International Know-how Trade and Foreign Direct Investment

by

Uwe Eiteljörg and Martin Klein
International Know-how Trade and Foreign Direct Investment

Uwe Eiteljörge* and Martin Klein †
Martin-Luther-Universität Halle-Wittenberg

May 1998
(revised)

Abstract

The improved international tradability of services and the better protection of intellectual property rights – both of which have been results of the Uruguay Round – increase the international tradability of know-how. This paper investigates the economic impact of this. It is shown that know-how maybe under-traded or over-traded. In the first case know-how is not traded although it would be welfare improving, in the second case know-how trade takes place but welfare is reduced. The results depend on the distinction of a productivity effect and a market power effect of international know-how trade. The welfare-increasing productivity effect arises because trade in know-how raises the buyer’s productivity without lowering the seller’s. The market power effect arises because trade in know-how redistributes market power between the buyer and the seller and eliminates the seller’s competitive edge. Although a more balanced distribution of market power is positive for welfare, there may be situations where an incumbent acquires foreign know-how mainly in order to keep a potential entrant out of its domestic market. These are situations where know-how is over-traded from the point of view of domestic welfare.

*Institute of Agricultural Development in Central and Eastern Europe (IAMO); e-mail: eiteljoerge@iamo.uni-halle.de
†Contact Address: Martin-Luther-Universität, Wirtschaftswissenschaftliche Fakultät, D-06099 Halle, Germany; Tel. +49-345-5523325; Fax: +49-345-5527189; e-mail: klein@wiwi.uni-halle.de
1 Introduction

Like the removal of restrictions to international trade in goods, the increased international tradability of know-how should be expected to raise welfare both in know-how exporting and importing countries because the opportunity sets of agents in both countries are enlarged. The purpose of this paper is to show that this initial intuition is incorrect. It will be shown that know-how may be under-traded or over-traded. In the former case know-how is not traded although it would be welfare-improving. In the latter case know-how trade takes place but – paradoxically – welfare is reduced.

Our results are obtained in the context of a game-theoretic model of foreign direct investment (FDI). The basic theoretical approach to FDI is due to Hymer (1976) who suggested that FDI is motivated by the desire to internalize – i.e. to maintain control over – certain firm-specific advantages such as technological advantages generated by superior know-how. The industrial economics of FDI were first considered by Caves (1971). Subsequently several papers have investigated the choice between exports and FDI in a setting of imperfect competition, e.g. Krugman (1983), Smith (1987) and Dei (1990). Horstmann and Markusen (1992), Motta (1992) and Wong (1995), ch. 13, extend this basic model by incorporating game-theoretic considerations.

In this paper we adopt their game-theoretic approach but extend it by expanding the range of options available to the know-how owner. We assume that, in addition to the choice between exports and FDI, the investor has the third option of licensing his superior technological know-how to his competitor in the target market. Whereas exporting and FDI are mutually exclusive in our model, exporting or FDI on the one hand and licensing on the other hand are not, i.e. licensing may occur simultaneously with exports or FDI by the licensor.

Our paper is similar in spirit to several others in the literature. In a closed economy context, Katz and Shapiro (1985) investigate the licensing of innovations in a three-stage game, where innovations are endogenous in the first stage. The rate of innovation depends on the licensing arrangement that emerges in the later stages. Our paper differs from theirs because we focus on the link between licensing and direct investment and we assume that innovation is exogenous. This reflects a situation where innovations are produced chiefly for the home market. Ethier and Markusen (1991) investigate the link between exports, FDI and licensing in a general equilibrium framework. Our paper differs from theirs in that we use a partial equilibrium approach and that we focus explicitly on the welfare consequences of know-how trade. Finally, Wong (1995, p. 602 ff) briefly investigates the licensing of innovations in the context of an FDI-model. His approach is similar to ours (using reservation prices) but he only focuses on the question under which conditions licensing will take place in equilibrium.
The remainder of the paper is organized as follows. The section 2 presents the model. Section 3 then investigates the conditions under which know-how trade will take place. Finally, section 4 examines the welfare aspects of know-how trade.

2 The model

2.1 The structure of the game

Our point of departure is an international firm with specific "know-how". We assume that, initially, the international firm's know-how is an untradable asset because clearly defined and enforceable international property rights are absent. The firm's options in international marketing are to supply foreign markets through exports or through local production, both of which are indirect ways to market the firm's know-how abroad. We assume that, due to a change in trade rules firm-specific know-how becomes tradable. The international firm thus acquires an additional marketing option namely to license its know-how to the foreign incumbent.

