U.S. Direct Investment and the Production Structure of the Manufacturing Sector in France, Germany, Japan, and the U.K.

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1. Introduction

Direct investment has grown at a very impressive pace in recent years, particularly among the industrialized countries, where its growth rate has exceeded, often by a substantial margin, that of domestic capital formation, international trade and output. In fact, the explosion of foreign direct investment (FDI) in the 1980s has played a similar role as the growth of world trade in the 1970s and the integration of financial markets of the early 1980s to further the globalization process among the economies of the industrialized nations.

The prime channel of the flow of FDI has been the multinational enterprises and there is a large body of literature on the role and actions of multinational corporations and the impact of their activities on the trade, investment in host countries and financial markets. A number of studies have attempted to identify the determinants of FDI flow from one country to another and to various sectors of the different economies around the world. A few researchers have also attempted to incorporate foreign investment outflows as part of the multinational firms' investment decisions. Although significant progress has been made to understand the role played by the multinationals in trade and investment around the globe, little systematic effort has been made

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1The author wishes to thank Theofanis P. Marumenas and Bhaswar Mukhopadhyay for their excellent research assistance and Catherine Labio for her help in preparing this manuscript.


3Ostry (1990)


6Stevens (1975).
to estimate quantitatively the effect of foreign direct investment in plant and equipment on the structure of production of the host countries.\textsuperscript{7} Part of the problem is that the figures on direct investment inflows for host countries given by the IMF in the balance of payment statistics are a composite including financial flows that may be unrelated to real investment. They include not only new investment by parent companies in starting new and expanding old affiliates, but also, for some countries, retained earnings, as well as funds raised in the host countries themselves for financing new or existing investment. That is, the conventional FDI figures from IMF actually requires neither capital flows nor investment in capacity. They are essentially a measure of extension of ownership or corporate control across national boundaries.\textsuperscript{8}

The only available data on FDI that provide a detailed and systematic breakdown of foreign investment into investment in plant and equipment and other components are those for U.S. FDI published by the U.S. Department of Commerce. Using these data it is possible to analyze how the impact of FDI on productive capacity may have affected the demand for employment, materials, and capital investment as well as productivity growth in the host country.

In this paper we focus on the U.S. firms' expenditures for plant and equipment in the manufacturing sectors of four major OECD countries, France, Germany, Japan, and the U.K., during the period 1968-1988. We shall hereafter use foreign direct investment (FDI) to mean expenditures for plant and equipment (P&E) by the US firms' affiliates in the manufacturing sectors of

\textsuperscript{7}Blomström and Wolff (1989).

\textsuperscript{8}Froot (1991).
the four countries. We treat the stock of foreign capital in plant and equipment as an input in the production process of the host sectors, where it interacts with domestic inputs such as labor, materials, and domestic capital to produce a given level of output. We particularly focus on two sets of basic issues: (1) the patterns of substitution and complementarity between domestic inputs and foreign capital input and (2) the effect of foreign capital on output expansion and productivity growth in the host sectors.

The rest of this paper is organized as follows: In section 2 we specify a model of the firm's production decision that explicitly takes into account the product demand facing the industry and distinguishes between variable and quasi-fixed factors of production. The description of the data used to construct the variables of the models is presented in section 3. A brief description of the growth rates of output and inputs and their shares is given in section 4. In section 5 we discuss the estimation results and analyze the pattern of elasticities and characteristics of the production structure in the manufacturing sectors of the host countries. We estimate the return for domestic and foreign investment in plant and equipment and the contribution of foreign investment to growth of employment and productivity growth in each of the sectors in section 6. The conclusions are stated in the final section of the paper.

2. Model Specification

Foreign investment in plant and equipment enters the cost function of the manufacturing sector of the host country as an input. We assume that the production decisions are governed by the maximization of the expected present value of the flow of funds. We use the duality approach to production theory to formulate the underlying theoretical framework of our model.
The representative variable cost function can be written as

\begin{equation}
(1) \quad c^\gamma = C^\gamma(\omega_t, y_t, K_t, \Delta K_t)
\end{equation}

where $c^\gamma$ is the normalized (by the nth variable factor price) variable cost, $C^\gamma$ is the twice continuously differentiable variable cost function, $\omega$ is the \(n-1\) dimensional vector of relative variable factor prices, $y$ is the output quantity, $K$ is the two dimensional vector of quasi-fixed capital inputs, which includes domestic capital ($K_d$), and foreign capital ($K_f$), $\Delta K$ is the two dimensional vector of net investment ($\Delta K_{it} = |K_{it} - K_{it-1}|$, $i=K, F$).

As with domestic capital, an increase in foreign capital lowers variable costs in the short run as larger foreign and domestic capital stocks are combined with the variable factors to produce a given level of output ($\partial c^\gamma / \partial K < 0$). Also, there are adjustment costs to undertaking new investment and expand the firm's productive capacity ($\partial c^\gamma / \partial \Delta K > 0$ (see Mohnen, Nadiri and Prucha [1986]).

The specific form of the variable cost function, which includes the adjustment cost of both domestic and foreign capital stocks, is given by

\begin{equation}
(2) \quad \ln c^\gamma_t = \beta_0 + \sum_{i=1}^{n-1} \beta_i \ln \omega_{it} + \beta_y \ln y_t + \sum_{k=1}^m \beta_k \ln K_{kt}
\end{equation}

\begin{equation}
+ \sum_{i=1}^{n-1} \delta_i \ln y_t \ln \omega_{it} + \sum_{k=1}^{n-1} \beta_{ik} \ln K_{it} \ln K_{kt}
\end{equation}

\begin{equation}
+ \sum_{k=1}^m \beta_{yk} \ln y_t \ln K_{kt} + \sum_{k=1}^m \sum_{q=1}^m q \beta_{kq} \ln K_{kt} \ln K_{qt}
\end{equation}

\begin{equation}
+ 0.5 \sum_{k=1}^m \sum_{q=1}^m \mu_{kq} = \mu_{qk}
\end{equation}

\begin{equation}
(2) \quad i = L, M
\end{equation}

\begin{equation}
(2) \quad k = K_d, K_f
\end{equation}

where $\mu_{kq} = \mu_{qk}$. The functional form is restricted translogarithmic and
implies that marginal adjustment costs are zero when net investment is zero.\textsuperscript{9}

