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Growing Trade in Intermediate Goods: Outsourcing, Global Sourcing or Increasing Importance of MNE Networks?

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Growing Trade in Intermediate Goods: Outsourcing, Global Sourcing or Increasing Importance of MNE Networks?

by

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October 2000

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Growing Trade in Intermediate Goods: Outsourcing, Global Sourcing or Increasing Importance of MNE Networks? *

Abstract:
Trade in intermediate goods as one possible link between rising trade and foreign direct investment is examined. To explain growing intermediate goods trade, three hypotheses are brought forward: outsourcing, global sourcing and the increasing importance of MNE networks. These hypotheses are tested by employing a cross-section framework, which uses OECD input-output table data, and an analysis, which relies on German time-series data. Increasing importance of MNE networks is found to be a reason of growing trade in intermediate goods in the cross-section and the time-series framework. The evidence for outsourcing and global sourcing is found to be much weaker.

JEL-Classification: F 11, F 21, F 23
Keywords: Globalization, Intermediate Goods Trade, Outsourcing, Global Sourcing, Multinational Enterprise

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The remarkable increase in international trade and foreign direct investment has been one of the most often discussed topics in academic and political debate over the last 15 years. But still there seems to be no consensus on the driving forces, the links between international trade and FDI and, therefore, the consequences of their growth in recent years (see, for instance, Krugman 2000, Leamer 2000).

This paper looks at one of the possible links between international trade and FDI: trade in intermediate goods. Imported inputs account for roughly one half of total imports of developed countries. This share proved to be remarkably constant over the last two decades. Given the stronger growth of trade relative to production, the share of imported inputs on total inputs increased strikingly over this time period. Using input-output data from six OECD countries and German time series data three hypotheses of the strong growth of imported input are tested: outsourcing, increasing MNE networks and global sourcing.

According to the outsourcing hypothesis (Feenstra and Hanson 1996), rising imports of intermediate goods result from companies' strategies to relocate a part of their production to foreign countries with comparative advantages in the production of these specific product categories. Companies in industrialized countries shift labor-intensive stages of their production process to labor abundant countries with lower wages. Therefore, FDI in low-wage countries is necessary. Increasing imported inputs use is, according to the outsourcing hypothesis, related to growing outward FDI stocks of companies in industrialized countries. In contrast, the MNE network hypothesis argues that the increasing imported input use is due to trading networks of MNEs. Intense trading between MNEs' affiliates in foreign countries and companies of the home country (including of course the MNE parent company) lead to higher input imports. Increasing imported inputs are, therefore, related to growing inward FDI stocks. The global sourcing hypothesis stands for an influence of neither the outward nor the inward FDI stock on imported input. According to global sourcing, companies buy their inputs wherever the best conditions are offered. Increasing use of imported inputs is, therefore, due to a grown propensity to import intermediates, which has been generated by globalization.

This paper includes five parts. Part one reviews the related literature. Part two brings forward some explanation of the growing importance of imported inputs. Part three tests these explanations by using an econometric model which includes 24 industrial sectors of six OECD countries. These six countries (Australia, France, Germany, Japan, the United Kingdom and the United States) account for about two thirds of World GDP and about one half of World trade. Following the cross-section analysis part four presents time series evidence on the change of imported inputs in the last 25 years. Part five concludes.

1. Related Literature

Trade in intermediate goods did not attract very much attention until recently. In theoretical and empirical research trade was thought of as trade in finished goods. With the increasing international division of labor through disintegration of the production process, which has increased strongly in the last two decades, trade in intermediate goods called for more attention (Krugman 1995). When Campa and Goldberg (1997) collected facts on external orientation of particular industries in four countries (United States, Canada, United Kingdom and Japan) they presented, beside ex- and imports figures, shares of imported inputs relative to total inputs used in domestic production. Their work points to a growing dependence on imported input in the production of nearly all manufacturing industries in Canada, the United Kingdom and the United States. There are sectoral as well as national differences. Almost all Japanese sectors, for instance, do not rely so heavily on imported intermediate inputs. Furthermore, in contrast to the other analyzed countries, the imported intermediate goods' share of total imports of Japan declined over the last 25 years (Campa and Goldberg 1997).

Hummels et al. (1998) use the term vertical specialization for the increasing imports of inputs used in the production of goods that are exported. Modern companies operate with production plants, subsidiaries or through arm-length relationship, in several countries. That enables them to exploit the advantages of different locations. Their units are connected by international trade. Hummels et al. (1998) argue that the increase in the use of imported inputs is the link between rising international trade volumes and increasing international production. They find in case studies and an input-output-table analysis a large and increasing share of trade that can be attributed to vertical specialization based trade. This share differs among countries. Larger countries show lower levels of vertical specialization than small countries, since large countries can more easily support every stage of production in many differentiated goods. Hummels et al. also report sectoral differences with machinery and chemicals having the largest contribution to the increase of vertical specialization based trade relative to total trade.

In Diehl (1999) cost functions for 28 German manufacturing sectors are estimated, which include prices of imported intermediate inputs as one (out of eight) exogenous variable, to infer the effect of outsourcing on the demand for unskilled labor relative to skilled labor. For five industries (including leather, textile and clothing) a significant effect of outsourcing has been found.

Another type of analysis is offered by Andersson and Fredriksson (2000), who looked at Swedish company data to shed some light on intra-firm trade of Swedish MNEs from 1974 to 1990. Intra-firm trade of Swedish companies has increased strongly since the mid 1970s. Andersson and Fredriksson find a shift in the composition of intra-firm trade of Swedish parent companies in favor of intermediate goods. Their share of total intra-firm trade (trade in finished goods, in intermediate goods and in capital goods) has risen from 30% in 1970 to almost 70% in 1990. The total intra-firm trade in this sample has more than tripled over the 20 years period from 850 Mill. Swedish Kroner to 3,050 Mill. Swedish Kroner (current prices).