This setup can be modelled as a game between the international firm and the domestic incumbent as shown in figure 1. The first stage of the game has the know-how monopolist – the international firm – quote a price for the use of its know-how. If the price is too high from the point of view of the domestic incumbent, i.e. if it exceeds his reservation price $A$ (to be specified below) then there is no trade in know-how and we get a conventional FDI-game in which the international firm has the advantage of its superior know-how while the domestic incumbent has the advantage of lower market access cost. If the price for the international firm's know-how is sufficiently low, know-how is traded. Again an FDI-game ensues, albeit now different because the international firm has lost its technological edge while the domestic incumbent has retained his advantage of lower market access cost. Throughout the game we assume that both players have complete information and we use sub-game perfectness as the equilibrium concept.

2.2 Output demand and production cost

The joint market demand function for both products is represented by the function

$$Q_f + Q_d = V(1 - P),$$  \hspace{1cm} (1)

where $Q_f$ and $Q_d$ denote, respectively, the sales of the international firm and of the domestic incumbent. The parameter $V > 0$ can be interpreted as a measure of "market volume". $P$ denotes the market price, which is the same for both products be-
Figure 1: The Know-how Game

international firm chooses reservation price of know-how

low price

high price

trade in know-how

exports

local production

exports

local production

int. firm chooses mode of supply

int. firm chooses output

incumbent chooses output

\[ \begin{array}{c|c|c|c}
\pi_f & \pi_f & \pi_f & \pi_f \\
\pi_d & \pi_d & \pi_d & \pi_d \\
\end{array} \]
cause they are assumed to be perfect substitutes. There are three factors of production: capital, $K$, labor, $L$, and labor-augmenting know-how, $N$, which are combined in a standard neoclassical production function $Q(K, L, N) = Q(K, LN)$, with $Q(\lambda K, \lambda LN) = \lambda Q(K, LN)$. We assume that the stock of know-how is given while capital and labor can vary freely. If the investor supplies the target market through exports his production cost is

$$C = rK + wL,$$

where $r$ is the world interest rate and $w$ is the wage rate in the investor's home base. Note that exporting does not generate fixed cost. Efficient factor combination yields the cost function

$$C = (g + t)Q,$$

where $t > 0$ is the sum of per-unit tariffs and transportation costs – in the following referred to as trading costs – and $g = g(r, w, N)$ measures the minimal marginal production cost attainable at the current interest and wage rates and with the firm-specific level of know-how and the given production function $Q(.)$. Marginal cost rises with factor prices and falls with increasing know-how.\(^1\)

If the investor supplies the target market through local production his cost is

$$C = rK + wL + F,$$

$F$ being the fixed cost for setting up a new production facility. Since we focus on know-how as the key determinant of FDI, we assume that the local wage and interest rates are equal to world rates. Proceeding as before we obtain the following cost function for local production of the international firm:

$$C = gQ + F$$

with the same marginal production cost $g(r, w, N)$ as above.

The local incumbent's production cost is the same as for the international firm in the case of exportation:

$$C = rK + wL$$

On the one hand the local incumbent does not have to set up a new production facility i.e. he does not have to face fixed cost, on the other hand the incumbent possesses only the basic know-how, $N = 1$, therefore he faces different marginal costs. His cost function is

$$C = \gamma Q,$$

\(^1\)In the special case of a Cobb-Douglas production function $Q = K^{1-\lambda}(NL)^\lambda$ marginal cost is

$$g = \left(\frac{r}{1-\lambda}\right)^{1-\lambda} \left(\frac{w}{\lambda N}\right)^\lambda.$$
with $\gamma = g(w, r, 1)$. In order to ensure consistency between the market demand function (1) and the cost functions we have to assume $\gamma < 1$. Since the know-how of the international firm is superior to the know-how of the domestic incumbent, i.e. $N > 1$, its marginal production costs are lower than his:

$$0 < g < \gamma < 1$$

(8)

Note that the marginal cost gap $\gamma - g$ is strictly positive and, ceteris paribus, a monotonically increasing function of the international know-how, $N$. Therefore the size of the marginal cost gap is a proxy for the know-how advantage of the international firm.

### 2.3 Non-tradable know-how

Both firms maximize their profits in a noncooperative fashion, using their output quantities as their strategic variables. If the international firm chooses exports as the mode of market supply, the Cournot-Nash equilibrium quantities and the equilibrium price are as follows:

$$Q_d = (1 + g + t - 2\gamma)\frac{V}{3}, \quad Q_f = (1 + \gamma - 2[g + t])\frac{V}{3}, \quad P = \frac{1}{3}(1 + g + t + \gamma)$$

(9)

If the international firm chooses local production (FDI) the equilibrium allocation is:

$$Q_d = (1 + g - 2\gamma)\frac{V}{3}, \quad Q_f = (1 + \gamma - 2g)\frac{V}{3}, \quad P = \frac{1}{3}(1 + g + \gamma)$$

(10)

Because of the avoidance of trading costs $t$, the international firm's sales under FDI are bigger and the domestic firm's sales are smaller. Moreover, because total sales under FDI are bigger, the product price is lower and consumer surplus in the target country is bigger.

