Global Sourcing:
An Empirical Test of the Hold-up Model

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Abstract

This paper uses Spanish firm-level data to test the model of global sourcing proposed by Antrás and Helpman (2004). Our contribution to the literature is twofold. First, we suggest a novel diagrammatical representation of the model which highlights the distinction between the location and the incentive advantage of alternative sourcing strategies. The two types of advantage are driven by fundamentally different channels of influence, and confronting them separately with the corresponding fixed cost disadvantage improves our understanding of possible patterns of equilibrium sourcing strategies with heterogeneous firms. Second, we develop a three-stage empirical strategy for bringing the theory to a very rich Spanish firm-level data set. The first stage of our strategy involves non-parametric tests on productivity distributions of firms pursuing different sourcing strategies. The second stage estimates sourcing premia across firms in a unified regression framework for all sourcing strategies. And finally, in stage three we allow for lagged adjustment and exploit the time variation in productivity and sourcing strategies.

JEL-Classification: F14, F23, L22, L23

Keywords: productivity, holdup, property rights theory, sourcing strategies, firm-level data

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1 Introduction

Recent literature has turned attention to special features of trade in intermediate inputs that sets it apart from trade in final goods. A canonical model, going back to Antràs (2003) and Antràs & Helpman (2004), focuses on a hold-up problem that derives from relationship specificity of intermediate inputs and lack of perfect contracts, and it highlights firms’ choice between relying on independent input suppliers and vertical integration of input provision. Thus, the hold-up model of global sourcing attempts to explain both where (domestic or foreign) and how (intra-firm or non-related party) inputs are sourced.

In this paper, we intend to contribute to the literature on global sourcing in two ways. First, we present a novel presentation of the hold-up model of global sourcing which highlights the distinction between the location and the incentive advantage of alternative sourcing strategies. The two types of advantage are driven by fundamentally different channels of influence, and confronting them separately with the corresponding fixed cost disadvantage improves our understanding of possible patterns of equilibrium sourcing strategies among heterogeneous firms. The location advantage has to do with countries’ factor cost for production of certain inputs, whereas the incentive advantage relates to the organizational form of the relationship between a final goods producer and an input supplier in view of the distorted decision making that derives from the hold-up problem. Second, we develop an empirical strategy for bringing the theory to the data. In doing so, we draw on a Spanish firm-level data set that has unique advantages, allowing for a precise empirical identification of key theoretical variables. Our strategy involves three stages which, taken together, come very close to an empirical test of the hold-up model.

The hold-up model of global sourcing has been developed against the backdrop of an enhanced interest, both in academia and the policy debate, in offshore sourcing. In open economies, firms source their inputs on a global scale. In the past two decades, this has been reinforced by revolutionary improvements in transport and communications, which have facilitated an ever stronger fragmentation of production chains, thus greatly expanding the realm of tradable inputs. As a result, firms increasingly engage in what is generally called “offshoring”, i.e., moving the source of certain types of inputs, hitherto provided “in-house”
During the past two decades, offshoring has caught a lot of attention, starting with early papers by Jones & Kierzkowski (1990) and Feenstra & Hanson (1997), and picking up renewed momentum with more recent contributions by Grossman & Helpman (2005, 2002) and particularly the hold-up model of global sourcing proposed by Antràs & Helpman (2004) and the task trade model developed by Grossman & Rossi-Hansberg (2008, 2010).

However, the empirical significance of offshoring has been subject to some debate. Much depends on how offshoring is measured. A popular approach is to look at trade in intermediate inputs. This type of trade has been very important for a long time, but for some countries it has recently gained in importance. Figure 1 takes a snapshot of some OECD and emerging market economies for 2006.\footnote{The source is Miroudot et al. (2009).} For example, 58 percent of 2006 manufacturing imports into OECD countries was intermediate goods, and for trade in services the share of intermediates was 73 percent. For manufactures, the variation in the share of intermediates across countries is relatively low; above average shares are observed for South Korea, Japan, Brazil and China, below average shares are found for the US, the UK and Russia. For services, the US, Japan and Brazil show below average shares, while the European countries as well as Russia and Japan show above average figures. Figure 2 depicts growth rates in volumes of imported intermediates from 1995 to 2006 (for goods trade) and 1995 to 2005 (for services trade).\footnote{For a few countries, the most recent trade data available for services relate to 2003 or 2004; see Miroudot et al. (2009), Table A.7.} On average, trade in intermediates has not increased much more than trade in other types of goods or services, but some countries exhibit marked differences. Thus, German trade in both intermediate and capital goods as well as intermediate services did increase more than trade in final goods. France has experienced particularly strong growth of trade in intermediate services, as did the UK, Turkey and China. An opposite pattern is reveled for Italy and the Netherlands. The general impression, however, is one of a high shares of intermediates in trade of both goods (mostly more than half) and services (mostly more than 60 percent), and for most countries a moderate upward trend in these shares between 1995 and 2005.

One may question that the share of intermediates in trade correctly measures the empiri-
cal significance of offshoring. For one thing, it likely fails to capture the recent trend of trade in tasks. In many cases, if firms unbundle labor inputs and start locating the performance of certain tasks abroad, this does not involve shipment of any tangible intermediate that catches the eye of trade statistics.\(^3\) Moreover, the economic significance of offshoring is better captured by the share of imported intermediates in production than by the share of intermediates in trade. Hummels et al. (2001) and Yi (2003) measure the degree of vertical specialization through the content of imported intermediates in a country’s exports of a certain good, using input-output data. Measured in this way, several OECD countries have witnessed a marked increase in vertical specialization during the 1980s and 1990s. According to Yi (2003), a Dollar’s worth of US 1997 exports has embodied as much as 20 cents worth of imported intermediate inputs. Miroudot & Ragoussis (2009) show that for the OECD and some emerging economies the share of imported intermediates in exports has risen from around 20 percent

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\(^3\)Introductions to scientific papers are full of anecdotal evidence, but there is relatively little systematic evidence on trade in tasks. A possible, though imperfect, way to measure the empirical significance of task trade is to look at direct job losses from reorganization of production. The study on offshoring by the OECD (2007) surveys some micro-based evidence on direct job losses due to restructuring efforts have included offshoring. However, Bhagwati et al. (2004) point out that for the US such job losses are minuscule compared to the labor market turnover. Blinder (2009) and Kletzer (2009) identify jobs that are likely to be affected by such trade in tasks, based on job characteristics, and conclude that such job losses may be significant in the future. For a more recent attempt to identify the empirical significance of task trade, see Lanz et al. (2011).
in 1995 to slightly more than 25 percent in 2005. Employing the Feenstra & Hanson (1999) methodology, the OECD (2007) estimates sector-specific shares of intermediate inputs in total non-energy inputs into domestic production and compares such offshoring indices across a sample of 12 OECD countries as well as across time (1995 to 2000). Figure 3 presents unweighted averages across all 12 countries, revealing that manufacturing sectors rely more heavily on offshoring than the services sectors and that they do so much more with manufacturing inputs than with services, while the opposite holds true for service sectors. Thus, judged from production-based measures, the empirical significance of offshoring is much lower for service sectors and for intermediate services than for manufacturing and imported goods. This is a notable contrast to the impression that one is bound to obtain from looking at trade data alone; see above.

High shares of intermediates in total trade and rising shares of imported inputs in production have prompted trade theorists to rethink trade in intermediates. Traditionally, trade theory has - almost by definition - rested on the premise that outputs are traded while inputs are not. For primary inputs, particularly labor, this may seemed justified. And at any rate, the relationship between trade in goods and factor movements has received early and contin-
<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing intermediate import ratio of manufacturing sector</td>
<td>25.73%</td>
<td>23.37%</td>
</tr>
<tr>
<td>Manufacturing intermediate import ratio of services sector</td>
<td>5.03%</td>
<td>3.91%</td>
</tr>
<tr>
<td>Services intermediate import ratio of manufacturing sector</td>
<td>1.92%</td>
<td>1.94%</td>
</tr>
<tr>
<td>Services intermediate import ratio of services sector</td>
<td>5.48%</td>
<td>4.76%</td>
</tr>
</tbody>
</table>

Source: OECD (2007)

Figure 3. Ratio of inputs provided from offshore, 1995, 2000

ued attention, ever since Ohlin’s discovery that under certain conditions the two are perfect substitutes. For intermediate inputs, a possible justification for neglecting trade might lie in the belief that, to the extent that they are traded, this is governed pretty much by the same principles and has the same effects as trade in final goods. However, modern trade theory holds that this belief is flawed. Buyers and sellers of intermediate inputs enter a relationship which is fundamentally different from a transaction in final goods. The relationship is plagued by contractual imperfections, not unlike the relationship between firms and workers.\(^4\) Arguably, acknowledging such imperfections for both intermediates and labor sets modern trade theory apart from traditional theory.

More specifically, in an environment characterized by product differentiation and imperfect competition, the producer of a special variety of a final good will typically rely on tailor-made, specific inputs. This potentially has severe consequences for the provision of these inputs. Search for suitable input suppliers may be costly, depending on such things as market thickness. Considerations relating to market thickness will thus become an important element in a firm’s decision where to source certain inputs, in addition to considerations relating to countries’ factor cost.\(^5\) A second consequence, which is the focus of this paper, is that buyers and sellers of such inputs may face hold-up problems, due to relationship specificity of their investments and unverifiable product characteristics. Lack of enforceable contracts then raises the question of a suitable organizational form of input provision.

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\(^4\)See Jones (2000) for other characteristics of input trade that have traditionally been neglected, but have nothing to do with contractual imperfections.

\(^5\)This aspect of offshoring is at the center of Grossman & Helpman (2005).
As regards the organizational form, a key distinction that has recently been introduced in both theoretical and empirical contributions is between arms-length transactions that involve independent parties and foreign direct investment (FDI), or intra-firm trade. This holds true particularly for vertical FDI. Data on intra-firm trade are relatively scarce. The US has a comprehensive data set, drawn from its census, and the OECD has collected evidence for a some additional countries. According to Lanz & Miroudot (2011), the share of related party imports in total US imports of goods has remained relatively stable, at just about less than a half, during the period 2002-2009, while for US exports this share has indeed fallen from 32 percent in 2002 to somewhat less than 30 percent in 2009. For US exports of services, the intra-firm share has risen from 20 percent in 2002 to somewhat more than 25 percent in 2009, and for service imports it has risen from somewhat less than 13 percent to around 22 percent. Available evidence for other OECD-countries indicates that their shares of intra-firm trade have risen over the past decade for both goods and services. Moreover, there are marked differences in these shares both across trading partners (with large shares particularly for US trade with OECD partners) and across industries (with high shares in automobiles, pharmaceuticals and transport equipment).

It seems fairly straightforward that variations in intra-firm shares of trade across products (industries), trading partner and time have much to do with contractual frictions that for some reason hamper arms-length transactions. Moreover, given the presumption that such frictions are more prevalent for trade in intermediates than for final goods and services, and given the high share of intermediates in trade of both goods and services, it seems vital to suitably enrich our models of trade, so that we may explain not only the location, but also the organizational form of input provision. We now have a body of literature that we can draw upon for this end. The canonical approach features the hold-up model of input trade, originally proposed by Antràs (2003) and generalized to a full-fledged model of global sourcing in Antràs & Helpman (2004), Antràs (2005) and Antràs & Helpman (2008). This strand of literature draws on the theory of property rights developed by Grossman & Hart (1986).

The OECD study is Lanz & Miroudot (2011). For a recent study that exploits the US Census data on intra-firm trade with transactions-based firm data in an attempt to empirically explain the above mentioned variation across countries and industries is Bernard et al. (2010).
More recently, Antràs & Staiger (2011) have explored normative implications that derive from input provision which is plagued by a hold-up problem. An alternative approach with a somewhat different theoretical notion of intra-firm trade has been developed by Grossman & Helpman (2002, 2004), drawing on the theory managerial incentives developed by Holmström & Milgrom (1991).  

In a nutshell, the Antràs-Helpman (AH) hold-up model of global sourcing runs as follows. Production of final goods requires two essential inputs: an intermediate input and a “headquarter input” provided by the final goods producer. By assumption, the final goods producer is unable to generate the intermediate input, hence she relies on a supplier. Final goods are differentiated, hence final goods producers have market power. But differentiated final goods also imply the needs for tailor-made inputs, which in turn has two consequences. First, enforceable contracts that specify all relevant characteristics of the input are not available (incomplete contracts). And secondly, both types of inputs have no use outside this specific production relationship (relationship specificity). Hence, both the headquarter and the input supplier anticipate that, having invested in their respective inputs, they will be pitted against each other in bargaining over the surplus of the production relationship. The model assumes Nash bargaining, with the outcome depending, among other things, on the ex post outside options that the two agents have. As a result, the production relationship is plagued by a hold-up problem. Due to insufficient incentives, both inputs are provided in less than optimal amounts and, potentially at least, in an inefficient input mix.

The AH-model assumes that the legal system offers the headquarter an organizational form, called vertical integration, which affords the final goods producer a residual property right in the intermediate input, as in Grossman & Hart (1986). By choosing vertical integration, the final goods producer may thus enhance her outside option in the bargaining stage, relative to the other organizational form, called outsourcing, which means relying on an independent supplier. Importantly, vertical integration does not avoid the hold-up problem, but simply implies an enhanced incentive for investment in the headquarter input, and a lower

7For early survey papers on input trade which is subject to contractual imperfections, see Spencer (2005) and Helpman (2006).
incentive for the intermediate input supplier, than would be the case with outsourcing.