The accumulation of the capital stocks occurs by the following processes,

\begin{equation}
K_t = I_t + (I_m - \delta)K_{t-1}
\end{equation}

where $I_t$ is vector of gross investment, $I_m$ is the two dimensional identity matrix and $\delta$ is the two dimensional diagonal identity matrix of depreciation rates such that $0 \leq \delta_i \leq 1$ (K,F).\textsuperscript{10}

We assume the representative inverse product demand function of the

\begin{equation}
\frac{p_t}{D(y_t, z_t)}
\end{equation}

where $p_t$ is the relative product price, $D$ is the twice continuously differentiable inverse product demand function, and $z$ is a vector of exogenous variables which affect product demand. We consider a very simple inverse product demand function

\begin{equation}
\ln p_t = \alpha_0 + \alpha_1 \ln y_t + \sum_{i=1}^{n} \alpha_i \ln z_{it}
\end{equation}

Production decisions are governed by the maximization of the expected present value of the flow of funds. Thus

\textsuperscript{9}See Morrison and Berndt (1981) and Mohnen, Nadiri and Prucha (1986).

\textsuperscript{10}It is assumed that capital services are proportional to the capital stocks.
(6) \[ \max_{(y_s,v_s,k_s)} e = \sum_{s=t}^\infty E(t) \alpha(t,s) [D(y_s,k_s,z_s)y_s + G^y(\omega,s,k_s,k_s-K_{s-1}) - q_s^T(k_s - (I_m-\delta)k_{s-1})] \]

where \( v \) is the vector of variable factor quantities, \( \alpha(t,s) \) is the discount factor and \( q \) is the vector of normalized (by the nth variable factor price) capital purchase prices. Expectations are conditional on existing information and are formed over future relative variable factor prices and capital purchase prices.

The specific equilibrium conditions defined by (6) can be found by using equations (2), (3), and (5), applying Shephard's Lemma\(^{11}\) and carrying out the maximization. The equilibrium conditions are:

(7.1) variable input shares:
\[ \omega_{it}v_{it}/c_t^y = \beta_i + \beta_{iy} lny_t + \sum_{k=1}^m \beta_{ik} lny_k \quad i = 1, \ldots, n \]

(7.2) revenue shares:
\[ p_t y_t/c_t^y = (1 + \alpha_y + \sum_{i=1}^h \alpha_{y1} lny_{it})^{-1} \]
\[ (\beta_y + \sum_{i=1}^{n-1} \beta_{iy} lny_{it} + \sum_{k=1}^m \beta_{yk} lny_k) \]

(7.3) quasi-input shares:
\[ \omega_{kt}k_{kt}/c_t^y = \beta_k + \sum_{i=1}^{n-1} \beta_{ik} lny_{it} + \beta_{yk} lny_k + \sum_{q=1}^m \beta_{kq} lny_k \]
\[ + \sum_{q=1}^m \mu_{kq} (\Delta k_{qt} - (1+\rho_{k})^{-1} \Delta k_{qtr1}) K_{kt}/c_t^y \]

\( K=F \)

\(^{11}\)See Dievert (1974).
where the relative rental rates on the capital inputs are $\omega_k^e = q_{kt} \left( \frac{1 - (1+\rho_t)^{-1}(1-\delta_k)q_{kt+1}^e/q_{kt}}{k=1,\ldots,m} \right)$, $\rho_t$ is the discount rate such that $\sigma(t,t+1) = (1+\rho_t)^{-1}$, and the superscript $e$ denotes the conditional expectation of a variable.

Equation set (7.1) denotes the equilibrium conditions for the variable factors of production. In equilibrium the ith variable factor cost share is directly affected by both domestic and foreign capitals through the $\beta_{ik}$ parameters. The equilibrium condition for output is given by equation (7.2). In equilibrium the revenue/cost ratio is influenced by foreign capital and domestic capital through the parameters $\beta_{yk}$. Equation set (7.3) characterizes the equilibrium conditions for the domestic and foreign capital inputs. In equilibrium the marginal cost of each capital input, which consists of their user cost and the marginal adjustment cost, is offset by the expected marginal benefit, which consists of the variable cost reduction in period $t$ and the future adjustment cost reduction from having a larger capital input. Clearly, adjustment costs create the intertemporal links. These costs generate the trade-off between marginal cost increases in period $s$ and marginal cost decreases in period $t+1$.

3. Construction and Description of the Data

The relevant data for the manufacturing sector of the four countries, France, Germany, Japan and the UK, were assembled from different sources. The period covered is from 1968 to 1986, for all the countries. A brief description of the variables and the data sources are given below.

A. Real Output, Materials and Employment

The aggregate real output is measured as the real Gross Product of total manufacturing in 1982 prices. Data on real output of the four
countries were obtained from the OECD National Accounts (1982, 1989) and the UN Industrial Statistics Yearbook (1974, 1980, 1989). The data for Japan, France, West Germany and the UK are converted into 1982 US dollars using the purchasing power parity numbers for each country prevailing in 1982 obtained from Summers and Heston (1988).

The series on materials were calculated by subtracting value added from gross output, in constant U.S. dollars. The value added data were obtained from the same sources as those for real gross output.

Labor is measured by man-hours. The employment figures refer to the total number of employees in the total manufacturing sector. The data are taken from Labor Force Statistics published by the OECD, except for Japan data which are taken from the Yearbook of Labor Statistics (1970, 1975, 1980, 1988) published by the International Labor Office (ILO). The data on the average number of hours worked per week are obtained from the same source for each of the sectors.