The choice between exports and local production depends on the international firm's profit under either strategy. The firm is indifferent between the two alternatives if the equation

$$(1 + \gamma - 2[g + t])^2\frac{V}{9} = (1 + \gamma - 2g)^2\frac{V}{9} - F$$

holds, where the left-hand side is the profit in the case of exports while the right-hand side reflects profits under FDI. Solving for the level of market size at which there is indifference, we get

$$V_i = \frac{9F}{4t(1 + \gamma - 2g - t)} > 0.$$  

(12)

\[2\text{The inequality follows from the assumption } Q_f > 0 \text{ which implies } 1 + \gamma - 2g - 2t > 0 \text{ which in turn implies } 1 + \gamma - 2g - t > 0.\]
2.4 Tradable know-how

Suppose now that the international firm’s know-how becomes tradable. This raises the productivity of the incumbent but does not reduce the productivity of the international firm since in this respect know-how is a public good. As a rule, we assume that know-how is indivisible and can be traded only as a whole, not in bits and pieces. In other words, the only choice is between know-how or “no-how”, but not between different degrees of “some-how”.³ We also assume that the international firm charges a flat licensing fee which is independent from the output of the receiving firm (i.e. a lump-sum amount). After trade in know-how both firms therefore have the same production function and the same marginal production costs. The Cournot-Nash equilibria are then as follows. With exports we have:

\[ Q_d = (1 - g + t) \frac{V}{3}, \quad Q_f = (1 - g - 2t) \frac{V}{3}, \quad P = \frac{1}{3} (1 + 2g + t) \] (13)

With FDI we have:

\[ Q_d = Q_f = (1 - g) \frac{V}{3}, \quad P = \frac{1}{3} (1 + 2g) \] (14)

It is easy to verify that trade in know-how generally lowers product prices, raises the domestic incumbent’s output and reduces the international firm’s output. Prima facie, the reduction in product prices suggests that the consumer surplus has increased. But note that prices under the export strategy with know-how trade, \((1 + 2g + t)/3\), may be higher than prices under the FDI strategy without know-how trade, \((1 + g + \gamma)/3\). This will be the case if \(g + t > \gamma\), i.e. if transport costs are relatively high and if the know-how advantage of the international firm is not too big. In this case it is not immediately clear whether trade in know-how raises consumer surplus. The reason is that trade in know-how “delays” the switch from exports to FDI. This can be seen as follows. Solving as above for the value of the market size at which the international firm is indifferent between exports and local production, we get

\[ V_2 = \frac{9F}{4t(1 - g - t)} > V_1. \] (15)

This inequality means that with trade in know-how the switch from exports to local production occurs at bigger market sizes than without trade in know-how. It follows directly from the fact that the domestic incumbent’s marginal cost is reduced by the acquisition of the international know-how, i.e. \(g < \gamma\).

Before we proceed it is useful to summarize those effects of trade in know-how which follow immediately from the model:

³There may be exceptions to this rule if know-how is provided through services because the know-how owner then has tighter control over the flow of information. But the rule appears to be realistic if know-how is traded through licensing where a given technology has to be provided as a whole.
Proposition 1 Trade in know-how crowds out FDI, in the sense that (i) the switch from exports to FDI occurs at larger market volumes and (ii) optimal sales under FDI are lower.

2.5 Parameter restrictions

Our maintained assumption in this paper is that both under exports and under local production we have a genuine duopoly, i.e. both firms sell positive quantities. This assumption puts upper limits on both competitors’ marginal costs and thus implies restrictions for those parameters which affect marginal costs under exports or FDI and with or without trade in know-how. The resulting 8 inequalities can be reduced to the following 2 non-redundant inequalities. The first inequality provides an upper boundary for the marginal cost gap:

\[ \gamma - g < \min\{\gamma, 1 - \gamma\} \]  

(16)

The first argument on the right hand side follows from the fact that \( g \) is positive, the second argument results from the requirement that \( Q_d > 0 \) applied to (10). The second inequality – arising from the requirement that \( Q_f > 0 \) in (13) – sets an upper boundary for the trading costs:

\[ t < \frac{1 - g}{2} = \frac{(1 - \gamma) + (\gamma - g)}{2} \]  

(17)

The equivalent expansion on the right hand side shows that, at given factor prices reflected in \( \gamma \), this upper boundary increases linearly with the marginal cost gap. Note that these two inequalities can be combined to yield

\[ t < \min\left\{\frac{1}{2}, 1 - \gamma\right\} \]  

(18)

3 Know-how trade and reservation prices

Now we turn to the question whether internationally tradable know-how is traded. Will the international firm sell its know-how and relinquish its know-how monopoly? Will the domestic incumbent find it profitable to buy the international know-how?

