Contractual Enforcement and the Industry Dynamics of Offshoring[*]

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Abstract

How do improved institutions in a host country influence the decision of firms on the geographical fragmentation of production? What are the channels through which a trend towards offshoring affects innovation and growth in the home country? Using an endogenous growth model in an incomplete contract environment with heterogeneous firms, we study the long-run effects of offshoring. Improved prospects for offshoring foster growth when they raise expected profits and reallocate labor from production to R&D. Industry dynamics reveal several channels through which this occurs: a shift of production to the South (extensive margin) and an increase in the relative size of each offshored firm (intensive margin). These effects fade out as more firms offshore, giving way to the negative growth consequences of increased bargaining weight of upstream offshored divisions. Therefore, long-run benefits of offshoring are exhausted as it expands until growth is hindered after an optimal level of fragmentation in the industry.

Keywords: offshoring, heterogeneous firms, incomplete contracts, growth, innovation, industry dynamics.

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1 Introduction

Offshoring, along with debates and literature related to it, has enjoyed an exponential growth in recent years. In particular, the controversy on the issue exploded in February 2004 when N. Gregory Mankiw rationalized offshoring through its long term positive consequences on the US economy. He argued that 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.[1] Trade economists have since rushed to support. Blinder (2006) calls offshoring the third industrial revolution, which can eventually be a sound occurrence for all workers, as the first and the second were regardless of initial skepticism. Baldwin (2006) calls the process "a second unbundling" that has occurred as a consequence of rapidly falling communication and coordination costs. Grossman and Rossi-Hansberg (2006) argue how traditional trade theory must give way for a paradigm more relevant to today's world, namely trade in 'tasks'. They show the benefits of this phenomenon by pointing out its positive impact on real wages of all workers in the home country. Finally, Rodrigues-Clare (2007) uses a dynamic model to show that the negative terms of trade effect of offshoring is outweighed by long-run gains from a positive research effect that emerges from the Schumpeterian channel.

At the same time, a large branch of international trade literature on firm organization has been devoted to the incomplete nature of contracts in arrangements between firms.[2] On the dynamic side of this front, Naghavi and Ottaviano (2006, 2008a, 2008b) use a growth model à la Grossman and Helpman (1991) to study the potential tension that may arise between the static and dynamic implications of the fragmentation of production. They find that while outsourcing gives rise to complementary upstream and downstream innovation, incomplete contracts may prevent static gains of specialized production from carrying through in the long run. They also find that offshoring can

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[1] 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).

[2] See McLaren (2000), Grossman and Helpman (2002), Antras (2003), Grossman and Helpman (2003), Marin and Verdier (2003), Antras and Helpman (2004), Grossman and Helpman (2005), Grossman, Helpman and Szeidl (2005) and Nunn (2007).

slow growth by reducing feedback from offshored plants to labs. Yet, in equilibrium, firms either all outsource or they all vertically integrate. This limits the analysis by restricting the equilibria to steady states or balanced growth paths in which all firms are of the same type. To explore industry dynamics, one needs a richer model with firm heterogeneity to study the organizational choice of each individual firm that corresponds to its unique level of technology and how this changes over time.[3]

To do this, we introduce firm heterogeneity à la Melitz (2003) in the above literature and allow different modes of organizations to exist simultaneously.[4] Our model differs from previous heterogenous literature as it is not a typical extra fixed cost that leads more productive firms to undertake a certain mode of organization. Using fixed cost differences to distinguish firms on the basis of their productivity could be misleading. Theoretically, it is not clear how fixed costs are ranked across organizational forms.[5] In addition, no evidence on the empirical side shows whether an extra fixed cost can be associated with the decision to outsource. We model the organizational decision of firms based on their ability to use a patent to discover new efficient production processes. More productive firms forgo specialization gains and keep all production in-house to benefit from better coordination. Less productive firms offshore intermediate production to take advantage of standardized production techniques with higher labor productivity, while risking coordination imperfections.[6]

We address the problem in a set-up with two regions, North and South, and two sectors, production and R&D. The North is the market for final products, which are horizontally differentiated. Varieties are supplied according to blueprints that are invented and patented by R&D labs. Firms

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[3] Grossman and Helpman (2004), Antràs and Helpman (2004) and Grossman, Helpman and Szeidl (2005) study the organization of firms in the presence of heterogeneous firms in a static set up.

[4] The only other growth models with heterogeneous firms to our knowledge are Baldwin and Robert-Nicoud (2008) and Segerstrom and Gustaffson (2006), which explore the impact of trade liberalization on growth in the presence of heterogeneous firms.

[5] For instance, Antràs and Helpman (2004) assumes that fixed costs of vertical integration are larger while Grossman, Helpman and Szeidl (2005) supposes that outsourcing fixed costs are more substantial.

