Outsourcing, Innovation and Long-run Growth∗

Gianmarco I.P. Ottaviano†

University of Bologna
and
CEPR

February 5, 2007

PRELIMINARY AND INCOMPLETE DRAFT
COMMENTS AND SUGGESTIONS ARE WELCOME

Abstract

This paper models the organizational decisions of firms in dynamic industries characterized by ‘creative destruction’ due to ongoing quality improvement. The value chain consists of three tasks (‘product design’, ‘technical implementation’ and ‘commercialization’) that require different core competences. The attention is on the behavior of firms that have core competences in technical implementation and decide whether or not to insource product design and commercialization. While insourcing takes them away from their core competences, it allows them to avoid the contractual costs associated with outsourcing. Various technological and institutional parameters affect the organizational choice, which in turn has direct and indirect effects on innovation and growth.

Keywords: economic growth, incomplete contracts, innovation, theory of the firm.

JEL Classification: D23, F10, L23, O30, O40.

†Università di Bologna, Dipartimento di Scienze Economiche, Piazza Scaravilli 2, 40126 Bologna, Italy. Email: gianmarco.ottaviano@unibo.it
1 Introduction

This paper models the organizational decisions of firms in dynamic industries characterized by ‘creative destruction’ due to ongoing quality improvement. Within industries the value chain consists of three tasks: ‘product design’, ‘technical implementation’ and ‘commercialization’. There are three types of firms, ‘designers’, ‘manufacturers’ and ‘resellers’ that have core competences in ‘product design’, ‘technical implementation’ and ‘commercialization’ respectively. The attention is on the decision of manufacturers on whether or not to insource product design and commercialization. Insourcing takes them away from their core competences, so they are less efficient than designers and resellers in the insourced tasks. On the other hand, outsourcing faces additional contractual costs that can be avoided through vertical integration. These costs stem from an incomplete contractual environment that forces firms performing different tasks to bargain over the division of their joint surplus ex-post, i.e. after having sunk relation-specific investments. The source of contractual incompleteness is the fact that tasks performed short of the contracted standards are useless but whether they meet the standards or not is impossible to assess by third parties. This generates a hold-up problem that reduces the incentives to sink relation-specific investments and thus causes inefficiencies in terms of lost joint surplus.

The constraints on ex-post bargaining depend of the type of contracted task. In particular, product designs are assumed to be more relation-specific than commercialization services. This has an impact on the bargaining power of designers and resellers vis-à-vis manufacturers. Using Nash concepts to model ex-post bargaining, the bargaining power of designers and resellers depends on their exogenous bargaining weights and their endogenous outside options. The different degrees of specificity of product design and commercialization are then captured by assuming that the former task gives larger bargaining weight but weaker outside options to designers than the latter task gives to resellers.

The analysis distinguished between ‘technological’ and ‘institutional’ parameters. The technological parameters measure the differentiation between core competences and between the services offered by different vintage qualities. The institutional parameters measure the ‘efficiency’ of contracts in terms of allowing each party to appropriate the surplus from its relation-specific investment. As far as organizational choices are concerned, two sets of results stand out. The first set compares industries operating within the same country that differ in terms of their technological parameters. Integration both upstream and downstream characterizes industries such that core competences in the three tasks of the value chain are very similar and new vintage qualities are much better than previous ones. Analogously, outsourcing prevails both upstream and downstream in industries with pronounced differentiation between core competences and limited differentiation between vintages. Outsourcing takes place downstream but not upstream in industries in which vintages as well as core competences in technological implementation and commercialization are very different whereas core competences in product design and technological imple-
mentation are quite similar. Vice versa, outsourcing happens upstream but
not downstream in industries in which vintages as well as core competences in
technological implementation and commercialization are quite similar whereas
core competences in product design and technological implementation are very
different.

The second set of results compares the same industry across countries that
differ in terms of their institutional parameters. The industry integrates both
upstream and downstream in countries with poor contract enforcement. It in-
tegrates only upstream when product design contracts are efficient and com-
mercialization contracts are not. Vice versa, it integrates only downstream
when commercialization contracts are efficient and product design contract are
not. Outsourcing prevails both upstream and downstream when the efficiency
of both types of contracts is good. Moreover, starting from an initial situation
in which manufacturers are integrated both upstream and downstream and let-
ting contractual efficiency improve gradually and proportionately across tasks,
product design is outsourced first in industries in which vintages are very dif-
f erent and core competences are more differentiated between product design
and technological implementation than between technological implementation
and commercialization. Vice versa, commercialization is outsourced first in sets
of industries in which vintages are rather similar and core competences are
more differentiated between technological implementation and commercializa-
tion than between product design and technological implementation.