3.1 Reservation prices and market size

Our key tool in answering these questions are the reservation prices of both firms. The reservation price of the international firm is the price at which it becomes profitable to the firm to sell its know-how to the incumbent. The domestic incumbent’s reservation price on the other hand is the price at which it ceases to be profitable to him to buy the
international firm's know-how. Both reservation prices are calculated from indifference conditions:

- At its reservation price $\bar{A}$ the international firm is indifferent between selling and not selling its know-how. The reservation price is calculated as the difference between its profit without and with the sale of its know-how.

- Conversely, the reservation price of the domestic incumbent $A$ makes him indifferent between buying and not buying the know-how from the international firm. It is calculated as the difference between its profit with and without the know-how purchase.

Trade in know-how will occur if and only if the reservation price of the incumbent is at least as high as the reservation price of the international firm, i.e. if we have $\bar{A} \leq A$.

Reservation prices depend on profits which in turn depend on market size and on the other parameters of the model. With respect to the key parameter market size we can distinguish three regimes:

- In small markets ($V < V_1$), where the international firm chooses the export strategy no matter whether know-how is traded or not, we have

  $\bar{A} = (2 + \gamma - 3g - 4t)(\gamma - g)\frac{V}{g}$,
  \[\bar{A} = 4(1 - \gamma + t)(\gamma - g)\frac{V}{g}.\] \hspace{1cm} (19) \hspace{1cm} (20)

- In large markets ($V_2 < V$), where the international firm chooses FDI no matter whether know-how is actually traded or not, we have

  $\bar{A} = (2 + \gamma - 3g)(\gamma - g)\frac{V}{g}$,
  \[A = 4(1 - \gamma)(\gamma - g)\frac{V}{g}.\] \hspace{1cm} (21) \hspace{1cm} (22)

- In intermediate markets ($V_1 \leq V \leq V_2$) trade in know-how and FDI are substitutes. Exports are chosen if know-how is traded, FDI is chosen if know-how is not traded. This yields the following reservation prices:

  $\bar{A} = (2 + \gamma - 3g - 2t)(\gamma - g + 2t)\frac{V}{g} - F$,
  \[\bar{A} = 4(1 - \gamma + t/2)(\gamma - g + t/2)\frac{V}{g} \] \hspace{1cm} (23) \hspace{1cm} (24)
It is straightforward to verify that the reservation price of the international firm exhibits no jumps at the connection points $V_1$ and $V_2$ between regions of different market size. The reason is that the profit of the international firm has to satisfy a value matching condition if the firm switches between exports and FDI. Note, however, that the reservation price of the domestic incumbent does not have to satisfy a similar value matching condition and therefore may jump at these points.

Before we proceed with our analysis we provide an illustration of the role of reservation prices in determining know-how trade. Figure 2, which shows both reservation prices as functions of market volume $V$, is based on a numerical simulation of the equations of the model. Figure 2a together with equations (21) and (22) shows that in small markets both reservation prices are linearly homogenous functions of market volume. As in this segment the slope of $A$ exceeds the slope of $\bar{A}$, we also have $\bar{A} < A$, so that know-how is traded. At $V_1$, the transition point to intermediate markets, the reservation price of the international firm begins to increase with a steeper slope. The reservation price of the domestic incumbent jumps, reflecting at the same time an increase in its slope at $V_1$. The continuity of $\bar{A}$ and the upward jump of $A$ combined increase the margin between the two reservation prices. This continues throughout the interval of intermediate market sizes. Then at $V_2$ the slope of $\bar{A}$ drops, although it remains bigger than in small markets. At the same time $A$ drops. In the specific example it drops below $\bar{A}$ so that trade in know-how becomes impossible. This situation continues for all markets larger than $V_2$.