B. Domestic and Foreign Capital Stocks

The data on total net capital stock for total manufacturing were obtained from OECD, Flows and Stocks of Fixed Capital 1962-1987, except for Japan. The series for Japan was constructed using the usual perpetual inventory method; the benchmark capital stock was obtained from Bureau of Labor Statistics, 1988, Working Paper 189, p. 68, and the investment flows were obtained from OECD, Flows and Stocks of Fixed Capital, 1962-1987.

Foreign Capital is derived from expenditures on plant and equipment by majority-owned nonbank foreign affiliates of nonbank US companies. The data for each sector in the host countries were obtained from the
Survey of Current Business (March 1966 - March 1990) published by the Bureau of Economic Analysis (BEA) of the US Department of Commerce. The capital series are constructed using the depreciation rates of domestic capital. The benchmark capital stock of foreign capital is generated by dividing the real foreign investment in 1968 by the depreciation rate plus the rate of growth of output for the period 1968-1986 in each of the sectors. The net domestic capital stock used in the model is obtained by subtracting the foreign capital stock from the net capital stock described above.

C. Prices of Output and Inputs

The price of output is obtained from the ratio between gross output in current US dollars and that in 1982 US dollars. Using the data on current and constant value added, the price of material is calculated by the same procedure. Both prices are calculated net of corporate income tax. The data on the corporate income tax rate are taken from the U.S. Dataset for the United States and the values for the other countries is set to a constant. In particular, it is equal to 0.54 for Japan, 0.50 for France, 0.62 for Germany, and 0.52 for the UK.

The price of labor is measured by the hourly compensation of employees paid by the resident producers. The data on hourly compensation are obtained from the Yearbook of Labor Statistics of the ILO (1970, 1975, 1980, 1988) for all the countries.

The deflators for domestic capital were obtained from Summers and Heston (1988). The rental rate of capital is equal to $w_k = A_k^* (r + \delta_k)$ where $r$ is the real rate of return, $\delta_k$ is the depreciation rate of capital and $A_k = p_k^* ((1-t_x) + ((1-t_x) \alpha/(r+\delta_k))$, where $p_k$ is the price
of capital, $t_x$ is the corporate tax rate, and $\alpha$ is a weighted average of the ratios of investment in structure and the total investment and of the investment in equipment and the total investment. The real rate of return is calculated as $r = i(1-t_x)$ where $i$ is the government bond yield. The data on government bond yields are taken from *International Financial Statistics* published by the IMF.

The deflator for foreign capital is calculated as the ratio between the U.S. affiliates' capital expenditures in current US dollars and the U.S. affiliates' capital expenditures in 1982 US dollars. The data are obtained from the *Survey of Current Business* (March 1966 - March 1990) published by the BEA.

4. Some Descriptive Features

In table 1a we provide the mean values of the quantities of output, costs and inputs in the manufacturing sectors of Japan, France, Germany, and the UK for the period 1968-86. In table 1b the shares of inputs and revenues as percent of total cost and the growth rates of gross output and factors of production for these sectors are presented. The summary statistics show considerable differences among the sectors as to their size, measured by quantity of their production and the structure of their production as indicated by the quantities and share of inputs in total costs. The growth rate of output has been sizable for the Japanese manufacturing sector (over 6%), moderate (about 3%) for the French and German manufacturing sectors, and slow (less than 1%) for the British manufacturing sector. The employment growth rate has been positive but small in magnitude for Japan while employment has declined in all other countries' manufacturing sectors,
especially that of the UK. Domestic capital stock has increased at an impressive growth of over 7% for Japan, over 3% for France, and about 1.2% for Germany. The manufacturing sector in the UK has experienced a slow growth rate of domestic capital formation of less than 0.5% in the period 1968 to 1986. The growth of foreign capital on the other hand has been extremely rapid in the manufacturing sector of each of the host countries. The average rate of growth of US owned capital stock in plant and equipment has been about 10% for the period in all the sectors except that of the British economy; the rate for British manufacturing sectors has been lower, but still very high, close to 8%. Another way of documenting the enormous growth of foreign capital in these sectors is to look at their levels in 1968 and 1986: the level of real capital stock in plant and equipment owned by US firms increased—by about 8 times in Japan, 5.8 times in France, 7.7 times in Germany and 5 times in the UK in the period. Although the share of foreign capital in the total costs of the manufacturing sectors is still rather low, it is the most rapidly growing part of capital formation in the manufacturing sector of these countries.

5. Estimation Results

To estimate the effects of US owned capital on the costs, input demand, and revenue shares of the manufacturing sectors in the host countries we modify the model described in section 2 in two specific ways: first, we specify a simple cost and product demand function and, second, we treat foreign capital as an exogenous variable. That is, we assume that in the short run the amount of U.S. foreign direct investment in the manufacturing sector of the particular country is given and it serves as a shift variable in
the cost function. The specific form of the variable cost, product demand, and the associated factor and revenue shares are given below.

Cost Function

\[
\ln(C_t^v/P_{mt}) = \beta'_0 + \beta'_1 \ln \omega_t + \beta'_y \ln y_t \\
+ \beta'_K \ln K_t + \beta'_F \ln F_t \\
+ \beta'_L \ln \omega_t \ln y_t \\
+ \beta'_L \ln \omega_t \ln K_t + \beta'_L \ln \omega_t \ln F_t \\
+ \beta'_y \ln y_t \ln K_t + \beta'_y \ln y_t \ln F_t \\
+ \beta'_Y \ln K_t \ln F_t + \mu K \Delta K_t
\]

(8)

Inverse Demand Function:

\[
\ln(p_t/p_{mt}) = \alpha'_0 + \alpha'_y \ln y_t
\]

(9)

