Teaching locals new tricks: foreign experts as a channel of knowledge transfers

James R. Markusen
University of Colorado, Boulder
NBER and CEPR

Natalia Trofimenko
Kiel Institute for World Economics

Abstract

Gains from productivity and knowledge transmission arising from the presence of foreign firms have received a good deal of empirical attention, but theoretical micro-foundations for this mechanism are limited. Here we develop a dynamic model in which foreign experts may train domestic workers who work with them. Gains from training can in turn be decomposed into two types: (a) obtaining knowledge and skills at a lower cost than if they were self-learnt at home, (b) producing domestic skilled workers earlier in time than if the domestic economy had to rediscover the relevant knowledge through "reinventing the wheel." We use fixed effects and nearest neighbour matching estimators on a panel of plant-level data for Colombia that identifies the use of foreign experts, to show that these experts have substantial, although not always immediate, positive effects on the wages of domestic workers and on the value added per worker.

"I once asked a plumber who came to fix my water heater, and who did it in three minutes, how he dared to charge me eighty thousand lire for turning a little knob. He told me it had taken him twenty years to learn which knob to turn."

from "Wilful Behavior" , a novel by Donna Leon

"I wanted to work for a foreign company so I could learn from experts. My life would be much harder if I didn't have this job. Now I can think about the future. If I can afford it, I want to send my son to study overseas - maybe Australia or the United States."

Dang Thi Hai Yen, production manager at a Vietnamese factory sub-contracted by Nike, Inc.

James R. Markusen
Department of Economics
University of Colorado, Boulder
Boulder CO 80309-0256
james.markusen@colorado.edu
1 303 4920748 (voice) 1 303 4928960 (fax)

Natalia Trofimenko
Kiel Institute for World Economics
Düsternbrooker Weg 120
24105 Kiel Germany
natalia@trofimenko@ifw-kiel.de
49 431 8814-245 (voice) -502 (fax)

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1. Introduction

There now exists a well-developed empirical literature on the transmission of technical/managerial knowledge and productivity "spillovers" between countries and whether trade or investment is a more important channel of transmission (Keller 1998, 2002ab, Haskel and Slaughter 2002, Gong and Keller 2003, Javorcik and Spatareanu 2003 and Javorcik 2004).

In the latter vein of literature, several different ideas for the micro-foundations of the transmission mechanism have been proposed or modelled. Theoretical models have looked at linkages as a source of productivity spillovers, so that upstream and/or downstream firms benefit from the arrival of multinationals (Markusen and Venables, 1999). This has generally been in the form of variety effects from supporting an increased number of intermediate or final goods. Rodriguez-Clare (1996), for example, develops a model of how the multinationals can improve welfare by generating more linkages compared to the linkages that would be generated by the domestic firms they displace from the labor market. The second stream of theoretical analysis looks at workers or local firms learning from watching or working for foreign firms with a resulting increase in their productivity (Ethier and Markusen 1996, Fosfuri, Motta, and Rønde 2001, Markusen 2001, Glass and Saggi 2002). Empirical work in search of spillovers to local firms include Haddad and Harrison (1993), Aiken and Harrison and Lipsey (1996), Blomström and Kokko (1998), Blomström and Sjöholm (1999), Aitken and Harrison (1999), Blalock (2002), Javorcik and Spatareanu (2003) and Javorcik (2004). Other empirical literature has documented that local firms and their managers often get their start as employees of multinational firms (Katz 1987, Hobday 1995, Hall and Khan 2003).

Very little in this literature is directed at modelling the precise micro-mechanism of how foreign skilled workers impart those skills to domestic workers. To close this gap is the purpose of our paper. We focus on direct imports of the services of foreign experts as a method of both providing an important good or service and for training domestic workers faster and/or cheaper than they can learn on their own. We depart from the tradition of comparative steady-state analysis used in new growth theory, since we want to explicitly consider timing issues rather than merely steady-state levels and growth rates. For this reason, we use a very simple competitive constant-returns model with no spillovers, externalities, or other bells-and-whistles.

Firms and workers are initially identical in the model in period 1. In period 2, any/all firms can choose to hire foreign experts for one period. Due to the general-equilibrium structure of the model, there are ranges of parameters for which some firms do and some do not hire foreign experts. Workers in firms hiring foreign experts have a higher productivity in period 2 and (generally) in period 3. In period 4, productivity in firms not hiring foreign experts catches up to those that do.

The model solves for the wage profiles of workers in firms that use foreign experts and those that do not as a basis for our empirical section. In general, the model predicts that workers in firms with foreign experts should accept lower wages in period 2 in exchange for higher wages in period 3. However, if there are perfect spillovers to the other firms or if foreigners are just used to substitute for scarce skilled workers in period 2, this effect is not present; that is, there is not observed effect of foreign experts on the wages of those in firms with versus without foreign experts.

Our empirical section uses Colombian Manufacturing Surveys (1977-1991), where the use of foreign experts is identified in each period (if any) for each plant. The surveys contain a sample of 304 plants for which we observe three distinct stages – before employing any foreign experts, while foreign experts remain with the plant, and after they leave – and this information allows us to evaluate contemporaneous and posterior impact of the experts on the wages of skilled and unskilled workers and labor productivity. We find the impact to be large and positive (although not always immediate). However, the longer the plant postpones the decision to hire foreign experts, the smaller is the experts' contribution to the increased wages or productivity.

Perhaps the most important challenge to our analysis is that the decision to hire a foreign expert is non-random, and the factors that enter into this decision are likely to have an element of personal choice on behalf of the plant's manager and are not directly observable. Plant fixed-effects and nearest neighbor matching estimators are used to overcome this problem. In the former we include plant fixed effects to remove the impact of any time-invariant characteristics and find that the use of foreign experts increases the wages of skilled workers and value added per worker by about 11 percent in the post-expert period. In the latter we use a number of observable plant characteristics to pair the plants employing foreign experts with similar plants who don't and find that the use of foreign experts raises wages of unskilled and skilled workers by 5 and 6 percent respectively in the post-expert period. The impact on the value added per worker is approximately 8 percent and is present in both contemporaneous and post-expert periods.

2. The four-period model

Our model is a competitive, perfect-foresight Arrow-Debreu style general-equilibrium model. There are four time periods, which deserves some comment. The first period is to establish a "before" wage for skilled workers. Foreign experts can be used in the second period. Two "after" periods are used in order to focus on the timing effects of using foreign experts. Workers in firms that use foreign experts at t = 2 get a productivity boost in period 3, while workers that don't catch up to the former in period 4[1]. The following outlines the model.

(a) There are four time periods

(b) There are two goods, X and Y; both sectors competitive, constant returns to scale

(c) There are two factors, R and a (initially) homogeneous supply of unskilled labor L

(d) Y is produced from a sector-specific factor R and unskilled labor L

(e) X is produced using labor that grows in productivity over time through learning-by-doing. X is non-traded.

(f) Foreign experts may also be used in X production in period 2 working with domestic labor in fixed proportions.

(g) Learning by X sector workers is embodied in the workers and is sector specific.

Let subscript t denote time period. Y_t is produced from R_t, and L_t:

$$Y_t = Y(R_t, L_{yt}) \tag{1}$$

The role of R is to add convexity to the model: unskilled workers going to train must be drawn from the Y sector at increasing cost in terms of Y.

At time t = 1, there is a once-and-for all division of the homogeneous labor supply L_1 into Y sector workers and X sector workers. With homogeneity and perfect foresight, all workers earn the same present value of wages over the four time periods.

[1] "Firms" are not well defined in such a model, but we will use that term rather than talk about production activities, which would probably be more elegant.

$$L_1 = L_y + L_x \tag{2}$$

In period 1, X sector workers produce output according to the simple relationship

$$X_1 = \pi_1 L_x \tag{3}$$

where π is a measure of productivity. At t = 2, there can exist either or both of two firm types (more correctly, there are two production activities), one that uses only domestic workers (type-d) and one that uses foreign experts, *F*, (type-f) working with domestic workers, where the total number of domestic workers is the number given by L_x in (2) and (3).

$$X_{d2} = \pi_{d2} L_d \qquad X_{f2} = \pi_{f2} \min\lfloor L_f, \alpha F \rfloor \qquad L_x = L_d + L_f \qquad \pi_{d2} < \pi_{f2} \tag{4}$$

where α is just a scaling parameter (the number of domestic workers per foreign worker) that plays little role in our analysis. Outputs from the two firm types are homogeneous.