The analysis of reservation prices thus shows that in the specific parameter constellation of figure 2, know-how is only traded in small and intermediate markets. Figures 2b and 2c, which show the optimal output levels of the international firm (b) and the domestic incumbent (c) for the same range of market sizes as figure 2a, illustrate the mechanism behind this. In both figures solid lines indicate output under the actual regime of know-how trade while dashed lines indicate output in the case where know-how is generally nontradable. The reason for the increase in the reservation price $A$ between $V_1$ and $V_2$ is that by buying the know-how the domestic incumbent can prevent an increase in the international firm’s output from the switch to direct investment. The jumps in the reservation price reflects the strategic value of know-how, which arises from the fact that it provides the incumbent with more “market power”.

---

4 The parameters are as follows: $\gamma = 6$, $g = .25$, $t = .25$, $F = 100$.

5 This is necessarily the case because (i) the reservation price $A$ has to satisfy a value matching condition at this point and (ii) the line representing $\bar{A}$ has a negative intercept because of the fixed cost $F$.

6 The fact that $A$ jumps at $V_1$ (and subsequently drops at $V_2$) is independent from the specific parameter values underlying the figure. For this, see appendix.
Figure 2: Reservation Prices and trade in Know-how
Figure 2 reveals some of the generic characteristics of the relationship between reservation prices and market size but it is not completely generic, as the slopes and the positions of the reservation price schedules depend on the specific parameter values. In particular, the result that know-how is traded only for market sizes smaller than \( V_2 \) is not generic. Depending on the parameter values it is for instance possible that know-how is never traded or that it is traded for all market sizes. Nevertheless, the generic properties of the "slopes", "kinks" and "jumps" of the reservation price schedules permit the exclusion of some situations. For instance, if know-how is not traded at market sizes smaller than \( V_2 \), it is also not traded at bigger market sizes.

3.2 The likelihood of know-how trade

In this section we turn to the question under which parameter constellations know-how is actually traded. We shall begin by analysing small and large markets. Due to the linear homogeneity of both reservation prices their slopes and levels yield the same information, making an answer straightforward. In small markets we have

\[
A \geq \bar{A} \iff \gamma - g \leq \frac{2}{3} (1 - \gamma + 4t).
\]  

(25)

In large markets we have

\[
A \geq \bar{A} \iff \gamma - g \leq \frac{2}{3} (1 - \gamma).
\]  

(26)

Both conditions state that trade in know-how will occur, provided the know-how advantage of the international firm – which is reflected in the marginal cost gap (\( \gamma - g \)) – is not too large. As (\( \gamma - g \)) is positive and monotonically increasing in \( N \), the upper bounds on (\( \gamma - g \)) in (25) and (26) are effectively upper bounds on \( N \).

Next we investigate intermediate market sizes, concentrating the analysis on the transition points. The condition for know-how trade at \( V_1, \bar{A}(V_1) \geq \bar{A}(V_1) \), is

\[
\gamma - g \leq \delta_1,
\]  

(27)

with

\[
\delta_1 = \frac{1}{3} \left[ 1 - \gamma + 3t + \sqrt{(1 - \gamma)^2 + 12t(1 - \gamma + t)} \right].
\]

The condition for know-how trade at \( V_2, \bar{A}(V_2) \geq \bar{A}(V_2) \), is

\[
\gamma - g \leq \delta_2,
\]  

(28)

with

\[
\delta_2 = \frac{1}{3} \left[ 1 - \gamma + t + \sqrt{(1 - \gamma)^2 + 8t(1 - \gamma + t/2)} \right].
\]
Note that we have $\delta_1 > (2/3)(1 - \gamma)$; and the same inequality holds for $\delta_2$.

We are now able to summarize our results in two propositions. Proposition 2 summarizes the relationship between market size, market structure and know-how trade:

**Proposition 2** *In the absence of market structure effects, the "likelihood" that know-how is actually traded falls with increasing market size, i.e. the bigger the market, the smaller is the subset of parameters with guarantee trade in know-how. If know-how trade has an impact on market structure, then the likelihood that know-how is traded is higher than in a similar situation without such an impact.*

The proof of the first part of proposition 2 follows directly from inequalities (25) through (28). Market structure effects of know-how trade are absent in small and large markets. Comparing inequalities (25) and (26) shows that (26) is more restrictive than (25), i.e. know-how trade in large markets occurs only for a smaller parameter set. Along the interval $[V_1, V_2]$ know-how trade crowds out FDI and thus has an effect on market structure, but this effect is the same throughout the interval. Comparing inequalities (27) and (28) shows that (28) is more restrictive than (27), i.e. know-how trade at the “upper end” of intermediate markets will take place for a smaller set of parameters.