There are two variable inputs, labor and materials, and two quasi-fixed inputs, domestic capital (K) and foreign capital (F). The quasi-fixity for K and F arises from the notion that changing the level of capital stocks requires some costs in the short run in terms of foregone output. The cost variable \( C^v \) is defined as \( C^v = \sum_i p_i x_i \), where \( p_i \) and \( x_i \) refer to the prices and quantities of variable inputs; \( \omega_i \) is the relative input prices defined as \( \omega_i = p_i/p_m \) where \( p_m \) is the price of materials. To account for differences in costs and demand that may exist among the manufacturing sectors of different countries we introduce intercept and slope dummies in the inverse demand function (9) and the linear input price and output variables in (8). That is,

\[
\alpha'_0 = (\alpha'_0 + \sum_h \alpha_{0h} D_h), \quad \alpha'_y = (\alpha'_y + \sum_h \alpha_{yh} D_h), \quad \beta'_0 = (\beta'_0 + \sum_h \beta_{0h} D_h), \quad \beta'_L = (\beta'_L + \sum_h \beta_{Lh} D_h), \quad \beta'_Y = (\beta'_Y + \sum_h \beta_{Yh} D_h), \quad \beta'_K = (\beta'_K + \sum_h \beta_{Kh} D_h), \quad \beta'_F = (\beta'_F + \sum_h \beta_{Fh} D_h)
\]

where \( D_h \) refers to sector dummies taking values of 1 and 0 and \( h \) is an identification index.
Revenue shares $s_y$:

\[(10.1) \quad \frac{p_t y_t}{C_t^y} = (1 + \alpha'_y)^{-1} (\beta'_y + \beta_{xy} \ln w_t + \beta_{yk} \ln K_t + \beta_{xf} \ln F_t + \beta_{yf} \ln F)\]

Labor share $s_L$:

\[(10.2) \quad \frac{w_t L_t}{C_t^y} = \beta'_L + \beta_{xy} \ln y_t + \beta_{yk} \ln K_t + \beta_{xf} \ln F_t\]

Domestic capital share $s_K$:

\[(10.3) \quad \frac{\omega_K^e \cdot K_t}{C_t^y} = -(\beta'_K + \beta_{yk} \ln \omega_t + \beta_{yk} \ln y_t + \beta_{xf} \ln F_t + \mu_K (\Delta K - (1 + \rho)^{-1} \Delta K_{t+1}) \cdot K_t / C_t^y)\]

The share of the input (materials) used for the normalization is calculated by $s_m = 1 - s_L$. Regularity conditions require that the cost function be concave in price of inputs in the Hessian matrix $[\partial^2 c / \partial w_i w_j]_{ii}$ of the cost function should be negative and semi-definite. Also, cost function should be nondecreasing in output and linear homogeneous in input prices. We assume that the errors attached on the above equations are optimizing errors and are jointly normally distributed with zero expected value and with a positive definite symmetric covariance matrix.

The estimating model consists of the cost function (8), the inverse demand function (9), and the share equations (10). We have used the pooled time-series cross-section data for the four manufacturing sectors for the period 1968-1988 to estimate the model. The results shown in table 2 indicated that the model is estimated well. The square of the correlation coefficients between the actual and predicted values is high and the standard errors of each equations are small. In addition, all regularity conditions
are satisfied. The likelihood ratio test indicates a decisive rejection of the hypothesis that the coefficients of the industry dummies are zero, suggesting that the cost and revenue conditions facing the manufacturing sectors in the four industrialized countries are not the same. The hypothesis that domestic capital is not subject to adjustment costs was also decisively rejected. Finally, the hypothesis that the coefficients of foreign capital variable in the cost function are jointly zero was strongly rejected as well.

The estimates in table 2 show that the coefficients of the model are statistically significant and the variables that enter the cost and inverse demand functions have the correct sign. Particularly, the parameters associated with foreign owned capital are statistically significant and suggest that an increase in US direct investment leads to a lowering of variable costs in the manufacturing sectors of France, Germany, Japan, and the UK.

6. Costs, Input Demand, and US Direct Investment

Using the estimates in table 2 we calculate the relevant short-run output price, variable cost and input demand elasticities and the impact of changes in U.S. owned capital stock on the costs, output and domestic inputs in the manufacturing sectors of the host countries. Some of these elasticities and the implied degree of returns to scale and markup are shown in table 3. The own and cross price elasticities of the variable inputs suggest a high degree of similarity among these elasticities across the manufacturing sectors. There is evidence of a modest but similar degree of increasing returns to scale in all the manufacturing sectors; the hypothesis that constant returns to scale prevail in these sectors was strongly rejected. The elasticity of
the inverse demand function, \( \epsilon_{py} \), is similar across the four sectors. It ranges from -0.23 in Japanese manufacturing about -0.30 in French manufacturing. Using these estimates we calculate the degree of markups of 30% to 42% in the manufacturing sectors of the four countries.\(^{12}\)

The elasticity of the variable cost function with respect to changes in output is shown in row 2 of table 3; they are similar in magnitude, about one, implying a unitary elasticity of the variable cost of the manufacturing sector in all countries, except Japan, where it is higher. The short-run effect of changes in domestic capital on the variable costs are shown in row 3. The magnitudes of the short-run and partial elasticities of variable cost with respect to domestic capital are generally small. The largest elasticity is recorded for French manufacturing, \(-0.145\). This elasticity is about \(-0.12\) for German and \(0.07\) for Japanese manufacturing and very small, about \(-0.05\), for British manufacturing. The effects of changes in the U.S. foreign direct investment in plant and equipment on output price, variable costs and demand for variable inputs are shown in table 4. The calculations were carried out by first holding the level of output constant and then allowing the level of output to vary. These two sets of calculations allow delineating the pattern of substitution among the inputs when output is fixed and expansionary effects of output when it is allowed to increase in response to the increase in U.S.-owned capital.