Workers who work with foreign experts may learn more, and this is then reflected in period 3 outputs.

$$X_{d3} = \pi_d L_d \qquad X_{f3} = \pi_{f3} L_f \qquad \pi_{d3} \le \pi_{f3} \tag{5}$$

The special case where $\pi_{d3} = \pi_{f3}$ has two interpretations. The first is that foreign experts simply relieve a labor shortage and allow more output to be produced at t = 2 while domestic workers learn by doing. There is no lasting effect on the workers who work with the foreign experts relative to those that don’t. They are just substitutes for scarce, or still not very productive, domestic workers. The second interpretation is that there is a perfect spillover of learning to workers in type-d firms and this cannot be internalized by market charges (in other words, we are *defining* a perfect spillover as $\pi_{d3} = \pi_{f3}$ if type-f firms are present, $\pi_{d3} < \pi_{f3}$ if they are not. More on this later.

It seems cheap to just assume that foreign experts have a permanent effect on the domestic workers they are paired with, so we assume that all X sector workers have the same productivity in period 4.

$$X_{d4} = \pi_{d4} L_d \qquad X_{f4} = \pi_{f4} L_f \qquad \pi_{d4} = \pi_{f4} \tag{6}$$

This assumes that the domestic workers would eventually have figured out which nob to turn. Foreign experts allow more or *cheaper* X production early on ($\pi_{d2} < \pi_{f2}$), and *quicken* the learning process of domestic workers if $\pi_{d3} < \pi_{f3}$ or if there are spillovers.

Foreign experts can be hired for a fixed price p_{fr} in terms of good Y (X is non-traded as noted earlier). In a partial-equilibrium model with fixed factor prices, only one of the two activities to produce X at t = 2 in (4) would be active: either all domestic workers would work with a foreign expert or no foreign experts would be hired. But in our general-equilibrium model, hiring foreign experts is increasing costly in terms of foregone consumption, and so there are a range of values of p_{fr}, given values of other parameters, such that there can co-exist both type-d and type-f firms in period 2. We are going to concentrate on this range, since it provides an interesting comparison of the wage paths of workers in the type-d and type-f firms.

Finally, we assume a positive rate of time preference in consumption, equal to a world rate of interest. The country can pay for its foreign experts at t = 2 by selling Y in any period, borrowing or lending at this interest rate. We have run the model assuming experts must be paid with Y_2 (no international borrowing or lending), and found that this makes no qualitative difference.

While the model seems conceptually simple, it involves a large number of dimensions: inequalities/equations and unknowns. Secondly, which relationships hold with equality and which are slack is determined in equilibrium. Together these two features make many of the analytical tools of traditional comparative-statics analysis of little value. Thus we will solve the model numerically. Each weak inequality is associated with a complementary non-negative variable, so the model is formally called a non-linear complementarity problem.

The model conceptually decomposes into three sets of relationships:

(a) Zero-profit inequalities for all production activities, including the “production” of utility from inputs of X and Y; complementary variables are activity levels (quantities).

(b) Market-clearing inequalities for all “commodities”, which is a general name for goods, factor, and utility (utility is modeled as produced and then purchased by the representative consumer). “Foreign exchange” is a commodity that is earned by exporting Y in one or more periods and is used to buy experts.

(c) An income-balance equation for the representative consumer.

The entire model is 56 weak inequalities in 56 unknowns. This is presented in the next section which can be skimmed or even skipped with (we hope) little loss of continuity.

3. The full model: inequalities and unknowns (may be skipped)

Notation is as follows, where prices are measured in real or utility terms (numeraire is the price of buying one unit of intertemporal utility:

Y_i , p_{yi} quantity and price of good Y at time t = i

R_i , p_{ri} quantity and price of Y-sector-specific factor R at time t = i

L_1 , p_{l1} quantity and asset price (not rental price) of unskilled labor L at time t = 1[2]

U_i , p_{ui} quantity and (rental) price of unskilled labor U at time t = i

S_1 , p_{s1} quantity and (rental) price of X sector (skilled) labor S at time t = 1

S_{di} , p_{di} quantity and (rental) price of X sector (skilled) labor S at time t = i who do not work with foreign experts at t = 2 (i = 2,3,4)

S_{fi} , p_{fi} quantity and (rental) price of X sector (skilled) labor S at time t = i who work with foreign experts at t = 2 (i = 2,3,4)

F , p_{fr} quantity and price of foreign experts F at time t = 2

E_i , p_e quantity of "foreign exchange" at time t = i, price of foreign exchange at t=1.

X_1 , p_{xi} quantity and price of good X at time t = i

X_{di} , p_{xi} quantity and price of good X at time t = i (i=2,3,4) produced by workers who have not worked with foreign experts

X_{f1} , p_{xi} quantity and price of good X at time t = i (i=2.3.4) produced by workers who are working with or have worked with foreign experts

Factors R_i and L_1 are fixed quantities. E is an artificial good: Y can be exchanged (exported) for E and E can then be exchanged for imported foreign experts F. With borrowing and lending allowed, E carries no subscript and thus exports of Y in any period can be exchanged for foreign experts in any period at the world interest rate, denoted ρ.

[2] Analogous to the price of a unit of capital, p_{11} is the present value at t=1 of a unit of unskilled labor. p_{ui}, following line, is the single period rental price of unskilled labor at t=i.

A key parameter in the model is *cost*, which is the number of units of Y that must be exchanged for one for expert. Higher levels of *cost* are bad.

Convexity in the model comes from the fixed factor R in the Y sector, which is assumed Cobb-Douglas in the simulations: labor is drawn into training and X production at increasing cost in terms of Y, with $c_{yi}(p_{ui}, p_{ri})$ denoting the unit cost function for Y_i.

Utility or welfare is treated as a produced good. The flow of utility in period i and the price of obtaining a unit of utility is

W_i , p_{wi}	quantity and price of welfare at t = i
W, p_w	quantity and price of intertemporal utility

The price of utility in period i and overall are given by standard cost or unit expenditure functions, denoted $c_{wi}(p_{yi}, p_{xi})$ and $c_w(p_{w1}, p_{w2}, p_{w3}, p_{w4})$ respectively. A CES with an elasticity of substitution greater than one is assumed in these functions (a value of 2 is used in the simulations within and between periods) and future consumption is discounted at rate ρ.

Here is the full model. Commodity and factor demands are found by the application of Shepard's lemma to cost and expenditure functions.

Zero-profit Inequality	Complementary variable	Description
$c_{yi}(p_{ui}, p_{ri}) \geq p_{yi}$	Y_i	Production activity Y_i
$p_{l1} \geq p_{u1} + p_{u2} + p_{u3} + p_{u4}$	U	Unskilled labor supply to Y_i
$p_{l1} \geq p_{s1} + p_{d2} + p_{d3} + p_{d4}$	S_d	Unskilled labor supply to X (working without foreign experts)
$p_{l1} \geq p_{s1} + p_{d2} + p_{d3} + p_{d4}$	S_f	Unskilled labor supply to X (working with foreign experts)

$p_{s1} \geq \pi_1 p_{x1}$	X_1	X_1 production
$p_{di} \geq \pi_{di} p_{xi}$	X_{di}	Production activity for X_{di} (i = 2,3,4)
$p_{f2} + p_{fr} \geq \pi_{f2} p_{x2}$	X_{f2}	Production activity for X_{f2}
$p_{fi} \geq \pi_{fi} p_{x1}$	X_{fi}	Production activity for X_{fi} (i = 3,4)
$p_e * \text{cost} \geq p_f$	F	Imports of experts at t = 2
$p_{yi} * (1+\rho)^{2-i} \geq p_e$	EY_i	Exports of Y at t = i
$c_{wi}(p_{yi}, p_{xi}) \geq p_{wi}$	W_i	Sub-welfare at t = i
$c_w(p_{w1}, p_{w2}, p_{w3}, p_{w4}) \geq p_w$	W	Total (present value) of welfare

The next set of inequalities are market clearing conditions for each of the goods, factors, and trade activities. The complementary variables are prices of these quantity variables. Inequalities are written as supply greater than or equal to demand, where a strictly greater-than relationship implies that the price is zero (a free good) in equilibrium. Demands for goods/factors exploit Shephard's lemma in activities Y_i and W_i where there is variable substitution among inputs.