The proof of the second statement can be developed with the help of figure 3 which shows trading costs $t$ on the horizontal axis and the marginal cost gap $(\gamma - g)$ on the vertical axis. The solid lines $BE$ and $GE$ represent, respectively, the general parameter restrictions (8) and (16). Within the admissible parameter set $OBEG$ the dashed lines represent the conditions for know-how trade defined in inequalities (25) through (28). All dashed lines originate at point $A$ and extend to points $C_1$, $D$, $C_2$ and $F$, respectively. With respect to the horizontal axis the first three points are ranked as $C_1 < D < C_2$. The area above each dashed line represents those parameter constellations for which no trade in know-how will result. The smallest parameter set is excluded in intermediate markets at market volume $V_1$ (line $AC_1$), followed by small markets (line $AD$), and intermediate market sizes at market volume $V_2$ (line $AC_2$), which in turn is followed by large markets (line $AF$). To prove the second statement it is necessary to compare small markets with intermediate markets at $V_1$ and, similarly, large markets with intermediate markets at $V_2$. The comparisons show that, at the same market volume, the presence of market structure effects (intermediate markets) expands the set of parameters under which know-how trade takes place.

---

7The figure is based on a factor cost level of $\gamma = .6$. Figures based on other factor cost levels exceeding the threshold $\gamma = 2/5$ are qualitatively identical. The role of this threshold is clarified in the proof of proposition 3.

8The proof of this ranking – straightforward but technical – is presented in the appendix. Note that although $C_1$ and $D$ are graphically very close, their ranking is unequivocal.
Figure 3: Conditions for Trade in Know-how
We can conclude that, as a general trend, market size has a negative impact on know-how trade. We use the expression "general trend" because the relationship between market size and know-how trade is discontinuous at the point $V_1$, where market size switches from small to intermediate, and the likelihood of know-how trade jumps up because of the presence of market structure effects. From this point on, however, it continues to decrease monotonically, with an additional discontinuous drop at point $V_2$.

The next proposition summarizes the relationship between marginal cost and know-how trade:

**Proposition 3** If factor costs are sufficiently low, trade in know-how occurs for all market sizes. For higher factor prices, a sufficient condition for trade in know-how is that the know-how gap $\gamma - g$ not too big.

The proof of the first part of the proposition makes use of the fact that $\gamma$ is a monotonically increasing function of the factor costs $w$ and $r$. By choosing a sufficiently low level of factor costs we can ensure $\gamma \leq 2/5$ and therefore $\gamma \leq (2/3)(1 - \gamma)$, which in turn implies $\gamma - g < (2/3)(1 - \gamma)$ for all levels of the international know-how $N$. Then by inequalities (25) through (28) know-how is traded for all market sizes. The second statement follows directly from (27) and (28).

4 Know-how trade and welfare

While the previous section focused on the question whether know-how is actually traded, the present section investigates the welfare consequences of know-how trade. For the purposes of this section we define two welfare measures, $W_1$ and $W_2$, which we investigate in turn. $W_1$ is equal to the consumer surplus ($S$) in the market while $W_2$ is the consumer surplus plus the domestic incumbent's profit ($\Pi$).

4.1 Consumer surplus

At price $P$, the consumer surplus is given by

$$S = (1 - P)^2 \frac{V}{2},$$

where for $P$ we have to substitute the equilibrium price of each of the four possible allocations discussed in section 2. Without trade in know-how, the consumer surplus in equilibrium can be written as a function of the parameters:

$$S_N = \begin{cases} 
(2 - \gamma - g - t)^2 V/18, & V \leq V_1 \\
(2 - \gamma - g)^2 V/18, & V > V_1
\end{cases}$$

(30)
With trade in know-how the know-how gap \( \gamma - g \) disappears so that consumer surplus becomes

\[
S_T = \begin{cases} 
(2 - 2g - t)^2V/18, & V \leq V_2 \\
4(1 - g)^2V/18, & V > V_2 
\end{cases}
\]  

The conditions for welfare gains from know-how trade are as follows:

- In small and large markets, \( V \leq V_1 \) or \( V > V_2 \):
  \[
  \gamma \geq g, 
  \]
  which is always satisfied since the marginal cost gap \( \gamma - g \) is strictly positive.

- In intermediate markets, \( V_1 < V \leq V_2 \), the condition for know-how trade to be welfare improving is that the welfare gain due to lower marginal cost to the domestic incumbent exceed the welfare loss resulting from the trading costs \( t \) of the international firm which now continues to supply the market through exports:
  \[
  \gamma - g > t 
  \]

The reason why \( t \) appears in the condition for intermediate markets but not in the condition for small and large markets is straightforward. While in small (large) markets the international firm chooses to serve the market through exports (local production), regardless of whether know-how is traded or not, in intermediate markets trade in know-how keeps the international firm from establishing a local production facility.