The organizational choices of manufactures have a double impact on growth.
They affect the intensity of research efforts as well as the contribution those
efforts make to aggregate growth. This is illustrated through a thought experi-
ments that captures a crucial aspect of the later stages of an industry life cycle:
withering opportunities for quality upgrade. Starting from a situation in which
vintages are different enough to induce downstream integration, a gradual fall in
their differentiation causes a slow down in research intensity and growth until it
triggers downstream outsourcing. However, as soon as the industry restructures,
the growth rate jumps upwards thanks to the exploitation of resellers’ core com-
petences, and it keeps on growing because contractual efficiency is improved by
the erosion of the resellers’ outside options. As differentiation between vintages
further diminishes, that channel loses strength and growth slows down again.

The model combines two well-established approaches. The first is the incomplete-
contracting approach to the theory of the firm due to Grossman and Hart (1986)
and Hart and Moore (1990). This approach has been applied to trade theory
in the wake of Grossman and Helpman (2002) and has given rise to a thriving
literature surveyed by Helpman (2006). The second is Grossman and Helpman’s
(1991) and Aghion and Howitt’s (1992) approach to endogenous growth through
rising product quality. In this respect, there are few contributions strictly re-
lated to this paper. Lai, Riezman and Wang (2005) endogenize the decision on
whether to outsource R&D or not by emphasizing the trade-off between the costs
of information leakage and the benefits of specialization. In Acemoglu, Aghion
and Zilibotti (2005) R&D is always insourced and firms closer to the technology
frontier have a stronger incentive to outsource production in order to concentrate on more valuable R&D. Acemoglu, Antras and Helpman (2006) investigate the channels through which institutional parameters determine countries’ comparative advantages by affecting firms’ decisions on technology adoption and organizational forms. Acemoglu and Zilibotti (1999), Martimort and Verdier (2000, 2004) as well as Francois and Roberts (2003) also study the qualitative impact of changes in the internal organization of firms on economic growth. In Naghavi and Ottaviano (2006) R&D is always carried out by independent laboratories and technological knowledge is not fully appropriable, hence the decision to outsource production generates externalities that may lead to a misallocation of R&D financing between individual ventures and global networks of innovators.

The rest of the paper is organized in five sections. Section 2 presents the growth model in the case of integration both upstream and downstream following Grossman and Helpman (1991, ch.4). Section 3 introduces the organizational choice and derives its implications for innovation and growth. Section 4 characterizes the organizational outcomes. Section 5 illustrates the interactions between organization and growth by a simple example based on the idea of the industry life cycle. Section 6 concludes.

2 Vertical integration

Consider a given set of industries indexed $j \in [0, 1]$. All industries employ labor as their only primary factor. There are $L$ workers, each supplying one unit of labor inelastically. All income belongs to workers, so $L$ is also the measure (‘number’) of consumers.

In all industries the value chain consists of three tasks: ‘product design’, ‘technical implementation’ and ‘commercialization’. There are three types of firms, ‘designers’, ‘manufacturers’ and ‘resellers’ that have core competences in the three tasks respectively. The attention will be on the decision of manufacturers on whether or not to insource product design and commercialization. For expositional purposes, however, the present section introduces the model when the three tasks are integrated within the same firm. This will clarify the dynamic properties of the model. The organizational choice on which tasks to insource or outsource will be discussed in Section 3.

2.1 Demand

All consumers share the same preferences and the same income. In particular, the preferences of the representative consumer are captured by the following utility function:

$$U_t = \int_t^\infty e^{-\rho(t-\tau)} \ln D(\tau) d\tau$$

(1)

where $\rho > 0$ is the rate of time preference. Instantaneous consumption $\ln D(t)$ consists of a basket comprising the outputs (‘products’) of all industries $j \in$
Each of these products is available in a discrete number of qualities (‘vintages’) \( q_m(j) \). The index \( m \) identifies the rank of the corresponding vintage along the quality ladder with higher \( m \) corresponding to higher quality. Specifically, the basket is defined such that:

\[
\ln D(\tau) = \int_0^1 \ln \left[ \sum_m q_m(j) x_{mt}(j) \right] dj
\]

where \( q_m(j) \) is the quality of vintage \( m \) of product \( j \) and \( x_{mt}(j) \) its consumption. The worst quality is the only one available at time \( \tau = 0 \). It is labeled \( q_0(j) \) and is normalized to unity, \( q_0(j) = 1 \). The quality ladder is assumed to imply the same constant step \( \lambda > 1 \) from any quality to the next better. Hence, quality \( m \) equals \( q_m(j) = \lambda^m \). The definition of the consumption basket implies that vintages are perfectly substitutable within products and products have unit elasticity of substitution between themselves. Therefore, in any instant \( t \) the representative consumer maximizes instantaneous utility by spreading aggregate expenditures \( E(t) \) evenly across products and by purchasing for each product the single vintage \( \tilde{m}_t(j) \) that offers the lowest price per unit of quality:

\[
x_{mt}(j) = \frac{E(t)}{p_{mt}(j)} \text{ for } m = \tilde{m}_t(j) \text{ and } x_{mt}(j) = 0 \text{ otherwise}
\]