In their econometric analysis Andersson and Fredriksson (2000) split intra-firm trade in trade in intermediate goods and trade in finished goods, since trade in the two groups is likely to be internalized for different reasons. They relate intermediate products trade to vertical integration and finished product trade to horizontal integration. The Tobit models presented in their paper confirm differences for both product groups. Per capita income is found to be the variable which exerts the strongest (positive) effect on finished products trade, but for intermediate products trade it is found to be insignificant. They argue that the regression on the volume of intermediate goods trade within firms rejects, therefore, traditional factor proportion models, since there is no straight-forward relationship between widening factor-price differentials and intra-firm trade in intermediates.

Rauch (1999) could offer another explanation than factor-price differentials for intermediate goods trade: trading networks. Based on econometric evidence, Rauch points to the importance of networks for international trade and foreign direct investment. He finds significant positive influence of proximity and a common language or colonial ties. These variables are more important for differentiated products than products traded on organized exchanges. Therefore, he argues, that in trade of differentiated goods “connection between sellers and buyers are made through a search process that because of its costliness does not proceed until the best match is achieved“ (Rauch 1999: 7 f.). This view is supported by studies on the influence of migration on import structures (Gould 1994; Dunlevy and Hutchinson 1999). These studies find a broad import enhancing effect of migration, especially for more finished and more differentiated goods.

Due to data constraints empirical analysis of intermediate product trade is rather rare. Sectoral studies (Campa and Goldberg 1997, Hummels et al. 1998) found an increase of international trade in inputs in recent years. Next to rising export and import levels and increasing FDI flows growing international integration can also be seen in the increasing use of imported input. The studies quoted above point to national and sectoral differences with smaller countries being more dependent on imported inputs. Machinery and chemicals are the sectors that lead international integration regarding imported input use. Differences in trade in intermediate and finished products could also be found in studies which used company data (Andersson and Fredriksson 2000).

2. Theoretical Considerations

The strong increase in intermediate products trade is not well understood. Mostly trade in intermediate goods is related to vertical integration, and vertical integration is related to traditional factor-proportion theories. Intermediate goods trade is, therefore, expected to exploit country differences. That is the outsourcing view of intermediate goods: labor intensive stages in the value chain are relocated to labor abundant low wage countries. Intermediate products are imported for further manufacturing or selling in the developed countries' markets (Feenstra 1998). According to the outsourcing hypothesis, increasing imported input figures point to increasing vertical trade on the basis of factor-proportion theories.

Feenstra and Hanson (1995) illustrate this process by using a Heckscher-Ohlin model with a continuum of intermediate goods z but only a single manufacturing good. There are three factors of production: unskilled and skilled labor, L and H, and capital K producing in two countries: the North and the South. The South is assumed to be unskilled labor abundant. Feenstra and Hanson (1995) interpret all activities as within one industry. The intermediate inputs are produced according to

$$x(z) = A_i \left[\min\left\{ \frac{L(z)}{a_L(z)}, \frac{H(z)}{a_H(z)} \right\} \right]^q \left[K(z)\right]^{1-q} \qquad (1)$$

where A_i is a constant that can differ between the North and the South, $a_L(z)$ and $a_H(z)$ give the fraction of unskilled and skilled labor for the production of one unit of the intermediate input z. The ratio $a_H(z)/a_L(z)$ is assumed to increase in z. Given these inputs the final good is costlessly assembled according to the production function

$$\ln Y = \int_0^1 a(z) \ln x(z)\, dz \qquad \text{with } \int_0^1 a(z)\, dz = 1. \tag{2}$$

Factor price equalization can not be achieved since factor endowments and technologies are assumed to be sufficiently different. In equilibrium the South produces and exports a range of inputs up to some critical ratio of skilled to unskilled labor, which characterizes the intermediate z^*, while the North produces the remainder. Taking the location of the production of intermediate goods into account, equation (2) changes to

$$\ln Y = \underbrace{\int_0^{z^*} a(z) \ln x(z)\, dz}_{I} + \int_{z^*}^1 a(z) \ln x(z)\, dz \,. \tag{3}$$

The second term on the right hand side expresses the intermediate inputs produced in the North. These are more skilled labor intensive than the imported inputs I (produced in the South) which are given in the first term on the right hand side. By using equation (1) the imported inputs I can be written as

$$\ln I = \int_0^{z^*} a(z) \ln \left[A_i \left[\min \left\{ \frac{L(z)}{a_L(z)}, \frac{H(z)}{a_H(z)} \right\} \right]^q [K(z)]^{1-q} \right] dz$$

or

$$\ln I = \int_0^{z^*} a(z) q \ln \left[A_i \min \left\{ \frac{L(z)}{a_L(z)}, \frac{H(z)}{a_H(z)} \right\} \right] dz + (1-q) \int_0^{z^*} a(z) \ln K(z)\, dz \quad . \tag{4}$$

Growth in the relative capital stock in the South or neutral technical progress relative to the North, will raise the critical ratio z^* dividing the Northern and Southern activities. Outsourcing occurs with relocation of production from the North to the South, if z^* rises. Although FDI in the low-wage country is not mandatory for this phenomenon to occur since it results more generally from any neutral increase in relative supply from the low wage country (Feenstra and Hanson 1995), FDI in low wage countries is seen as source of outsourcing in almost every study including Feenstra and Hanson (1995).