Market-clearing inequality	Complementary variable	Description
$Y_i \geq \frac{\partial c_{wi}}{\partial p_{yi}} W_i + EY_i$	p_{yi}	Supply - demand for Y_i
$U \geq \frac{\partial c_{yi}}{\partial p_{ui}} Y_i$	p_{ui}	Supply - demand for U_i
$R_i \geq \frac{\partial c_{yi}}{\partial p_{ri}} Y_i$	p_{ri}	Supply - demand for R_i
$L_1 \geq U + S_d + S_f$	p_{l1}	Supply - demand for L_1

$S_d + S_f \geq X_1 / \pi_1$	p_{s1}	Supply - demand for S_1
$S_d \geq X_{di} / \pi_{di}$	p_{di}	Supply - demand for SD_2 (i=2,3,4)
$S_f \geq X_{fi} / \pi_{fi}$	p_{fi}	Supply - demand for SF_i (i=2,3,4)
$F / \alpha \geq X_{f2} / \pi_{f2}$	p_{fr}	Supply - demand for F
$X_1 \geq \frac{\partial c_{w1}}{\partial p_{x1}} W_1$	p_{x1}	Supply - demand fo X_1
$X_{di} + X_{fi} \geq \frac{\partial c_{wi}}{\partial p_{xi}} W_i$	p_{xi}	Supply - demand for X_i (i=2,3,4)
$W_i \geq \frac{\partial c_w}{\partial p_{wi}} W$	p_{wi}	Supply - demand for W_i
$W \geq I / p_w$	p_w	Supply - demand for W
$\sum EY_i (1+\rho)^{-i+2} \geq \text{cost} * F$	p_e	Supply - demand for forgn. exchange

Income balance equation	Complementary Variable	Description
$I = p_{l1} L_1 + \sum p_{ri} R_i$	I	Income balance, rep consumer

In all, the model then consists of 53 inequalities in 53 unknowns. One equation is redundant by Walras' Law, so the price of a unit of welfare, p_w is used as numeraire and the corresponding equation is dropped from the model. The model is coded in Rutherford's MPS/GE, a subsystem of GAMS and solve using the non-linear complementarity solver in GAMS.

4. Results

We have run countless simulations of the model, altering the basic structure and parameter values to see what qualitative and quantitative conclusions emerge. We will present a very sparse set of outcomes here, but we feel that these are generally representative and robust to wide ranges in parameter values and to minor changes in model specification.

We do concentrate on parameter values such that the solution to the model has both typed and type-f firms active in equilibrium. This puts some restrictions on the π's and on the *cost* parameter, where *cost* is the amount of Y that must be exchanged for a foreign expert as discussed in the previous section. For higher values of *cost*, for example, only type-d firms operate in equilibrium and only type-f for much lower values. The following are the productivity parameters for our first simulation.

$\pi_1 = 0.5$ $\pi_{d2} = 0.7$ $\pi_{d3} = 0.8$ $\pi_{d4} = 1.2$

$\pi_1 = 0.5$ $\pi_{f2} = 1.0$ $\pi_{f3} = 1.0$ $\pi_{f4} = 1.2$

These are rather arbitrary indeed. Given equal productivities at t = 1 and t = 4, many simulations show that the important feature of this is that $\pi_{d3} < \pi_{f3}$. Workers who worked with foreign experts at t = 2 have an advantage over workers who didn't at t = 3. This is very important in determining the qualitative nature of the solution, as we shall see. Productivity differences at t = 2 are not so important.

Figures 1 and 2 give a solution to this model for a value of *cost* that supports both firm types in equilibrium. Figure 1 shows the time path of wages for unskilled Y-sector workers (PU), X sector workers in type-d firms (PD) and X sector workers in type-f firms (PF). Given the competitive assumptions of the model and the initial homogeneity of labor, all workers earn the same present value of earnings over the four time periods. Type-d and type-f workers have the same productivity in period 4, type-d workers "catch up", so they must have the same competitive wage at t = 4 as shown. Type-f workers have a higher productivity at t = 3, and hence they earn more than type-d workers at t = 3. This in turn is compensated for by workers in type-f firms having to accept a lower wage at t = 2. Both types of X-sector workers earn less in periods 1 and 2 than Y-sector workers in compensation for higher earnings later on.

Figure 1 offers several empirical predictions about what we might see in the data. Most useful is the comparison between the firms that use foreign experts and those that don't (recall that all firms are ex ante identical in our model, so by assumption there is no firm-level heterogeneity).[3] We observe before, during and after periods for the foreign experts in Figure 1, just as we can in our empirical section to follow. One result from Figure 1 is that wages in the "during" period t = 2 are predicted to be lower for firms that use foreign experts, in compensation for building the human capital of the workers later. Second, wages are predicted to be higher in the "after" period t = 3 in the firms that use foreign experts. We will test these predictions in our empirical section.

Figure 2 shows real consumption profiles for our simulated economy, and then also computes the profile with no foreign experts allowed. Here we see that the use of foreign experts allows higher consumption in periods 2 and 3, the "learning on the quick" idea in terms of consumption. Gains from trade are taken in the form of higher consumption in earlier periods.

It is interesting and important to note, that the no-experts results in Figure 2 also occurs if we switch the assumptions to allow for perfect spillovers to the firms that do not use foreign experts. This is computed by raising π_{d3} from 0.8 to $\pi_{d3} = 1.0 = \pi_{f3}$ if foreign experts are used (type-f firms are active) but holding it at 0.8 otherwise. The effect of this, for the value of *cost* and other parameters used, is that it is not profitable for type-f firms to enter, and thus the existence of the spillovers blocks the beneficial effects that foreign experts might bring. It is often

[3] We shall relax the assumption of homogeneous firms in our empirical analyses.

forgotten in discussions about the beneficial effects of spillovers that these are market failures, and the inability to internalize this positive externality can mean that the economy is worse off. That is precisely what happens in this particular case: the lack of “property rights” prevents the use of foreign experts and their beneficial effect is lost.

Figures 3 and 4 compute a second interesting case by raising the value of π_{d3} to 1.0 as just considered but by also lowering *cost* so that foreign experts will be used. Productivity parameters are now:

$\pi_1 = 0.5$ $\quad\pi_{d2} = 0.7$ $\quad\pi_{d3} = 1.0$ $\quad\pi_{d4} = 1.2$

$\pi_1 = 0.5$ $\quad\pi_{f2} = 1.0$ $\quad\pi_{f3} = 1.0$ $\quad\pi_{f4} = 1.2$

As suggested above, this case has two interpretations. First, the foreign experts just have a temporary effect, they are like having additional workers around in an environment where skilled workers are scarce. Once they go, productivity returns to the same level for all skilled workers. Second, there is a perfect spillover to workers who have not worked with foreign experts in period 3 (but caution, $\pi_{d3} = 1.0$ if foreign experts are present in period 2, it is 0.8 otherwise).

With the lower value of *cost* relative to that in Figures 1-2, foreign experts are used in the simulation of Figures 3-4. The wage path shown in Figure 3 is interesting and important. The wage profile is identical for workers in both type-f and type-d firms. In general equilibrium, wages for both types of skilled workers must be the same in periods 1,3,4, and so must be the same in period 2 as well. The difference in productivity between the type-d and type-f workers at t = 2 is exactly the payment to the foreign experts when both firm types exist in equilibrium.

The importance of this result lies in its implications for empirical work that tries to discern the productivity benefits from foreign experts by comparing firms that do and do not use these experts. In the present case, we would detect no difference in the data, yet under the spillovers interpretation, the economy is certainly getting a productivity boost from the foreign experts. Somewhat ironically, the existence of spillovers may prevent the researcher from discovering the benefits of foreign workers.

Figure 4 presents three consumption profiles. The one denoted “equilibrium” corresponds to the results in Figure 3. Then we assume that this is a case of perfect spillovers, and compute the counterfactual of no spillovers, lowering π_{d3} to 0.8 regardless of whether or not foreign experts are present. The difference between these two is interesting and instructive. The elimination of spillovers leads to more foreign experts being hired at t = 2, and so consumption is higher at t= 2 without spillovers. As emphasized above, the existence of non-internalized positive externality may mean less, not more, following the general-equilibrium response of firms. But the productivity gained by workers in type-d firms in period 3 leads to a higher consumption level with spillovers at t = 3 and t = 4. The overall effect on intertemporal welfare is slightly higher with spillovers in this case (not shown), but we cannot feel confident that this is a general result, and such a general result is certainly not suggested by general theory (recall in the previous simulation that introducing spillovers unambiguously decrease welfare).

The dashed line in Figure 4 plots the consumption profile when foreign experts are banned. Unlike the case of Figure 2, this is not the same as that with spillovers, since in the present case foreign experts are used in spite of the spillover. This curve “no F” is identical to that in Figure 2, and is reproduced just for comparison. Again, we see that the effect of foreign experts is to increase consumption in the middle periods, raising welfare quicker than without their services.

Before continuing, we might note that there are surely institutional constraints which may lead to difference wage paths even if our model is an otherwise good representation of reality. In particular, it may not be possible for firms to pay (competitive equilibrium) low wages in early periods in exchange for higher ones later. There are all sorts of reasons why this could be true, ranging from minimum wages, to industry-wide wage setting (requiring common wages in typed and type-f firms) to an imperfect ability to predict future productivity, and so forth.