The welfare improvement condition (33) can be integrated with the conditions for know-how trade of figure 3. This leads to figure 4 from which we can see for which parameter constellations market-determined know-how trade leads to a welfare improvement. Figure 4a is based on high factor cost \( \gamma = .6 > 2/5 \) as figure 3, figure 4b reflects low factor cost \( \gamma = .2 < 2/5 \), in which case know-how is traded for all market sizes. In small and large markets, all parameter constellations in the admissible set \( OBEQ \) lead to a welfare improvement. In intermediate markets, the dashed line connecting points \( O \) and \( H \) and \( O \) and \( E \), respectively, in the two figures reflects inequality (33). Parameter constellations above that line lead to a welfare improvement in intermediate markets, points below indicate a deterioration.

"Problem areas" in the figure are those subsets of parameters where the market-determined allocation of know-how does not yield the welfare-optimal solution. First, there are those parameter constellations under which know-how is not traded although trade would lead to a welfare improvement. This problem occurs only in figure 4a: above line \( AF \) and to the left of line \( OE \) know-how in large markets and – for different market sizes – to the left of lines \( AC_2, AD \) and \( AC_1 \), respectively. Secondly, there are
Figure 4: Trade in Know-how and Welfare

- High factor prices (gamma=.6)

- Low factor prices (gamma=.2)
parameter constellations for which know-how is traded but welfare is reduced because the additional trading costs exceed the marginal cost gain. In both figures 4a and 4b this occurs only in intermediate markets below line OE and OH, respectively.

The following proposition summarizes the welfare results that we established so far:

**Proposition 4** If welfare is measured by the domestic consumer surplus, international know-how trade improves welfare for most, but not for all market sizes. This generates two kinds of inefficiencies: (i) In markets of all sizes, know-how trade may not take place although it would be welfare-improving. (ii) In markets of intermediate size know-how trade may lead to a deterioration of welfare because the (welfare-improving) cost reduction of the domestic incumbent is more than matched by the (welfare-reducing) cost increase of the international competitor who does not carry out the FDI but continues to supply the market through exports.

4.2 Consumer surplus and domestic profit

Now we incorporate the profit of the domestic incumbent in the domestic welfare measure in order to check to what extent the welfare results of the previous section only reflect a redistribution between domestic consumers and the domestic incumbent firm. The domestic incumbent's profit without and with know-how trade is given by

\[ \Pi = \begin{cases} (P_N - \gamma)^2V & , \ A < \bar{A} \\ (P_T - g)^2V - A & , \ A \geq \bar{A}, \end{cases} \]  

(34)

where \( P_N \) and \( P_T \), respectively, denote the equilibrium product price without and with know-how trade and \( A \) is the price actually paid for know-how. If know-how is not traded, we have \( A = 0 \). If know-how is traded, we know that \( A \) will be in the interval \([\bar{A}, \bar{A}]\) but the exact value has to be bargained for between the two players.

Using reservation prices, the increase in profit resulting from know-how trade can be written as follows. The incumbent's reservation price is, by definition, the price which makes him indifferent between buying and not buying the know-how. Using the notation in (34) we can therefore write

\[ A = (P_T - g)^2V - (P_N - \gamma)^2V. \]  

(35)

Thus the incumbent's profit increase from know-how trade is simply the difference between the maximal price he is willing to pay and the price that he actually pays:

\[ \Delta \Pi = \begin{cases} 0 & , \ A < \bar{A} \\ A - A & , \ A \geq \bar{A} \end{cases} \]  

(36)
If know-how is not traded, the welfare results based on the consumer surplus are obviously unchanged because the domestic profit – by definition – is unchanged. If know-how is traded, the change in the domestic incumbent’s profit will always be nonnegative. It will be zero in the extreme case where the international firm has the dominant bargaining position, in which case we have $A = A$. But the bigger the bargaining power of the domestic incumbent, the closer $A$ is to $\overline{A}$, and if the incumbent has the dominant position, we set $A = \overline{A}$. In general we can write $A = \beta A + (1 - \beta)\overline{A}$, where the free parameter $\beta \in [0, 1]$ measures the relative “bargaining power” of the domestic incumbent. With this notation, the domestic profit increase from know-how trade is equal to $\beta (A - \overline{A})$, where the term in parentheses measures the size of the “cake” – the total bargaining gain – which is distributed among the two opponents. Regarding $\beta$ – the relative size of the domestic incumbent’s “piece” of the cake – any value in the interval $[0, 1]$ is a priori possible. But in order to understand how the incorporation of domestic profits changes the results, it suffices to distinguish the following two stylized regimes.