[6] Using Japanese firm level data from the period 1994-2000, Hijzen, Inui, and Todo (2007) give empirical evidence on how the scope for productivity improvements from offshoring depends negatively on the initial level of productivity of the firm. This in turn provides an effective channel for less productive firms to catch up and restore competitiveness.

must first purchase a patent, and engage in a random draw to find their capacity in using the patent to experiment new production processes. Production takes place along a vertical chain consisting of two stages, intermediate supply ('upstream') and final assembly ('downstream'). Both R&D and final assembly take place in North. The South is a potential offshoring site for the production of intermediates using a standardized traditional technology that offers productivity gains to producers with bad draws. In addition, the South lacks credible institutions to perfectly enforce contracts.[7] We follow 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).[8]

We show that improvements in the quality of the contractual environment in the South can be interpreted as better prospects for offshoring. We then look at the impact of contractual enforcement and an expansion of offshoring on growth and disentangle it into a direct and an indirect effect. The direct effect is determined by the change in the share of expenditure accrued to offshored downstream divisions due to increased bargaining weight of the upstream division. This is always negative as it brings about a pure transfer of surplus from downstream to upstream divisions, thus lowers expected profits. The indirect effects work through industry dynamics and correspond to the change in the share of expenditures accruing to offshored downstream divisions due to a change in the offshorers' overall share of expenditures. This in turn can be broken down into an 'extensive margin' that shows the change in the relative number of offshorers, and an 'intensive margin' that measures the variation in their relative size with respect to an average firm in the industry. Both indirect effects

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[7] Nunn (2007) for instance uses several proxies to measure contract incompleteness in the South: a weighed average of a number of variables that measure individuals' perceptions of the effectiveness and predictability of the judiciary and the enforcement of contracts in 159 countries between 1997 and 1998 from Kaufmann et al. (2003); the measures of judicial quality and contract enforcement from Gwartney and Lawson (2003) and World Bank (2004).

[8] In particular, we use the transaction cost approach à la Williamson (1975, 1985), the key idea to which 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. At the same time, we follow the Antràs (2003) property-rights approach à la Grossman and Hart (1986) and Hart and Moore (1990) to allow for the possibility of hold up also within the boundaries of a firm.

have a positive impact on growth as they raise expected profits and result in a reallocation of labor from production to R&D. An initial improvement of weak contractual institutions leads to growth as the indirect effects dominate. As more firms offshore, they lose grounds and give way to the negative direct effect. Further offshoring could eventually impede growth and lead the home economy towards an inefficient equilibrium with "too much" offshoring activities.

The rest of the paper is organized as follows. Section 2 introduces the model. Section 3 characterizes the market equilibrium. Section 4 analyzes the interactions between offshoring, innovation and economic growth. Section 5 concludes.

2 A Dynamic Model of Offshoring

2.1 Demand side

The economy consists of two regions, North and South. We assume that all workers and consumers belong to the North but can be employed in South as expatriates to work in the offshored plants. Hence the South is simply a potential production site. This structure blocks the "Schumpeterian" channel to rule out the substitutability of Southern labor for Northern labor (an indication of the tacitness of knowledge), with the intention of abstracting from typical labor market debates on wages that have been widely studied empirically and are being widely studied theoretically parallel to the writing of this paper.[9] This helps single out the additional impacts of offshoring on growth in the home country that have often been neglected in the literature. In addition, observed empirical evidence does not always approve of the phenomenon of one job being shifted abroad being immediately one job released at home.[10]

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-

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[9] For very recent elegant theoretical analyses of offshoring as means of trade and its effects on real wages see Baldwin and Robert-Nicoud (2007), Grossman and Rossi-Hansberg (2006) and Rodrigues-Clare (2007).

[10] See for instance Debande (2006) for the US and Japanese cases.

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

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

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 σ is the own and cross demand elasticity of any variety, and thus 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 $C(t)$:

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

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

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

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

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

is aggregate demand. Throughout the rest of the paper, we leave the time dependence of variables implicit when this does not generate confusion.

2.2 Supply side

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 regions 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 δ.

There are two sectors, innovation (R&D) and production. Perfectly competitive labs invent blueprints for the production of the differentiated varieties. 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 freely traded intermediates can be produced also in South ('offshoring'). Southern production takes place through a standardized traditional technology, which allows one unit of labor to produce $\varphi_o > 0$ units of intermediates. Northern production can rely on new advanced technologies that are generated by process innovation. This is a risky endeavor as long as its outcome is uncertain and the property rights on patents have to be bought in advance before experimenting new production processes. Specifically, after buying the rights to use the blueprints from labs, producers randomly draw their productivity level φ from a continuous cumulative distribution $G(\varphi)$ with support $[0, \infty)$ so that offshoring offers productivity gains to producers with bad draws $\varphi < \varphi_o$. Final assembly in turn needs one unit of the intermediate component for each unit of the final good no matter where intermediates originate from. Intermediates are variety-specific: once produced for a certain assembly line, they have no alternative use.