The effects of foreign capital on cost and input shares can be used to calculate the "productivity effect" and "factor bias effects." The

\(^{12}\)The \( \chi^2 \) test of the hypothesis of no markup was rejected for each of the industries confirming some degree of monopoly power in each of the sectors.
productivity effect is a measure of shift in cost due to an increase in U.S.-
owned capital stock. The productivity measure for each manufacturing sector
is computed using the expression

\[ \epsilon_{CF} = \frac{\partial \ln C^V}{\partial \ln F} = \beta_F^v + \beta_{\ell F} \ln \omega_t + \beta_y \ln y + \beta_K \ln K. \]

The elasticity estimates in row 1 of table 4 measure the "productivity effect"
of U.S.-owned capital assuming the levels of output and stock of domestic
capital are held fixed. The results indicate that increases in foreign
capital reduce variable costs in all four manufacturing sectors. The
magnitude of these elasticities vary among the sectors in the host countries:
over 6% for Japanese manufacturing, and about 4% for the manufacturing sectors
of France, Germany, and the UK. The "factor bias effect" of U.S.-owned
capital, defined as \( \partial s_{\ell}/\partial \ln F \), is measured by the estimates of parameters \( \beta_{\ell F} \)
in equation (10.2). If the factor cost share increases, decreases, or does
not change, U.S.-owned capital is factor using, factor saving, or neutral in
the host countries' manufacturing sector. The results shown in table 4 do not
vary much among the manufacturing sectors in the short run. U.S.-owned
capital is labor and material saving, with the largest effects in the Japanese
manufacturing sector.

The total effects of foreign capital on variable costs and variable input
demand and on the domestic capital stock in the short run are shown in table

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13These elasticities, though much smaller in magnitudes than their
counterparts for domestic capital, may be on the high side. The stock of
foreign capital enters as a shift variable in the cost function (8) and
probably captures the effect of other omitted variables. Also, the
magnitudes of these elasticities are likely to be smaller if foreign
capital stock is considered as an endogenous variable of the model.
4. Conditional elasticities of labor demand with respect to increases in U.S.-owned capital are calculated using the relation

\[ \epsilon_{LF} = \frac{\partial \ln L}{\partial \ln F} = \epsilon_{CF} + \frac{\beta_{LF}}{s_L}, \]

which is the sum of the "productivity effect" and the "factor bias effect". If the sign of the expression in (12) is positive, negative or zero, it implies that the foreign capital and the input are complements, substitutes, or neutral, respectively. Note that the sign of \( \epsilon_{LF} \) depends on the sign and magnitude of productivity and factor bias effects; they could reinforce or offset each other.\(^{14}\) The results in panel A of table 4 suggest that increases in U.S.-owned capital reduces the demand for both labor and materials and therefore it is a substitute to both variable inputs when the levels of output and stock of domestic capital is held constant. The magnitude of the substitution effect is much larger for employment than for materials in all four manufacturing sectors.

The elasticity estimates so far were calculated by holding the level of output fixed. However, the output level changes in response to a change in level of U.S.-owned capital. Changes in U.S.-owned capital shift the average and variable costs downward and the marginal cost to the right. Since the output demand function is sloping downward, as a result of the shift in the average and marginal variable costs output increases and output prices

\(^{14}\)The elasticity of intermediate inputs is found by

\[ \epsilon_{MF} = \epsilon_{CF} - \frac{\beta_{LF}}{1 - s_L}, \]
decline. The elasticities shown in panel B of table 4 are calculated allowing the level of output to vary, but still the stock of domestic capital is held constant. The relevant elasticities are given by the following expressions:

(13.1) \( \eta_y = \frac{\partial \ln y}{\partial \ln F} = \frac{\epsilon_{CF} s_y + (1 + \epsilon_{py})^{-1}}{s_y (1 + \epsilon_{py} - \epsilon_{cy})} \)

(13.2) \( \eta_y^{-} = \frac{\partial \ln p}{\partial \ln F} = \epsilon_{py} \eta_y \)

(13.3) \( \eta_{CF} = \frac{\partial \ln C}{\partial \ln F} = \epsilon_{CF} + \epsilon_{cy} \eta_y \)

(13.4) \( \eta_{LF} = \frac{\partial \ln L}{\partial \ln F} = \epsilon_{LF} + \eta_y (\epsilon_{cy} + bL_{y}/s_L) \)

(13.5) \( \eta_{MF} = \frac{\partial \ln M}{\partial \ln F} = \epsilon_{MF} + \eta_y (\epsilon_{cy} - bL_{y}/(1-s_L)) \)

The effect of changes in stock of U.S.-owned capital on output price of manufactures in the host countries are all negative and range between -0.07 for France to -0.111 for the UK. But the effect of changes in U.S.-owned capital on the level of output, costs, and demand for variable inputs are very large by comparison. The elasticities of output with respect to foreign capital vary considerably, ranging from 0.25 in France to about 0.44 in Japan. When output is variable the demand for labor and materials is positive, suggesting that the output expansion effect overwhelms the substitution effects noted earlier when output did not vary. The magnitudes of these elasticities are much higher in the Japanese and British manufacturing sectors than in the French and German sectors. The important point is that the total effect of an increase in U.S.-owned capital reduces output price and increases both output and the demand for variable inputs.

In table 5 we present the elasticities of output price, level of output, cost, and factors of production with respect to changes in foreign capital by
allowing the stock of domestic capital to vary. In panel A we show the results when the level of output is held fixed while the results in panel B are the elasticity estimates when both the levels of output and stock of domestic capital are allowed to vary. The elasticities of cost and the variable inputs shown in panel A of table 5 are obtained by totally differentiating equations (8), (10.2) and (10.3). They are similar to those shown in panel A of table 4. The reason for this similarity is that the estimated coefficient of the adjustment cost and the partial effects of domestic capital on cost and labor share equations are very small; otherwise there would be a substantial difference among these two sets of estimates. What is important to note, however, is that domestic and U.S.-owned capital stock are complements to each other, i.e., an increase in foreign capital induces domestic investment. The magnitude of the elasticity of domestic capital with respect to U.S.-owned capital, ε_{KF} is highest for the British and Japanese manufacturing sectors and rather small the German and particularly the French sectors.