Kleinert (1999, 2001) offers a different explanation for growing trade in intermediate goods. There the trading network idea is employed in a formal model of the emergence of MNEs. Modern production generally relies on many intermediate inputs that are supplied by independent companies as well as affiliates and subsidiaries of the own company. Often these inputs are specific to the company's product or production process. When a company internationalizes its production, the production in the foreign affiliate depends, at least partly, on the supply of the intermediate inputs from the home country network of the MNEs. The establishment of a supplier network in the host country is time-consuming, and many adjustments of the production process are necessary. Hence, it is cheaper for the foreign affiliate to import intermediate inputs from the home country. The volume of imported inputs increases, therefore, in number and size of affiliates of foreign MNEs that produce in the country. For simplicity, the two country model in Kleinert (1999) assumes only specific intermediate goods, which must be imported. Non specific inputs are assumed away. Hence, a foreign affiliate of a MNE imports all intermediate inputs, a plant in its home country or a national company imports no inputs. The imports of inputs of the foreign country F, I_F, equal the product of the number of F-based affiliates of MNEs from the home country H, $m_{H,F}$, and the value of intermediate inputs used in the production of an affiliate.

$$I_F = m_{H,F}\, pz_H^M qz_H^M \tag{5}$$

pz_H^M stands for the price index of all (imported) inputs used in the foreign affiliate of the H-based MNEs, qz_H^M for the quantities of these inputs. The superscript M indicates that only affiliates of foreign MNEs import intermediate goods. According to the MNE network explanation, not companies' outward FDI of a country is decisive for the amount of imported inputs but inward FDI of foreign country's MNEs.

No formal model of global sourcing is presented here. The idea behind global sourcing can be described as follows: decreasing distance costs and technological progress, which ease changes in production processes (shorter product cycle, smaller production series), lead to an increase in the use of foreign inputs relative to domestic inputs.

In the following two parts, the three explanations will be tested in a cross-section and a time series analysis. The outsourcing and MNE network explanation can be tested directly, the global sourcing hypothesis only in a more indirect manner. In the cross-section analysis the size of the intercept contains some information about the global sourcing hypothesis: a positive intercept points to the fact that there is global sourcing, a growing positive intercept to increased propensity to global sourcing. The global sourcing hypothesis of increased imported inputs use relies on growing intercepts. In the time series regression in part four the test of significance of the trend variable could be interpreted as “test“ of the global sourcing hypothesis. If there is a tendency towards more intense use of imported input (global sourcing) this should show up in the time trend variable.

3. Evidence from Cross-Section Analyses

3.1. The Data

Intermediate inputs can be derived from input-output tables, which characterize the interrelations among sectors. The tables show how much oil, chemicals or steel are used in machinery, for instance. The value of inputs used in every sector is reported. The OECD (1997) published input-output tables for ten countries for several years between the late 1960s and 1990. The economy is divided into 35 sectors, of which 24 are goods producing industries, 22 of those are manufacturing. These input-output tables include an imported transaction matrix, which reports the imported inputs of every sector from every other sector. The total use of intermediate inputs and gross production of every industry can also be derived from this statistic. Although the most recent input-output matrix is from 1990, the OECD tables provide a very impressive data set on the use of imported and domestic inputs and gross production of every sector over a time span of 20 years (except for Italy of which only 1985 data are available).

It has been impossible to collect data on sectoral disaggregated inward and outward FDI stocks of the same quality. Again the OECD offers the best data. The International Direct Investment Yearbook (1993) reports data on FDI for 23 OECD countries, including all ten countries for which input-output data are available. The quality of the data differs depending on the national raw data the OECD receives. Especially information on FDI stocks is rather rare. The United States and Germany report a sectoral breakdown of FDI stocks equal to the OECD input-output tables back to the late 1970s, Australia's figures date back to the early 1980s. Japanese statistics collect only FDI flows, which are aggregated to stock figures. France started to conduct company surveys of outward and inward FDI stocks only in the late 1980s and early 1990s. Statistical data on FDI stocks for the United Kingdom are available from the mid 1980s for agriculture and eight manufacturing sectors. Although Italian FDI stock data are available, Italy is excluded from the econometric analysis because of missing input-output data for 1990. Canada, the Netherlands and Denmark report no FDI stock data or only of a very small number of sectors. Therefore, they are excluded. The OECD data of the six countries which are included in this analysis are filled with data from the national statistics on which the OECD data is based.

3.2. Cross-Section Estimations

The outsourcing hypothesis can be tested by estimating equation (4). The dependent variable on the left hand side is the logarithm of the imported inputs which are available from the OECD input output table as described above. For the six OECD countries under consideration (the North), sectoral disaggregated imported input data are used for the analysis. In a cross-section analysis the first term on the right hand side

$\int_0^{z^*} a(z) q \ln\left[A_i \min\left\{L(z)/a_L(z), H(z)/a_H(z)\right\}\right] dz$, can be seen as a constant which is likely to vary among different sectors. It is not necessary to calculate proxies for this integral. It is sufficient to control for the sectoral differences. The second term is a product of an unknown coefficient (between zero and one) and the logarithm of the capital stock used in the production of the imported inputs: $(1-q)\int_0^{z^*} a(z) \ln K(z)\, dz$. This capital stock is employed in the foreign country (South). The foreign capital stock can neither be calculated nor proxied by outward FDI of the inputs' importing countries. But outward FDI is the appropriate variable to test the role of globalization (except for the small share of technology transfer which is not bound to FDI) in outsourcing. Since FDI in other countries is made responsible for the increase in imported inputs use in domestic production in many developed countries, this should show up in the data. Outsourcing in this test is bound to outward FDI and is, therefore, different from Feenstra and Hanson's definition, but equal to their reasoning. Sectoral outward FDI stocks of the input importing country are, therefore, used as explanatory variable. Outward FDI stocks of sector *x* are the sum of all outward FDI stocks of *x* in any sector *y* (*y=1...n*) in the foreign country. FDI can be chosen as freely by companies as the amount of imported inputs. The outward FDI stock of a sector fits, therefore, the imported input variable, which is also the sum of imports from all sectors. Equation (4) changes to

$$\ln I = c + b_1 \ln FDI_{Outward} + b_3 Dummy_{Sector} + b_4 Dummy_{Country} + u \quad . \qquad (6)$$

For the outsourcing hypothesis to hold, β_1 must be positive (β_1>0). Country Dummies are included to control for national differences among the six countries which are together called the North. Australia for instance is likely to import less inputs because of its distance from its trading partners, the United States because of its economic size.