Offshoring is associated with contractual costs that arise from weak legal institutions in the South. Specifically, only high quality variety-specific intermediates can be processed whereas low quality ones are useless even though supplied at zero cost. Contracts between the upstream and the 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 the former by ω.

Finally, we introduce endogenous growth by assuming 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/n units of labor where $k > 0$ is a parameter and n is the total number of blueprints that have already been patented.[11]. 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.

2.3 Timing

In each period t the following sequence of actions take place. First, independent labs engage in R&D to innovate new patents. Second, producers enter by purchasing a blueprint, realize their productivity levels in terms of non-standardized production and choose the location of upstream divisions. Third, upstream divisions manufacture the inputs needed by their downstream counterparts. Fourth, once intermediate production is completed, the upstream and downstream divisions of producers that have offshored bargain over the share of total revenues from final sales and inputs are handed over by the former to the latter. Lastly, final assembly takes place and final products are sold to households.

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[11] 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/n^{ξ} with $0 < \xi < 1$ (Jones, 1995).

3 Market 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: 'inshorers' have both divisions in North whereas 'offshorers' have their upstream divisions in South and their downstream ones in North. Under inshoring, as incomplete contracts are not an issue, the upstream division of a producer with labor productivity φ selects intermediate output $x(\varphi)$ to maximize operating profit $\pi_v(\varphi) = r_v(\varphi)/\sigma = p_v(\varphi)y_v(\varphi)/\sigma$ where $r_v(\varphi)$, $p_v(\varphi)$ and $y_v(\varphi)$ are final revenues, final price and final output (itself equal to intermediate production). Given the demand curve (4), profit maximization yields markup pricing

$$p_v(\varphi) = \frac{\sigma}{\sigma - 1}\frac{1}{\varphi}$$

with associated output $x_v(\varphi) = y_v(\varphi) = Ap_v(\varphi)^{-\sigma}$ and operating profit $\pi_v(\varphi) = r_v(\varphi)/\sigma = Ap_v(\varphi)^{1-\sigma}/\sigma$.

Under offshoring, the producer uses the standardized technology with upstream labor productivity φ_o and gets the joint surplus of its divisions under incomplete contracts. Such surplus is given by the revenues from final sales and is divided between divisions through Nash bargaining. Absent any outside option, revenues are therefore split according to the bargaining weights of the two parties with a share $(1 - \omega)$ going to the downstream division and the remaining share ω going to the upstream one. The upstream division decides how much input x_o to produce anticipating that bargaining outcome. Hence, it maximizes $\pi_u = \omega p_o y_o - x_o/\varphi_o$ where p_o and y_o are final price and final output (itself equal to intermediate production). Given the demand curve (4), this yields markup pricing for final sales

$$p_o = \frac{\sigma}{\sigma - 1}\frac{1}{\omega\varphi_o}$$

with associated output $x_o = y_o = Ap_o^{-\sigma}$ and revenues $r_o = p_o y_o = Ap_o^{1-\sigma}$.[12] A share $\pi_d = (1 - \omega)r_o$ goes to the downstream division while the complementary share goes to the upstream

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[12] The upstrean division does not face an incentive constraint as the optimal output is always positive.

one. Accordingly, after subtracting labor costs, the upstream division is left with $\pi_u = \omega r_o/\sigma$: larger upstream bargaining weight and stronger product differentiation shift a larger share of a given joint surplus r_o from downstream to upstream divisions. Hence, the overall operating profit of the offshorer is $\pi_o = \pi_d + \pi_u = [1 + (\sigma - 1)(1 - \omega)]\, r_o/\sigma$.[13] Since the downstream division does not contribute anything before the bargaining stage, the joint surplus r_o (but not the joint profit π_o) is at its maximum when ω goes to one. For this reason ω can be interpreted as a measure of the 'quality' of the contractual environment: the larger ω, the lower the rents appropriated by offshorers' downstream divisions.

As producers can freely choose between inshoring and offshoring, the operating profits they earn are equal to $\pi(\varphi) \equiv \max[\pi_v(\varphi), \pi_o]$. The fact that $\pi_v(\varphi)$ is an increasing function of productivity φ implies that there exists a unique threshold productivity level ('cutoff') φ^* above which producers prefer to inshore. This cutoffs solves $\pi_v(\varphi^*) = \pi_o$ and is therefore equal to

$$\varphi^* = (\omega\varphi_o)\,[1 + (1 - \omega)(\sigma - 1)]^{\frac{1}{\sigma-1}} \tag{6}$$

The cutoff is decreasing in σ because weaker product differentiation shifts surplus from upstream to downstream divisions exacerbating intermediate underproduction and thus promoting inshoring. For symmetric reasons, the cutoff is increasing in the upstream bargaining weight ω. It is also increasing in φ_o as offshoring is fostered by any improvement in the productivity of the standardized technology.