A riskless bond exists that allows consumers to freely borrow and lend at interest rate \( r(t) \). Intertemporal utility maximization then yields the standard consumption smoothing result:

\[
\frac{\dot{E}(t)}{E(t)} = r(t) - \rho
\]

Following Grossman and Helpman (1991), aggregate expenditures are chosen as numéraire, which implies \( E(t) = 1 \) and therefore by (4)

\[
r(t) = \rho
\]

for any \( t \in [0, \infty) \).

### 2.2 Supply

In all industries all vintages are produced using the same technology that transforms one unit of labor into one unit of output. Accordingly, the marginal cost of production is equal to the wage rate \( w \) whatever the industry and the quality level.

Market structure is modelled as oligopolistic Bertrand competition. Perfect substitutability between vintages of the same product then implies that in each industry the supplier of the best quality (‘leader’) maximizes its profit by quoting a price that is just low enough to prevent any competitor (‘follower’) from selling at all (‘limit pricing’). Since what matters to consumers is the price per unit of
quality, the limit pricing strategy implies that only the best available vintage is sold at a price equal to the quality-adjusted marginal cost of the second-best vintage. Given the assumption of a constant quality step $\lambda$, the market price is thus the same in all industries and constant through time:

$$p = \lambda w$$  \hfill (6)

Note that the step $\lambda$ determines the mark-up above marginal cost, itself a measure of the extent of vertical differentiation.

Recalling that aggregate expenditures have been normalized to one and are evenly spread across a set of industries of unit measure, the flow profit of the leader in any industry, $\pi = (p - w)E/p$, evaluates to:

$$\pi = 1 - \frac{1}{\lambda}$$  \hfill (7)

where (6) has been used to substitute for the price.

Being unable to sell, followers concentrate their efforts in trying to invent a new vintage of better quality than the one of the incumbent leader (‘state of the art’). This is a costly and risky activity whose probability of success depends on the amount of labor employed in R&D (‘R&D intensity’). R&D is assumed to be a memoryless process as no benefit arises for a firm from its past unsuccessful efforts. Benefits, however, arise from the incumbent leader’s success as followers can inspect the state-of-the-art products and learn the features that are relevant to incremental improvement. This knowledge spillovers from leaders to followers will sustain technological progress in the long run.

As in Grossman and Helpman (1991), the analysis is confined to symmetric equilibria in which all industries share the same R&D intensity. The industry index $j$ is therefore dropped from now on. In all industries the research technology is such that a follower exerting an R&D effort of intensity $\iota$ for a time interval $dt$ faces a probability $\iota dt$ of moving the state of the art one step up the quality ladder. This research effort is financed by issuing equity claims that give right to the flow profit associated with market leadership in case of success, and nothing otherwise. Since the individual research risk is idiosyncratic, well-diversified equity holders will be interested in the maximization of the net expected gains from R&D. These are given by $v\iota dt - w\iota dt$ where $v$ is the stock value of leadership and $a$ is the labor requirement per unit of R&D intensity.$^1$

Accordingly, positive and finite R&D intensity $\iota \in (0, \infty)$ requires

$$v = wa$$  \hfill (8)

2.3 Equilibrium

Since the linear R&D technology of followers makes them indifferent with respect to the level of the research effort, their maximization of the net expected gains

---

$^1$The incremental gain from moving two steps ahead of the closest competitor equals $[1 - (1/\lambda)^2] - [1 - (1/\lambda)]$, which is strictly smaller than $\pi$. Therefore any effort aimed at moving more than one step ahead will not be financed in equilibrium. This prevents leaders from innovating and followers from pursuing quality improvements larger than $\lambda$. 

---
does not pin down their R&D intensity. This is determined instead at the aggregate level.