Of course, in a world of complete and enforceable contracts, this is not a problem: higher earlier wages may be absorbed by lower later wages relative to the paths shown in Figures 1 and 3. Note that in our model, type-f workers are indifferent between either the PD or PF wage profiles. While this is fine in theory, it will of course confound the empirical analysis since, as in the case of Figure 3, there will be little measurable difference between workers in type-f and type-d firms. This could be wrongly interpreted as the foreign experts having no effect.

As a point of theory, having to pay higher wages early on in exchange for lower wages later leads to precisely the type of hold-up problem in later periods that has been the subject of much interest in the offshoring/outsourcing literature (see for example Ethier and Markusen (1996), Fosfuri, Motta, and Rønde (2001), Markusen (2001), Antrás (2002, 2003), and Glass and Saggi (2002)). While this is a very interesting issue, it is unfortunately beyond the scope of the present paper. But the empirical caveat of the previous paragraph must be noted.

With the results of Figures 1 and 3 in mind, we now turn to an empirical analysis.

5. Empirical Analysis

Our theory model is primarily focused on the *timing* of learning and productivity increases, since firms go to the same productivity values in the long-run regardless of whether or not foreign experts are used. The latter allow the accumulation of skills *cheaper* and especially *earlier*. This is not an easy thing to test empirically, at least with available data that we are aware of. Further, the competitive labor-market assumption means that all workers share in the benefits, not just those who work directly with the foreign experts.

We are able to test the hypothesis that foreign experts visiting local plants share their knowledge and improve the plant's productivity. As a data source we employ plant level data from the the Annual Manufacturing Survey (1977 – 1991) collected by Colombia's Departamento Administrative Nacional de Estadistica (DANE). AMS data covers all establishments employing ten or more workers and, among other things, reports values of production, domestic and foreign sales, imported and domestically purchased intermediate inputs, wage bills by skill category, capital stocks, ownership, taxes and subsidies. Roberts and Tybout (1996) provide a more comprehensive description of the data. There are several advantages using these data. First, the plants report directly the number of foreign experts employed in a given period. Secondly, the panel nature of the data allows us to discern the within-plant changes in productivity resulting from the assistance from foreign experts. Thirdly, these statistics can be supplemented by the interviews of the plant managers covering the same time frame to provide more detail on the learning process (Morawetz, 1981; Berry and Escandon, 1994).

We start by comparing the profiles of 715 plants who report having employed foreign experts at least once during the period in question with the plants who have never done so. To these means, we run a series of regressions, in which plant characteristics are regressed on the dummy variable indicating whether the plant has employed any foreign experts during at least one period over the 1977-1991 span, plant size and a set of industry, year and region fixed effects. The findings from these regressions are presented in Table 1. The reported coefficients can be interpreted as percentage difference between the two types of plants. Irrespective of whether size is added as an additional covariate, the firms opting for the help from foreign expert are more capital and skilled labor intensive, import a higher share of raw materials, and export a higher share of their output. Their workers are more productive (measured by value added per worker or sales per worker) and are better paid irrespective of the skill level.

To truly exploit the panel nature of the data, for the rest of the analysis we restrict our sample to 304 plants, which we observe during three distinct stages – before employing any foreign experts, while foreign experts remain with the plant and after they leave.

To discern how foreign experts affect productivity, we estimate variations of the following wage equation:

(1) $\ln(w)_{ijkt} = \alpha_0 + \alpha_1 During_{ijkt} + \alpha_2 After_{ijkt} + \delta Z_{ijkt} + Ind_j + Time_t + Area_k + \varepsilon_{ijkt}$

The subscripts *i*, *j*, *k*, and *t* denote plant, industry, region and time. Our dependent variable is the natural logarithms of real wages for skilled and unskilled workers. We have selected these variables on the supposition that wages are sufficiently correlated with the workers' marginal productivity. In fact, Verner (1999) finds that wages do not keep pace with productivity gains, a finding that suggests that, if anything, we underestimate the effect of foreign experts on the productivity of local workers. However, we also repeat the analysis using value added per worker as the measure of worker productivity (see Cahuc et al. (2002) for discussion against the use of output per worker).

Our main independent variables are indicators for whether the plant is currently employing foreign experts ("During") or has employed them in the past ("After"). The omitted category is the period prior to the employment of foreign experts. The coefficient on the variable "During" can be potentially interpreted as the immediate impact of experts on productivity, since more than half of the plants report only one period in which they employ a foreign expert.

Drawing on the literature on firm-level determinants of wages, our vector of additional controls, *Z*, includes total labor force, skill intensity, capital intensity, share of imported raw materials (on the assumption that plants investing in imported and better quality raw materials are also the ones seeking out higher quality workers), and regional wages to reflect opportunity costs. Following the literature on rent sharing and efficiency wages, we also include plant's market share and sales per worker. All specifications include industry, year and region fixed effects. We also experiment with other covariates, such as unemployment rates (to reflect opportunity costs), industry protection measures, industry growth rates, and Herfindahl index of industry concentration (on the assumption that the increasing degree of competition may raise the effort level that the managers must exert to remain viable and will motivate them to turn to outside sources). None of these factors is found to be important in the determination of wages or value added per worker in our sample. Given a relatively small sample size, we choose a more parsimonious specification and do not include these variables. To account for general forms of heteroskedasticity and serial correlation in the error term, we compute robust standard errors clustered by plant.

We gather a general idea of the impact of foreign experts on domestic workers by considering a specification in which we control only for industry, year and region effects. As shown in Table 2, the percentage increase in wages and value added per worker relative to the period prior to the employment of foreign experts is positive and significant. The wages increase by approximately 8 percent. This increase is immediate (as evidenced by the positive coefficient on the variable "During") and is retained after the foreign experts leave. The instantaneous increase in the value added per worker is a walloping 19 percent, which remains at a high 7 percent after the expert leaves the plant.

Apart from the coefficient on the "During" variable in the specifications with wages for skilled workers and value added per worker, the inclusion of additional controls does not change much either the magnitude or the significance level of the impact of foreign experts on productivity. Table 3 shows that after the foreign expert leaves the plant, workers' wages are 5.3-7.3 percent and value added per worker is 8.5 percent higher than during the period prior to the visit by the foreign expert.

One may wonder whether the "intensity of the treatment" matters, i.e. whether the number of employed foreign experts or the time they spend at the local plant matters for the productivity gains. Unfortunately, there is not much variation in the data to test the first hypothesis: of all non-zero values for the number of foreign experts, 85% report only 1 expert present. Similar problem arises when we look at the number of periods with non-zero values for foreign experts – half of the plants invite a foreign expert for only one period.

As an alternative to using the number of periods the expert stays at the plant as a continuous independent variable, in panels A and B of Table 4 we report the findings from the analyses conducted separately for two types of plants: those who invite an expert only once and those keep the experts for a longer time. The plants that invite an expert for only one period experience a 12 percent jump in value added per worker. The wages of unskilled workers increase by 8 percent after the expert leaves. Such pattern appears to be consistent with the situation in which an expert is invited to fix (or set up) equipment or give recommendations regarding product design, rather than for on-going training.

The results reported in Panel B for the subset of the plants welcoming foreign experts on a more consistent basis indicate that the benefits may be cumulative: the productivity starts increasing while the expert is still at the plant (although we can no longer interpret this jump as instantaneous) but the gain is at its highest after the expert leaves. This pattern appears to be consistent with the theory of on-the-job training, which requires a longer interaction period and generates more permanent productivity gains.

Perhaps the most important challenge to our empirical analysis is that the decision to hire a foreign expert is non-random, and the factors that enter into this decision are likely to have an element of personal choice on behalf of the plant's manager and are not directly observable. The same factors may also be affecting the productivity of local workers. Plant fixed-effects and nearest neighbor matching estimators are used to overcome this problem.

In the former we include plant fixed effects to remove the impact of any time-invariant characteristics. Here we rely solely on the within-plant variation to identify the effect of foreign experts on the productivity of various types of workers. The inclusion of the fixed effects in Table 5 dampens the impact of foreign experts on all three measures of productivity. The impact remains statistically significant (and surprisingly unchanged in magnitude) only in the specification for skilled workers. The loss of statistical significance is not surprising given that the fixed effects along with year dummies absorb most of the variation in the data. Limiting the sample to those plants that have employed foreign experts for longer than one period, bounces both the magnitude and the significance of the coefficients up to the levels observed in the OLS specifications. Both value added per worker and the wages of skilled workers increase by approximately 11 percent after the visit by foreign experts. The wages of both skilled and unskilled workers increase by approximately 3-5 percent during the visit by foreign experts, however this increase is not statistically significant. The increase in the value added per worker during the visit by foreign experts is 8 percent and is significant at 5 percent level, which is perfectly consistent with the finding by other authors that wages do not keep pace with labor productivity gains.