The test for the MNE networks is also straight forward. In equation (5) imported inputs equal the product of the number of affiliates of foreign companies and their use of intermediate goods. The role of MNEs in a sector of a host country is proxied by the inward FDI stock in this sector. The inward FDI stock in *x* is the sum of all FDI from all foreign sectors *y* (*y=1...n*) in sector *x*. It fits,therefore, the imported inputs. The use of these data implies equal intermediate input shares and equal capital coefficients over all sectors. Sector Dummies shall control for differences among the various sectors. Taking logs and including a constant, which allows intermediate inputs' imports by host country companies, the equation to be estimated is given in (7).

$$\ln I = c + b_2 \ln FDI_{Inward} + b_3 Dummy_{Sector} + b_4 Dummy_{Country} + u \tag{7}$$

The MNE network hypothesis implies $\beta_2>0$. The Country Dummies are included for the same reason as in equation (6). A third equation is estimated which includes outward and inward FDI stocks.

$$\ln I = c + b_1 \ln FDI_{Outward} + b_2 \ln FDI_{Inward} + b_3 Dummy_{Sector} + b_4 Dummy_{Country} + u \tag{8}$$

Equation (6), (7) and (8) are tested using sectoral data for three time points: the late seventies/early eighties, the mid eighties and 1990. The late seventies/early eighties are tested with data from only three countries: Germany (1978 data), Japan (1980) and the United States (1982). France and the United Kingdom did not report FDI stocks at this time, for Australia no input-output table is available for the early eighties. The number of observations is rather low: 44, including very few Japanese data. The other analyses are conducted using data from all six countries. The mid eighties data are from 1984 for the United Kingdom, from 1985 for France, Japan and the United States, and from 1986 for Australia and Germany. French stock data are calculated by using the late eighties stock data and subtract the flow data, which are reported in OECD (1993).

Figure 1 allows a first glimpse at the data. Imported inputs seem to be positively related to outward FDI as well as inward FDI for all three time points. Although this is a first indicator, a econometric analysis, which controls for national and sectoral differences, is needed to make sure that the correlation does not only depend on sectoral size effects.

Table 1 reports the estimation results for the late seventies/early eighties[1]. All regressions are run by using the White (1980) correction for heteroskedasticity. Columns I to III give the estimates without any dummy variable, in IV to VI dummies are included to allow for sectoral differences.

1 All estimations are conducted by using the software package EViews 3.1.

Figure 1: Imported Inputs and FDI (Mill. $)

