $\lambda$ do not appear in (25), globalization (lower $\tau$) and production cost divergence (higher $\lambda$) can indeed lead to offshoring when it has an adverse effect on growth.

## 5 Conclusion

The debate on offshoring has mostly focused on its static effects on product and labor markets. This is someway reflected by the limited attention that international trade theory has devoted to investigating the effects of offshoring on R&D activities in the country of origin. We have studied these effects in an endogenous growth model in which offshoring is associated with reduced feedback from offshored plants to domestic labs as well as coordination problems between the offshored and domestic divisions of firms.

In our model production and transport cost parameters affect the static decision to relocate plants but not R&D. Accordingly, offshoring may be chosen by firms when it damages the growth rate of the country of origin. In particular, when offshoring reduces the feedback from plants to labs, it is likely to bring dynamic losses when the country of origin is large, and in sectors in which R&D is cheap and product differentiation strong. It is also likely to slow growth in sectors in which contractual incompleteness leaves a strong bargaining power to offshored divisions. Our findings are an initial attempt to start filling the theoretical gap in the international trade literature on the dynamic effects of offshoring on R&D, with the hope to inspire more empirical research on the topic.

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