For either of the two organizational forms, final goods producers may decide to turn to domestic or foreign input suppliers. They choose their sourcing strategy, i.e., a combination of location and organizational form of obtaining the intermediate input, so as to maximize expected profits from this production relationship. This choice is driven by two types of advantages: A location advantage of obtaining the input in the domestic or the foreign economy. The model assumes a cost advantage of foreign input suppliers. In addition, depending on the bargaining details of the hold-up problem, there is an incentive advantage in favor of either vertical integration of outsourcing. Importantly, the advantage of one organizational mode or location, respectively, over the other in sourcing the intermediate input is magnified by a firm’s productivity. The optimal sourcing strategy is then determined by confronting this advantage with a specific structure of fixed cost disadvantage associated with different organizational forms and locations of sourcing. In an environment akin to Melitz (2003), where firms differ in their productivity, the industry equilibrium is shaped by a productivity-based self-selection of firms into sourcing modes.

Empirical tests of the AH hold-up model are somewhat tricky, because it allows for a multiplicity of outcomes regarding the exact sorting of firms into different sourcing strategies, mirroring different combinations of input cost advantages (relating to the location and organizational form of sourcing) and associated fixed cost disadvantages. Hence, ambiguity seems bound to prevail, at least for realistic data availability. It is, therefore, not surprising that the literature has so far not been able to test the AH-model. Our own contributing to this literature is twofold. First, we suggest a novel representation of the AH model which highlights the distinction between the location and the incentive advantage of alternative sourcing strategies. And second, against the backdrop of this model presentation, we develop a three-stage empirical strategy for bringing the theory to the data. Our empirical strategy focuses on the prediction of a systematic relationship between a firm’s productivity and its sourcing strategy. We rely on a Spanish firm-level data set with rich and precise information on productivity and sourcing behavior. Our data set has several features that are of special importance in this context. It allows for high precision in separating trade in intermediate inputs from other forms of intra-firm trade, and in separating input procurement by the firm’s
headquarter from trade where the importer has a position different from that of a headquarter. Of equal importance, our data allows for a precise measurement of the elasticity of the output with respect to the input that is provided by the headquarter itself.

The first stage of our strategy involves non-parametric tests for productivity distributions of firms pursuing different sourcing strategies. Assuming the model is correct, this allows us to pin down the relevant equilibrium pattern of sourcing strategies for firms with different productivities. The second stage then estimates sourcing premia simultaneously in a unified regression framework for all sourcing strategies. Sourcing premia are defined on productivity, in analogy to the literature on exporter premia\(^8\) and estimated econometrically using an adjusted Olley & Pakes (1996) approach. The key question at this stage will be whether the estimated sourcing premia corroborate our non-parametric results. We find an affirmative answer which we interpret as empirical support of the AH model. And finally, in stage three we exploit time variation in productivity and sourcing strategies. Allowing for lagged adjustment of sourcing strategies to productivity changes, we examine whether the firms that switch between alternative sourcing strategies between two consecutive periods in time exhibit sourcing premia over “stayers” that are in line with the AH prediction.

The remainder of our paper is structured as follows. In section 2, we develop our new representation of the AH model of global sourcing. We abstain from a laborious derivation of the model details, but focus on the key channels and predictions that guide our empirical strategy. In section 3, we first briefly describe our data set and then pave the way for an empirical implementation of our empirical strategy by estimating the productivity of firms, duly taking into account that choosing a certain sourcing strategy is an important element of firm behavior. In section 4, we first briefly discuss earlier empirical papers related to the AH hold-up model and then implement our 3-stage empirical strategy, first presenting a non-parametric comparison of productivity distributions across sourcing modes. This is followed by an estimation of “sourcing premia”, first assuming instantaneous adjustment and then allowing for lagged adjustment of sourcing strategies to productivity changes. Section 5 concludes with a brief summary and an outlook on further research.

\(^8\)See Bernard & Jensen (1999); for a survey see Bernard et al. (2007).
2 The hold-up model of global sourcing

The hold-up model of global sourcing does not readily lend itself to empirical testing. Setting data limitations aside, a crucial difficulty lies in the multiplicity of possible sourcing equilibria, which appears to defy a straightforward testing procedure. In this section, we want to present the model in a form which helps us solving this problem. We propose a novel diagrammatical approach in presenting the key mechanisms of the model, which then allows us to derive a three-stage empirical strategy that comes close to an empirical test. We first present the model, focusing on the sourcing decision, and then turn to the empirical strategy that we subsequently apply to our Spanish firm-level data set.

2.1 A skeletal view on the hold-up model of global sourcing

For a large part of this section, we keep with the simpler version of the model pioneered by Antràs & Helpman (2004) where there are two inputs none of which is contractible. The generalized version presented in Antràs & Helpman (2008), where each of the two inputs incorporates a fraction of contractible and a remaining fraction of non-contractible tasks, will briefly be dealt with where appropriate and useful. In this canonical hold-up model of global sourcing, the headquarter of a firm enters a relationship with the supplier of an intermediate input $X^m$, in order to produce a differentiated final good $Y$. Production is governed by $Y = \theta \left[ X^h / \eta \right]^\eta \left[ X^m / (1 - \eta) \right]^{1 - \eta}$, where $X^h$ denotes the headquarter’s own service and $\eta$ is the elasticity of output with respect to the headquarter service, henceforth called the “headquarter intensity” of production. Given product differentiation, the final good producer has market power. We assume a constant elasticity of demand equal to $1/\alpha$, where $0 < \alpha < 1$. However, the model is completely general as regards the destination of sales.

The legal environment is assumed to offer two organizational forms for this relationship, called outsourcing and vertical integration, respectively. In either case, both the headquarter and the input supplier anticipate that once their respective inputs have been produced they

\footnote{A standard interpretation of this market environment invokes the familiar monopolistic competition framework with Dixit-Stiglitz-type preferences.}
will be pitted against each other in a bilateral negotiation about how to share the revenue generated from selling the final product. The difference between outsourcing and vertical integration lies with the bargaining details. More specifically, the two organizational forms afford the two agents different ex post outside options at the bargaining stage, leading to different revenue shares accruing to the headquarter and the input supplier. Anticipating these shares, they also face different incentives to invest into input provision in the pre-negotiation stage of decision making. The organizational form of sourcing thus sets the incentives for providing inputs for the production relationship.

The fundamental assumption thus is that the legal or institutional environment is asymmetric in that it bestows the exclusive power to choose the organizational form of the relationship on one of the two agents. Indeed, this is what defines the headquarter in this model. On a fundamental level, the model is silent on any other features of the two inputs, say the skill-intensity or even the capital intensity. Antrás & Helpman (2004, 2008) assume that both inputs draw on labor. We formulate the model in a more general way, assuming that each of the two inputs draws on an unspecified number of primary resources commanding given wage rates.\(^{10}\) A central tenet of the AH-model is that, whatever the pattern of outside options that the two agents face in an outsourcing relationship, the alternative organizational form of vertical integration offers an enhanced (though costly) outside option for the headquarter. For simplicity, the model assumes that in an outsourcing relationship both parties have a zero ex post outside option.

Bargaining then maximizes the Nash-product, with a share \(\gamma^O\) of the revenue generated by the production relationship accruing to the headquarter and a share \(1 - \gamma^O\) going to the input supplier. Vertical integration means that the headquarter acquires a property right in the input. Should the negotiation fail, it may simply seize the intermediate input, produce

\(^{10}\)In assuming given factor prices, our model is partial equilibrium in nature. One could make a case for the headquarter input being associated with ownership in the non-labor productive assets, which might in turn be associated with the capital stock of a firm. Alternatively, \(X^h\) might be interpreted as value added, with a certain capital intensity, which is separable from intermediate inputs \(X^m\), with a different capital intensity. On a fundamental level, we must distinguish between three questions: i) Where in a multi-input production process do the special input characteristics lead to a hold-up problem? ii) What is the capital-intensity or skill-intensity of these inputs? And iii) who has the right choose the organizational form of the production relationship?
the final output, and keep the revenue. However, in the event of non-agreement, revenue is reduced to a fraction $\delta < 1$ of what it would otherwise be. Thus, exercising the property right is not costless, but it still affords the headquarter a positive outside option. The gain from successful “trade” between the two parties is thus reduced to $(1 - \delta) R^I$, where $R^I$ indicates revenue available in case of agreement, to be derived below. Writing $\gamma^I$ for the headquarter’s revenue share under vertical integration, we have $\gamma^I = [\delta + \gamma^O (1 - \delta)] > \gamma^O$, and the supplier’s share is reduced to $1 - \gamma^I = 1 - [\delta + \gamma^O (1 - \delta)] < 1 - \gamma^O$. Thus, compared to outsourcing, a strategy of vertical integration enhances the headquarter’s incentive to incur the cost of producing $X^h$ while reducing the supplier’s incentive to produce the intermediate $X^m$.

Decision making takes place in three stages. In stage three output is produced and revenue is shared. In stage two both agents decide about the input levels in a non-cooperative way, each maximizing its expected revenue net of the cost of producing the input. In stage one, the headquarter chooses the organizational form and location of input sourcing, so as to maximize its total profit from the production relationship. For simplicity, the model assumes a zero ex ante outside option for input suppliers, with infinitely elastic “supply of suppliers”. In other words, a headquarters can always secure participation of an input supplier, as long as the supplier may expect a revenue share that just offsets the cost of providing the input, given the incentive that both parties face in input provision. The choice of the organizational form by the headquarter takes place in the usual way through backward induction.

Clearly, the ex post share of revenue accruing to the headquarter, together with its incentive implications for provision of both inputs, is a key determinant of organizational choice. But it seems plausible that it is also influenced by the fixed cost of operating the production relationship, which might be different in the two organizational forms. The AH-model assumes that each of the two organizational forms of sourcing comes with a fixed cost, borne by the headquarter. Suppose, then, that the fixed cost of running the sourcing strategy $\kappa \in \{I, O\}$ absorbs $F^\kappa$ units of headquarter services, whereby $I$ and $O$ stand for vertical in-

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11 This follows Grossman & Hart (1986).
12 As will become evident below, in addition to this cost of exercising the property right, there may also a cost of obtaining this right in that the fixed cost of operating the relationship with vertical integration is larger than with outsourcing.
tegration and outsourcing, respectively. Then, the headquarter may expect total profits from running the firm with strategy $\kappa$ equal to

$$
\Pi^\kappa = R^\kappa - (X^{bh}\kappa + F^\kappa) c^h (w) - X^{m\kappa} c^m (w).
$$

(1)

In this expression, $X^{bh}\kappa$ and $X^{m\kappa}$ denote the input levels generated in stage two under the incentive structure afforded by the organizational form $\kappa$, and $c^h (w)$ denotes the minimum unit-cost of producing input $X^h$, given factor prices $w$, and analogously for input $X^m$. It can be shown that equilibrium profits from selling the final good are

$$
\Pi^\kappa = Z^\kappa \theta^{\alpha/(1-\alpha)} - c^h (w) F^\kappa.
$$

(2)

Thus, profits are linear in the term $\theta^{\alpha/(1-\alpha)}$, which we will henceforth denote by $\Theta$. The slope of this linear relationship is given by

$$
Z^\kappa = A [1 - \alpha \gamma^\kappa \eta - \alpha (1 - \gamma^\kappa) (1 - \eta)] \left[ c^g \left( \frac{c^h (w)}{\gamma^\kappa}, \frac{c^m (w)}{1 - \gamma^\kappa} \right) / \alpha \right]^{-\frac{1}{1-\alpha}}.
$$

(3)

In this equation, $c^g(\cdot)$ indicates the minimum unit-cost function dual to the above production function for $Y$. Moreover, $A$ indicates the size of the market for the final good.$^{13}$

The ingenuity of the AH model lies in the term $Z^\kappa$. The second bracketed expression in (3) tells us that the hold-up problem acts like a tax on the two inputs used in production of the final good.$^{14}$ It raises $c^g$ above the minimum cost that would obtain in a complete-contracts-environment. For an equal ex-post share of revenue, $\gamma^\kappa = 1/2$, the “hold-up-tax” does not distort the input mix, relative to a complete-contracts-environment, but it still depresses revenue $R$ and profits $\Pi$. In a complete-contracts-environment, the share of headquarter-cost in total cost, $c^h(\cdot)/c^g(\cdot)$, is equal to the elasticity $\eta$, the so-called headquarter intensity. The same holds true if $\gamma = 0.5$, in which case the input-mix is not distorted. But if $\gamma \neq 0.5$, then the input-mix is distorted, and the headquarter intensity $\eta$ differs from the cost share

$^{13}$A detailed derivation of these relationships is found in Kohler & Smolka (2011a).

$^{14}$Note that the first bracketed term is always positive, since by definition all parameters in this expression have values between 0 and 1.
\( c^h(\cdot)/c^\eta(\cdot) \). This is an important point that needs to be observed in empirical tests of the AH-model where one might be tempted to infer \( \eta \) from observed cost shares. This is correct only in the knife-edge case where \( \gamma^\kappa \) is equal to 0.5. The data used when implementing our empirical framework allows us to identify \( \eta \) independently of the headquarter cost share.