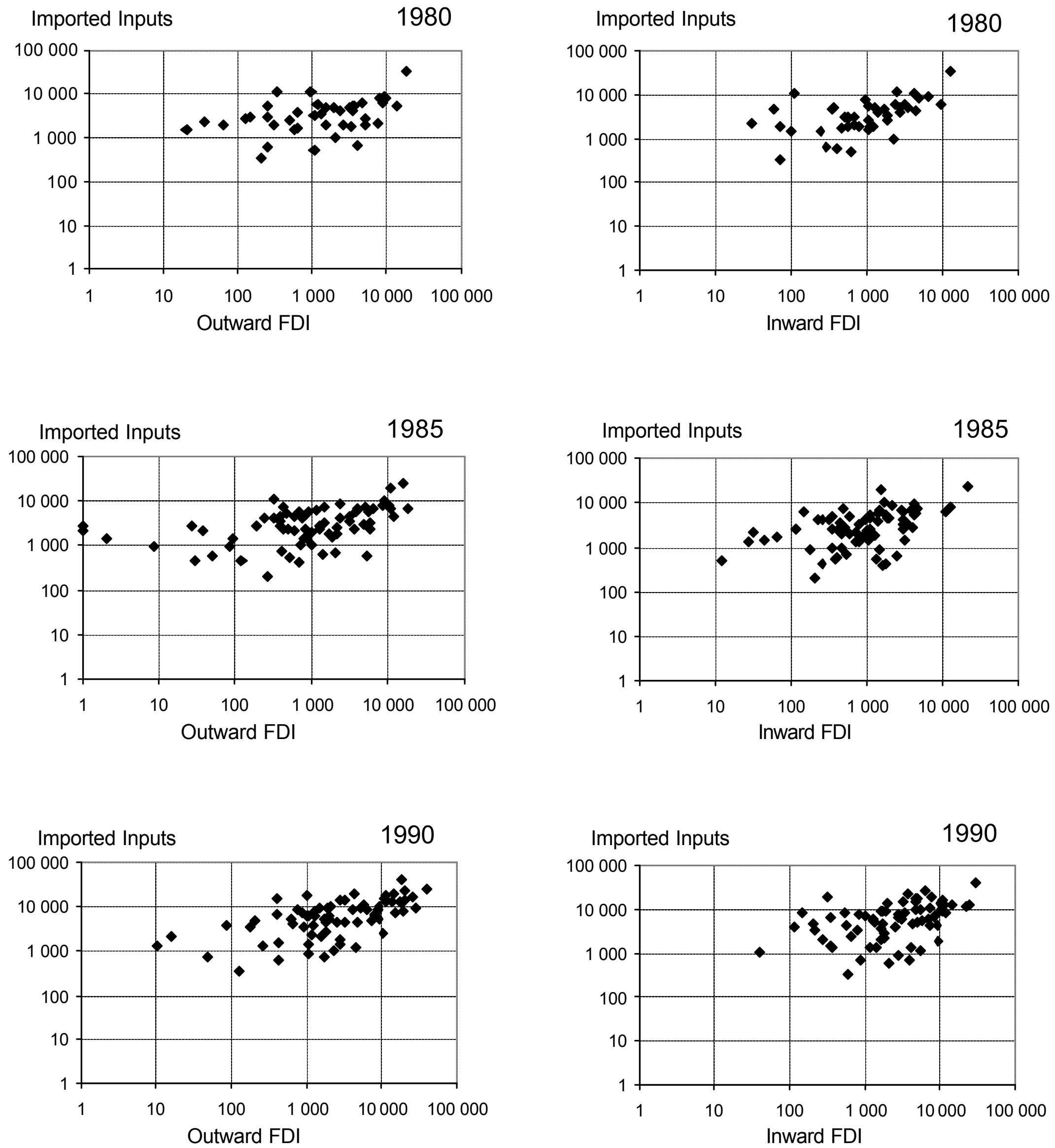

Table 1: Outsourcing and MNE Networks in the Late Seventies/Early Eighties[a]

	I	II	III	IV	V	VI	VII	VIII	IX
C	6.602***	5.788***	5.708***	7.057***	6.22***	6.187***	0.572	0.981	0.166
ln(Output)							0.708***	0.536***	0.665***
$\ln(FDI_{Outward})$	0.206***		0.0375	0.153***		0.045	-0.033		-0.163
$\ln(FDI_{Inward})$		0.335***	0.307**		0.283***	0.237*		0.182**	0.265**
Elec. Equipment					-0.448**				
Non-Metalic Minerals				-0.728**	-0.845**	-0.768**			
Petroleum				1.62***	1.131***	1.226***			
Mining				-1.206**	-1.164**	-1.153**			
Other Transport				-1.065					
Adjusted R^2	0.11	0.25	0.23	0.39	0.40	0.40	0.39	0.45	0.48
F-Statistic	6.54**	15.3***	7.57***	6.4***	6.84***	6.65***	14.6***	18.6***	14.14***
Jarque-Bera Prob	0.55	0.92	0.93	0.22	0.45	0.53	0.90	0.85	0.92

[a] Dependent variable: ln(imported inputs); method: least squares; number of observations: 44; White heteroskedasticity-consistent standard errors & covariance. — *, **, *** significant on 10%, 5% and 1% level.

Columns VII to IX include the value of the sectoral production output in order to control for differences in the size of the sectors. Since larger sectors are supposed to import more inputs, the output variable is expected to have a positive sign.

Table 1 gives support to the outsourcing explanation as well as to the MNE network explanation of imported input use in production. The outward FDI stock has a positive effect on imported inputs in regression I and regression

IV, the test which includes Dummy variables to control for sectoral differences. In regression VII, which includes the value of outputs to control for sectoral differences, the outward FDI stock fails to exert a significant influence. The same holds true for the regression which includes inward and outward FDI stocks III, VI and IX. The insignificant coefficient in these regressions might result from multicollinearity of the explanatory variables. The correlation coefficient between the log of outward and inward FDI stocks is 0.633 which exceeds the critical value for 44 observations of 0.302. The correlation between the log of outward FDI and the production output is 0.627, which is rather high, too. That could explain the insignificant coefficient of outward FDI in regression III, VI, VII and IX: multicollinearity inflates the standard error.

The coefficient of the inward FDI stock variable proved to be more robust against specification changes. The inward FDI stock variable always exerts a significant positive influence on imported inputs in this sample. The explanatory power and the F-Statistic are higher (regression II) than of the outward FDI stock equation (regression I). A ten per cent increase of the inward FDI stock increases imported inputs by 3.3 per cent, whereas a ten per cent increase of the outward FDI stock increases imported inputs by 2 per cent.

Regressions IV to VI point to large sectoral differences. Not surprisingly the petroleum and coal products sector imports significantly more inputs (oil and gas). The reliance of imported intermediate inputs uses in production was at 19% for the United States, 78% for Germany and 82% for Japan in the early 1980s, far above average levels (8%, 18% and 14%, respectively). Other significant dummy variables confirm sectoral differences. Including more sectoral dummy variables does not change the coefficients of the FDI stocks in regressions IV to VI. The production output variable proved to add to the explanatory power and the F-statistics of the estimated equations. The coefficient is significantly positive for all three regressions. The size of the constant drops.

The analysis for the mid eighties includes six countries (Australia, France, Germany, Japan, the United Kingdom and the United States). The numbers of observation increased to 75. An outlyer, the French non-metallic mineral sector was excluded in all mid eighties and 1990 regressions to ensure normal distribution of the residuals. The results, which basically confirm the results from Table 1, are given in Table 2.

The country dummy for Australia was included to ensure normal distributed residuals. By using data from six instead of three countries, the estimation results improved (even without the Australia dummy), as seen in higher R^2 and F-statistics[2]. That points to the fact that the results from Table 1 do not only apply to the three largest economies. Again, the MNE network hypothesis gained stronger support than the outsourcing hypothesis.

Table 2: Outsourcing and MNE Networks in the Mid Eighties[a]

	I	II	III	IV	V	VI	VII	VIII	IX
C	7.533***	6.118***	6.149***	7.47***	6.19**	6.311***	2.791***	3.083***	2.763***
ln(Output)							0.513***	0.356***	0.408***
ln($FDI_{Outward}$)	0.085**		-0.019	0.099**		-0.018	-0.021		-0.07**
ln(FDI_{Inward})		0.295***	0.31***		0.301***	0.296***		0.183***	0.224***
Australia	-1.5***	-1.65***	-1.69***	-1.38***	-1.62***	-1.63***	-0.80***	-1.01***	-1.08***
Non-Metallic Minerals				-0.62*	-0.715**	-0.72***			
Petroleum				0.938**		0.218			
Metal				-0.645**	-0.67**	-0.623**			
Elec. Equipment					-0.43***				
Adjusted R^2	0.40	0.56	0.55	0.47	0.61	0.60	0.59	0.65	0.66
F-Statistic	25.4***	47.7***	31.5***	14.3***	24.2***	19.4***	36.6***	46.4***	37.4***
Jarque-Bera Prob	0.22	0.65	0.71	0.15	0.48	0.65	0.47	0.16	0.28

[a] Dependent variable: ln(imported inputs); method: least squares; number of observations: 75; White heteroskedasticity-consistent standard errors & covariance. — *, **, *** significant on 10%, 5% and 1% level.