Proposition 1 *Given $\frac{\partial\varphi^*}{\partial\omega} > 0$, improved contractual institutions in the South always encourages offshoring.*

Since $1/(\omega\varphi_o)$ is the amount of labor embedded in unit revenues, it will turn out to be useful to denote by $\widetilde{\varphi}_o \equiv \omega\varphi_o$ the 'delivered' productivity of offshored labor. We will call this simply

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[13] For the upstream division the adverse incentive due to ex post bargaining under incomplete contracts has extactly the same impact of an iceberg trade cost that melts a fraction $(1 - \omega)$ of intermediate output shipped from South to North, and therefore does not generate revenues for that division. The fact that here the fraction $(1 - \omega)$ of revenues is recovered by the downstream division explains why the overall operating profit of the offshorer is larger than that of the simple iceberg case.

'offshored productivity' and we will contrast it with producer-specific 'inshored productivity' φ. Note that (6) shows that a marginal producer drawing exactly φ^* has higher inshored than offshored productivity ($\varphi^* > \widetilde{\varphi}_o$) so that the range $(\omega\varphi_o, \varphi^*)$ identifies producers whose decision to offshore reduces aggregate productivity. This accounts for how incomplete contracts make offshoring affect aggregate productivity negatively even if $\varphi < \varphi_o$. We can also see from (6) that for $\omega = 1$ we have $\varphi^* = \widetilde{\varphi}_o = \varphi_o$, which implies that all firms with a productivity level $\varphi < \varphi_o$ would offshore and their decision to do so would improve aggregate productivity.

To summarize, producers' organizational choices give the following cutoff results for prices and overall profits:

$$p(\varphi) = \begin{cases} \frac{\sigma}{\sigma-1}\frac{1}{\widetilde{\varphi}_o} \\ \frac{\sigma}{\sigma-1}\frac{1}{\varphi} \end{cases} \quad \text{and } \pi(\varphi) = \begin{cases} \frac{1+(\sigma-1)(1-\omega)}{\sigma} A p(\varphi)^{1-\sigma} \\ \frac{1}{\sigma} A p(\varphi)^{1-\sigma} \end{cases} \quad \text{for } \varphi \in \begin{cases} [0, \varphi^*) \\ [\varphi^*, \infty) \end{cases} \tag{7}$$

3.2 Innovation

At the innovation stage, labs invent new blueprints at a marginal cost that depends on acquired experience k/n and their output determines the law of motion of n. In particular, we have

$$\dot{n} = \frac{nL^I}{k} - \delta n, \tag{8}$$

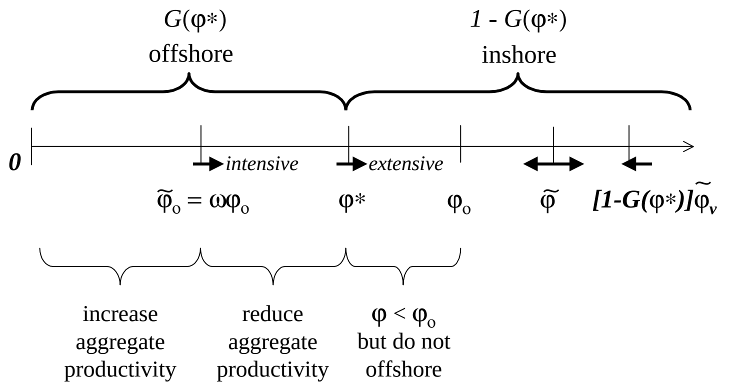
where $\dot{n} \equiv dn/dt$, L^I is labor employed in inventing new blueprints, n/k is its productivity and δ is the rate of depreciation.

Due to learning, as innovation cumulates, it becomes increasingly cheaper to introduce new patents and, being priced at marginal cost, their value falls through time. Specifically, if we call J the asset value of a patent, marginal cost pricing gives $J = k/n$, which implies $\dot{J}/J = -\dot{n}/n$.

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 producers $\overline{\pi}$. Arbitrage in the capital market then requires the dividends $\overline{\pi}$ and capital gains $\dot{J}$ to match interest payments RJ and depreciation δJ so that:

$$R + \delta = \frac{\overline{\pi} n}{k} - \frac{\dot{n}}{n} \tag{9}$$

Figure 1: The Productivity Distribution and an Increase in ω



where the equality is granted by the definition of J.