We now ask a different question which is at the center of Antràs & Helpman (2004): Given the hold-up problem, how do variations in \( \gamma^\kappa \) change the minimum unit cost appearing in (3). It is relatively obvious, that the unit unit-cost \( c^\gamma \) is minimized, if \( \gamma^\kappa = \eta \). This is intuitive: The ex post share of revenue should mirror the importance of the input. If \( \eta > \gamma^\kappa \), then the incentive structure is distorted towards “underprovision” of the headquarter input, and vice versa for \( \eta < \gamma^\kappa \). “Underprovision” here simply means that the minimum cost of \( c^\gamma \) could be reduced by a higher \( \gamma^\kappa \), leading to a higher ratio of headquarter-to-intermediate input.

In view of decision making, notice that equations (2) and (3) look at the entire profit to be obtained from this production relationship. The expected headquarter profit is \( \gamma^\kappa R^\kappa - c^h (w) (X^h + F^\kappa) \) minus a participation fee paid to the input supplier. This fee depends on the input supplier’s ex ante outside option. If it is zero, the profit as given in (2) is equal to the expected headquarter profit. However, the model does not change in any significant way if the supplier’s ex ante outside option is non-zero. Hence, for simplicity the AH-model assumes a zero ex ante outside option for the input supplier.

We now turn to our novel formulation of the choice problem that the final goods producer faces. It is a discrete choice between \( \gamma^O \) and \( \gamma^I \), whereby \( \gamma^I > \gamma^O \). For a given location of sourcing, and normalizing \( c^h (W) = 1 \), the relevant comparison revolves around

\[
\Pi^O - \Pi^I = (Z^O - Z^I) \Theta - (F^O - F^I)
\]

\[
= z^O(\eta) \Theta - f^O
\]

The first line uses \( \Theta := \theta^{\alpha/(1-\alpha)} \), which is unambiguously increasing in the firm’s productivity \( \theta \). In the final line we have introduced \( z^O := Z^O - Z^I \) to denote the incentive advantage of outsourcing (advantage of integration if negative). From (3), we know that \( z^O \) depends on the headquarter intensity \( \eta \): \( z^O = z^O(\eta) \). Moreover, we have introduced \( f^O := F^O - F^I \) to denote the fixed cost disadvantage of outsourcing (disadvantage of integration if negative).
Vertical integration always seems more attractive than outsourcing on account of a higher revenue share accruing to the headquarter, However, in addition to the direct revenue share effect, there is an incentive effect, meaning that a higher $\gamma$ increases (lowers) the incentive for the headquarter (intermediate input supplier) to invest into input provision. The two bracketed terms in (2) capture the net effect on the headquarter’s expected profit. From what we have said above, it is relatively obvious that for a sufficiently large value of $\eta$, the incentive effect reinforces the revenue effect, in that $Z^I > Z^O$, or $z^O < 0$. Conversely for a sufficiently low headquarter intensity, where we have $z^O > 0$. By continuity, we may state that $z^O(\eta) < 0$, with a well defined borderline value $\eta^*$ defined by $z^O(\eta^*) = 0$. Throughout this paper, we interpret $\eta$ as a parameter which is industry-specific.

We now realize two things. First, the headquarter intensity determines whether or not outsourcing commands an incentive advantage over vertical integration. And secondly, this advantage gets “leveraged” by the firm’s productivity $\theta$. The falling line in the $f^O-\Theta$-space of figure 4 assumes a headquarter intensity $\eta_1 > \eta^*$, which means an incentive advantage of integration, and it separates $f^O-\Theta$-combinations (to the northeast) that lead to integration from those leading to outsourcing (to the southwest). The rising line does the same for a different headquarter intensity $\eta_0 > \eta^*$. Note that the line coincides with the horizontal if $\eta = \eta^*$. We use this representation instead of the familiar profit lines because it highlights the generality of the AH model in allowing for the incentive advantage to work in either direction.
Moreover, it allows for a continuous variation of the corresponding fixed cost disadvantage.\footnote{It is important to recognize that figure 4 and the subsequent figures never look at whether the maximum profit of a firm with a given productivity is indeed positive. We want to focus on the choice of sourcing strategy, and not on firm survival.}

We are now ready to investigate the sorting of firms into different organizational modes of sourcing. We call a case where all firms chose the same organizational form, independently of their productivity level, a \textit{single strategy equilibrium}. The following proposition exhausts all possible sorting equilibria:

**Proposition 1.** \textbf{A:} \textit{a)} A single strategy equilibrium with $\kappa = O$ arises, iff $z^O(\eta) < 0$ and $f^O > 0$. A single strategy equilibrium with $\kappa = I$ arises, iff $z^O(\eta) > 0$ and $f^O < 0$. \textit{b)} An equilibrium with positive productivity-based sorting of firms into $\kappa = O$ arises, iff $z^O(\eta) > 0$ and $f^O > 0$, and positive productivity-based sorting into $\kappa = I$ arises, iff $z^O(\eta) < 0$ and $f^O < 0$. This is conditional upon both sourcing strategies leading to positive profits for productivity levels above a certain threshold value.

The proposition immediately follows from figure 4, the upper half of which depicts a case with positive productivity-based sorting into integration for a headquarter intensity $\eta_0$ and a fixed cost disadvantage of integration equal to $f_0$, with a cut-off productivity level equal to $\Theta_0$.

The AH model assumes that headquarters are always located in the domestic economy, but may search for input suppliers in the domestic or the foreign economy. The usual assumption is that the foreign economy has a cost advantage on the intermediate input: $c^m(w^F)/c^m(w^D) < 1$. We use an index $\ell = D, F$ to indicate domestic and foreign sourcing, respectively. In view of our empirical focus on Spanish firms, it is important to note that in a multi-factor environment this cost advantage need not be one of cheap foreign low-killed labor, as it is often assumed.\footnote{Indeed, the cost advantage need not even be driven by factor prices at all. For instance, Grossman & Helpman (2005) develop a model with costly search where market thickness, as opposed to factor prices, is an important determinant of the costs of input provision in a given market, foreign or domestic. The AH model is general in this regard and does not depend on any specific determinant of international cost differences for the intermediate input.} By complete analogy to $z^O$, we now introduce $g^F_{\kappa} := Z^{F\kappa} - Z^{D\kappa}$ to measure the foreign location advantage (if positive) in the organizational form $\kappa$. Note that a foreign advantage on factor cost $c^m(\cdot)$ does imply $g^{FO} > 0$, but it does not necessarily gen-
erate a foreign sourcing advantage in case the supplier is vertically integrated. The reason is that the input-mix chosen in the production relationship is distorted by the hold-up problem. Recall that the ex post revenue share that accrues to the headquarter in the case of integration is determined by the institutional parameter $\delta$. Suppose that this parameter varies across sourcing locations, so that the term $\gamma^I$ becomes location-specific, meaning $\gamma^{FI} \neq \gamma^{DI}$. Then, considering an integration strategy, a factor cost advantage of the foreign economy may be partly eroded, and even be turned into a disadvantage, $g^{FK} < 0$, if $\gamma^{FI} < \gamma^{DI}$. Hence, given the aforementioned foreign factor cost advantage on $e^m(\cdot)$, we always have $Z^{FO} > Z^{DO}$, but the same is not true for a comparison between $Z^{FI}$ and $Z^{DI}$.

It seems plausible to introduce a differential fixed cost of operating the relationship also with respect to the location of sourcing, given the organizational form. We use $d^{FK} := F^{FK} - F^{DK}$ to denote the fixed cost disadvantage of the foreign location. Then, for a given organizational form $\kappa$, offshoring emerges iff

$$g^{FK}(\eta) \Theta > d^{FK}. \quad (5)$$

We may now envisage a proposition 1.B which is completely analogous to proposition 1 above, but now taking as given the location strategy and looking at productivity-based sorting into sourcing locations. The analogy is obvious enough; to save space we abstain from an explicit formulation.

2.2 Towards an empirical strategy for testing the hold-up model

Up to this point, we have looked at the location and organizational dimension of sourcing in isolation. In order to move towards an empirical strategy for testing this model, we must now bring these dimensions together. With each dimension allowing for four different sorting equilibria, we should expect a bewildering multiplicity of outcomes that severely complicates empirical tests. We now develop a 3-stage strategy, geared to our Spanish firm-level data, that allows us to come close to an empirical test of the model. In section 4 of the paper we then apply this empirical strategy to our data set.
In a nutshell, the strategy works as follows. The first stage employs non-parametric tests to compare productivity distributions of firms that pursue different organizational modes of sourcing, separately for each location. A perfectly analogous comparison is made for different locations, separately for each organizational mode. Assuming that the AH model is correct, stage 1 thus pin down which, if any, of the alternative cases of propositions 1.A and 1.B is relevant empirically. The second stage then combines the organizational and location dimensions of sourcing in a unified regression framework to estimate sourcing premia, similar to the exporter premia familiar from the literature; see Bernard & Jensen (1999). Accepting the stage 1 interpretation of our non-parametric results significantly reduces the number of possible sourcing patterns and, thus, the “permissible” patterns of sourcing premia. In this sense, the second stage regression analysis may be viewed as a validation check of stage 1.

Stages 1 and 2 interpret sourcing strategies observed at any point in time as equilibrium phenomena. The third stage allows for lagged adjustment and exploits the time variation of productivity levels and sourcing strategies. The key point here is that, given the results of stages 1 and 2, certain changes across time of a firm’s sourcing behavior may be rationalized as a lagged adjustment to an equilibrium strategy, while others may not. In a regression framework akin to stage 2, we therefore examine the degree to which the observed time pattern of sourcing is in line with “permissible adjustments”.

Bringing the sourcing dimensions together, we arrive at a decision problem which is summarized in table 1. In writing $z^{\ell O}$, the table introduces a location dimension also for the incentive advantage of outsourcing that we have analyzed above. Reading the table in a row-wise fashion, the criterion on $z^{\ell O}$ looks at the incentive implications from the hold-up problem, given a certain location $\ell = F$ or $\ell = D$. Reading it column-wise, the criterion $g^{F \kappa}$ requires that, for any given organizational form, the sourcing strategy must also make sense as a location decision. Figure 5 looks at the two decision margins in a more transparent way that allows us to highlight the driving forces behind the sorting equilibrium.

Figure 5 simplifies in assuming $f^{\ell O} = f^O$ for $\ell = D, F$, and similarly for the fixed cost disadvantage of offshoring: $d^{F \kappa} = d^F$ for $\kappa \in \{O, I\}$. More general cases will be discussed below. It has two panels (a) and (b) which we shall explain below. Within each panel, the
upper half of the figure depicts lines in $d^F$-$\Theta$-space where $d^F = g^{FO}(\eta_1)\Theta$ and $d^F = g^{FO}(\eta_1)\Theta$, respectively, assuming that there is a foreign location advantage on factor cost, but a fixed cost disadvantage of offshoring. This, of course, is only one of several cases, but we have chosen it here in anticipation of the empirical results that we shall report below on stage 1 of our empirical strategy. Given the positively sloped lines in the upper half of figure 5, points to the southeast of each line dictate offshoring, given the respective organizational form, and conversely for points to the northwest. Recall that - other things equal - the slopes of these lines are steeper with a lower headquarter elasticity $\eta$. The lines plotted must therefore be seen as corresponding to a certain value $\eta_1$.

### Decision criteria for global sourcing

<table>
<thead>
<tr>
<th>organizational form</th>
<th>outsourcing ($g^{FO}$)</th>
<th>vertical integration ($g^{FI}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>foreign sourcing ($z^{FO}$)</td>
<td>$g^{FO} &gt; d^{FO}, z^{FO} &gt; f^{FO}$</td>
<td>$g^{FI} &gt; d^{FI}, z^{FO} &lt; f^{FO}$</td>
</tr>
<tr>
<td>domestic sourcing ($z^{DO}$)</td>
<td>$g^{FO} &lt; d^{FO}, z^{DO} &gt; f^{DO}$</td>
<td>$g^{FI} &lt; d^{FI}, z^{DO} &lt; f^{DO}$</td>
</tr>
</tbody>
</table>

**Table 1.** The decision problem of global sourcing

The bottom half does the same for $f^O = z^{DO}(\eta_1)\Theta$ and $f^O = z^{FO}(\eta_1)\Theta$, assuming an incentive advantage of integration, i.e., $z^{IO}(\eta_1) < 0$. The central mechanism of the AH-model implies that $z^{IO}$ similarly depends on the headquarter intensity. Indeed, we know from the previous subsection that for this reason $z^{IO}$ is ambiguous in sign. In drawing downward-sloping lines in the bottom half, 5 thus assumes a specific elasticity $\eta_1 > \eta^*$, which is “sufficiently high” in leading to $z^{IO} < 0$. Again, this anticipates the empirical outcome that we obtain on the nonparametric tests, which suggest positive productivity-based sorting into $\kappa = I$. Note that this type of sorting also implies $d^O < 0$; see proposition 1.A. above. Given these negatively sloped lines in the bottom half of the figure, for points to the northeast of $z^{IO}(\eta_1)$ we have $z^{IO}(\eta_1) < f^O$, meaning that the incentive advantage of vertically integrating a supplier located in $\ell$ is strong enough to compensate for the fixed cost disadvantage of integrating this supplier, and conversely for points to the southwest.