F-statistic and R^2 are higher in all regressions run with mid eighties data. The coefficient of the FDI_{Inward} variable is of higher significance. As in the regressions reported in Table 1, significant sectoral differences were found.

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2 The R^2 and F-statistics presented here are not comparable to the early eighties regression, because the regressions of Table 2 include the Australia Dummy.

Dummy variables and production output in regression IV through IX control for these sectoral differences. Furthermore, the country dummy for Australia proved to be significant. Australian companies import significantly less input from other countries than the other economies in this sample which can be explained by Australia’s geographic location.

The last cross section regressions are presented for 1990, the last year for which OECD input-output table data are available (Table 3). The sample includes the same six countries as the mid eighties regression. The lack of Japanese FDI stock data for petroleum and rubber products and non-metallic products reduces the number of observations to 73.

Table 3: Outsourcing and MNE Networks in 1990

	I	II	III	IV	V	VI	VII	VIII	IX
C	7.27***	6.751***	6.579***	7.281***	7.014***	6.799***	2.966***	2.866***	2.837***
ln(Output)							0.472***	0.421***	0.428***
$\ln(FDI_{Outward})$	0.198***		0.068	0.21***		0.099	0.07		-0.016
$\ln(FDI_{Inward})$		0.27***	0.22**		0.253***	0.18**		0.161***	0.171**
Australia	-1.51***	-1.88***	-1.74***	-1.33***	-1.8***	-1.58***	-0.89***	-1.11***	-1.13***
Non-Metallic Minerals				-1.13***	-1.24***	-1.2***			
Petroleum				1.156***					
Metal				-0.57**	-0.462**	-0.52***			
Profess. Goods				-1.03***	-1.07***	-1.07***			
Mining				-0.94***	-0.61***	-0.74***			
Adjusted R^2	0.56	0.61	0.62	0.72	0.71	0.72	0.68	0.71	0.71
F-Statistic	47.7***	58.4***	39.4***	28.1***	30.7***	27.5***	51.8***	60.2***	44.5***
Jarque-Bera Prob	0.51	0.92	0.87	0.42	0.97	0.78	0.81	0.44	0.42

[a] Dependent variable: ln(imported inputs); method: least squares; number of observations: 76; White heteroskedasticity-consistent ctandard errors & covariance; — *, **, *** significant on 10%, 5% and 1% level.

Table 3 confirms the results of the earlier time points. As in the mid eighties' regressions the country dummy for Australia was included to ensure normal distributed residuals. The coefficient of $FDI_{Outward}$ seems to be larger and more robust to specification changes compared to the regressions which used early and mid eighties data. But still, the FDI_{Inward} variable is more robust and has more explanatory power. The MNE network hypothesis has been supported in all regressions. Notwithstanding the multicollinearity with the output variable, which are used to control for sector size, the coefficient remains significant at the 1% level. Its size changes only little in all specification changes. Furthermore it proved to be remarkably stable over time, too.

3.3. Discussion of the Results

Cross-section estimations gave strong support to the hypothesis that the increasing use of imported inputs is triggered by a world wide production network of MNEs. The result seems to be robust to specification changes and for different time points. Unfortunately, the last input-output table which includes an imported transaction table is published for 1990, a time when the latest wave of economic integration just had started. Given the strong increase of FDI by MNEs in the 1990s the importance of MNE networks is likely to increase. The stable elasticity of imported inputs to changes in inward FDI stocks in a period with drastically increased FDI flows points to a very stable economic relation between the production of MNEs in a host country and their propensity to import inputs. Given the large home bias which has been found in the trade of all countries (with the possible exception of Hong Kong and Singapore), it is very likely that the bulk of the imports of MNEs is drawn from their home countries. Unfortunately, this hypothesis can not be tested, since the imported transaction table of the input-output matrix does not separate by the country from which the input is imported.

Results from other research can be used to support this hypothesis. First, there is the company data analysis of exports of Swedish MNEs from Sweden to their affiliates all over the world, which include a large share of intermediate goods trade (Andersson and Fredriksson 2000). Blomström et al. (2000) report varying ratios of inputs imported from the home country to affiliates' sales of foreign affiliates of Swedish MNEs in different industries. They range from 10% for food, paper and non-electric machinery to 37% for transport equipment. Second, Rauchs (1999) trading network theory can be employed.

Evidence for outsourcing as major driving force of increasing imported inputs use is much weaker. However, outsourcing does not necessarily depend on outward FDI (Feenstra and Hanson 1995). In this cross-section analysis outsourcing that does not depend on outward FDI is not distinguishable from global sourcing. Global sourcing is represented in the intercept which is significant positive for all regressions I to VI at all three time points. Companies have used the advantages of global sourcing on a significant level over the analyzed period. But the intercept did not change over time. It is not statistically different on the 10% level for the estimation of the three time points. Furthermore, in regression VII to IX the estimated coefficient of the output variable can be interpreted as elasticity of imported input demand with respect to production output. Global sourcing as explanation for increasing imported inputs' use refers to an increase in demand for foreign inputs, the elasticity must rise for global sourcing to hold. A test of equality of the coefficients, could not reject the hypothesis of unchanged parameters over the analyzed time period at the 10% level. Although there has been significant global sourcing, it is, therefore, probably fair to say that global sourcing is not the dominant driving force behind the increase in imported inputs used in production.