The elasticities in panel B, table 5, are obtained by totally differentiating equations (8), (9), and (10.1), (10.2), and (10.3) with respect to U.S.-owned capital. When both the levels of output and domestic capital stock are allowed to adjust there are substantial increases in the magnitudes of all the relevant elasticities. For example, the output elasticities increase by 40% for the Japanese and British sectors and by 80% to 90% for the remaining two sectors compared to the case where the level of domestic capital was held constant (panel B, table 4). The long-run output elasticity with respect to foreign capital seem to be about 0.5 except for Japan where it is over 0.6. The same pattern is evident for the variable
inputs. Interestingly the magnitudes of the elasticities of labor and materials are quite similar in each of the sectors which contrasts with the results shown in panel B of table 4. Finally, the complementarity relationship between the two types of capital stock is reconfirmed. The magnitude of the elasticities of domestic capital with respect to U.S.-owned capital are larger by seven to twenty times than when the output level is held constant (panel A of table 5).

An alternative method to assess the effect of the US owned capital stock on productivity growth in the manufacturing sectors of Japan, France, Germany, and the UK can be obtained by regressing the growth rate of total factor productivity (TFP) on the growth rates of conventional inputs—labor, materials, and domestic capital—and the growth rate of the U.S.-owned capital stock. Using the pooled time-series data for the four sectors for the period 1968-1986 the following TFP growth equation:

\[
TFP = .006 + .004t + .05TIN + .07\hat{F} \quad R^2 = .31
\]

\[
(.004) \quad (.002) \quad (.021) \quad (.020) \quad DW = 1.6
\]

where \( t \) is an index of time, \( TIN \) is the combined growth rates of domestic inputs (weighted by their cost shares) and \( \hat{F} \) is the growth rate of stock of U.S.-owned capital.\(^{15}\) The coefficients of the regression have the correct sign and are statistically significant. The coefficient of \( \hat{F} \) in the TFP

\(^{15}\) In calculating TFP foreign capital is excluded from the set of inputs. We estimated the TFP equation with intercept dummies and slope dummies for the variable \( \hat{F} \). However, the coefficients of the dummy variables were not statistically significant.
regression is related to our measures of cost elasticities noted earlier as "productivity effect". It can be shown that the coefficient of \( \hat{f} \) in the above equation \( \gamma_f = - \frac{\epsilon_{CF}}{\epsilon_{CY}} (1 - \epsilon_{CK} - \epsilon_{CY}) \), where \( \epsilon_{CF}, \epsilon_{CY}, \) and \( \epsilon_{CK} \) are the elasticities of variable cost with respect to U.S.-owned capital stock, output, and domestic capital respectively. The average measure for \( \gamma_f \) calculated using the elasticity estimates in table 3 is about 0.05 for the combined sample of the four sectors, which is close to the estimate of the coefficient of \( \hat{f} \) in the TFP regression. These results suggest that the growth rate of foreign capital contributes significantly to TFP growth in the four manufacturing sectors.

7. Summary and Conclusions

We have examined the effect of the US direct investment in plant and equipment in the manufacturing sectors of four OECD countries: France, Germany, Japan, and the United Kingdom. The capital stock owned by US firms is incorporated as an input in the production structure for these sectors. We derive quantitative estimates of how output prices, output levels, costs, and the factors of production in the manufacturing sectors of the host countries have responded to changes in stock of U.S.-owned capital in the period 1968-1986. The results suggest significant effects on the output, costs, level of inputs such as employment and domestic capital, and productivity growth in these sectors. Increases in U.S. foreign investment in plant and equipment Foreign capital reduces costs and price of output; it reduces demand for employment and materials if the level of output in the manufacturing sector of the host countries is held fixed but when the level of output is allowed to vary, the impact of U.S. FDI is to increase output substantially in all of the
four sectors and also increase the demand for employment and materials and
domestic capital. Expansion in U.S. investment stimulates significant new
domestic investment in plant and equipment and the growth of total factor
productivity is enhanced significantly in the manufacturing sectors of Japan,
France, Germany, and the UK.

There are several issues that require further research. A major issue is
to include demand for U.S. investment as an endogenous variable in the model.
To do so requires a careful construction of the rental price of this type of
investment. Second, it might be useful to specify the inverse demand function
to include the direct effect of U.S. investment because some of the
investments are geared towards producing new products. A third interesting
issue is to examine the effect of the U.S.-owned investment, which spills over
to sectors outside the manufacturing sector in the host countries. Finally,
since this type of investment is often closely related to transfer of
knowledge and technology, the model can be modified to include R&D efforts as
another decision variable.
REFERENCES


### TABLE 1a
Quantities of Output Costs and Inputs in the Manufacturing Sectors of Japan, France, Germany, and the UK* (mean values) 1966-1986

<table>
<thead>
<tr>
<th>Elasticities</th>
<th>JAPAN</th>
<th>FRANCE</th>
<th>GERMANY</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Output</td>
<td>352.7</td>
<td>165.2</td>
<td>175.0</td>
<td>197.9</td>
</tr>
<tr>
<td>Labor</td>
<td>74.7</td>
<td>28.9</td>
<td>37.6</td>
<td>38.4</td>
</tr>
<tr>
<td>Material</td>
<td>244.9</td>
<td>99.1</td>
<td>102.9</td>
<td>133.1</td>
</tr>
<tr>
<td>Net Domestic Capital</td>
<td>166.9</td>
<td>102.9</td>
<td>152.3</td>
<td>189.2</td>
</tr>
<tr>
<td>Foreign Capital</td>
<td>2.4</td>
<td>3.9</td>
<td>8.1</td>
<td>12.5</td>
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</table>

* In billions of 1982 US dollars

### Table 1b
Descriptive Statistics
Total Costs, Revenue, Input Shares and Growth Rates of Outputs and Inputs (mean values) 1968-1986