3.3 Aggregation

In characterizing the aggregate behavior of our heterogeneous economy, we follow Melitz (2003) and define average (output-weighted) productivity as:

$$\widetilde{\varphi} \equiv \left\{ G(\varphi^*)\widetilde{\varphi}_o^{\sigma-1} + \left[1 - G(\varphi^*)\right] \widetilde{\varphi}_v^{\sigma-1} \right\}^{\frac{1}{\sigma-1}} \tag{10}$$

where, as already mentioned, $\widetilde{\varphi}_o \equiv \omega\varphi_o$ is the common productivity of offshorers and

$$\widetilde{\varphi}_v = \left[\frac{1}{1 - G(\varphi^*)} \int_{\varphi^*}^{\infty} \varphi^{\sigma-1} dG(\varphi) \right]^{\frac{1}{\sigma-1}}$$

is the average (output weighted) productivity of inshorers. Since $\varphi^* > \widetilde{\varphi}_o$, we have $\widetilde{\varphi}_v > \widetilde{\varphi} > \varphi^* > \widetilde{\varphi}_o$, $d\widetilde{\varphi}_v/d\varphi^* > 0$ and $d\widetilde{\varphi}/d\varphi^* \lesseqgtr 0$. Also note that $\widetilde{\varphi}$ can also be less than φ^*. Figure 1 shows a ranking of the productivity levels.

We also define E_o as the share of expenditures going to offshorers, and P_o and C_o as the corresponding exact price and quantity indices such that $P_oC_o = E_o$. Analogously, we define E_v as the share of expenditures going to inshorers, and P_v and C_v as the corresponding exact price and quantity indices such that $P_vC_v = E_v$ and $E_o + E_v = E$. Then we have:

$$\widetilde{p}_v = \frac{\sigma}{\sigma-1}\frac{1}{\widetilde{\varphi}_v},\ P_v = \{n\left[1-G(\varphi^*)\right]\}^{\frac{1}{1-\sigma}}\widetilde{p}_v,\ C_v = \frac{E_v}{P_v},\ E_v = \left(\frac{P_v}{P}\right)^{1-\sigma}E \tag{11}$$

where $\widetilde{p}_v$ is the average price of inshorers. Analogously, we can write

$$p_o = \frac{\sigma}{\sigma-1}\frac{1}{\widetilde{\varphi}_o},\ P_o = \{nG(\varphi^*)\}^{\frac{1}{1-\sigma}}p_o,\ C_o = \frac{E_o}{P_o},\ E_o = \left(\frac{P_o}{P}\right)^{1-\sigma}E$$

and

$$\widetilde{p} = \frac{\sigma}{\sigma-1}\frac{1}{\widetilde{\varphi}},\ P = \left\{nG(\varphi^*)p_o^{1-\sigma} + n\left[1-G(\varphi^*)\right]\widetilde{p}_v^{1-\sigma}\right\}^{\frac{1}{1-\sigma}},\ C = \frac{E}{P}$$

3.4 Financial market clearing

Since producers discover their productivity only after acquiring the right to use a patented blueprint, the dividends they are willing to pay to labs equal their expected operating profits

$$\overline{\pi} = G(\varphi^*)\pi_o + [1-G(\varphi^*)]\widetilde{\pi}_v \tag{12}$$

where, since $r_o = E_o/\left[nG(\varphi^*)\right]$, the operating profit of a typical offshorer π_o can be rewritten in terms of aggregate variables as

$$\pi_o = \frac{\left[1+(\sigma-1)(1-\omega)\right]E_o}{\sigma n G(\varphi^*)}$$

and, by definition, the average operating profit of inshorers equals

$$\widetilde{\pi}_v = \frac{E_v}{\sigma n[1-G(\varphi^*)]}$$

By (11), expected operating profits (12) simplify to

$$\overline{\pi} = \frac{E}{\sigma n}\left[1+(\sigma-1)\,\Omega\right] \tag{13}$$

where $\Omega \equiv (1-\omega)\,E_o/E$ is the share of aggregate expenditures accruing to the downstream divisions of offshorers. Expression (13) shows that expected profits are an increasing function of Ω. Shifting a unit of expenditures from inshorers to the same number of offshorers increases average profits because the payoff of offshored downstream divisions is determined by revenues while that of inshored downstream divisions is determined by profits. These are only a fraction $1/\sigma$ of revenues, which explains why the positive impact of Ω on $\overline{\pi}$ is larger when σ is larger.

Once substituted into (9), expression (13) allows us to restate the Euler condition (2) as:

$$\frac{\dot{E}}{E} = \frac{E}{\sigma k}\left[1 + (\sigma - 1)\,\Omega\right] - \frac{\dot{n}}{n} - \delta - \rho \tag{14}$$

3.5 Labor market clearing

Aggregate labor endowment L is absorbed by innovation (L_I) as well as by inshored and offshored intermediate production. Inshorers' and offshorers' employment levels amount to $L_v = E_v/(\widetilde{p}_v\widetilde{\varphi}_v)$ and $L_o = E_o/(p_o\varphi_o)$ respectively. Accordingly, given (11), total employment in intermediate production simplifies to

$$L_v + L_o = \frac{\sigma - 1}{\sigma}E(1 - \Omega)$$

which, together with (8), allows us to rewrite the labor market clearing condition $L = L_I + L_v + L_o$ as

$$L = k\left(\frac{\dot{n}}{n} + \delta\right) + \frac{\sigma - 1}{\sigma}E(1 - \Omega) \tag{15}$$

Employment in production is a decreasing function of the share Ω of aggregate expenditures accruing to the downstream divisions of offshorers. This is the dual of the previously discussed result that expected profits increase with Ω as long as larger expected profits induce a reallocation of labor from production to R&D.