Henceforth, let \( \iota \) denote such the aggregate R&D intensity. Then, over the time interval \( dt \), leadership is destroyed with probability \( \iota dt \). This gives equity holders an expected capital gain equal to \( (1 - \iota dt)v \) and an expected capital loss equal to \( -\iota dt \). Equity holders also earn profits \( \pi dt \). In equilibrium all this has to match the return on the riskless bond \( r dt \). After neglecting terms of order \((dt)^2\), the resulting arbitrage condition becomes \( v - \iota + \pi = rv \). Following Grossman and Helpman (1991), let \( V \equiv 1/v \) be the inverse of the aggregate value of the stock market.\(^2\) Using this definition together with (5) yields:

\[
\frac{V}{V} = \pi V - \iota - \rho
\]

The characterization of the equilibrium is completed by imposing the aggregate budget constraint, which requires aggregate revenues to be entirely absorbed by wages and profits \( v \iota + E = wL + \pi \). The definition of \( V \) and (8) then imply

\[
\iota = \frac{L}{a} - (1 - \pi)V
\]

so that followers’ R&D intensity is positive provided that \( L > a(1 - \pi)V \).

In steady state \( \dot{V} = 0 \). Imposing this condition on (9) and (10) yields

\[
V^* = \frac{L}{a} + \rho
\]

\[
\iota^* = \frac{\pi L}{a} - (1 - \pi)\rho
\]

where the value of \( \pi \) is given by (7). Hence, in steady state aggregate R&D intensity \( \iota^* \) is an increasing function of the labor endowment \( L \) and the technological step \( \lambda \) as well as a decreasing function of the R&D marginal labor requirement \( a \) and the rate of time preference \( \rho \).

In the dynamic equilibrium described by (11), each industry experiences occasional quality improvements whose arrivals are governed by independent Poisson processes. The technological evolution of each industry is therefore both choppy and random. At the aggregate level, however, the law of large numbers kicks in and technological progress is both smooth and nonrandom with a constant fraction of industries \( \iota \) upgrading their products each period. This implies that the consumption index (2) grows at a constant growth rate \( g^* \). To find this rate, recall that only the top vintage of each product is sold and commands the same price in all industries. Using (8) and (11) to substitute for \( w \) in (6) allows one to write the common price as \( p^* = \lambda/(L + \rho a) \), which is

\(^2\)The aggregate equity value equals \( v \) because the measure of incumbent leaders equals the measure of industries \( j \in [0, 1] \).
therefore constant in steady state. Hence, given (3), the consumption index (2) can be rewritten as

\[ \ln D(t) = \int_0^1 \ln \tilde{q}_t(j) \, dj - \ln p^* \]

so that consumption growth is driven by changes in \( \tilde{q}_t(j) \) only, i.e. only by quality upgrading. Now let \( f(m,t) \) be the probability that the state-of-the-art quality in an industry moves \( m \) steps up in a time interval of length \( t \). With a continuum of industries following the same Poisson process, \( f(m,t) \) is also the fraction of industries moving \( m \) steps up the quality ladder in the same time interval. Therefore, \( f(m,t) \lambda^m \) is the aggregate quality improvement due to industries that move \( m \) steps up in the time interval \( t \) and \( f(m,t) \ln \lambda^m \) is the associated increase in the consumption index. Summing up across all possible \( m \)'s gives the instantaneous increase in the consumption index

\[ \int_0^1 \ln \tilde{q}_t(j) \, dj = \ln \lambda \sum_{m=0}^{\infty} f(m,t) m \]

The summation term on the right hand side represents the expected number of improvements in a time interval of length \( t \), which for a Poisson distribution equals \( \lambda t \). This implies that in steady state the consumption growth rate \( d \ln D(t)/dt \) evaluates to

\[ g^* = \lambda^* \ln \lambda \] (12)

Hence, the technological step \( \lambda \) has both an indirect and a direct effect on growth. First, a larger \( \lambda \) raises R&D intensity and thus the number of industries that upgrade the quality of their products each period. Second, a larger \( \lambda \) increases the contribution of each innovating industry to aggregate quality upgrading.

### 3 Outsourcing

Consider now the other organizational options that manufacturers face when they have the possibility to outsource the creation and the commercialization of new vintages.

#### 3.1 Timing of events

In each period the timing of events is as follows. First, follower manufacturers decide whether to insource or outsource the design of new vintages. As in Section 2, an R&D intensity equal to \( \iota \) leads to successful innovation with probability \( \iota \) over the time interval \( dt \). If insourced, intensity \( \iota \) is achieved by employing \( a \iota \) units of labor. If outsourced, it is instead achieved by employing \( c a \iota \) units of labor with \( c \in (0,1) \). This lower labor requirement captures the higher efficiency of specialized designers due to their core competences. Designs are relation-specific in that they have no value outside the original relation. Moreover, their
quality is unobservable to third parties, which leads to ex-post bargaining after their provision but before their technical implementation can take place. Ex-post settlements are assumed to be attained through Nash bargaining with \( \omega \in (0, 1) \) representing the bargaining weight of the designers. After settlement, manufacturers perform the technical implementation of the designs using a linear technology that transform designs one-to-one into prototypes ready for commercialization.