17In other words, our stage 1 results indicate that, if the AH-model is correct, it cannot be true that $g^{FI} < 0$, which would be perfectly possible a priori; see proposition 1.B above.
It is obvious that, given $\eta_1$, steep slopes $g^{F\kappa}$ indicate a large foreign cost advantage on $c^m(\cdot)$. In a similar way it may be said that steep slopes $z^{IO}$ indicate a large incentive advantage of integration, i.e., a high value of $\gamma^{II} - \gamma^{IO} > 0$. Thus, the light-shaded cone spanned by the demarcation lines $g^{F\kappa}$ in the upper half of the figure and the lines $z^{IO}$ in the bottom half measures the strength of the foreign location advantage, driven by factor costs,

\footnote{There is a subtlety involved here in that an increase in the value of $\gamma^{II}$, given the value of $\gamma^{IO}$, need not increase the steepness of the lines $z^{IO}$. The reason is that $\gamma^{II}$ may already be above the first-best level where the pure revenue share effect and the incentive effect offset each other. In this case, a further increase of $\gamma^{II}$ will harm, not raise, the firm's profit.}

Figure 5. Input provision in the organization and location dimension
relative to the strength of the domestic integration advantage, driven by the hold-up problem in the production relationship and the bargaining shares determined by the institutional environment (strength of property rights). Notice that the measure of this cone is invariant to the headquarter intensity, since a rise in $\eta$ makes the $g$-lines steeper while at the same time making the $z$-lines flatter.

The dark-shaded cone in the upper half of figure 5, determined $g^{FO} - g^{FI}$ measures the strength of the foreign location advantage in an outsourcing relationship relative to a relationship with vertical integration. The mirror-image cone in the bottom half measures the strength of the integration advantage for domestic sourcing relative to offshoring. Obviously, these cones are not independent of each other. Indeed, it is straightforward to show that $g^{FI} (\eta) - g^{FO} (\eta) = z^{DO} (\eta) - z^{FO} (\eta)$, again independently of $\eta$. Except for a knife-edge case, both cones have non-zero measure. In the appendix, we explore the conditions responsible for whether $g^{FI} (\eta) - g^{FO} (\eta) < 0$, as depicted in both panels of figure 5, or the other way round. It will shortly become evident, however, that the equilibrium sorting pattern is independent on whether this detail.

We are now ready to determine the equilibrium pattern of sorting of firms into different organizational modes as well as locations of sourcing. We must first introduce three definitions. The dark-shaded cones represent what we now define as cones of indeterminacy:

**Definition 1.**

- **a) Cone of indeterminacy in location**: Points in $d^F$-$\Theta$-space where the optimal location of sourcing is not determined independently of the organizational mode.
- **b) Cone of indeterminacy in organizational form**: Points in $d^O$-$\Theta$-space where the optimal organizational mode of sourcing is not determined independently of the sourcing location.

Given what we have said above, the difference between panels (a) and (b) of figure 5 now becomes clear. Figure 5(a) depicts the case of a strong foreign cost advantage in the input $X^m$, combined with a weak incentive advantage of integration. Figure 5(b) reverses the relative strengths of the two types of advantage. The next definition brings in the fixed cost disadvantages that impinge on the the optimal sourcing strategy.

**Definition 2.** **Strong sourcing advantage**: Combinations of fixed cost disadvantages $d^F$ and $f^O$ where the two cones of indeterminacy in location and organizational mode, respectively,
have no overlapping ranges \([\Theta_0, \Theta_1]\) and \([\Theta_2, \Theta_3]\), respectively, in the productivity variable \(\Theta\).

Figure 5 depicts cases of a strong sourcing advantage: panel (a) has a strong location advantage, while panel (b) has a strong incentive advantage of integration, where these two cases are generally defined as follows.

**Definition 3.**

a) **Strong location advantage:** The interval \([\Theta_0, \Theta_1]\) lies in the cone of indeterminacy in location, and \([\Theta_2, \Theta_3]\) lies in the cone of indeterminacy in location, whereby \(\Theta_1 < \Theta_2\).

b) **Strong incentive advantage:** The interval \([\Theta_0, \Theta_1]\) lies in the cone of indeterminacy in organizational mode, whereas \([\Theta_2, \Theta_3]\) lies in the cone of indeterminacy in location, whereby \(\Theta_1 < \Theta_2\).

With a strong location advantage (figure 5(a)), foreign sourcing and integration are unambiguously dominating for productivity levels above an upper threshold value \(\Theta_3\), while for productivity levels below a lower threshold value \(\Theta_0\) domestic sourcing through independent parties becomes optimal. Firms with intermediate productivity levels rely on independent foreign suppliers. Notice that the lines \(z^{DO}\) and \(g^{FI}\) do not generate relevant cut-off points, given the fixed cost disadvantages depicted. In the figure, this is indicated by dashed instead of solid lines. In the opposite case (figure 5(b)), the intermediate range of productivities features firms that pursue domestic integration instead of foreign outsourcing.

Figures 5(a) and 5(b) both assume that \(g^{FO} (\eta) > g^{FI} (\eta)\), which implies \(z^{FO} (\eta) > z^{DO} (\eta)\).\(^{19}\)

We now briefly consider the opposite case where the foreign location advantage is stronger for integration than for an outsourcing relationship. In terms of figure 5, this simply requires relabeling the \(g\)- as well as the \(z\)-lines. The outcome for this case is relatively easy to see, hence we abstain from a separate diagram. Clearly, for productivity levels above \(\Theta_3\) in figure 5 integrating a foreign supplier is still the dominant strategy, both for a strong location and a strong incentive advantage. However, now \(\Theta_3\) no longer is a threshold value. Take the case of a strong location advantage, i.e., a relabeled version of figure 5(a). Crossing \(\Theta_3\) from

\(^{19}\)There is a minor intricacy involved here in that this case can only arise if the revenue shares for integration and outsourcing vary across sourcing locations. The reason is that, given the assumed foreign cost advantage in producing the input \(X^m\), equal shares would imply that \(z^{FO} > z^{DO}\). The intuition for this is that a lower unit cost of the final good, as implied by foreign sourcing is equivalent to a productivity increase of the firm.
above would make outsourcing a dominant domestic strategy ($z^{DO}$-line in bottom half of the figure), but at $\Theta_3$ domestic sourcing is still dominated by offshoring for any organizational mode ($g$-lines in upper half of the figure). Hence, $\Theta_3$ plays no role as a cut-off value. On the other hand, by the same token $\Theta_2$ now becomes a threshold level, as does $\Theta_1$, while $\Theta_0$ loses its role as a cut-off level. The case of a strong incentive advantage (analogue to figure 5(a)) follows the same line of argument.

Thus, two conclusions emerge regarding the change from $g^{FO} - g^{FI} > 0$ to the opposite sign. The first is a remarkable result: In qualitative terms, the equilibrium pattern of productivity-based sorting into different sourcing strategies is entirely determined by the relative strength of the location and the incentive advantage and by the corresponding fixed cost disadvantages, and it is not affected by whether the location advantage is stronger for one or the other organizational form of sourcing. The second is that it narrows the intermediate range of productivity levels where firms choose foreign outsourcing or domestic integration, respectively. The following proposition summarizes our results.

**Proposition 2.** Suppose we have case b) of proposition 1.A, with a case of strong sourcing advantage. Suppose, moreover that there is a uniform fixed cost disadvantage of location across organizational forms, and of integration across locations. Then, the following holds: a) Independently of whether the location advantage is stronger for one or the other organizational form of sourcing, firms with a productivity level above (below) a certain upper (lower) threshold value profit will pursue foreign integration (domestic outsourcing). b) If sourcing is driven by a strong location advantage (incentive advantage) then firms with a productivity between these threshold values choose independent foreign input suppliers (integration of domestic suppliers). c) The productivity ranges of domestic outsourcing and foreign integration are expanded at the expense of the intermediate range, if the location advantage is larger for integration than for outsourcing.

Remember that case b) of proposition 1 is supported by our non-parametric results. But what if sourcing is subject to no strong advantage, whether of the location-type or the incentive-type? There will then be an overlapping productivity range to the right of $\Theta_2$, where both the incentive and the location advantage seem ambiguous. However, except for the knife-
edge case where the two ambiguity ranges fully coincide, there will still be a non-overlapping range to the left of $\Theta_3$ which either favors domestic integration or foreign outsourcing, just as in the case of a strong advantage. We may speak of a weak location or incentive advantage, respectively. It is relatively straightforward to show that for this weakened case the sourcing pattern of proposition 2b is upheld.

Notice that in all cases considered so far we have encountered no more than three equilibrium sourcing strategies. To obtain an equilibrium sorting where each of the four strategies is dominating for a certain range of productivity values, we need to allow for the fixed cost disadvantages to be asymmetric, meaning that $d^{FO} \neq d^{FI}$ and $f^{FO} \neq f^{DO}$. Then, a situation may arise where moving below $\Theta_3$ makes foreign outsourcing a dominating strategy, as in the case of a strong location advantage, while moving above $\Theta_0$ makes domestic integration a dominating strategy, as in the case of a strong incentive advantage. In other words, we then have something like a combination of the two weak advantage versions. An unlimited range of productivity values will then have each of the four sourcing strategies appear as an equilibrium strategy for a certain sub-range of productivity values.

Arguably, stages 1 and 2 of our procedure involve relatively little true testing of the AH-model. Remember that stage 1 aims at identifying which of the possible sorting patterns of propositions 1.A and 1.B, respectively, seem empirically relevant. It does so by comparing non-parametric estimations of the productivity level distributions among firms pursuing a certain sourcing strategy. Of course, this stage involves no testing at all. Assuming that the model is true, however, the outcome of this stage allows us to focus on the case considered in figure 5 and to derive proposition 2. Our estimation of productivity premia on different sourcing strategies aims at something like a test of proposition 2. In principle, the estimated premia could violate those of proposition 2. Admittedly, however, the power of this test is very limited, since we rely on the same productivity data that we use in stage 1. Moreover, it still lacks empirical observation of key variables, such as headquarter intensity and the fixed cost rankings of sourcing strategies. Barring reliable empirical information on these variables, stage 3 is supposed to fill the void, to some extent at least, by exploiting the time-variation in our data.
In a nutshell, stage 3 runs as follows. Suppose that our estimated sourcing premia indicate that sourcing is subject to a weak (or even strong) location advantage, where intermediate productivity levels feature a strategy of foreign outsourcing. Now suppose we observe a large number of firms pursuing foreign outsourcing at time $t$ and some of them switching to foreign integration at some time $t+i$ in the near future. Assuming lagged adjustment of sourcing strategies, we should then be able to establish a sourcing premium of these switching firms at time $t$, or more generally at some point $t − j$ in the recent past, over the “stayer-firms”, i.e., those which retain foreign outsourcing also at time $t$. A similar dynamic pattern can be established for other types of advantage identified in proposition 2. Failure to establish such patterns in the time variation of our data would clearly speak against the model. In this sense stage 3 adds an important element of testing to our empirical strategy.

3 Micro-level data on sourcing and productivity

In this section, we provide a short description of the firm-level survey data we employ in our empirical analysis, and briefly describe our algorithm for estimating total factor productivity at the level of the firm. More detailed information on the data along with a stylized picture of sourcing heterogeneity among Spanish manufacturing firms can be found in Kohler & Smolka (2011b).

3.1 Data description

The data come from the “Encuesta Sobre Estrategias Empresariales” (ESEE)\textsuperscript{20}, an annual survey of Spanish manufacturing firms carried out by the SEPI Foundation, Madrid.\textsuperscript{21} They consist of an unbalanced panel of some 4,600 legal entities with information on firms’ strategic behaviors, as well as revenue and balance sheet statistics, covering the years 2000-2009. The SEPI Foundation collects the data by means of a complex random sampling procedure, sending

\textsuperscript{20}“Survey on Business Strategies”.\
\textsuperscript{21}“Sociedad Estatal de Participaciones Industriales”. The SEPI Foundation promotes research and study opportunities in Spain. For more information, see http://www.funep.es.
out survey questionnaires\textsuperscript{22} to all firms with more than 200 employees and to only a subset of firms with a number of employees between 10 and 200. This subset is selected according to a stratified sampling scheme, in which each combination of a single industry (out of a total of 20 industries at NACE-09 classification)\textsuperscript{23} and a single size group (out of four size groups)\textsuperscript{24} is fixed as a distinct and independent stratum in advance, giving rise to a total of 80 strata. Note that, given the way of sampling, we can establish representativeness of the data for different industries (at distinct points in time) and the manufacturing sector at large. Importantly, the SEPI Foundation preserves these highly desirable sample properties over time by controlling for the dynamics in the panel which result from firms exiting and entering markets.\textsuperscript{25} In both the descriptive data exploration and the econometric analysis to come, we always use the sampling information in order to obtain consistent and efficient estimates and statistics, and to draw inferences about all firms in the Spanish manufacturing industry as a whole.\textsuperscript{26}

A key advantage of the Spanish survey data is that from 2006 onwards they allow to explore both the location and the incentive advantage dimension of firms' global sourcing decisions. To this end, we refer to firms’ answers to the following questions in the questionnaire:\textsuperscript{27}

- \textit{Of the total amount of purchases of goods and services that you incorporate (transform) in the production process, indicate — according to the type of supplier — the percentage which these represent in the total amount of purchases of your firm in [year].}

  (a) \textit{Spanish suppliers which belong to your group of companies or which participate in

\begin{footnotesize}
\begin{itemize}
\item The SEPI Foundation uses an extended questionnaire every four years and a reduced annual questionnaire for the years in between.
\item See table A.1 in the appendix for a comprehensive list of industries.
\item Size groups are (i) between 10 and 20 employees, (ii) between 21 and 50 employees, (iii) between 51 and 100 employees, and (iv) between 101 and 200 employees.
\item For more information about this procedure, see http://www.funep.es/esee/en/einfo_que_es.asp.
\item Specifically, we weight each observation by the inverse of its probability of being sampled, using size-group-specific information on the total number of firms in a given NACE-09 industry (provided by the Social Security Directorate through the SEPI Foundation) and the representation of each size group in the sample. Moreover, we incorporate the strata definitions into STATA with the help of the \texttt{svyset} command, thereby taking advantage of potential gains in efficiency.
\item The original survey questions are given in Spanish. The original questionnaires corresponding to each survey year are downloadable at http://www.funep.es/esee/sp/svariables/indice.asp.
\end{itemize}
\end{footnotesize}
your firm’s joint capital. [yes/no] / [if yes, then percentage rate]