To assess the validity of our findings, we also employ propensity score matching and construct a counterfactual for the wages and productivity outcomes that the plant would have had, had it not hired any foreign experts (see Arnold and Javorcik (2005) for an application of the propensity score matching to the analysis of the knowledge transfer). We do so by paring up each plant with foreign experts with a very similar plant employing only domestic workers based on a number of "pre-treatment" – i.e. "prior to employment of foreign experts" – characteristics.

These characteristics include the plant's total employment, capital intensity, profitability (sales per worker), share of imported raw materials, market share, industry, and location. To reduce the dimensionality problem when considering differences on more than one observable characteristic, these characteristics are summarized into a single scalar (propensity score) reflecting the probability of a plant to use foreign experts (the results from the logit estimation are reported in Table 6). A plant without foreign experts but with a similar propensity score as a plant with foreign experts will then be used as the missing counterfactual. The success of the propensity score matching is confirmed in Table 7, where one can see that the matched firms display considerable homogeneity as opposed to the stark differences we observe in the unmatched sample.

In Table 8 we repeat the fixed effects estimation of the effect of foreign experts on the wages of skilled and unskilled workers and the value added per worker on the matched and the unmatched samples. This effect, as in previous analyses, is captured by the contemporaneous dummy "During" and the dummy for the post-treatment period "After." There is a considerable difference in the estimation results for the whole sample and the matched sample. The effects estimated based on the whole sample are almost always larger and more significant than for the matched sample. This illustrates the potential problem that the estimation on the full sample suffers from endogeneity bias which leads to an overstatement of the causal effect of foreign experts on wages and productivity. Taking the estimates in Table 8 at face value, our findings for the matched sample indicate that foreign experts raise wages of unskilled and skilled workers by 5 and 6 percent respectively in the post-expert period. The impact on the value added per worker by approximately 8 percent and is present in both contemporaneous and post-expert periods. The matching method thus confirms our finding that the use of foreign experts exerts positive effect on the workers' wages and productivity.

As noted earlier, our theory model is focused on the timing issue: obtaining skills earlier in time through the use of foreign experts. This is not easy to test, but we think that we make some progress using the approach shown in Table 9. The sample is again plants that have before, during and after periods for use of foreign experts within the sample period. The dependent variable is the log of post-expert wages or value added minus the log of pre-expert wages or value added. Two new regressors are used instead of the “during” and “after” dummies. The first is the “waiting time”, defined as the number of periods the plant waited before hiring an expert (this is time-invariant and so precludes using plant fixed effects). The second is the pre-expert level of the (log) of skilled wages, unskilled wages, or value added per worker corresponding the dependent variable.

Results in Table 9 indicate significant, negative effects of waiting time on changes in wages (effects on values added per worker are economically small and statistically insignificant). This is at least consistent with our theory, which is that workers eventually but slowly learn on their own. Thus the longer the waiting time before using the foreign experts, the less is the their contribution to increased wages. Adding the pre-expert *level* of wages or value as a regressor in the three right-hand regressions of Table 9 cuts the effect of waiting time in half in the two wage regression, but it remain statistically significant at the 10% level. Since we cannot observe the origin/entry date of most firms (sample starts in 1977), the pre-expert level of wages may itself be a reasonable proxy for experience and learning accumulated up to the beginning of the sample period (industry and region fixed effects are used). To the extent that this interpretation is valid, then the negative effects of the pre-expert wage (or value added) level in all three regressions is again consistent with the model: if the higher initial wage or value added per worker indicates a higher level of earlier skill accumulation, then a negative coefficient is expected. The fact that these coefficients are all less than one indicates that the higher initial wage reduces but does not eliminate the contribution of the foreign experts.

Our analysis supports the general predictions of the theory that we are able to test with the available data. The exception is that we do *not* find a negative effect on the workers' wages during the period(s) in which foreign experts are present at the plant. Recall that domestic workers should be willing to accept temporarily lower wages in exchange for higher ones later, once the training has taken place. It is the case that in the fixed-effects (Table 5) and matching (Table 8) regressions, the "during" coefficients on wages are statistically insignificant and half the size of the "after" coefficients on skilled wages. It is also the case that in these regressions, the "during" point estimates on wages are about half the size of the "during" coefficient on value added. We thus feel that the estimates do not stray too far from the theoretical predictions. As discussed in the theory section, minimum wage requirements, industry-wide wage setting, imperfect ability to predict future wages as well as trade unions may help explain the lack of empirical evidence for this theoretical prediction.

Finally, the results are consistent with the version of the model in Figures 1-2 where there are no spillovers and where the productivity advantage persists after the experts leave. Alternatively, the findings are not consistent with perfects spillovers and/or a result that foreigners are simply "filling in" for scarce domestic workers (Figures 3-4).

6. Conclusions

This paper provides theoretical micro-foundations for the mechanism of knowledge transfer, a phenomenon much studied empirically but lacking theoretical underpinnings. It develops a dynamic model in which knowledge is transmitted through one specific channel – the foreign experts visiting the local plant and training its workers. The use of foreign experts allows the accumulation of skills at a lower cost than if they were self-learnt at home and earlier in time than if the domestic economy had to rediscover the relevant knowledge through "reinventing the wheel." Our model has a number of empirical implications for the wages of skilled and unskilled domestic workers and their productivity, some of which we are able to test with the data from Colombia. Specifically, we use fixed effects and nearest neighbour matching estimators on a panel of plant-level data that identifies the use of foreign experts and show that these experts have substantial, although not always immediate, positive effects on the wages of domestic workers and on the value added per worker. We are also able to shed some light on the timing issue and find that the longer the plant postpones the decision to hire foreign experts, the smaller their contribution to the improved wage and productivity profiles.

By and large, the empirical results are consistent with the theory. Although the expected negative "during" effect on wages is positive, it is insignificant and much smaller than the "after" effect as predicted. Results are consistent with the no-spillovers version of the model, and with foreigners generating lasting productivity effects rather than just serving as "temporary help" when domestic skills are poor.

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Figure 1: Wage profiles - no spillovers