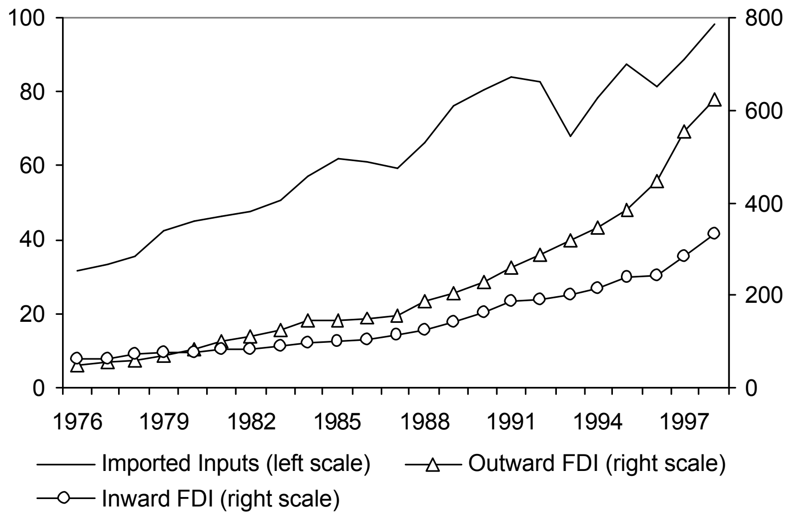
4. Time-series evidence

The sectoral data analyzed in the last section pointed to a robust relationship between the inward FDI stock and imported inputs used in production. The outsourcing theory received some support, too. In this section the relationship between imported inputs and outward or inward FDI stocks will be explored further by using annual time series data from Germany between 1976 and 1998. The period is chosen for the reason of data availability, the number of observations is rather low. German FDI stock data (inward and outward) are reported by the Bundesbank back to 1976. The foreign FDI stock invested in Germany increased over this period from 65.8 billion DM to 332.6 billion DM. The increase of the FDI stock of German companies in foreign countries was much more impressive: in 1998 the outward FDI stock was, with 619.5 billion

DM, more than 12 times higher than in 1976 (49.1 billion DM). Over the analyzed time period German outflows exceeded the FDI inflows.

Imported inputs are also taken from the Bundesbank. Since 1973 the Bundesbank has reported imported manufactured inputs in their Balance of Payments Statistics (Deutsche Bundesbank various issues). These manufactured goods imported to be used as inputs in manufacturing more than tripled in the period analyzed: from 31.5 billion DM to 98.3 billion DM (Figure 2).

Figure 2: Imported Inputs, Outward and Inward FDI 1976–1998 (Bill. DM)



Source: Deutsche Bundesbank (1999, various issues).

Since the increase in these imported manufactured inputs has not kept pace with the increase in total imports since the mid seventies their share on total imports declined from 14.5% to 12.1% over this period. This category (imported manufactured inputs reported by the Bundesbank) is much smaller than the roughly 50% of import which are imported inputs according to the input-output data. Adding raw materials and semi finished products (also taken from Bundesbank, various issues) to the imported manufactured inputs increases their joint share on total imports to approximately a third, still less than the 50% from the input-output tables. Manufactured goods which are final goods but are used as inputs account for the remainder. In the absence of an alternative it must be assumed that these intermediates are affected in the same way by the exogenous variables as the imported manufactured inputs, which are used here for the time series analysis.

World wide economic integration has increased remarkably during the last two decades. FDI and trade have grown strongly. The aim of this part is to test, whether intermediate inputs imports and FDI stocks (inward and outward) form a meaningful, stable long run economic relation: does the value of imported inputs depend on inward or outward FDI stock levels in the long run? Therefore, equation (4) and (5) derived in part two are analyzed. As in part three the equations are estimated in the log-linear form.

Since both FDI stocks and imported inputs are I(1) variables (Table 4) a stable I(0) relation depends on cointegration of the inward or outward FDI stock and the imported inputs. I(0) variables follow stationary stochastic processes. They have a finite and constant mean and a finite and constant variance-covariance matrix. A variable is called integrated of order 1, I(1), if it has to be discretely differenced once to form a stationary process. Whereas stationary variables return after a shock to their pre-shock level, integrated variables do not. They change to a new level.

Table 4: Phillips-Perron Tests[a] for Unit Roots

ln(I)	Δln(I)	$\ln(FDI_{Outward})$	$\Delta \ln(FDI_{Outward})$	$\ln(FDI_{Inward})$	$\Delta \ln(FDI_{Inward})$
-1.5559	-4.395***	-0.0475	-3.6375**	2.0329	-2.9969**
I(1)	I(0)	I(1)	I(0)	I(1)	I(0)

[a] Phillips and Perron (1988). The test is carried out with two lags included, which ensures freedom of autocorrelation.— *, **, *** denotes rejection of the hypothesis of an unit root at 10%, 5% and 1% level.

In general, the linear combination of two or more integrated variables is also integrated. However, two variables that are I(1) may be related in an economically meaningful way, so that the linear combination of the variables is I(0)[3]. If variables are related in such a way, it is called cointegration.