Second, manufacturers that have successfully engineered the prototypes of new vintages decide whether to insource or outsource their commercialization. In both cases one unit of labor is needed to commercialize a unit of output, which implies a marginal cost equal to \( w \) as in Section 2. However, in the case of outsourcing the quality step \( \lambda \) is magnified by a factor \( \alpha \in (1, \infty) \). This captures the additional quality improvement specialized resellers are able to contribute starting from the new prototypes thanks to their core competences. On the other hand, since outsourcing requires the transmission of the prototypes to the resellers, there is an additional risk of dissipating manufacturers’ intangible assets. This happens because the quality of the prototypes is unobservable to third parties but they keep some value for the resellers even outside the original relations. In particular, when prototypes are used outside the original relation, the corresponding quality step \( \lambda \) is reduced by a factor \( \beta \in (1/\lambda, 1) \). This reduction captures the fact that prototypes can not be exploited to its full potential without the support of the original manufacturers. Hence, \( \beta \) measures the extent of dissipation of the manufacturer’s intangible assets. As before, ex-post settlements are assumed to be governed by Nash bargaining. However, differently from the case of designers, the ex-post bargaining weight of the resellers is set to zero in order to stress the role of their outside options. The underlying idea is that prototypes are less relation-specific than designs.

The analysis will focus on symmetric equilibria, i.e. equilibria in which manufacturers make the same choices in all industries. To see whether such equilibria exist, one has to check that conditional on all other past, present and future manufacturers making choices compatible with symmetry, no single manufacturer has a unilateral incentive to behave asymmetrically. As an individual innovator is negligible to the aggregate functioning of the economy, in evaluating the incentive to deviate from symmetry, manufacturers takes the aggregate variables as given at their symmetric equilibrium values.

### 3.2 Commercialization

The model is solved backwards starting from the commercialization stage. Since the size of the quality step embedded in a new prototype does not depend on the way the underlying design has been created, also the profits at the commercialization stage are independent from the organizational choices at the product design stage. It is also immaterial whether the commercialization of the current state of the art is outsourced or not as what matters for the profits of a prospective leaders is only the quality step ahead of the incumbents.

When commercialization is insourced, profits are still given by (7). When it
is outsourced, there are two possible scenarios. In the first, the resellers renege and use the new prototypes to commercialize the new vintages on their own. This implies a reduction in the quality of the new vintages as well as a reduction in the price resellers can command. In particular, since quality falls by a factor \( \beta \in (1/\lambda, 1) \), the price that, once adjusted for quality, just matches the marginal cost of the closest competitors equals

\[
p_R = \lambda \beta w < p
\]

with associated profit

\[
\pi_R = 1 - \frac{1}{\lambda \beta} < \pi \tag{13}
\]

In the second scenario, resellers keep their commercialization commitment with manufacturers and, thanks to their support, are able to increase the quality step by a factor \( \alpha \in (1, \infty) \). This implies a price equal to

\[
p_M = \lambda \alpha w > p
\]

with associated profit

\[
\pi_M = 1 - \frac{1}{\lambda \alpha} > \pi \tag{14}
\]

Since the bargaining weight of the resellers is zero, ex-post bargaining leaves them as well off as if they had reneged and transfers the residual joint surplus to manufacturers. Accordingly, resellers get \( \pi_R \) whereas manufacturers get \( \pi_O \equiv \pi_M - \pi_R \). Results (13) and (14) therefore imply:

\[
\pi_O = \left( \frac{1}{\beta} - \frac{1}{\alpha} \right) \frac{1}{\lambda} \tag{15}
\]

Hence, while under insourcing the profit of manufacturers (7) is an increasing function of the technological step \( \lambda \), under outsourcing it becomes a decreasing function as a larger step raises the outside option of resellers (13) more than the joint surplus from the commercialization contract (14).

To sum up, manufacturers choose to outsource the commercialization of their new vintages whenever \( \pi_O - \pi > 0 \) or equivalently, by (7) and (15), whenever

\[
\frac{1}{\beta} > \lambda + \frac{1}{\alpha} - 1 \tag{16}
\]

Since this condition is memoryless, when it holds manufacturers choose outsourcing whatever the commercialization choices of incumbent leaders and whatever the organizational choice in product design. To alleviate future notation, call \( \pi_{\text{max}} = \max(\pi_O, \pi) \).