<table>
<thead>
<tr>
<th>Country</th>
<th>$C^*$</th>
<th>$S_Y$</th>
<th>$S_L$</th>
<th>$S_m$</th>
<th>$S_X$</th>
<th>$S_F$</th>
<th>$\gamma$</th>
<th>$\lambda$</th>
<th>$\delta$</th>
<th>$\chi$</th>
<th>$\phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
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<td>1.160</td>
<td>.197</td>
<td>.739</td>
<td>.062</td>
<td>.008</td>
<td>.063</td>
<td>.007</td>
<td>.059</td>
<td>.073</td>
<td>.104</td>
</tr>
<tr>
<td>France</td>
<td>91.4</td>
<td>1.283</td>
<td>.168</td>
<td>.714</td>
<td>.113</td>
<td>.004</td>
<td>.029</td>
<td>-.008</td>
<td>.026</td>
<td>.032</td>
<td>.103</td>
</tr>
<tr>
<td>Germany</td>
<td>106.8</td>
<td>1.733</td>
<td>.251</td>
<td>.649</td>
<td>.096</td>
<td>.005</td>
<td>.027</td>
<td>-.015</td>
<td>.029</td>
<td>.012</td>
<td>.100</td>
</tr>
<tr>
<td>U.K.</td>
<td>110.3</td>
<td>1.107</td>
<td>.198</td>
<td>.742</td>
<td>.057</td>
<td>.004</td>
<td>.007</td>
<td>-.024</td>
<td>.009</td>
<td>.004</td>
<td>.077</td>
</tr>
</tbody>
</table>

* In billions of 1982 US dollars
### Table 2
The Parameter Estimates*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimates</th>
<th>Standard Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_0$</td>
<td>1.2549</td>
<td>0.1153</td>
</tr>
<tr>
<td>$\alpha_y$</td>
<td>-0.2329</td>
<td>0.0222</td>
</tr>
<tr>
<td>$\alpha_{y2}$</td>
<td>-0.0620</td>
<td>0.0180</td>
</tr>
<tr>
<td>$\alpha_{y3}$</td>
<td>-0.0410</td>
<td>0.0170</td>
</tr>
<tr>
<td>$\alpha_{y4}$</td>
<td>-0.0380</td>
<td>0.0170</td>
</tr>
<tr>
<td>$\beta_0$</td>
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<td>0.3870</td>
</tr>
<tr>
<td>$\beta_\ell$</td>
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<td>0.0060</td>
</tr>
<tr>
<td>$\beta_{\ell2}$</td>
<td>0.0245</td>
<td>0.0306</td>
</tr>
<tr>
<td>$\beta_{\ell3}$</td>
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</tr>
<tr>
<td>$\beta_y$</td>
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<td>0.0622</td>
</tr>
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<td>$\beta_{y2}$</td>
<td>0.0332</td>
<td>0.0156</td>
</tr>
<tr>
<td>$\beta_{y3}$</td>
<td>0.0336</td>
<td>0.0165</td>
</tr>
<tr>
<td>$\beta_{y4}$</td>
<td>-0.0059</td>
<td>0.0183</td>
</tr>
<tr>
<td>$\beta_{\ell4}$</td>
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<td>0.0300</td>
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<td>$\beta_K$</td>
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</tr>
<tr>
<td>$\beta_{K2}$</td>
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</tr>
<tr>
<td>$\beta_{K3}$</td>
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</tr>
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<td>$\beta_{K4}$</td>
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<td>0.0190</td>
</tr>
<tr>
<td>$\beta_F$</td>
<td>0.0960</td>
<td>0.0709</td>
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<tr>
<td>$\beta_{\ell K}$</td>
<td>-0.0095</td>
<td>0.0058</td>
</tr>
<tr>
<td>$\beta_{\ell F}$</td>
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<td>0.0065</td>
</tr>
<tr>
<td>$\beta_{K Y}$</td>
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<td>0.0130</td>
</tr>
<tr>
<td>$\beta_{Y K}$</td>
<td>0.0130</td>
<td>0.0115</td>
</tr>
<tr>
<td>$\beta_{Y F}$</td>
<td>-0.0355</td>
<td>0.0120</td>
</tr>
<tr>
<td>$\mu_{K F}$</td>
<td>0.0091</td>
<td>0.0057</td>
</tr>
<tr>
<td>$\mu_{K K}$</td>
<td>0.0004</td>
<td>0.0001</td>
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</tbody>
</table>

Log of Likelihood: 1830.8

<table>
<thead>
<tr>
<th>Equation</th>
<th>Stand. Error</th>
<th>$R^2$</th>
<th>D-W</th>
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</thead>
<tbody>
<tr>
<td>Inverse demand</td>
<td>0.389E-01</td>
<td>0.78</td>
<td>2.00</td>
</tr>
<tr>
<td>Variable Cost</td>
<td>0.8887-02</td>
<td>0.99</td>
<td>1.64</td>
</tr>
<tr>
<td>Revenue share</td>
<td>0.2338-01</td>
<td>0.96</td>
<td>1.53</td>
</tr>
<tr>
<td>Labor share</td>
<td>0.118E-01</td>
<td>0.92</td>
<td>1.86</td>
</tr>
<tr>
<td>Domestic Capital</td>
<td>0.572E-02</td>
<td>0.97</td>
<td>1.33</td>
</tr>
</tbody>
</table>

* $\alpha_{y2}$, $\alpha_{y3}$, $\alpha_{y4}$, $\ell_2$, $\beta_{\ell3}$, $\beta_{\ell4}$, $\beta_{K2}$, $\beta_{K3}$, $\beta_{K4}$, and $\beta_{y2}$, $\beta_{y3}$, $\beta_{y4}$ are country dummy variables.
\[ \text{TABLE 3} \]
Price, Costs and Inputs Elasticities*  
(mean values)