(b) Other suppliers located in Spain. [yes/no]/[if yes, then percentage rate]

• For the year [year], indicate whether you imported goods and services that you incorporate (transform) in the production process, and the percentage which these imports – according to the type of supplier – represent in the total value of your imports. [yes/no]

(a) From suppliers which belong to your group of companies and/or from foreign firms which participate in your firm’s joint capital. [yes/no]/[if yes, then percentage rate]

(b) From other foreign firms. [yes/no]/[if yes, then percentage rate]

Since the survey also includes information on the total amount of purchases as well as the total value of imports for each observation, we can compute for each firm in each of the years 2006, 2007, 2008, and 2009 whether or not (and the extent to which) it has acquired intermediate inputs from a related and, separately, from an unrelated party, both in the home and in a foreign economy. Note that the framing of the above questions requires any input supplier to constitute a different legal entity (either related or unrelated to the firm), and any input to have been incorporated (transformed) in the production process. This nicely fits into the AH modeling setup. In what follows, we thus distinguish among four sourcing options: foreign integration (henceforth FI), foreign outsourcing (FO), domestic integration (DI), and domestic outsourcing (DO). Clearly, the simultaneous and coherent coverage of all sourcing modes generates a much more comprehensive picture of firms’ global sourcing behaviors than was the case with earlier studies. A drawback, however, is that the sourcing information do not refer to well-identified transactions of firms. This means that we cannot trace a firm’s acquisition of a certain input at a specific point in time back to a particular sourcing mode. Put differently, what we observe are the pure extensive and intensive margins of firms (with a potentially large number of different products, inputs, and/or sourcing markets), not of product-country-firm combinations or the like.

A pivotal variable in our analysis is a firm’s relative productivity level in a given industry. Antràs & Helpman (2004) incorporate Hicks-neutral differences in productivity across firms in their model, which ultimately determine a headquarter’s specific sourcing choice, given
industry characteristics. It is now well-known that firm-level estimates of total factor productivity (TFP) are often plagued by biases originating in endogenous selections into markets, simultaneous choices of input factors, omitted firms’ input and output prices, and endogenous product mixes. Taking advantage of several unique features of our data, we apply an extended Olley & Pakes (1996) estimation algorithm and provide consistent estimates of total factor productivity as a firm-specific, time-variant phenomenon.

3.2 Estimating total factor productivity

In this subsection, we first sketch firms’ behaviors in monopolistically competitive markets and a dynamic industry environment, deliberately gearing the setting towards our estimates of total factor productivity to come. In particular, we adapt the Olley & Pakes (1996) behavioral framework in that we explicitly allow firms’ global sourcing decisions to have an impact on firms’ market exit and investment decisions. In so doing, we presume that having access to different sourcing locations potentially alters a firm’s basic economic environment in which it maximizes profits. In a second step, we then fully exploit the richness of our data to provide consistent estimates of total factor productivity at the level of the firm. For this purpose, we incorporate the sourcing decisions of firms into the estimation algorithm. As will become evident later, this procedure pays attention to the fact that having access to foreign sourcing markets (with underlying primitives different from the ones prevailing in the domestic economy) has an influence on how firms adjust investments to productivity shocks and the existing capital stock of the firm. Our approach is motivated by and akin to Van Biesebroeck (2005) and De Loecker (2007) who both control for the export status in the Olley & Pakes (1996) algorithm.

Behavioral framework. In general terms, we let firms behave as in the dynamic industry setting described in Olley & Pakes (1996). Specifically, we let profits of a headquarter firm $i$ in a given industry $j$ at time $t$ be a function of (i) firm-specific state variables capital $K_{it}$ and relative productivity $\omega_{it}$, (ii) industry-specific state variables and parameters, and (iii) firm-specific non-fixed inputs, labor $L_{it}$ and intermediates $X_{it}^m$. 

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As regards firm-specific state variables, the firm’s capital accumulation happens to follow

\[ K_{it+1} = i_{it} + (1 - \delta_{it}) K_{it} \]  

(6)

where \( \delta_{it} K_{it} \) is depreciation and \( i_{it} \) investment. Firm productivity evolves over time according to an exogenously given Markov process and is assumed to be observed by the final good producer.

Industry-specific state variables and parameters include the structures in the selling markets, factor prices, and all other relevant industry characteristics such as fixed production costs, fixed sourcing costs, and the headquarter intensity of production. Factor prices \( w_t = (w^D_t, w^F_t) \) evolve as two exogenously given, independent first-order Markov processes, where the superscripts \( D \) and \( F \) indicate the domestic and the foreign economy, respectively.

At the beginning of each period, a headquarter gains knowledge about its productivity level and takes two decisions. It first decides on whether or not to stay in the market and produce final goods. If it stops producing, it receives an outside option and disappears. If it continues producing, it places a capital investment \( i_{it} \), employs labor, and acquires intermediates. To make progress, we assume the existence of a Markov perfect Nash equilibrium, which is the outcome of all headquarters maximizing their expected discounted values of net cash flows in future periods. A headquarter’s decision about market exit and capital investment depends on expected distributions of the selling market structure and factor prices, given the current set of information. Both the profit and the value function in the Markov perfect Nash equilibrium depend on all industry characteristics. Generally speaking, all firms are operating in the same industry environment. However, and contrary to Olley & Pakes (1996), we argue that firms have access to different sourcing markets upon using different sourcing modes. Thus, firms with different sourcing strategies face different sourcing market structures with different factor prices, which, in turn, has important repercussions on their decisions regarding market exit and investment.

More specifically, the Markov perfect Nash equilibrium determines the headquarter’s exit rule. For a sufficiently high productivity \( \omega_{it} \geq \omega_{jt} (K_{it}) \) the firm will stay in the market and shut down production otherwise. In a similar vein, the equilibrium generates an investment
policy function according to which firms invest depending on their productivities and their capital stocks, provided they do not leave the market.

\[ i_{it} = i_{it}^\phi(\omega_{it}, K_{it}) \]  

Both decision rules reflect all industry characteristics such as market structures, factor prices, fixed costs, and headquarter intensity. As a consequence, the policy functions are in principle identical across headquarters in a given industry at a specific point in time. Crucially, however, the investment rule further depends on a firm’s sourcing mode \( \phi \in \Phi = \{FI, FO, DI, DO\} \), which is why the function carries a superscript indicating the firm’s sourcing channel. The fundamental reason behind this sourcing-dependent investment policy function is that firms operate in different sourcing markets, thereby exploiting cross-country factor price differentials. Moreover, this behavior results in further differences in the process of capital accumulation which translate into differences in the productivity cut-off levels. This, in turn, has an impact on headquarters’ market exit decisions.

**Estimation algorithm.** Tying in with the set up of the AH model and our behavioral framework, we assume that in each industry \( j \) headquarter firms produce differentiated final goods according to the following production function.

\[ Y_{it} = \Theta_{it} \left( \frac{X_{it}^h}{\eta} \right)^{\eta} \left( \frac{X_{it}^m}{1 - \eta} \right)^{1 - \eta} \]  

where each final-good producer employs capital and labor to manufacture the headquarter input \( X_{it}^h = K_{it}^\alpha L_{it}^\beta \). Log-linearizing the production function and substituting \( X_{it}^h \), we get the following estimable equation

\[ y_{it} = c + \eta \alpha k_{it} + \eta \beta l_{it} + (1 - \eta) x_{it}^m + \tilde{\eta} + \omega_{it} + \epsilon_{it} \]  

where \( \theta_{it} = c + \omega_{it} \) is the natural log of productivity of firm \( i \) at time \( t \), \( \tilde{\eta} = (\eta - 1) \ln(1 - \eta) - \eta \ln(\eta) \), and \( \epsilon_{it} \) is an iid error term capturing unobservable stochastic shocks or measurement errors. \( y_{it} \) is the natural log of real production, \( x_{it}^m \) is the natural log of purchased inputs, \( k_{it} \) is the natural log of capital, \( l_{it} \) is the natural log of labor, \( \omega_{it} \) is the firm-specific
deviation from the average productivity level $c$ of industry $j$ over the entire time horizon, and $(c + \tilde{\eta}, \eta\alpha, \eta\beta, 1 - \eta)$ is a vector of parameters to estimate (allowed to vary across industries). Our main interest lies in (i) computing the unobserved total factor productivity level for each firm and (ii) recovering the output elasticity with respect to the headquarter input from consistent estimates of the above equation. The production function is, however, not ready for estimation. The reason has to do with endogeneity of input choices (transmission/simultaneity bias) and self-selection of firms into markets (selection bias); see Olley & Pakes (1996). Denoting the inverse of the investment policy function derived from the Markov perfect Nash equilibrium as $\psi_t(i_t, k_t)$, we can restate the above equation as

$$y_{it} = c + \lambda_t^{\phi_{it}}(i_{it}, k_{it}) + \eta\beta l_{it} + (1 - \eta)x_{it}^m + \tilde{\eta} + \epsilon_{it}. \quad (10)$$

The polynomial $\lambda_t^{\phi_{it}}(i_{it}, k_{it}) = \eta\alpha k_{it} + \psi_t^{\phi_{it}}(i_{it}, k_{it})$ depends only on observables, $\phi_{it}, i_{it},$ and $k_{it}$. Importantly, and contrary to Olley & Pakes (1996), it now depends, as the investment rule, on the firm’s sourcing mode. The modified equation constitutes the estimation algorithm’s first step, in which we can only identify the coefficients of the non-fixed inputs, labor and intermediates, but not that of the state variable, capital. The reason is that capital is needed both as a production factor and as part of the inverted investment rule. An immediate implication is that we can also not identify the coefficient on the sourcing mode since it enters the equation separately and interacted with all terms of the polynomial. We thus have to estimate a firm’s survival probability in a second stage and then, using these estimates, recover the coefficients for both capital and the sourcing mode in a third stage. The second stage probit model estimates

$$Pr[X_{it+1} | J_t] = Pr[\omega_{it+1} \geq \omega_{it+1}(k_{it+1}, \psi_t^{\phi_{it}}(i_{it}, k_{it}))] = Pr_t^{\phi_{it}}[i_{it}, k_{it}] \quad (11)$$

where $J_t$ is the information available at time $t$. We can write the survival probability as a sourcing-dependent function of $i_{it}$ and $k_{it}$. The idea is that the sourcing mode $(i)$ has a permanent influence on the capital accumulation process through investment, thus shifting

---

28For notational convenience, we have dropped the industry index.
the productivity threshold, and (ii) affects $\psi_{it}^\phi (i_t, k_{it})$, with which we proxy the productivity shock $\omega_{it}$. Furthermore, next period’s capital stock can be calculated from this period’s capital stock and investment.

For the purpose of recovering the capital coefficient as well as the sourcing mode coefficient, we have to consider the expectation of $y_{it+1} - \eta \beta l_{it+1} - (1 - \eta) x_{it+1}^m$ conditional on information available at $t$ and on that the firm does not shut down production. The third stage thus uses

$$E[y_{it+1} - \eta \beta l_{it+1} - (1 - \eta) x_{it+1}^m | J_t, \omega_{it+1} \geq \omega_{it+1}] = c + \tilde{\eta} + \eta \alpha k_{it+1} + g(\omega_{it+1}, \omega_{it})$$ (12)

which can be rewritten as the following estimable equation, given that certain technical conditions are met: ²⁹

$$y_{it+1} - \tilde{\eta} \beta l_{it+1} - (1 - \eta) x_{it+1}^m = c + \tilde{\eta} + \eta \alpha k_{it+1} + g(\lambda_{it}^\phi_{it} - \eta \alpha k_{it}, \hat{x}_{it+1}^\phi_{it}) + v_{it+1}$$ (13)

where $v_{it+1}$ is the error term and the superscripts indicate that, again, the firms’ sourcing decisions are controlled for. Applying non-linear least squares to this last equation, we are left with consistent estimates of $\eta \alpha$ from this last stage and $\eta \beta$ and $(1 - \eta)$ from the first stage, controlling for simultaneity and selection and accounting for firms’ sourcing decisions. ³⁰

**Data for TFP estimation.** We feed the estimation algorithm with the ESEE firm-level data from 2000-2009, using year-specific information on each firm’s real value of production, real purchases, real investment, real capital stock, labor employment, import status, and exit decisions.

The **real value of production** is defined as production plus other operating income expressed in terms of year 2000 prices. For deflation of production and other operating income, we combine information on firm-level variations in goods prices from the ESEE and an industry-level price index from the National Statistics Institute (INE) in Spain for years in which firms are not sampled. The computation of firm-specific goods price indexes is important for three reasons. First, if firms have some market power (due to, for example, product differentiation)

²⁹For these and other technical details, see Olley & Pakes (1996).