### 3.3 Innovation

At the product design stage research efforts are financed by floating equity claims on the capital market. By analogy with the results in Section 2.3, the
instantaneous return on those claims is equal to $\pi_{\text{max}}/v+\dot{v}/v-\iota$ where the value of leadership $v$ depends on the organizational choice of innovation. Under insourcing the maximization of profits from product design implies the same value as (8). Differently, under outsourcing manufacturers get $(1-\omega)\nu dt$ whereas the designers gets $\omega\nu dt - wca\nu dt$. Designers’ profit maximization with positive R&D intensity then requires that the value of leadership under outsourcing equals

$$v_S = \frac{wca}{\omega}$$

(17)

Since $\pi_{\text{max}}$ is the same for both R&D arrangements, taking aggregate variables $\iota$ and $w$ as given, manufacturers are able to offer higher returns to investors under outsourcing than insourcing whenever $v_S - v < 0$ or equivalently, by (8) and (17), whenever

$$\omega > c$$

(18)

that is, whenever the underprovision of R&D intensity due to hold-up problems does not offset the technological advantage of designers.

Also condition (18) is memoryless and thus applies whatever the product design choices of incumbent leaders and whatever the organizational choice on commercialization. Note that all the parameters involved are different between (16) and (18), so there is no interaction between the organizational choices on commercialization and product design. To alleviate future notation, call $v_{\text{min}} = \min(v_S, v)$ and $a_{\text{min}} = \min\left(\frac{\omega}{\sigma}, a\right)$ so that $v_{\text{min}} = wa_{\text{min}}$ and $w = v_{\text{min}}/a_{\text{min}}$.

### 3.4 Aggregation

The equilibrium values of the aggregate stock market value $V$ and the R&D intensity $\iota$ are determined by an arbitrage condition and a resource constraint analogous to (9) and (10). As pointed out in Section ??, the individual organizational decisions on product design and commercialization are independent from one another. Nevertheless, they jointly determine aggregate behavior.

The arbitrage condition corresponding to (9) and the resource constraint corresponding to (10) are respectively

$$\frac{\dot{V}_\text{max}}{V_{\text{max}}} = \pi_{\text{max}} V_{\text{max}} - \rho - \iota$$

(19)

and

$$\iota = \frac{L}{a_{\text{min}}} - (1 - \pi_{\text{max}}) V_{\text{max}}$$

(20)

where $V_{\text{max}} \equiv 1/v_{\text{min}}$. In steady state, $\dot{V}_{\text{max}} = 0$ so that (19) and (20) can be solved together to yield

$$V^{*}_{\text{max}} = \frac{L}{a_{\text{min}}} + \rho$$

(21)

$$\iota^{*}_{\text{max}} = \pi_{\text{max}} \frac{L}{a_{\text{min}}} - (1 - \pi_{\text{max}}) \rho$$
The larger $\pi_{\text{max}}$, the larger the steady state R&D intensity. The smaller $a_{\text{min}}$, the smaller the value of the stock market and the larger the R&D intensity in steady state. Based on (16) and (18), the dependence of $\pi_{\text{max}}$ and $a_{\text{min}}$ on parameter values can be summarized as follows:

$$
\begin{align*}
\pi_{\text{max}}, a_{\text{min}} &< \frac{1}{\beta} < \lambda + \frac{1}{\alpha} - 1 & \frac{1}{\beta} > \lambda + \frac{1}{\alpha} - 1 \\
\omega > c & \quad 1 - \frac{1}{\beta}, a & \left(\frac{1}{\beta} - \frac{1}{\alpha}\right) \frac{1}{\lambda}, a \\
\omega < c & \quad 1 - \frac{1}{\beta}, a & \left(\frac{1}{\beta} - \frac{1}{\alpha}\right) \frac{1}{\lambda}, a
\end{align*}
$$

(22)

As to steady state growth, again by analogy with the results in Section 2.3, the growth rate of aggregate consumption is

$$
g_{\text{max}}^* = \left\{ \begin{array}{ll} 
\tau_{\text{max}}^* \ln \lambda & \text{for } \frac{1}{\beta} < \lambda + \frac{1}{\alpha} - 1 \\
\tau_{\text{max}}^* \ln \alpha \lambda & \text{for } \frac{1}{\beta} > \lambda + \frac{1}{\alpha} - 1
\end{array} \right.
$$

(23)

where the technological step is larger when resellers’ core competences in commercialization are exploited to magnify the quality improvement of new vintages. Together with (21) and (22), (23) shows how the organizational choices of manufacturers on product design and commercialization affect the growth rate of the economy. The organization of product design determines $a_{\text{min}}$ and therefore has an indirect effect on $g_{\text{max}}^*$ through its impact on R&D intensity $\tau_{\text{max}}^*$. The organization of commercialization has both an indirect and a direct effects on $g_{\text{max}}^*$. The former derives from the impact of $\pi_{\text{max}}$ on R&D intensity $\tau_{\text{max}}^*$. The latter from the impact of commercialization on the technological step $\alpha \lambda$.