4 Offshoring and Growth

The market clearing conditions (14) and (15) define a dynamic system in two unknowns: the growth rate of the stock of patents ($\dot{n}/n$) and the expenditures level (E). A unique balanced growth path exists along which these variables are constant and is achieved without any transition dynamics.[14] Calling the corresponding growth rate and expenditures level by g_s and E_s respectively, then im-

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[14] See Grossman and Helpman (1991, ch.3) for details.

posing $\dot{n}/n = g_s$, $E = E_s$ and $\dot{E} = 0$ in (14) and (15) allows us to find:

$$g_s = \frac{L}{k}\left(\frac{1}{\sigma} + \frac{\sigma-1}{\sigma}\Omega\right) - \frac{\sigma-1}{\sigma}(1-\Omega)\rho - \delta,\ E_s = L + \rho k \tag{16}$$

While expenditures E_s do not depend on Ω, the growth rate g_s is instead an increasing function of Ω. The reason is that, by definition, a rise in Ω shifts expenditures from inshorers to offshorers. This shift, as discussed above, generates larger expected profits and smaller employment in production. The resulting reallocation of labor from production to R&D promotes innovation and growth.

Since E_s does not depend on Ω, the quality of the contractual environment ω does not affect expenditures. It affects, however, the growth rate through various channels funneled through the impact of Ω on g_s. To disentangle these channels, we use (10) and (11) to rewrite the share Ω of expenditures accruing to the downstream divisions of offshorers as

$$\Omega = (1-\omega)\frac{E_o}{E} = (1-\omega)\left(\frac{P_o}{P}\right)^{1-\sigma} = (1-\omega)\,G(\varphi^*)\left(\frac{\widetilde{\varphi}_o}{\widetilde{\varphi}}\right)^{\sigma-1}$$

where $\widetilde{\varphi}_o \equiv \omega\varphi_o$ is offshored productivity and $\widetilde{\varphi}$ is the average (offshored and inshored) productivity as defined in (10). Since $dg_s/d\Omega > 0$, the sign of the impact of ω on g_s depends on the sign of $d\Omega/d\omega$. This can be decomposed as:

$$\frac{d\Omega}{d\omega} = -s_o + (1-\omega)\frac{ds_o}{d\omega}$$

where $s_o \equiv E_o/E$. Consider a marginal increase in ω. The first term of the right hand side is the direct effect of larger ω. It is negative as it identifies the corresponding fall in the share of expenditures accruing to offshored downstream divisions holding the overall share of expenditures accruing to offshorers constant. It captures a pure surplus reallocation from downstream to upstream divisions due to the increased bargaining weight of the latter. The second term on the right hand side is the indirect effect. It identifies the change in the share of expenditures accruing to offshored downstream divisions due to a change in the overall share of expenditures accruing to offshorers holding the bargaining weights constant. This adjustment takes place along two margins: the relative number of offshorers as determined by $G(\varphi^*)$ ('extensive margin') and their relative size with respect to the average producer $r_o/\widetilde{r} = (\widetilde{\varphi}_o/\widetilde{\varphi})^{\sigma-1}$ ('intensive margin'):

$$\frac{ds_o}{d\omega} = \frac{dG(\varphi^*)}{d\omega}(r_o/\widetilde{r}) + G(\varphi^*)\frac{d(r_o/\widetilde{r})}{d\omega},$$

where $\widetilde{r} = A\tilde{p}^{1-\sigma}$. The impact of larger ω is positive on both margins. Since a larger bargaining weight of upstream divisions alleviates their underproduction of intermediates, as ω rises, not only offshorers become larger but also more producers decide to offshore. Along the extensive margin, by (6) we have $d\varphi^*/d\omega > 0$ and thus $dG(\varphi^*)/d\omega > 0$. Along the intensive margin, using $\widetilde{\varphi}_o \equiv \omega\varphi_o$ and (10), we have

$$\frac{r_o}{\widetilde{r}} = \left(\frac{\widetilde{\varphi}_o}{\widetilde{\varphi}}\right)^{\sigma-1} = \frac{\widetilde{\varphi}_o^{\sigma-1}}{G(\varphi^*)\widetilde{\varphi}_o^{\sigma-1} + [1-G(\varphi^*)]\,\widetilde{\varphi}_v^{\sigma-1}} = \frac{(\omega\varphi_o)^{\sigma-1}}{G(\varphi^*)\,(\omega\varphi_o)^{\sigma-1} + \int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)} \tag{17}$$

which, given $d\varphi^*/d\omega > 0$ and $dG(\varphi^*)/d\varphi^* > 0$, is an increasing function of ω (see appendix for proof).