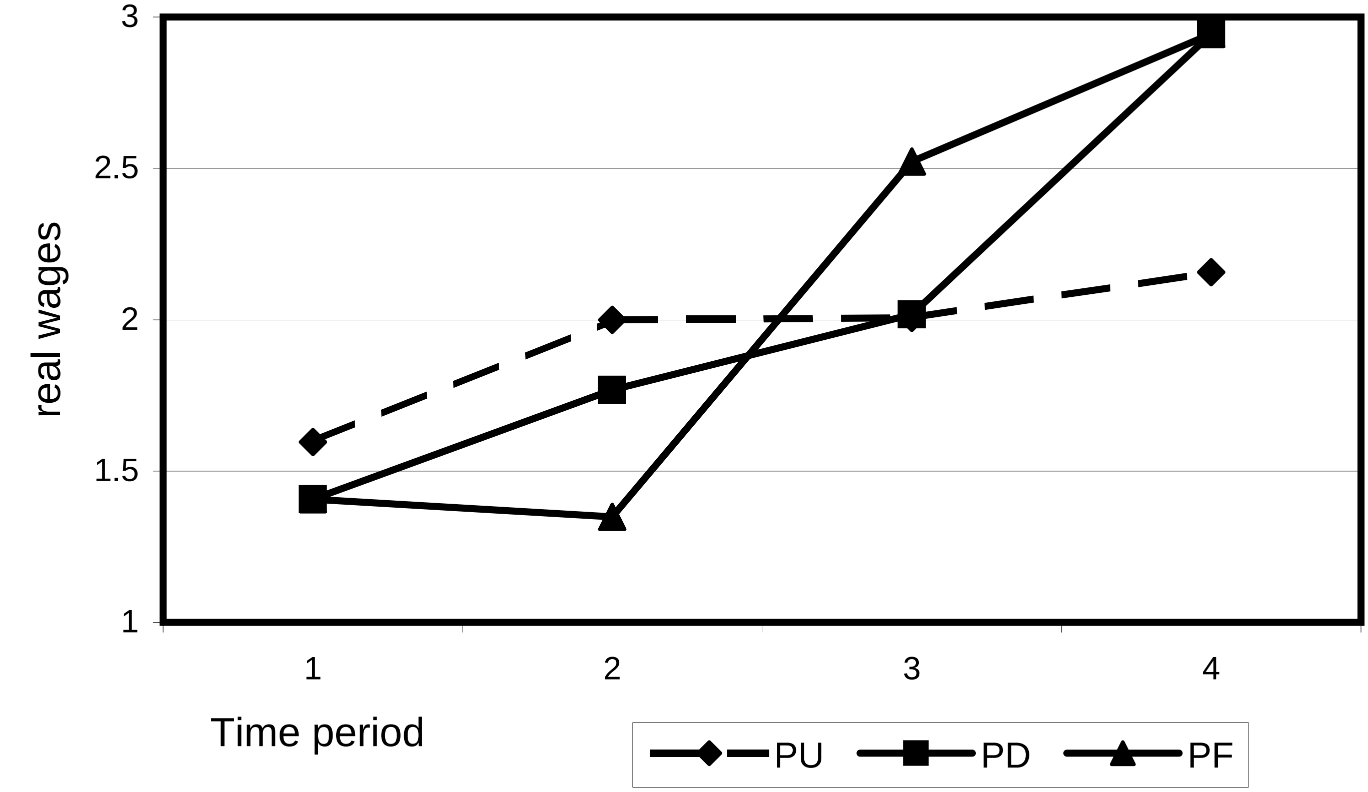

Figure 2: Consumption profiles

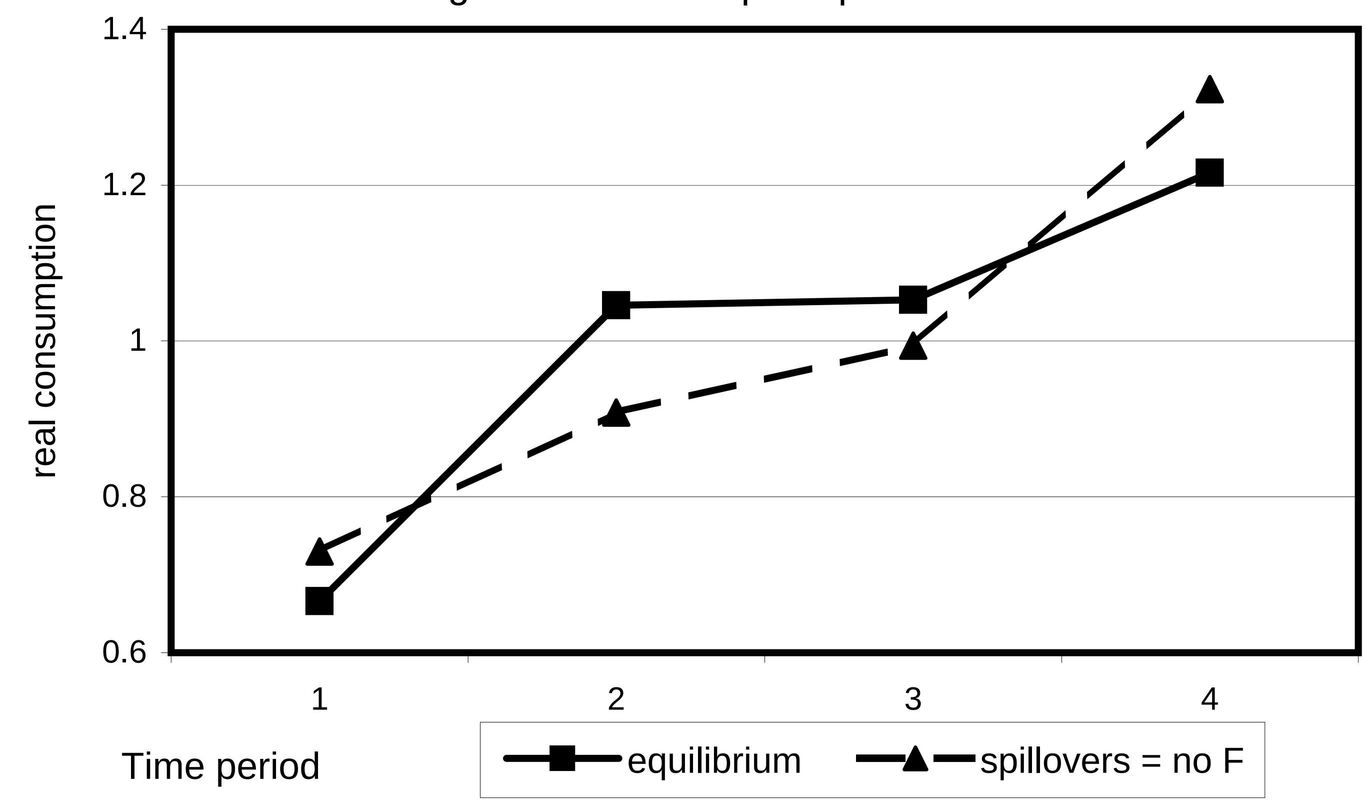

Figure 3: Wage profites with perfect spillovers

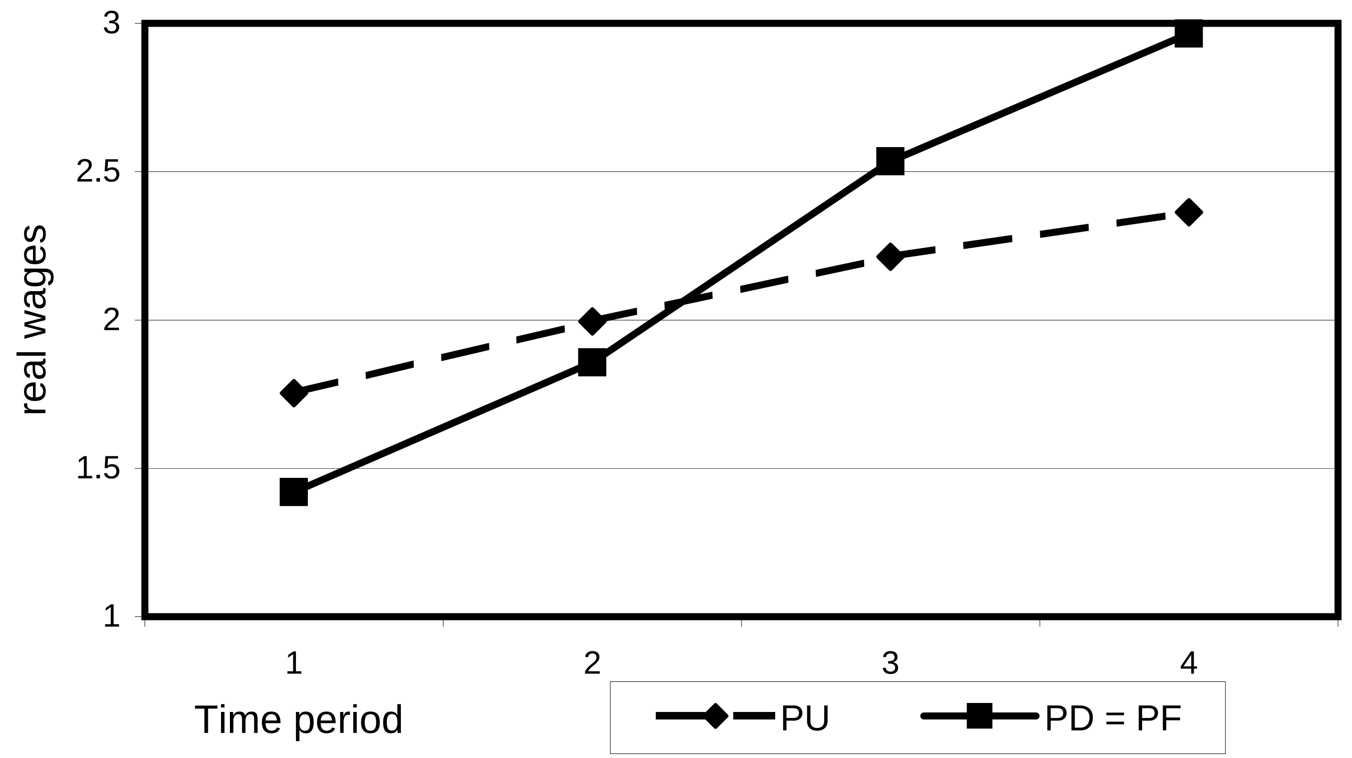

Figure 4: Consumption profiles

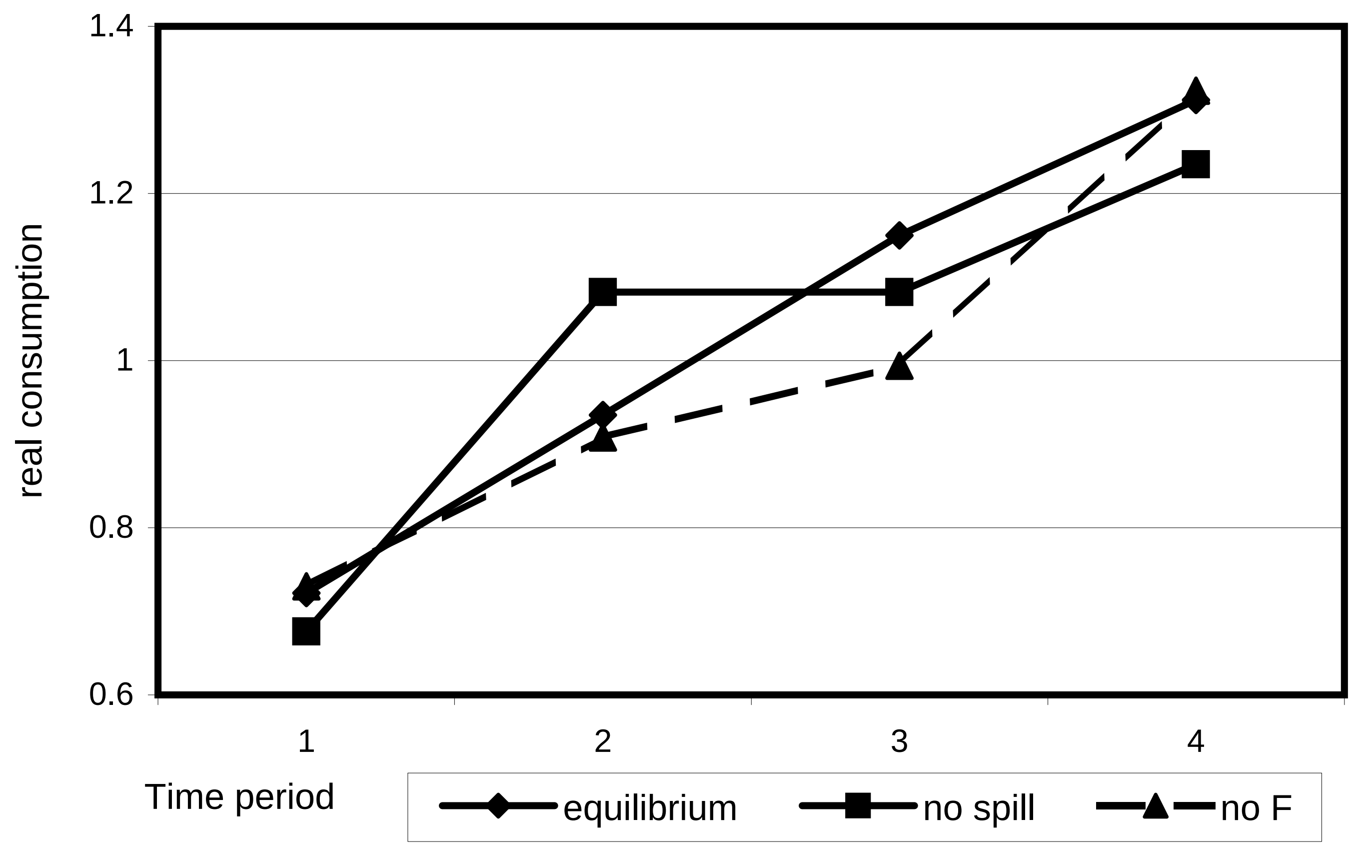

Table 1: Difference in Mean Characteristics Between Plants With Foreign Experts and Those Without

Additional Controls:	3-Digit Industry, Year and Region Fixed Effects				3-Digit Industry, Year and Region Fixed Effects and Plant Size			
Dependent Variable:	Coeff	Robust Std Error		R-squared	Coeff	Robust Std Error		R-squared
log (Capital Per Worker)	0.563	0.015	***	0.15	0.353	0.016	***	0.18
Exports / Total Sales	0.033	0.002	***	0.04	0.012	0.002	***	0.07
Share of Imported Raw Materials	0.086	0.001	***	0.19	0.049	0.001	***	0.24
log (Unskilled Workers Wage)	0.324	0.005	***	0.24	0.134	0.005	***	0.35
log (Skilled Workers Wage)	0.436	0.006	***	0.19	0.137	0.006	***	0.39
log (Local Technicians Wage)	0.450	0.009	***	0.17	0.138	0.009	***	0.37
log (Value Added Per Worker)	0.571	0.009	***	0.24	0.304	0.009	***	0.30
log (Sales Per Worker)	0.501	0.010	***	0.30	0.255	0.010	***	0.34
Skilled Workers / Total Labor	0.049	0.002	***	0.21	0.023	0.002	***	0.23

Results from regressing plant characteristics on the dummy variable indicating whether the plant has employed any foreign experts during the reporting period 1977-1991

Based on 16712 plants (92,642 observations) of which 15,997 plants (85,473 observations) have never employed foreign experts and 715 plants (7,169 observations) employed foreign experts in at least one reporting period.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Percentage Change in Wages and Labor Productivity During the Time an Expert is Visiting the Plant and After He/She Leaves Relative to the Pre-Expert Levels

	log (Unskilled Wage)			log (Skilled Wage)			log (Value Added Per Worker)		
	Coefficient	Robust Std Error		Coefficient	Robust Std Error		Coefficient	Robust Std Error	
During	0.078	0.021	***	0.080	0.027	***	0.193	0.040	***
After	0.072	0.021	***	0.058	0.027	**	0.078	0.040	**
3-digit Industry Fixed Effects	Yes			Yes			Yes		
Year Fixed Effects	Yes			Yes			Yes		
Region Fixed Effects	Yes			Yes			Yes		
R-squared	0.27			0.22			0.31		
N	2921			2921			2921		

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: Percentage Change in Wages and Labor Productivity During the Time an Expert is Visiting the Plant and After He/She Leaves Relative to the Pre-Expert Levels (Controlling for Plant Characteristics)

	log (Unskilled Wage)			**log (Skilled Wage)**			**log (Value Added Per Worker)**		
	Coefficient	Robust Std Error		Coefficient	Robust Std Error		Coefficient	Robust Std Error	