Equations (21)-(23) also show that manufacturers’ organizational choices always maximize the growth rate of the economy given the parametric conditions they face.

4 Organizational choice

To help the interpretation of the results obtained in Section 3.4, it is useful to distinguish between ‘technological’ and ‘institutional’ parameters. The technological parameters are $c$, $\lambda$ and $\alpha$. These respectively measure the substitutability between the competences required for product design and technological implementation ($c = 1$ means perfect substitutability), the differentiation between the services offered by neighbouring product vintages ($\lambda = 1$ means perfect substitutability), and the differentiation between the competences required for technological implementation and commercialization ($\alpha = 1$ means perfect substitutability). The institutional parameters are $\omega$ and $\beta$ and measure the contractual ‘efficiency’. In particular, $\omega$ measures the extent to which designers can appropriate the surplus deriving from their R&D efforts ($\omega = 1$ means full appropriability and thus ‘efficient’ R&D contracts). The parameter $\beta$ is an inverse measure of the extent to which manufacturers can prevent the dissipation of their intangible assets by excluding resellers from the independent use of prototypes ($\beta = 1/\lambda$ means full excludability and thus ‘efficient’ commercialization contracts).
Figure 1: Integration versus outsourcing

Figure 1 summarizes the implications of different technological and institutional parameters on organizational choices. Contractual efficiency in commercialization ($1/\beta$) is measured along the horizontal axis while contractual efficiency in product design ($\omega$) is measured along the vertical axis. To the left of the vertical line $CC$, condition (16) is violated: commercialization contracts are too inefficient to make outsourcing an attractive organizational option for manufacturers. The opposite is true to the right $CC$ where (16) holds. Below the horizontal line $RR$, condition (18) is violated: product design contracts are too inefficient to make outsourcing an attractive organizational option for manufacturers. The opposite is true above $RR$ where (18) holds. Hence, $CC$ and $RR$ divide the feasible values of institutional parameters in four regions that meet at point $A$ where the choice among different organizational forms is immaterial as all option yield the same payoffs. Moving clockwise, southwest of $A$ manufactures integrate both upstream and downstream, northwest they integrate only downstream, northeast they outsource both upstream and downstream, southeast they integrate only upstream. The corresponding values for $\pi_{\text{max}}$ and $a_{\text{min}}$ are the ones reported in (22).

Figure 1 can be used to address two types of questions. The first type compares different sets of industries operating within the same country. All sets of industries are modeled in the same way as in the above and differ in terms of their technological parameters. The second type of questions compares the
same set of industries across countries that differ in terms of their institutional parameters.

**How does the organizational form vary across different sets of industries within the same country?** To answer this question, one has to assess for which values of the technological parameters \((c, \alpha, \lambda)\) a given pair of institutional parameters \((1/\beta, \omega)\) falls in each of the four regions in Figure 1. Integration both upstream and downstream characterizes sets of industries where core competences in the three tasks of the value chain are very similar (large \(c\), small \(\alpha\)) and new vintages are much better than previous ones (large \(\lambda\)). The reason is that there is little to gain from specialization in tasks and a lot to lose from dissipation. Analogously, outsourcing prevails both upstream and downstream in sets of industries with large differentiation between core competences and small differentiation between vintages. In sets of industries in which vintages as well as competences in technological implementation and commercialization are very different (large \(\lambda\), large \(\alpha\)) but core competences in product design and technological implementation are similar (large \(c\)), outsourcing takes place downstream but not upstream. Vice versa, in sets of industries in which vintages as well as competences in technological implementation and commercialization are very similar (small \(\lambda\), small \(\alpha\)) but core competences in product design and technological implementation are very different (small \(c\)), outsourcing happens upstream but not downstream.

**How does the organizational form chosen by the same set of industries vary across countries?** In terms of Figure 1, this requires to assess which values of the institutional parameters \((1/\beta, \omega)\) fall in each of the four regions for given technological parameters \((c, \alpha, \lambda)\). The same set of industries integrates both upstream and downstream in countries with poor contract enforcement. It integrates only upstream when product design contracts are relatively efficient and commercialization contracts are not. Vice versa, it integrates only downstream when commercialization contracts are relatively efficient and product design contract are not. Finally, when the enforcement of both types of contracts is good, outsourcing prevails both upstream and downstream.