Proposition 2 *Stronger contractual enforcement in the South promotes growth if* $(1-\omega)\,\frac{ds_o}{d\omega} > s_o$ *and hampers growth if the reverse is true.*

Figure 1 shows the effect of an increase in ω in the productivity distribution of firms graphically. We can see that this directly raises $\widetilde{\varphi}_o$, while it reduces $[1-G(\varphi^*)]\,\widetilde{\varphi}_v$ through a change in φ^*. This makes the change in average productivity $\widetilde{\varphi}$ ambiguous in ω, yet inferior to the rise in $\widetilde{\varphi}_o$. Also, the productivity range along which offshoring raises aggregate productivity increases if the change the intensive margin is larger than that in the extensive margin ($\frac{\partial\widetilde{\varphi}_o}{\partial\omega} > \frac{\partial\varphi^*}{\partial\omega}$) so that the two values converge, and falls if the opposite holds and they diverge.

To sum up, the improved quality of the contractual environment increases the share of expenditures accruing to offshorers through a positive indirect effect on their relative size ('intensive margin') and number ('extensive margin'). This enlarges also the share of expenditures captured by offshored downstream divisions, which is good for growth as expected profits rise. On the other hand, through a negative direct effect, improved contractual quality reduces the fraction of increased offshorers' expenditures appropriated by downstream divisions, which is bad for growth as through this channel expected profits fall. Overall, the indirect effect dominates when ω is small and the direct when ω is large. This is because as ω increases and more firms offshore, more productive firms throw away their patent and go for the standardized technology. Also as φ^* increases and gets closer to φ_o, unit labor saving for each new firm that switches to offshoring diminishes. This generates a non-linear relation between contractual quality improvement and the growth rate, which reaches its maximum for an intermediate value of ω. Finally, since the positive impact of Ω on $\overline{\pi}$ is larger when σ is larger, the positive indirect effect loses strength with respect to the negative direct one as the demand elasticity rises.

5 Conclusion

This paper uses an endogenous growth model of offshoring with heterogeneous firms to study its effects on growth when contracts are incomplete in the South. We investigate the decision of individual firms on their organization, which corresponds to their productivity level and the efficiency of institutions in the South. We then study the impact of industry dynamics on innovation and growth in the home country. The novel contributions we hope to add to existing literature are (1) a dynamic model with the simultaneous existence of a combination of different organizational modes in equilibrium, (2) an organizational choice independent from extra fixed costs associated with different modes, (3) investigation of the industry dynamics and growth as offshoring expands, as opposed to a comparative static analysis of offshoring versus inshoring.

We explain the rise of offshoring as a consequence of an improvement in the quality of contractual environment the South. We then demonstrate several channels through which this ongoing process influences R&D activities and incentives for the creation of new blueprints in the North. Creating better prospects for offshoring has a direct negative effect on expected profits and growth by lowering the surplus share of downstream producers. On the other hand, firm heterogeneity reveals other indirect channels that enhance growth by increasing expected profits and reallocating labor from production to R&D. These work through adjustments in the expenditure accruing to offshored downstream divisions due to a change in the overall share of expenditures accruing to offshorers. Namely, they take place along an 'extensive' and an 'intensive' margin. A more favorable contractual environment results in a greater number and a larger relative size of offshorers with respect to the average producer in the industry. A combination of the direct and indirect effects and their strength determine whether an expansion of offshoring contributes to innovation and growth in the North. We conclude that an improvement of very weak contractual institutions always leads to higher growth. Offshoring stimulates innovation until a point after which its increasing costs begin to dominate its fading benefits. This discourages the creation of blueprints and eventually slow growth. Therefore, there may be "too much" offshoring activities in equilibrium from a growth perspective.

Contrary to existing literature, our study shows the adverse long term growth effects of offshoring for the North. This raises questions whether analyses on the consequences of offshoring based on real wages can fully absorb the mechanisms through which it influences the market. We show that many conventional wisdom positive aspects of offshoring are depleted as a larger proportion of the market engages in the phenomenon. Our analysis of course has its setbacks and leaves much work for future research on the welfare implications and growth aspects of offshoring for all countries involved in the trend.