³⁰We manipulate the existing STATA command `opreg` for our purposes.
and firm mark-ups behave differently over time, then the use of industry price indexes is likely
to result in a correlation between the input choices and the error term. Second, if unobserved
demand shocks drive firm prices up or down, then this will lead to inconsistent estimates
whenever we do not consider firm-specific price variations; see Klette and Griliches (1996)
and De Loeker (2007). Third, if firms within the same industry (for example exporters and
non-exporters) face different selling market structures, then, again, deflation of output based
on an industry-level price index biases the estimates; see De Loeker (2007). Real purchases
are the costs of total purchases and the costs of external services, deflated by industry-specific
price indexes (INE).

Real investment is the value of investment (in Euros) in real estate, constructions, and
equipment, deflated with an industry-price index from the INE. The real capital stock is the
observed value (in Euros) of real estate, constructions, and equipment, net of depreciation, and
deflated with an industry-price index from the INE. Labor employment enters the production
function estimates as effectively worked hours, which reduces the probability of non-stochastic
measurement errors. The import status controls for a firm’s sourcing location (foreign sourcing
versus domestic sourcing). This is the only relevant information on firms’ sourcing behaviors
which is available to us for the entire time span from 2000-2009. Note that we cannot control
for different sourcing countries since we do not have information on import origins other than
that of world regions in 2002 and 2006. Exit decisions are well documented in the Spanish
data such that we can differentiate between firms shutting down production and firms staying
in the market but ceasing to belong to the set of sampled firms.

4 Empirical analysis

As we have detailed in the theoretical section, the AH model suggests that firms which face a
hold-up problem in sourcing select themselves into different sourcing strategies, depending on
their productivity levels and certain structural characteristics of the underlying production
relationship. In this section, we want to examine whether our data lend empirical support
for a productivity ranking that can be rationalized as an AH data generating process. Our
analysis proceeds in three steps. First, we apply a non-parametric test based on the principle
of first order stochastic dominance, in order to compare empirical cumulative productivity distributions for certain groups of firms that differ in their sourcing behaviors. To be more precise, we test for dominance between two groups of firms that choose different organizational forms, viz. outsourcing and vertical integration. We do so separately for domestic sourcing and for offshoring. We also test for stochastic dominance between two groups of firms that differ in terms of their sourcing locations (domestic or offshore), given the organizational form. The purpose of this stage is to pin down which of the various types of productivity-based sorting patterns identified in our propositions 1A and 1B is relevant empirically.

In the second step, we adopt the Bernard & Jensen (1999) methodology, which has seen extensive use in estimating productivity- and size-premia of exporting relative to non-exporting firms. We modify this approach so that it allows for an estimation of productivity-premia for firms engaging in different sourcing modes. We look at all sourcing modes in a unified econometric framework. Assuming that the AH model of sourcing is correct, the outcome of stage 1 restricts permissible patterns of sourcing premia in stage 2. Moreover, the outcome of stage 2 tells us about which of the combinations of sourcing advantages highlighted in proposition 2 is empirically relevant.

Finally, in stage 3, we exploit the time variation in our data by examining the firms that exhibit a change in their sourcing strategies relative to those who do not. Given the outcomes of stages 1 and 2 of our strategy, and assuming lagged adjustment in the AH hold-up model, we can pin down permissible patterns of adjustment in the sense of switching between alternative sourcing strategies. More specifically, by comparing productivity levels of “switching firms” to those of “stayers” we are able to see if the dynamic adjustment of firms’ sourcing behavior may be rationalized as the outcome of the AH hold-up model, enriched by lagged adjustment.

Our empirical analysis is related to a number of empirical papers that have investigated firms’ sourcing behavior in an international context. Tomiura (2007) finds a positive relationship between foreign sourcing and productivity levels of Japanese firms. However, the analysis is not placed in the context of an empirical test of any sourcing model. Defever & Toubal (2007) aim at a test of the AH model of global sourcing in that they explore the role of firm-level productivity level as an explanatory factor of French firms’ organizational form.
of offshoring. They do find support for the model, but due to data limitations they cannot address domestic sourcing. Nunn & Trefler (2008) look at US “related-party” trade to see if the share of intra-firm trade is related to industry and product characteristics as suggested by Antràs & Helpman (2004, 2008). They do find empirical support of the model, but their data do not allow them to test the model in the firm-level productivity dimension that we focus on here. Using Spanish firm-level data for 1990-2002, Fariñas & Martín-Marcos (2010) use non-parametric tests on productivity distributions to find that offshoring firms are significantly more productive than firms sourcing domestically. However, they do not address the organizational mode of sourcing which is at the core of our analysis. Federico (2010) estimates sourcing premia comparable to stage 2 of our approach. He also finds similar results, but does not place the analysis in a comparable framework of testing the AH model. In Kohler & Smolka (2011b), we similarly estimate sourcing premia comparable to stage 2 of this paper, but we place the analysis in a somewhat broader context that extends beyond the hold-up problem highlighted by the AH model.

4.1 Applying a non-parametric test

In this subsection we employ a non-parametric approach to investigate whether or not we can establish a systematic link between productivities of firms and their sourcing behaviors. For this purpose, we form groups of firms in two independent steps. The first distinguishes between integrating and outsourcing firms, separately for domestic and for foreign sourcing. The second step draws lines between offshoring and non-offshoring firms, conditional on the choice of organizational form. In each case, we assign firms to one of two sourcing categories, depending on their reported sourcing modes. Given the fact that complex sourcing strategies are a prevalent phenomenon in our data, we establish an ex-ante hierarchy in terms of sourcing categories. In light of the distribution of sourcing modes across firms, the natural choice for this hierarchy is to say that firms are (i) DO firms if they outsource (but do not integrate) domestically and DI firms whenever they acquire some inputs from a vertically integrated domestic supplier, (ii) FO firms if they outsource (but do not integrate) internationally and FI firms whenever they import some inputs from a vertically integrated foreign supplier, (iii) non-offshore integrating firms if they integrate domestically (but not internationally) and
offshore integrating firms whenever they acquire some inputs through vertical FDI, and (iv) non-offshore outsourcing firms if they outsource domestically (but not internationally) and offshore outsourcing firms if they purchase some inputs from foreign independent suppliers.\footnote{Firms which do not report any sourcing are classified as DI firms, given that they pursue a “deep” vertical integration strategy at home. All qualitative results reported in this paper are insensitive to excluding such firms from the sample.}

In each step, the splitting up of firms into two sourcing categories allows us to compute the empirical cumulative distribution functions for our measure of total factor productivity for both sourcing groups. Suppose we compare two cumulative distribution functions $F(z)$ and $G(z)$, each of which represents the productivity distribution of one sourcing mode. We say that $F(z)$ stochastically dominates $G(z)$ at first order, if $F(z) - G(z) \leq 0 \ \forall \ z \in \mathbb{R}$ and $\exists \ z \in \mathbb{R}$ with $F(z) - G(z) < 0$. Computing the distribution free Kolmogorov-Smirnov test statistic (K-S test), we can then conclude 1. whether or not the two groups share the same underlying productivity distribution (two-sided test) and 2. whether or not the distribution of one group dominates that of the other group (one-sided test). Formally, we test the following hypotheses.

1. The two-sided test we are interested in is whether

$$H_0 : F(z) - G(z) = 0 \ \forall \ z \in \mathbb{R} \ against \ H_1 : \exists \ z \in \mathbb{R} \ with \ F(z) - G(z) \neq 0$$

can be rejected.

2. The one-sided test is to see if it is true that

$$H_0 : F(z) - G(z) \leq 0 \ \forall \ z \in \mathbb{R} \ against \ H_1 : \exists \ z \in \mathbb{R} \ with \ F(z) - G(z) > 0$$

cannot be rejected.

The K-S test uses the maximum vertical distance between the curves of two cumulative distribution functions as the statistic $D$, which makes it a particularly robust and useful test whenever the true distributions are unknown. Since the K-S testing procedure assumes
independence across observations, we implement it separately for the years 2006, 2007, 2008, and 2009. Table 2 reports the 2009 results of the K-S test, which we apply separately to small and large firms. Looking at small firms, we find statistically significant productivity differentials between outsourcing and integrating firms, irrespective of whether the input source is domestic or offshore; see the two upper left panels in table 2. In particular, the null hypothesis of the two-sided test under which the samples are drawn from the same underlying productivity distribution is rejected in all cases. Furthermore, we can never reject the null hypothesis of the one-sided test which evaluates whether integration dominates outsourcing. By way of contrast, we always have to reject the null hypothesis when performing the one-sided test with sourcing group categories reversed. Similar observations can be made by testing for productivity differentials between offshoring and non-offshoring firms, at least if we condition on outsourcing as opposed to integrating firms; see the two lower left panels.

If we restrict our attention to large firms, we see no clear-cut evidence in favor or against the one or the other organization/location, however. We are therefore worried about the possibility that the results we obtain for small firms might not generalize to the Spanish manufacturing industry as a whole. To investigate this issue, we repeat the testing procedure for the entire sample (including large and small firms simultaneously) and obtain results which are virtually identical to those of small firms. Since the small-size firms are underrepresented in our sample, we argue that our findings can be generalized without any further concerns.

Table 2. Kolmogorov-Smirnov Testing Procedure with Total Factor Productivity (2009)†

<table>
<thead>
<tr>
<th></th>
<th>Small firms</th>
<th></th>
<th>Large firms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum Vertical Distance</td>
<td>P-Value</td>
<td>Maximum Vertical Distance</td>
<td>P-Value</td>
</tr>
<tr>
<td><strong>DO&gt;DI</strong></td>
<td>0.2546</td>
<td>0.000</td>
<td>0.0833</td>
<td>0.280</td>
</tr>
<tr>
<td><strong>DI&gt;DO</strong></td>
<td>-0.0024</td>
<td>0.999</td>
<td>-0.0251</td>
<td>0.891</td>
</tr>
<tr>
<td>Two-Sided Test</td>
<td>0.2546</td>
<td>0.000</td>
<td>0.0833</td>
<td>0.498</td>
</tr>
<tr>
<td><strong>FO&gt;FI</strong></td>
<td>0.1821</td>
<td>0.024</td>
<td>0.0394</td>
<td>0.798</td>
</tr>
<tr>
<td><strong>FI&gt;FO</strong></td>
<td>-0.0224</td>
<td>0.945</td>
<td>-0.0597</td>
<td>0.596</td>
</tr>
<tr>
<td>Two-Sided Test</td>
<td>0.1821</td>
<td>0.033</td>
<td>0.0597</td>
<td>0.944</td>
</tr>
<tr>
<td><strong>DO&gt;FO</strong></td>
<td>0.1622</td>
<td>0.000</td>
<td>0.0080</td>
<td>0.990</td>
</tr>
<tr>
<td><strong>FO&gt;DO</strong></td>
<td>-0.0036</td>
<td>0.992</td>
<td>-0.1472</td>
<td>0.030</td>
</tr>
<tr>
<td>Two-Sided Test</td>
<td>0.1622</td>
<td>0.000</td>
<td>0.1472</td>
<td>0.045</td>
</tr>
<tr>
<td><strong>DI&gt;FI</strong></td>
<td>0.0783</td>
<td>0.606</td>
<td>0.0185</td>
<td>0.962</td>
</tr>
<tr>
<td><strong>FI&gt;DI</strong></td>
<td>-0.0650</td>
<td>0.708</td>
<td>-0.1162</td>
<td>0.218</td>
</tr>
<tr>
<td>Two-Sided Test</td>
<td>0.0783</td>
<td>0.947</td>
<td>0.1162</td>
<td>0.372</td>
</tr>
</tbody>
</table>

† Column one gives the null hypotheses to be tested. ‘Two-Sided Test’ stands for the null hypothesis that the two considered samples come from the same distribution. Columns two and four provide the maximum vertical distance between the two cumulative distribution functions.
In order to obtain a smooth graphical illustration of the distributions of total factor productivity for firms in different sourcing categories, we compute the probability density functions of the TFP index by means of kernel density estimation. We apply the same rule for assigning firms to sourcing groups as before. With the purpose of obtaining density functions that represent the distribution of TFP in the Spanish manufacturing industry at large, we first estimate densities for small and large firms separately and then calculate a weighted average of these estimates. The weights reflect for each sourcing group a firm’s probability of being a small or a large firm in that they consider both the sampling proportions of small and large firms in the ESEE data and the numbers of sampled firms in the two size groups belonging to the specific sourcing group. Formally, the estimated probability density function for, say, FI firms in Spanish manufacturing reads as

\[
f_{FI}(.|s) = \Pr(s = 0) \times f_{FI}(.)|s = 0) + \Pr(s = 1) \times f_{FI}(.)|s = 1)
\]

where \(s\) is a size group indicator and the \(f_{FI}\)’s on the right-hand side are the size group-specific Kernel density estimates.\(^{32}\)

Figures 6 and 7 display the estimated probability density functions for 2009. Each of the four panels depicts two functions, each representing a distinct sourcing strategy, as indicated in the legend. Figure 6 nicely illustrate that integrating firms draw their productivities from distributions different from those of outsourcing firms, independently of the sourcing location. From visual inspection we see reduced density estimates for integrating firms in the lower productivity ranges, but increased estimates in the higher productivity ranges, compared to densities for outsourcing firms. Figure 7 distinguishes between offshoring and non-offshoring firms, separately for vertical integration (left-hand figure) and outsourcing (right-hand figure). As suggested by the K-S testing procedure, the density of offshore outsourcing firms is strictly

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\(^{32}\)To give an example, we obtain the (estimated) probability of being a small (large) firm for an FI firm in 2009 by considering the sampling proportions of large and small firms (43 percent and 3.4 percent, respectively) and the numbers of FI firms among large firms and small firms in the sample (135 and 79, respectively). By multiplying these absolute numbers of firms by the inverses of the probabilities of being sampled of the two size categories, we can calculate the correct proportions of large and small FI firms in the Spanish manufacturing industry as a whole. Then, we get the (estimated) probability of being small for a randomly selected FI firm as \(\hat{P}(s = 0) = 0.881\) and of being large as \(\hat{P}(s = 1) = 0.119\).
Figure 6. Kernel Density Estimates for TFP levels — Exploring the Incentive Advantage

Figure 7. Kernel Density Estimates for TFP levels — Exploring the Location Advantage
lower than that of domestic outsourcing firms below a certain threshold level of productivity, and strictly higher above that threshold level.