During	0.031	0.019	*	0.022	0.024		0.088	0.028	***
After	0.073	0.018	***	0.053	0.024	**	0.085	0.027	***
Skilled Workers / Total Employment	0.260	0.041	***	0.075	0.054		0.453	0.060	***
log(Total Labor)	0.128	0.007	***	0.196	0.009	***	0.034	0.010	***
log(Capital Per Worker)	0.036	0.006	***	0.047	0.008	***	0.084	0.009	***
log(Sales Per Worker)	0.194	0.010	***	0.185	0.013	***	0.655	0.014	***
Share of Imported Raw Materials	-0.033	0.047		0.114	0.061	*	0.294	0.069	***
Market Share	0.454	0.187	***	0.714	0.243	***	0.716	0.268	***
Regional Wage	0.132	0.027	***	0.140	0.035	***	0.047	0.039	
3-digit Industry Fixed Effects	Yes			Yes			Yes		
Year Fixed Effects	Yes			Yes			Yes		
Region Fixed Effects	Yes			Yes			Yes		
R-squared	0.62			0.59			0.78		
N	2921			2921			2921		

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: The Impact of the Length of Interaction with Foreign Experts on Domestic Workers' Wages and Productivity

	A. One Period With Foreign Experts						B. Many Periods With Foreign Experts					
	log (Unskilled Wage)		**log (Skilled Wage)**		**log (Value Added Per Worker)**		**log (Unskilled Wage)**		**log (Skilled Wage)**		**log (Value Added Per Worker)**	
During	0.048		0.047		0.121	**	0.037		0.067	**	0.071	**
	[0.034]		[0.042]		[0.053]		[0.026]		[0.034]		[0.035]	
After	0.081	***	0.042		0.056		0.071	***	0.129	***	0.124	***
	[0.024]		[0.030]		[0.039]		[0.029]		[0.039]		[0.040]	
Skilled Workers / Total Employment	0.194	***	0.015		0.457	***	0.347	***	0.078		0.483	***
	[0.058]		[0.074]		[0.089]		[0.062]		[0.084]		[0.083]	
log[Total Labor]	0.125	***	0.183	***	0.050	***	0.123	***	0.154	***	-0.003	
	[0.011]		[0.014]		[0.018]		[0.010]		[0.014]		[0.013]	
log[Capital Per Worker]	0.051	***	0.059	***	0.061	***	0.045	***	0.047	***	0.095	***
	[0.009]		[0.012]		[0.014]		[0.010]		[0.013]		[0.013]	
log[Sales Per Worker]	0.182	***	0.166	***	0.631	***	0.182	***	0.191	***	0.682	***
	[0.014]		[0.017]		[0.021]		[0.015]		[0.021]		[0.021]	
Share of Imported Raw Materials	-0.041		-0.035		0.375	***	0.029	***	0.339	***	0.411	***
	[0.070]		[0.086]		[0.109]		[0.068]		[0.091]		[0.091]	
Market Share	0.888	***	1.760	***	0.319		0.029		0.564		1.243	***
	[0.294]		[0.365]		[0.454]		[0.277]		[0.370]		[0.365]	
Regional Wage	0.207	***	0.216	***	0.043		0.080	***	0.088	***	0.036	***
	[0.065]		[0.080]		[0.100]		[0.030]		[0.040]		[0.039]	
3-digit Industry Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes	
Year Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes	
Region Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes	
R-squared	0.67		0.65		0.78		0.63		0.65		0.82	
N	1431		1431		1431		1490		1490		1490	