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6 Appendix

- The cutoff φ^* is an increasing function of ω:

$$\frac{d\varphi^*}{d\omega} = \frac{d\left(\left(\omega\varphi_o\right)\left(1+(1-\omega)(\sigma-1)\right)^{\frac{1}{\sigma-1}}\right)}{d\omega} = (1-\omega)\,\sigma\varphi_o\left(1+(1-\omega)(\sigma-1)\right)^{\frac{\sigma-2}{\sigma-1}} > 0$$

- Since φ^* is an increasing function of ω, the average productivity of inshorers $\widetilde{\varphi}_v$ is a decreasing function of ω:

$$\frac{d\widetilde{\varphi}_v}{d\omega} = -\frac{1}{\sigma-1}\frac{\left[\frac{1}{1-G(\varphi^*)}\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]^{\frac{1}{\sigma-1}-1}}{1-G(\varphi^*)}\left(\varphi^*\right)^{\sigma-1}G'(\varphi^*)\frac{d\varphi^*}{d\omega} < 0$$

  where

$$\frac{d\left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]}{d\varphi^*} = -\frac{d\left[\int_{\infty}^{\varphi^*}\varphi^{\sigma-1}G'(\varphi)d\varphi\right]}{d\varphi^*} = -\left(\varphi^*\right)^{\sigma-1}G'(\varphi^*)$$

  is granted by the fundamental theorem of calculus.

- Since φ^* is an increasing function of ω, the relative size of offshorers with respect to the average producer $r_o/\widetilde{r}$ is an increasing function of ω:

$$\frac{d\left(r_o/\widetilde{r}\right)}{d\omega} = d\left[\frac{\left(\omega\varphi_o\right)^{\sigma-1}}{G(\varphi^*)\left(\omega\varphi_o\right)^{\sigma-1}+\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)}\right]/d\omega = \frac{num}{\left[G(\varphi^*)\left(\omega\varphi_o\right)^{\sigma-1}+\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]^2}$$

$$\begin{aligned}
num &= \frac{d\left(\omega\varphi_o\right)^{\sigma-1}}{d\omega}\left[G(\varphi^*)\left(\omega\varphi_o\right)^{\sigma-1}+\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]- \\
&\quad \left(\omega\varphi_o\right)^{\sigma-1}\left[G'(\varphi^*)\frac{d\varphi^*}{d\omega}\left(\omega\varphi_o\right)^{\sigma-1}+G(\varphi^*)\frac{d\left(\omega\varphi_o\right)^{\sigma-1}}{d\omega}-\left(\varphi^*\right)^{\sigma-1}G'(\varphi^*)\frac{d\varphi^*}{d\omega}\right] \\
&= \frac{d\left(\omega\varphi_o\right)^{\sigma-1}}{d\omega}\left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]-\left(\omega\varphi_o\right)^{\sigma-1}\left[G'(\varphi^*)\frac{d\varphi^*}{d\omega}\left(\omega\varphi_o\right)^{\sigma-1}-\left(\varphi^*\right)^{\sigma-1}G'(\varphi^*)\frac{d\varphi^*}{d\omega}\right] \\
&= \frac{\left(\omega\varphi_o\right)^{\sigma-1}}{\omega}(\sigma-1)\left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]-\left(\omega\varphi_o\right)^{\sigma-1}\left[G'(\varphi^*)\frac{d\varphi^*}{d\omega}\left(\omega\varphi_o\right)^{\sigma-1}-\left(\varphi^*\right)^{\sigma-1}G'(\varphi^*)\frac{d\varphi^*}{d\omega}\right] \\
&= \left(\omega\varphi_o\right)^{\sigma-1}\left\{\frac{\sigma-1}{\omega}\left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]-\left[\left(\omega\varphi_o\right)^{\sigma-1}-\left(\varphi^*\right)^{\sigma-1}\right]G'(\varphi^*)\frac{d\varphi^*}{d\omega}\right\}
\end{aligned}$$

With

$$\varphi^* = \left(\omega\varphi_o\right)\left[1+(1-\omega)(\sigma-1)\right]^{\frac{1}{\sigma-1}}$$

we have

$$\begin{aligned}
num &= \left(\omega\varphi_o\right)^{\sigma-1}\left\{\frac{\sigma-1}{\omega}\left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]-\left[1-1-(1-\omega)(\sigma-1)\right]\left(\omega\varphi_o\right)^{\sigma-1}G'(\varphi^*)\frac{d\varphi^*}{d\omega}\right\} \\
&= \left(\omega\varphi_o\right)^{\sigma-1}(\sigma-1)\left\{\frac{1}{\omega}\left[\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]+(1-\omega)\left(\omega\varphi_o\right)^{\sigma-1}G'(\varphi^*)\frac{d\varphi^*}{d\omega}\right\}
\end{aligned}$$

which is positive since $d\varphi^*/d\omega > 0$. Hence

$$\frac{d\left(r_o/\widetilde{r}\right)}{d\omega} = \frac{num}{\left[G(\varphi^*)\left(\omega\varphi_o\right)^{\sigma-1}+\int_{\varphi^*}^{\infty}\varphi^{\sigma-1}dG(\varphi)\right]^2} > 0$$