For $\beta = 0$ the bargaining power of the domestic incumbent is nil and so is his share in the total bargaining gain $(A - \overline{A})$. In this case the only domestic welfare effects of know-how trade arise from changes in the consumer surplus, which is the case already discussed in the previous section.

For $\beta = 1$ the domestic incumbent reaps the total bargaining gain. This gain raises the domestic welfare gain from know-how trade. By implication, the results concerning small and large markets, in which know-how trade unequivocally leads to welfare gains as measured by the consumer surplus do not change. The results of the previous section will only change with respect to intermediate markets, where know-how trade may reduce the consumer surplus. At $V_1$, the lower end of intermediate market sizes, the total change of domestic welfare is

\[
\Delta S + \Delta \Pi = (2 - 2g - t)^2 \frac{V}{18} - (2 - \gamma - g)^2 \frac{V}{18} + A - \overline{A} = \left[ \frac{8\delta (1 - \gamma + t) + 3t^2 - 3\delta^2}{1 - \gamma - t + 2\delta} \right] \frac{F}{8t} > 0, \tag{37}
\]

where $\delta = \gamma - g$. The positive sign of (37) depends on the sign of the expression in brackets. Because of (18) its denominator is strictly positive. Its numerator is also positive, which is demonstrated by the following inequalities in conjunction with (16):

\[8\delta (1 - \gamma + t) + 3t^2 - 3\delta^2 > 8\delta (1 - \gamma + t) \quad \text{and} \quad 8\delta (1 - \gamma - \delta) + 8\delta t > 0\]

\[\text{The determination of the know-how price } A \text{ can be thought of as the solution of a generalized Nash bargaining game which maximizes the weighted product of the bargaining gains of the two players, } (A - \overline{A})^{1-\beta}(A - A)^\beta.\]
This shows that, for markets of intermediate size, domestic welfare increases from know-how trade for $\beta = 1$, while it may drop for $\beta = 0$. Since the domestic profit increase is continuous in $\beta$, this implies that there is a value of $\beta$ in the interior of the interval $(0,1)$ for which the welfare effect is zero.

We summarize our results on the welfare effects of know-how trade in

**Proposition 5** If welfare is measured by the sum of the domestic consumer surplus and the domestic incumbent's profit, international know-how trade increases welfare for all market sizes, provided that the bargaining power of the domestic incumbent is sufficiently high. If the incumbent's bargaining power is low, the results of proposition 4 continue to hold.
5 References


6 Technical appendix

6.1 Discontinuities in the domestic reservation price

The size of the jump of $A$ at $V_1$ is given by

$$\lim_{V_1 \downarrow V_1} A - \lim_{V_1 \uparrow V_1} A = \frac{t}{2} (1 + g - 2\gamma + t/2) > 0.$$  (38)

Using the parameter restrictions in section 2.5 we can write $1 - \gamma + t/2 > 1 - \gamma > \gamma - g$, which in turn implies the inequality in (38). The size of the drop at $V_2$ is given by

$$\lim_{V_2 \downarrow V_2} A - \lim_{V_2 \uparrow V_2} A = (t - 3 + 3\gamma)(\gamma - g) < 0.$$  (39)

The inequality follows from $\gamma > g$ and $3(1 - \gamma) > 1 - \gamma > t$.

6.2 Conditions for know-how trade

This section proves the graphical ranking $C_1 < D$. The proof for $D < C_2$ is similar. Note that these rankings are only relevant under the general condition $\gamma > 2/5$, as explained in the main body of the paper.

First we assume that we have $2/5 < \gamma < 1/2$ so that the upper limit for the marginal cost gap is $\gamma$. From inequality (25) we know that line $AD$ in figure 3 reaches this upper limit at

$$t = \frac{5\gamma - 2}{8}.$$  (40)

From inequality (27) we can compute that line $AC_1$ reaches the upper limit at

$$t = \sqrt{1 + 2\gamma + 9\gamma^2} - 1 - 2\gamma.$$  (41)

(40) and (41) coincide at $\gamma = 2/5$ and at $\gamma = 14/27 > 1/2$. In the interior of the interval $[2/5, 14/27]$, (40) exceeds (41) since (40) is linear and (41) is convex. This proves the ranking for $2/5 < \gamma < 1/2$.

Now we assume that we have $\gamma \geq 1/2$. Then the upper limit for the marginal cost gap is $1 - \gamma$. From inequalities (25) and (27), lines $AD$ and $AC_1$ in figure 3 reach this upper limit, at

$$t = \frac{1 - \gamma}{8}.$$  (42)

and, respectively,

$$t = (\sqrt{17} - 4)(1 - \gamma).$$  (43)

Basic arithmetic shows that (42) exceeds (43). This completes the proof.