We draw two main conclusions from this first stage of our empirical analysis. First, there are significant productivity differentials between firms that choose a strategy of vertical integration and those that go for outsourcing. The productivity distribution for the first group of firms features clear stochastic dominance over the second. Notably, this statement holds true for both the domestic and the foreign sourcing markets. Importantly, the AH model rationalizes this finding as an equilibrium outcome, provided that (i) fixed costs are higher under integration than under outsourcing both, at home and abroad, and (ii) there is an incentive advantage of integration over outsourcing, which requires the output elasticity with respect to the headquarter input to be sufficiently high. Second, as regards the location choice of intermediate input production, we find evidence in favor of the idea that offshoring firms feature a higher productivity than domestic sourcing firms. This points towards a location advantage for the foreign economy, and higher fixed costs for foreign as opposed to domestic sourcing.

4.2 Estimating sourcing premia

In this subsection we estimate productivity premia for firms in different sourcing groups, using a regression framework akin to that introduced by Bernard & Jensen (1999). Generally speaking, we regress a firm’s total factor productivity level, estimated as described in the previous section, on binary variables that indicate a firm’s specific sourcing strategy. In the AH model, firms face a quaternary choice of intermediate input production where the unique profit-maximizing strategy is either foreign integration (FI), or foreign outsourcing (FO), or domestic integration (DI), or domestic outsourcing (DO). From our considerations in the theory section and the results of our non-parametric testing procedure, we expect this regression exercise to put foreign integration firms at the top and domestic outsourcing firms at the bottom of the productivity ranking of firms. Given the existence of complex sourcing strategies in the data, we put a hierarchical and mutually exclusive structure on sourcing modes. A natural choice for this structure is dictated by the relative frequencies of
sourcing strategies in the data, from which we hypothesize a fixed cost ranking that satisfies $f^{DO} < f^{FO} < f^{DI} < f^{FI}$. We then assign a given firm to the category which is associated with the highest hypothesized fixed cost whenever it sources inputs through two or more sourcing channels simultaneously.\footnote{For an analysis of sourcing premia with non-hierarchical, mutually inclusive sourcing dummies, see Kohler & Smolka (2011b).}

Formally, we estimate the following model, pooling the data and applying ordinary least squares (OLS).

$$
\theta_{it} = \beta_0 + \beta_1 FI_{it} + \beta_2 FO_{it} + \beta_3 DI_{it} + \\
+ \beta_4 Age_{it} + \beta_5 Export_{it} + \beta_6 (K/L)_{it} + \beta_7 (H/L)_{it} + \beta_8 (R&D/Sales)_{it} + \gamma_t + \mu_{it},
$$

where $\theta_{it}$ is firm $i$’s productivity level at time $t$, $FI_{it}$, $FO_{it}$, $DI_{it}$ are mutually exclusive sourcing dummies as explained above, $Age_{it}$ is the age of the firm, $Export_{it}$ is a dummy variable that controls for a firm’s exporter status, $(K/L)_{it}$ and $(H/L)_{it}$ are, respectively, a firm’s capital and skill intensity, $(R&D/Sales)_{it}$ is a firm’s technological effort, measured through the ratio of expenditure on research and development activities over total firm sales, $\gamma_t$ is a year fixed effect, and $\mu_{it}$ is the error term. As opposed to the non-parametric tests in the previous subsection, our regression framework thus allows us to compute average productivity differentials among firms in different sourcing modes, conditional on other firm characteristics. This seems important, given that the literature has documented a large degree of cross-firm heterogeneity in a number of relevant dimensions. By including our control variables in the regressions, we aim at controlling for such heterogeneity.

The way we have set up the model in equation (14) implies that pure domestic outsourcing firms ($FI = FO = DI = 0$) represent the baseline category against which all productivity differentials are to be interpreted. Table 3 reports coefficient estimates and further regression output, distinguishing between two types of samples. The first (columns (1) to (6)) is unrestricted and includes all firms of the original survey data. The second (columns (7) to (12)) is restricted to true headquarter firms, meaning that we exclude a firm if some other company owns more than 50 percent of the firm’s capital and/or if the firm is subject to
A first observation from this table is that in all regressions all three sourcing dummies (Foreign Integration, Foreign Outsourcing, Domestic Integration) are positive and statistically different from zero at reasonable levels of confidence. This means that, on average, pure domestic outsourcing firms (baseline category) perform poorest in terms of our measure of total factor productivity. This result is in line with our expectations, given the outcome of our non-parametric testing procedure in stage one of our empirical analysis; see also figure 5. Relative to domestic outsourcing firms, the productivity premia on foreign and domestic integration firms range between 15 to 35 percent, depending on the type and number of conditioning factors. Note that the premia can be recovered from estimated coefficients as \( \text{Premium} = 100 \times [\exp(\beta) - 1] \). For foreign outsourcing firms, the premium lies between 5 and 15 percent.

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Unrestricted Sample (All Firms)</th>
<th>Restricted Sample (True Headquarter Firms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) (2) (3) (4) (5) (6)</td>
<td>(7) (8) (9) (10) (11) (12)</td>
</tr>
<tr>
<td>Foreign Integration</td>
<td>0.303*** 0.285*** 0.219*** 0.180*** 0.146*** 0.140***</td>
<td>0.297*** 0.276*** 0.204*** 0.183*** 0.150*** 0.159***</td>
</tr>
<tr>
<td></td>
<td>(0.025) (0.025) (0.026) (0.026) (0.025) (0.025)</td>
<td>(0.081) (0.084) (0.083) (0.081) (0.082) (0.081)</td>
</tr>
<tr>
<td>Foreign Outsourcing</td>
<td>0.129*** 0.121*** 0.078*** 0.066*** 0.0525*** 0.0551***</td>
<td>0.133*** 0.125*** 0.083*** 0.071*** 0.058*** 0.062***</td>
</tr>
<tr>
<td></td>
<td>(0.013) (0.013) (0.014) (0.014) (0.014) (0.014)</td>
<td>(0.014) (0.014) (0.014) (0.014) (0.014) (0.014)</td>
</tr>
<tr>
<td>Domestic Integration</td>
<td>0.282*** 0.281*** 0.250*** 0.186*** 0.150*** 0.154***</td>
<td>0.236*** 0.235*** 0.215*** 0.165*** 0.149*** 0.156***</td>
</tr>
<tr>
<td></td>
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<td>(0.040) (0.039) (0.037) (0.038) (0.036) (0.036)</td>
</tr>
<tr>
<td>Firm Age</td>
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<td>0.002*** 0.001*** 0.001*** 0.001*** 0.001*** 0.001***</td>
</tr>
<tr>
<td></td>
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<td>(0.000) (0.000) (0.000) (0.000) (0.000) (0.000)</td>
</tr>
<tr>
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</tr>
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<td>(0.013) (0.013) (0.013) (0.013) (0.013)</td>
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<tr>
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<td>0.001*** 0.001*** 0.001***</td>
</tr>
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<td></td>
<td>(0.000) (0.000) (0.000)</td>
<td>(0.000) (0.000) (0.000)</td>
</tr>
<tr>
<td>Skill Intensity</td>
<td>0.287*** 0.308*** 0.267***</td>
<td>0.237*** 0.260***</td>
</tr>
<tr>
<td></td>
<td>(0.026) (0.026) (0.026)</td>
<td>(0.028) (0.028)</td>
</tr>
<tr>
<td>Technological Effort</td>
<td>-0.120** -0.167*** -0.220*** -0.280*** -0.302*** -0.233***</td>
<td>-0.108** -0.148** -0.166*** -0.195*** -0.263*** -0.267***</td>
</tr>
<tr>
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<td>(0.058) (0.058) (0.058) (0.057) (0.056) (0.050)</td>
<td>(0.069) (0.069) (0.060) (0.061) (0.070) (0.070)</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.120** -0.167*** -0.220*** -0.280*** -0.302*** -0.233***</td>
<td>-0.108** -0.148** -0.166*** -0.195*** -0.263*** -0.267***</td>
</tr>
<tr>
<td></td>
<td>(0.058) (0.058) (0.058) (0.057) (0.056) (0.050)</td>
<td>(0.069) (0.069) (0.060) (0.061) (0.070) (0.070)</td>
</tr>
<tr>
<td>H0: FI=FO</td>
<td>0.000 0.000 0.000 0.000 0.000 0.000</td>
<td>0.045 0.070 0.146 0.165 0.257 0.230</td>
</tr>
<tr>
<td></td>
<td>(0.000) (0.000) (0.000) (0.000) (0.000) (0.000)</td>
<td>(0.000) (0.000) (0.000) (0.000) (0.000) (0.000)</td>
</tr>
<tr>
<td>H0: FI=DI</td>
<td>0.525 0.901 0.336 0.841 0.915 0.897</td>
<td>0.499 0.651 0.896 0.832 0.991 0.968</td>
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<td>(0.000) (0.000) (0.000) (0.000) (0.000) (0.000)</td>
</tr>
<tr>
<td>H0: FO=DI</td>
<td>0.000 0.000 0.000 0.000 0.000 0.000</td>
<td>0.010 0.001 0.001 0.017 0.014 0.010</td>
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<td>(0.000) (0.000) (0.000) (0.000) (0.000) (0.000)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.058 0.064 0.083 0.123 0.140 0.143</td>
<td>0.059 0.064 0.086 0.115 0.128 0.131</td>
</tr>
</tbody>
</table>

† Note: The table gives estimation results obtained with an adjusted Bernard & Jensen (1999) methodology. Each column represents a separate regression where the dependent variable is a function of dummy variables for foreign integration, foreign outsourcing, domestic integration, a firm’s age, export status, capital intensity, skill intensity, and technological effort. All regressions include a comprehensive set of year dummies. Domestic outsourcing firms serve as the baseline category against which sourcing dummy coefficients are to be interpreted. Total factor productivity is estimated with an adjusted Olley & Pakes (1996) three-step algorithm, as described in the text. The sourcing dummies are hierarchical and mutually exclusive. If a firm is active in two or more sourcing modes simultaneously, we assign it to the category which is the least prevalent one in the data. The restricted estimation sample employed in columns (7) to (12) excludes firms with domestic or foreign parental companies. Firms which report no sourcing at all are coded as domestic integration firms. The lower part of the table gives $p$-values of tests for equality of coefficients. Robust standard errors are clustered by firm and given in parentheses. *, **, *** denote significance at the 10%, 5%, 1% levels, respectively.
Of equal importance is the observation of quite a robust ranking of sourcing dummy coefficients according to which foreign and domestic integration firms exhibit the highest levels of total factor productivity, while foreign outsourcing firms feature intermediate performance levels. This finding points towards a strong incentive advantage of integration, and a weak location advantage of offshoring, coupled with asymmetry in the relevant fixed cost disadvantages. Importantly, this pattern is confirmed by our tests for equality of coefficients in the large majority of cases. It also seems to be independent of both, the type of sample restriction that we employ and the control variables that we successively add to the model. Interestingly, in none of our regressions can we reject the null hypothesis that foreign integration firms and domestic integration firms operate with the same average productivity.

From table 3 we can also deduce a number of facts familiar from the empirical literature on firm heterogeneity in strategies of internationalization. In particular, we find a robustly significant export premium in the vicinity of 10 percent. Moreover, there is positive and highly significant correlation between a firm’s capital or skill intensity and its productivity. Maybe surprisingly, however, firms with higher technological effort levels feature lower levels of total factor productivity, on average, and conditional on other factors.

4.3 Investigating self-selection

In the previous subsection, we have established positive and significant correlation between all types of sourcing channels other than domestic outsourcing and firms’ total factor productivity levels, using a simple regression framework in which domestic outsourcing firms serve as the baseline category. We should highlight that these results do not lend themselves to ready conclusions about the direction of causality. The AH model, however, suggests that firms endogenously decide upon their sourcing strategies, once their (exogenously given) productivities are revealed. Essentially, this chain of reasoning requires firms to self-select into the one or the other location and organization of sourcing, which is a hypothesis that can be brought to our data. To our knowledge, the literature so far lacks an empirical investigation of the relevance of such self-selection behavior, at least as far as both the location and the organization dimension of sourcing are concerned. That said, there does exist a rich strand
of empirical literature that deals with self-selection into exporting or offshoring.