<table>
<thead>
<tr>
<th>Elasticities</th>
<th>JAPAN*</th>
<th>FRANCE</th>
<th>GERMANY</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price and Cost Elasticities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon_{PY}$</td>
<td>-0.197</td>
<td>-0.295</td>
<td>-0.274</td>
<td>-0.270</td>
</tr>
<tr>
<td>$\epsilon_{CY}$</td>
<td>1.137</td>
<td>1.010</td>
<td>1.003</td>
<td>0.936</td>
</tr>
<tr>
<td>$\epsilon_{CK}$</td>
<td>-0.074</td>
<td>-0.145</td>
<td>-0.092</td>
<td>-0.050</td>
</tr>
<tr>
<td>Variable Input Elasticities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon_{LL}$</td>
<td>-0.79</td>
<td>-0.81</td>
<td>-0.72</td>
<td>-0.79</td>
</tr>
<tr>
<td>$\epsilon_{MM}$</td>
<td>-0.21</td>
<td>-0.19</td>
<td>-0.28</td>
<td>-0.21</td>
</tr>
<tr>
<td>$\epsilon_{LM}$</td>
<td>0.79</td>
<td>0.81</td>
<td>0.72</td>
<td>0.79</td>
</tr>
<tr>
<td>$\epsilon_{ML}$</td>
<td>0.21</td>
<td>0.19</td>
<td>0.28</td>
<td>0.21</td>
</tr>
<tr>
<td>Scale and Markup</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE</td>
<td>1.14</td>
<td>1.18</td>
<td>1.17</td>
<td>1.16</td>
</tr>
<tr>
<td>MARKUP</td>
<td>30%</td>
<td>42%</td>
<td>38%</td>
<td>37%</td>
</tr>
</tbody>
</table>

* The relevant elasticities are defined as follows. 
(a) Price and cost elasticities:  
$\epsilon_{PY} = \frac{\partial \ln P}{\partial \ln Y}$  
$\epsilon_{CY} = \frac{\partial \ln VC}{\partial \ln Y}$  
$\epsilon_{CF} = \frac{\partial \ln VC}{\partial \ln F}$  
$\epsilon_{CK} = \frac{\partial \ln VC}{\partial \ln K}$  
$\epsilon_{ct} = \frac{\partial \ln VC}{\partial t}$  
(b) The own and cross price elasticities of variable inputs:  
$\epsilon_{LL} = \frac{\partial \ln L}{\partial \ln L}$  
$\epsilon_{MM} = \frac{\partial \ln M}{\partial \ln M}$  
$\epsilon_{LM} = \frac{\partial \ln L}{\partial \ln M}$  
$\epsilon_{ML} = \frac{\partial \ln M}{\partial \ln L}$  
(c) The scale and markup measures  
SCALE = (1-(\epsilon_{CF} + \epsilon_{CK}))/\epsilon_{CY}  
MARKUP = (P - MC)/P
Table 4  
Short-Run Output, Price, Input Elasticities,  
with respect to Foreign Capital*  

<table>
<thead>
<tr>
<th></th>
<th>Japan</th>
<th>France</th>
<th>Germany</th>
<th>U.K.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \epsilon_{CF} )</td>
<td>-0.063</td>
<td>-0.040</td>
<td>-0.042</td>
<td>-0.043</td>
</tr>
<tr>
<td>( \epsilon_{LF} )</td>
<td>-0.130</td>
<td>-0.110</td>
<td>-0.090</td>
<td>-0.111</td>
</tr>
<tr>
<td>( \epsilon_{MF} )</td>
<td>-0.045</td>
<td>-0.022</td>
<td>-0.022</td>
<td>-0.025</td>
</tr>
<tr>
<td><strong>B. Elasticities with Output Variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \eta_{PF} )</td>
<td>-0.101</td>
<td>-0.073</td>
<td>-0.080</td>
<td>-0.111</td>
</tr>
<tr>
<td>( \eta_{TF} )</td>
<td>0.435</td>
<td>0.248</td>
<td>0.295</td>
<td>0.409</td>
</tr>
<tr>
<td>( \eta_{CF} )</td>
<td>0.371</td>
<td>0.210</td>
<td>0.250</td>
<td>0.339</td>
</tr>
<tr>
<td>( \eta_{LF} )</td>
<td>0.333</td>
<td>0.154</td>
<td>0.214</td>
<td>0.299</td>
</tr>
<tr>
<td>( \eta_{MF} )</td>
<td>0.381</td>
<td>0.223</td>
<td>0.264</td>
<td>0.350</td>
</tr>
</tbody>
</table>

* The level of domestic capital K is held constant.
Table 5
Long-Run Output, Price, Input Elasticities, with respect to Foreign Capital*

<table>
<thead>
<tr>
<th></th>
<th>Japan</th>
<th>France</th>
<th>Germany</th>
<th>U.K.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Elasticities with Output Fixed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varepsilon_{\text{CF}}$</td>
<td>-0.068</td>
<td>-0.044</td>
<td>-0.047</td>
<td>-0.048</td>
</tr>
<tr>
<td>$\varepsilon_{\text{LF}}$</td>
<td>-0.132</td>
<td>-0.117</td>
<td>-0.016</td>
<td>0.112</td>
</tr>
<tr>
<td>$\varepsilon_{\text{MF}}$</td>
<td>-0.051</td>
<td>-0.027</td>
<td>-0.027</td>
<td>-0.032</td>
</tr>
<tr>
<td>$\varepsilon_{\text{KF}}$</td>
<td>0.073</td>
<td>0.027</td>
<td>0.040</td>
<td>0.108</td>
</tr>
<tr>
<td><strong>B. Elasticities with Output Variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_{\text{PF}}$</td>
<td>-0.147</td>
<td>-0.136</td>
<td>-0.139</td>
<td>-0.140</td>
</tr>
<tr>
<td>$\eta_{\text{YF}}$</td>
<td>0.632</td>
<td>0.460</td>
<td>0.510</td>
<td>0.520</td>
</tr>
<tr>
<td>$\eta_{\text{CF}}$</td>
<td>0.508</td>
<td>0.352</td>
<td>0.394</td>
<td>0.407</td>
</tr>
<tr>
<td>$\eta_{\text{LF}}$</td>
<td>0.522</td>
<td>0.336</td>
<td>0.390</td>
<td>0.410</td>
</tr>
<tr>
<td>$\eta_{\text{KF}}$</td>
<td>0.505</td>
<td>0.360</td>
<td>0.400</td>
<td>0.410</td>
</tr>
<tr>
<td>$\eta_{\text{KF}}$</td>
<td>0.782</td>
<td>0.470</td>
<td>0.546</td>
<td>0.682</td>
</tr>
</tbody>
</table>

* The adjustment cost of domestic capital is set to zero, i.e., domestic capital is a variable factor.