**How do different sets of industries reorganize as contractual efficiency improves?** Consider again Figure 1 and, for the sake of argument, start from an initial situation in which contracts are as inefficient as possible: \((1/\beta, \omega) = (1, 0)\). Now let contractual efficiency improve gradually and proportionately both in product design and commercialization, i.e. let \(1/\beta\) and \(\omega\) grow along a ray from the origin like the one identified by the dashed arrow in the figure. Depending on technological parameters, the same ray may pass below or above point \(A\). As contract efficiency increases, a set of industries whose \(A\) is located above the ray evolves from full integration to full outsourcing through integration only upstream. A set of industries whose \(A\) is located below the ray goes from full integration to full outsourcing through integration only downstream. Hence, while the initial and final organizational forms are the same, the transition is different. In particular, product design is outsourced
first in sets of industries in which vintages are very different (large \( \lambda \)) and core competences are more differentiated between product design and technological implementation than between technological implementation and commercialization (small \( c \), small \( \alpha \)). Vice versa, commercialization is outsourced first in sets of industries in which vintages are rather similar (small \( \lambda \)) and core competences are more differentiated between technological implementation and commercialization than between product design and technological implementation (large \( \alpha \), large \( c \)).

5 Industry life cycle

How does a set of industries restructure along its life cycle? What are the implications of restructuring for aggregate R&D intensity and growth? In terms of Figure 1, the maturation of a set of industries can be modeled as a gradual fall in their quality step \( \lambda \). For given institutional parameters, if the initial step is assumed to be large enough to violate (16), as \( \lambda \) falls at some point all industries shift from insourced to outsourced commercialization. This is due to the fact that under insourcing the profit of manufacturers (7) is an increasing function of the technological step \( \lambda \) whereas under outsourcing it is a decreasing function: shrinking opportunities for quality upgrade damage the outside option of resellers more than the joint surplus from the commercialization contract (see (13) and (14)).

Given (23), industry restructuring has both indirect and direct effects on the growth rate. As to the indirect effect, the shift to outsourcing turns R&D intensity from an increasing to a decreasing function of \( \lambda \). Hence, as the quality step keeps on shrinking, R&D intensity further increases due to the extra surplus manufactures are able to extract from resellers. The result is a positive impact on growth. As to the direct effect, industry restructuring generates an instantaneous upward jump in the technological trajectory as the contribution of each successful research effort rises from \( \lambda \) to \( \alpha \lambda \) thanks to the exploitation of resellers’ core competences. After that, for given R&D intensity, the shrinkage of technological opportunities has again a negative direct impact on the growth rate.

The behavior of the growth rate as a function of the technological step is shown in Figure 2. Moving from right to left, shrinking technological opportunities cause a slow down in innovation by vertically integrated firms until \( \lambda \) is low enough to trigger the outsourcing of commercialization. As soon as industries restructure, the growth rate jumps upwards because resellers’ core competences are put to work. Then it starts increasing as contractual inefficiency is reduced by the progressive weakening of the resellers’ outside options. However, this channel loses strength as \( \lambda \) further falls, which explains why Figure 2 has a hump for low values of the quality step.
This paper has modeled the organizational decisions of firms in dynamic industries characterized by ‘creative destruction’ due to ongoing quality improvement. Within industries the value chain consists of three tasks (‘product design’, ‘technical implementation’ and ‘commercialization’) that require different core competences. The attention is on the behavior of firms that have core competences in technical implementation and decide whether or not to insource product design and commercialization. Insourcing takes them away from their core competences, which makes them less efficient than designers and resellers. On the other hand, insourcing avoids the contractual costs associated with outsourcing. These costs stem from contractual incompleteness that gives raise to ex-post bargaining after parties have sunk relation-specific investments. The model shows that various technological and institutional parameters affect the organizational choice, which in turn has direct and indirect effects on growth. Indeed, organizational shifts are able to stimulate growth in industries with withering technological opportunities.

For simplicity, the modeling strategy has kept the parameters that govern the sourcing decision on product design separated from those that drive the sourcing decision on commercialization. Future research should investigate their interactions. For example, the outsourcing of commercialization may face a higher risk of dissipation of intangible assets when also product design is outsourced as both the designs and the prototypes of the new vintage qualities circulate out-
side the boundaries of manufacturers. Alternatively, the outsourcing of product
design may reduce the tacit component of manufacturers’ specific knowledge,
thus making it easier to patent before commercialization. Also for simplicity,
the technological step has been kept exogenously given. Another direction of
future research is to endogenize it, possibly exploiting the formal connections
between the adopted growth model of quality ladders and the static model with

References


to Frontier, Selection, and Economic Growth, Journal of European Eco-


Cambridge: MIT Press.

(2003) Plants and Productivity in International Trade, American Economic
Review 93, 1268-90.


in Industry Equilibrium, Quarterly Journal of Economics 117, 85–120.


City University of Hong Kong, mimeo.