Taking our theoretical considerations in section 2.2 and our results in stages 1 and 2 of our empirical test into account, we firstly expect sufficiently large exogenous improvements in productivity to prompt non-FI firms to self-select into a strategy of vertical foreign direct investment. This expectation applies to all sets of non-FI firms, including those which rely on domestic outsourcing as their only source of inputs but also those which pursue other (single or combined) strategies of input sourcing. It is, however, not quite clear how fast firms adjust their sourcing behavior to such changes in productivity. We therefore test for differentials in productivity levels and, separately, in productivity growth rates in the year before a firm acquires inputs from a foreign supplier through intra-firm trade for the first time. More specifically, we restrict our estimation sample to firms which (i) never rely on foreign integration in the four consecutive years 2006-2009 or (ii) which switch to foreign integration over the period 2006-2009. For our purposes, we set up two empirical models, the first of which reads as

$$\theta_{it} = \beta_0 + \beta_1 \Phi_{it+1} + \beta_2 A_{ge_{it}} + \beta_3 Export_{it} +$$

$$+ \beta_4 (K/L)_{it} + \beta_5 (H/L)_{it} + \beta_6 (R&D/Sales)_{it} + \gamma_{it} + \mu_{it},$$

(15)

where $\Phi_{it+1}$ is an indicator variable which takes on the value 1 if and only if a firm sources inputs through vertical FDI in period $t+1$ but has not done so in period $t$. The estimated parameter $\beta_1$ can then be used to compute the ex-ante productivity premium (in percent) of foreign integration firms relative to non-foreign integration firms, one year ahead of switching from non-FI status to FI status. All other variables in equation (15) are equivalent to those described in the previous subsection. Our second model looks at differences in ex-ante productivity growth rates instead of levels:

$$\frac{\theta_{it} - \theta_{it-1}}{\theta_{it-1}} = \beta_0 + \beta_1 \Phi_{it+1} + \beta_2 A_{ge_{it}} + \beta_3 Export_{it} +$$

$$+ \beta_4 (K/L)_{it} + \beta_5 (H/L)_{it} + \beta_6 (R&D/Sales)_{it} + \gamma_{it} + \mu_{it}.$$  

(16)
Table 4. OLS Regressions: Self-Selection Into Foreign Integration†

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Dependent Variable: Lagged Total Factor Productivity Level</th>
<th>Dependent Variable: Lagged Total Factor Productivity Growth</th>
</tr>
</thead>
<tbody>
<tr>
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<td>(1)</td>
<td>(2)</td>
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<tr>
<td>Foreign Integration</td>
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<td>(0.070)</td>
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<tr>
<td>Firm Age</td>
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<td>0.001**</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Export Status</td>
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<td>0.126***</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Capital Intensity</td>
<td>0.001***</td>
<td>0.001***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Skill Intensity</td>
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<td>0.322***</td>
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<td>(0.048)</td>
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<td>Technological Effort</td>
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</tr>
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<td>4,780</td>
</tr>
<tr>
<td>R²</td>
<td>0.016</td>
<td>0.024</td>
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</tbody>
</table>

† Note: In this table each column represents a separate regression where the dependent variable is a function of a dummy variable for foreign integration, a firm’s age, export status, capital intensity, skill intensity, and technological effort. All variables except for the sourcing dummy are given in one-year lags. The coefficient of the sourcing dummy reveals estimated *ex-ante* differences in productivity levels or growth rates between firms which self-select into foreign integration and firms which do not. Non-switching firms serve as the baseline category against which the sourcing dummy coefficient is to be interpreted. All regressions include a comprehensive set of year dummies. The estimation sample is restricted to firms which (i) never rely on foreign integration in the four consecutive years 2006-2009 or (ii) which switch to foreign integration over the period 2006-2009. Total factor productivity is estimated with an adjusted Olley & Pakes (1996) three-step algorithm, as described in the text. Robust standard errors are clustered by firm and given in parentheses. *, **, *** denote significance at the 10%, 5%, 1% levels, respectively.
Table 5. OLS Regressions: Self-Selection Into Foreign Outsourcing†

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<th>(12)</th>
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<td>0.127***</td>
<td>0.085***</td>
<td>0.073**</td>
<td>0.070**</td>
<td>0.073**</td>
<td>0.052**</td>
<td>0.051*</td>
<td>0.050*</td>
<td>0.050*</td>
<td>0.049*</td>
<td>0.054**</td>
</tr>
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<td>(0.030)</td>
<td>(0.031)</td>
<td>(0.030)</td>
<td>(0.030)</td>
<td>(0.030)</td>
<td>(0.027)</td>
<td>(0.027)</td>
<td>(0.027)</td>
<td>(0.027)</td>
<td>(0.027)</td>
<td>(0.027)</td>
</tr>
<tr>
<td>Firm Age</td>
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<td>0.002**</td>
<td>0.001*</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.000)</td>
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<td>(0.000)</td>
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</tr>
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<td>0.119***</td>
<td>0.123***</td>
<td>0.125***</td>
<td>0.123***</td>
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<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.012)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Capital Intensity</td>
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<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<td>(0.000)</td>
<td>(0.000)</td>
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</tr>
<tr>
<td>Skill Intensity</td>
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<td>0.275***</td>
<td>0.275***</td>
<td>0.275***</td>
<td>0.275***</td>
<td>0.275***</td>
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<td>-0.055</td>
<td>-0.067*</td>
<td>-0.055</td>
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<tr>
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<td>(0.071)</td>
<td>(0.071)</td>
<td>(0.071)</td>
<td>(0.071)</td>
<td>(0.071)</td>
<td>(0.036)</td>
<td>(0.034)</td>
<td>(0.036)</td>
<td>(0.034)</td>
<td>(0.036)</td>
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</tr>
<tr>
<td>Technological Effort</td>
<td>-0.013</td>
<td>-0.013</td>
<td>-0.013</td>
<td>-0.013</td>
<td>-0.013</td>
<td>-0.013</td>
<td>-0.010***</td>
<td>-0.010***</td>
<td>-0.010***</td>
<td>-0.010***</td>
<td>-0.010***</td>
<td>-0.010***</td>
</tr>
<tr>
<td></td>
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<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.004)</td>
<td>(0.004)</td>
<td>(0.004)</td>
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<td>-0.237***</td>
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<td>(0.077)</td>
<td>(0.076)</td>
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<td>(0.022)</td>
<td>(0.023)</td>
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<tr>
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<td>333</td>
<td>333</td>
<td>333</td>
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<td>333</td>
<td>333</td>
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<tr>
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<tr>
<td>R²</td>
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<td>0.135</td>
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<td>0.022</td>
<td>0.022</td>
<td>0.024</td>
<td>0.027</td>
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</tbody>
</table>

† Note: In this table each column represents a separate regression where the dependent variable is a function of a dummy variable for foreign outsourcing, a firm’s age, export status, capital intensity, skill intensity, and technological effort. All variables except for the sourcing dummy are given in one-year lags. The coefficient of the sourcing dummy reveals estimated ex-ante differences in productivity levels or growth rates between firms which self-select into foreign outsourcing and firms which do not. Non-switching firms serve as the baseline category against which the sourcing dummy coefficient is to be interpreted. All regressions include a comprehensive set of year dummies. The estimation sample is restricted to firms which (i) never rely on foreign outsourcing in the four consecutive years 2006-2009 or (ii) which switch to foreign outsourcing over the period 2006-2009. The sample furthermore excludes domestic and foreign integration firms. Total factor productivity is estimated with an adjusted Olley & Pakes (1996) three-step algorithm, as described in the text. Robust standard errors are clustered by firm and given in parentheses. *,**,*** denote significance at the 10%, 5%, 1% levels, respectively.
Table 6. OLS Regressions: Self-Selection Into Domestic Integration†

<table>
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<th>VARIABLES</th>
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<th>Dependent Variable: Lagged Total Factor Productivity Growth</th>
</tr>
</thead>
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<td>(0.043)</td>
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<td>0.002**</td>
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<td>(0.001)</td>
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<td>Export Status</td>
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<td>0.126***</td>
</tr>
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<td>(0.021)</td>
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<td>Capital Intensity</td>
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<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>Skill Intensity</td>
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<td>(0.049)</td>
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<td>(0.007)</td>
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<td>222</td>
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<td>( R^2 )</td>
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† Note: In this table each column represents a separate regression where the dependent variable is a function of a dummy variable for domestic integration, a firm’s age, export status, capital intensity, skill intensity, and technological effort. All variables except for the sourcing dummy are given in one-year lags. The coefficient of the sourcing dummy reveals estimated ex-ante differences in productivity levels or growth rates between firms which self-select into domestic integration and firms which do not. Non-switching firms serve as the baseline category against which the sourcing dummy coefficient is to be interpreted. All regressions include a comprehensive set of year dummies. The estimation sample is restricted to firms which (i) never rely on domestic integration in the four consecutive years 2006-2009 or (ii) which switch to domestic integration over the period 2006-2009. The sample furthermore excludes foreign integration firms. Total factor productivity is estimated with an adjusted Olley & Pakes (1996) three-step algorithm, as described in the text. Robust standard errors are clustered by firm and given in parentheses. *,**,*** denote significance at the 10%, 5%, 1% levels, respectively.
The regression results for equations (15) and (16), estimated via ordinary least squares, are shown, respectively, in columns (1) to (6) and (7) to (12) of table 4. Looking at columns (7) to (12) first, we see that the ex-ante growth rates of firms’ total factor productivities are not significantly correlated with their decisions of switching to a sourcing strategy of foreign integration. However, in all specifications in which we employ ex-ante productivity levels as the dependent variable, the estimated coefficient of the switching dummy for foreign integration is positive and significant at the 5 percent level of confidence. This is clear-cut evidence in favor of the idea that firms which acquire inputs through foreign integration for the first time are ex-ante significantly more productive than firms which do not, even if we condition on other firm characteristics such as export status or capital and skill intensity. This finding strongly supports the notion of firms self-selecting into vertical FDI, although the regression analysis does not permit the numbers to be interpreted in a strict causality sense. The magnitude of the ex-ante FI-sourcing premium is roughly comparable in magnitude to the FI-sourcing premia we obtained in the previous subsection, which is somewhat surprising, given that the baseline categories are not the same across the two regression equations.

We can also formulate hypotheses on firms’ self-selection behavior with respect to strategies of domestic integration and foreign outsourcing, similar to the one above. In principle, we rely on the same basic regression framework as given in equations (15) and (16). Yet, we need to be more careful to construct an estimation sample for which we can hypothesize an unambiguous relationship between switching behavior and productivity changes. For example, we expect foreign integration firms to switch to a foreign outsourcing strategy if they experience a sufficiently large decline in their levels of total factor productivity. In what follows, we therefore ensure in each case that firms for which stages 1 and 2 of our empirical test lead us to expect a negative correlation between switching behavior and productivity changes do not enter the estimation sample.

Tables 5 and 6 report the regression output for the self-selection hypothesis on foreign outsourcing and domestic integration, respectively. Very similar to our previous results, we find positive and robustly significant ex-ante sourcing premia for total factor productivity levels. Abstracting from all types of vertically integrated firms, firms switching from non-FO status to FO status exhibit higher ex-ante productivity levels than non-switching firms. The
same applies to firms dropping into the domestic integration category, conditional on excluding foreign integration firms from the estimation sample. Notably, such ex-ante productivity premia are slightly lower for FO and DI switchers than for FI switchers. Furthermore, only in case of firms which start sourcing from foreign independent suppliers can we also identify significant cross-firm heterogeneity in ex-ante productivity growth rates; see columns (7) to (12) in table 5 as opposed to those in table 6.

5 Final remarks

[to be written]
References


Appendix

Location advantage under outsourcing versus integration

What determines whether the location advantage is stronger or weaker for integration than for outsourcing? A first point to note here is that the above mentioned “holdup-distorted” input mix, reflected in the second bracketed term in (2) may partly erode the foreign input cost advantage.\textsuperscript{34} And this distortion is necessarily different across organizational forms.

\textsuperscript{34}Indeed, it may even be turned into a “holdup-distorted” input cost disadvantage. We have, however, already ruled this out by our assumption, supported by the nonparametric results, that \( g^{\kappa} > 0 \). Given \( c^m(w^f) < c^m(w^D) \), a sufficient condition is that the revenue shares \( \gamma^m \) are the same across locations.
since $\gamma^H > \gamma^O$. For any given organizational form, the foreign cost advantage receives its maximum leverage if $\eta = \gamma^F\kappa$, i.e., if the headquarter revenue share mirrors the importance of the headquarter input. A case where $g^{FO}(\eta) > g^{FI}(\eta)$, as in figures 5(a) and 5(b), may thus be interpreted as a situation where this holds true to a greater extent with foreign outsourcing than with foreign integration. An obvious case in point would be $\eta = \gamma^{FO}$. Another, perhaps less obvious case is given by $\eta < \gamma^O$, assuming that $\gamma^\kappa$ is uniform across $l = F, D$. By the same token, it is violated for a uniform $\gamma^\kappa$ if $\eta > \gamma^H$.

The second channel runs through the first bracketed term in (2). Suppose that this term is equal across the two sourcing locations. The term may then be interpreted as a leverage factor for the “holdup-distorted” foreign cost advantage for organizational form $\kappa$. One might be tempted to view $g^{FO}(\eta) > g^{FI}(\eta)$ as a case where this factor is larger for $\kappa = O$ than for $\kappa = I$. Indeed, it is relatively straightforward to show that this is true iff $\gamma^H (2\eta - 1) > \gamma^O (2\eta - 1)$. In turn, given that $\gamma^H > \gamma^O$, this is true iff $\eta > 1/2$. It thus appears that, conditional upon the foreign cost advantage being the same for $\kappa = O$ and $\kappa = I$, and conditional upon $\gamma^H > \gamma^O$, outsourcing makes greater use of this advantage than integration, provided that $X^k$ is a more important input than $X^m$. This is somewhat counterintuitive, given what we have said above about the strategic implications of $\eta$. However, one needs to be cautious here, since the foreign cost advantage is never the same for both organizational forms, as we have pointed out above.
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