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Impact of Foreign Experts on Domestic Workers' Wages and Poductivity, Fixed Effects Estimation

	All			Employ Foreign Experts for Longer Periods		
	ln(Unskilled Wage)	ln(Skilled Wage)	ln(VA per Worker)	ln(Unskilled Wage)	ln(Skilled Wage)	ln(VA per Worker)
During	0.024	0.003	0.032	0.031	0.049	0.081**
	[0.017]	[0.022]	[0.024]	[0.024]	[0.031]	[0.034]
After	0.028	0.054**	0.009	0.035	0.111***	0.113***
	[0.019]	[0.025]	[0.027]	[0.030]	[0.039]	[0.042]
log(Total Labor)	-0.011	0.073***	0.008	-0.021	0.076***	-0.024
	[0.015]	[0.019]	[0.020]	[0.021]	[0.028]	[0.029]
log(Capital Per Worker)	0.024***	0.029***	0.051***	0.001	0.031**	0.053***
	[0.008]	[0.010]	[0.010]	[0.011]	[0.014]	[0.015]
log(Sales Per Worker)	0.184***	0.195***	0.724***	0.197***	0.189***	0.762***
	[0.014]	[0.018]	[0.019]	[0.020]	[0.027]	[0.028]
Share of Imported Raw Materials	-0.02	0.021	0.08	0.01	0.036	0.091
	[0.059]	[0.075]	[0.081]	[0.090]	[0.119]	[0.127]
Market Share	-0.199	-0.09	1.884***	0.584	0.664	2.710***
	[0.413]	[0.531]	[0.589]	[0.606]	[0.795]	[0.836]
Constant	2.449***	2.398***	0.442***	2.550***	2.499***	0.449*
	[0.117]	[0.154]	[0.159]	[0.182]	[0.241]	[0.253]
Plant Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2921	2921	2921	1490	1490	1490
Number of plant	234	232	234	110	110	110
R-squared	0.3	0.18	0.54	0.34	0.18	0.58

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Determinants of Employment of Foreign Experts (Logit Estimation)

Dependent Variable: Employment of Foreign Experts (0 - no, 1 -yes)

log (Total Labor)$_{t-1}$	0.716	***
	[0.020]	
log (Capital per Worker)$_{t-1}$	0.241	***
	[0.021]	
log (Sales per Worker)$_{t-1}$	0.199	***
	[0.030]	
Share of Imported Raw Materials$_{t-1}$	0.794	***
	[0.147]	
Market Share$_{t-1}$	-1.607	***
	[0.534]	
Industry Fixed Effects		
Region Fixed Effects		
Time Fixed Effects		
Number of obs = 72,091		
Log likelihood = -9216.3935		
Pseudo R2 = 0.1519		
LR chi2(38) = 3300.99		
Prob > chi2 = 0.0000		

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: Mean Values of Selected Characteristics for Matched and Unmatched Samples

	Full Sample			Matched Sample			
				without foreign experts			
	without foreign experts	with foreign experts	**Diff Full Sample**	unmatched	used as comparison group	with foreign experts	**Diff Matched Sample**
log (Unskilled Worker Wage)	3.604	3.911	**0.307**	3.515	3.803	3.842	**0.040**
log (Skilled Worker Wage)	3.886	4.250	**0.364**	3.766	4.119	4.196	**0.076**
log (Value Added Per Worker)	4.573	5.183	**0.610**	4.431	4.970	5.079	**0.109**
log (Total Labor)	3.588	4.458	**0.869**	3.328	4.435	4.518	**0.082**
Skilled Workers / Total Employment	0.212	0.305	**0.093**	0.203	0.260	0.285	**0.026**
log (Capital per Worker)	3.339	3.972	**0.633**	3.231	3.924	3.947	**0.023**
log (Sales per Worker)	5.294	5.712	**0.417**	5.276	5.852	5.889	**0.036**
Share of Imported Raw Materials	0.077	0.139	**0.062**	0.057	0.139	0.146	**0.007**
Market Share	0.006	0.013	**0.007**	0.003	0.015	0.018	**0.003**

Table 8: The Effect of Foreign Experts on Domestic Workers' Wages and Productivity (Matched and Unmatched Samples)

	Unmatched Sample			Matched Sample		
	log(Unskilled Worker Wage)	log(Skilled Worker Wage)	log (Value Added Per Worker)	log(Unskilled Worker Wage)	log(Skilled Worker Wage)	log (Value Added Per Worker)
During	0.041*	0.047	0.118***	0.006	0.034	0.078**
	[0.024]	[0.035]	[0.036]	[0.023]	[0.034]	[0.035]
After	0.052**	0.053*	0.095***	0.045*	0.062**	0.076**
	[0.022]	[0.027]	[0.033]	[0.023]	[0.032]	[0.035]
log(Total Labor)	0.106***	0.211***	0.081***	0.144***	0.207***	0.074***
	[0.003]	[0.004]	[0.004]	[0.009]	[0.012]	[0.014]
log(Capital per Worker)	0.022***	0.006**	0.037***	0.049***	0.041***	0.088***
	[0.002]	[0.002]	[0.003]	[0.009]	[0.012]	[0.013]
log(Sales per Worker)	0.170***	0.186***	0.605***	0.201***	0.209***	0.629***
	[0.005]	[0.005]	[0.006]	[0.015]	[0.017]	[0.024]
Share of Imported Raw Materials	0.169***	0.220***	0.416***	0.065	0.271***	0.402***
	[0.023]	[0.026]	[0.031]	[0.059]	[0.079]	[0.081]
Market Share	1.906***	1.339***	2.104***	0.642***	0.470	0.781*
	[0.300]	[0.240]	[0.553]	[0.218]	[0.303]	[0.444]
Constant	1.912***	1.797***	0.716***	1.534***	1.600***	0.468***
	[0.023]	[0.024]	[0.029]	[0.074]	[0.089]	[0.106]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	87252	77359	81039	4798	4673	4404
R-squared	0.38	0.36	0.69	0.50	0.49	0.71

Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9: The Impact of Postponing the Decision to Hire Foreign Experts

	Unskilled wage	Skilled wage	VA per worker	Unskilled wage	Skilled wage	VA per worker
Waiting Time Before Hiring An Expert	-0.022***	-0.037***	0.003	-0.012*	-0.019**	-0.001
	[0.008]	[0.011]	[0.014]	[0.006]	[0.009]	[0.011]
Pre-Expert Level: Log(x) Pre-Expert				-0.634***	-0.611***	-0.742***
				[0.080]	[0.077]	[0.067]
Skilled workers / Total	-0.117	-0.227	0.065	-0.037	-0.073	0.485***
	[0.128]	[0.152]	[0.191]	[0.095]	[0.140]	[0.150]
Log (Total Labor)	-0.009	-0.013	-0.094**	0.068***	0.113***	0.003
	[0.019]	[0.027]	[0.040]	[0.020]	[0.027]	[0.032]
Log (Capital Per Worker)	0.014	0.02	0.036	0.030**	0.042**	0.075***
	[0.017]	[0.027]	[0.035]	[0.014]	[0.020]	[0.029]
Log(Sales Per Worker)	0.067***	0.060*	0.244***	0.166***	0.140***	0.519***
	[0.022]	[0.031]	[0.047]	[0.026]	[0.033]	[0.051]
Share Imported Raw Mat	-0.272	-0.038	0.510**	-0.188*	0.008	0.366**
	[0.170]	[0.213]	[0.236]	[0.113]	[0.147]	[0.161]
Market Share	0.987***	0.455	-0.334	0.710**	0.658	0.366
	[0.351]	[0.556]	[0.823]	[0.344]	[0.432]	[0.692]
Regional Wage	0.046	-0.028	-0.011	0.093**	0.096*	0.163**
	[0.048]	[0.068]	[0.076]	[0.040]	[0.050]	[0.077]
Industry/year/region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1236	1236	1236	1236	1236	1236
R-squared	0.19	0.18	0.27	0.44	0.42	0.59

*Dependent Variable: difference in logs of post and pre-expert wages or value added per worker

** "Waiting Time" is the number of periods the plant waited before hiring an expert; time-invariant

* significant at 10%; ** significant at 5%; *** significant at 1%