Cointegration ensures the absence of a spurious regression problem. Variables that are I(1) can show a relationship, which stems from the statistical interrelation of the trends of the I(1) variables, although there exists no long run economic relationship between these variables (spurious regressions). Therefore, both pairs of variables, inward FDI and imported inputs and outward FDI and imported inputs are tested for a cointegration relation using

[3] That could stem from the fact that the source of their non-stationarity is the same or that one of the variables is the source of the non-stationarity of the other variable.

the Johansen cointegration test (Johansen 1991). This procedure assumes all variables to be endogenous and tests for linearly independent cointegration relations. With only two variables there can be none or one cointegration relationship. Since the critical values of the test statistics depend on its specification a choice has to be made among the alternatives for whether a constant and/or a trend should be included in the specification of the cointegration equations. Table 5 gives the results of the Johansen cointegration test for two specifications: (i) constant, no trend in the long run relationship, and (ii) constant and trend in the long run relationship.

The Johansen cointegration test suggests that there is a stable long run relationship between the imported inputs and the inward FDI stock but none between the imported inputs and the outward FDI stock. The LR test, which uses the Trace statistic, only rejected the hypothesis of no cointegration equation between inward FDI and imported inputs but could not reject the hypothesis of one cointegration equation.

Table 5: The Johansen Cointegration Test[a]

	Cointegration Rank	Trace Statistic	5 Percent Critical Value
Model (i)	r=0	22.6016	19.96
$\ln(I)\ \ln(FDI_{Inward})$	r=1	5.89298	9.24
Model (ii)	r=0	33.4802	25.32
$\ln(I)\ \ln(FDI_{Inward})$	r=1	11.4447	12.25
Model (i)	r=0	16.4417	19.96
$\ln(I)\ \ln(FDI_{Outward})$	r=1	3.98145	9.24
Model (ii)	r=0	17.2475	25.32
$\ln(I)\ \ln(FDI_{Outward})$	r=1	5.65691	12.25

[a] lag length: 2

In the next step an error correction model (ECM) is set up to infer an estimate of the long run relationship of imported inputs and the inward FDI stock. Furthermore the ECM provides another test for cointegration of the variables. Given the low number of observations another cointegration test can yield some information about the robustness of the results obtained. Therefore, equation (4) and (5) are transformed into a ECM. That gives the outsourcing hypothesis a second chance.

$$\Delta \ln(I_t) = (l)\left[\ln\left(I_{t-1}\right) - c - b_1 \ln\left(FDI_{Inward,\, t-1}\right) + Trend\right] + dynamics + dummy + u_t \qquad (9)$$

$$\Delta \ln(I_t) = (l)\left[\ln\left(I_{t-1}\right) - c - b_1 \ln\left(FDI_{Outward,\, t-1}\right) + Trend\right] + dynamics + dummy + u_t \qquad (10)$$

From an economic point of view the error correction term is of special interest since it gives the long run relationship. Short run dynamics and dummies are only included to produce well behaved error terms u_t. If the imported inputs deviate from their long run equilibrium, this error will be corrected in the future. For stability this implies a negative loading coefficient l. A high t-value of the loading coefficient points to cointegration. Banerjee et al. (1998) computed the critical values for the loading coefficient which indicate a cointegration relation. Table 6 presents the results of the estimation of equation (9) and (10). The long run relation included a Trend variable which was dropped because of its insignificance. The short run dynamics are chosen to ensure normally distributed residuals. The lagged differences (t-1 and t-2) of the endogenous and the exogenous variable were included next to the unlagged difference of the exogenous variable and a dummy variable which controls for the sharp decrease in imported inputs in the 1993 recession in Germany. The insignificant variables were dropped after conducting an omitted variables test. Since the numbers of observations is very low the dynamics are kept to a minimum. Tests for autocorrelation up to forth order, heteroscedasticity, structural breaks, and the Jarque-Bera test were carried out to ensure that the residuals are well behaved. Interestingly the trend variable proved to be not significant. This could be seen as the rejection of global sourcing as an explanation for increasing intermediate products' imports.

Table 6: Outsourcing and MNE Networks in Germany in a Time Series Analysis

	ECM (9)	ECM (10)	Bewley (9)
λ^a	-0.2993**	-0.2735	
c	2.6419	2.4931	8.8264***
$\ln(FDI_{Inward, t-1})$	0.0975		
$\ln(FDI_{Outward, t-1})$		0.0857	
β_1			0.3257***
$\Delta\ln(I_{t-2})$	-0.3102***	-0.3479**	-1.0364*
$\Delta\ln(FDI_{Inward})$	0.8249***		2.7561**
$\Delta\ln(FDI_{Outward, t-2})$		-0.2026	
R 93	-0.18***	-0.2171***	-0.6013**
Adjusted R^2	0.84	0.66	0.80
F-Statistic	20.566	8.454	18.523

[a] Banerjee t-statistic. — *, **, *** significant on 10%, 5% and 1% level.

Like the Johansen cointegration test the ECM points to a stable long run relationship between imported inputs and the inward FDI stock[4] but not between imported inputs and outward FDI. The loading coefficient l in ECM (10) is not significantly different from zero, l in ECM (9) is significant at the 5% level. The long run influence of inward FDI on imported inputs is given by b_1 (=$\ln(FDI_{Inward,\ t-1}/\lambda)$). Coefficient and significance of the exogenous variable in the error correction term can easier be seen in the Bewley transformation of the ECM, which is given in the third column. The Bewley

4 The estimated coefficients of model (i) using the Johansen procedure
$\ln(I)=8.921+0.232*\ln(FDI_{Inward})$
(0.71) (0.164) standard deviations in parenthesis
are not statistically different from the long run ECM coefficients (without dummy R93) at the 10% level.

transformation is a reformulation of the ECM in order to infer the long run coefficients directly. The coefficient of b_1 equals $\ln(FDI_{Inward,\ t-1})/l$. The t value of this coefficient can be calculated, too. The influence of inward FDI is positive and significant at the 1% level. A 10% increase of inward FDI increases imported inputs by 3% according to this estimation. The long run coefficients and standard deviations are the same in the Bewley transformation and ECM, the short run differs. Furthermore, a test of weakly exogeniety was carried out. The hypothesis that inward FDI is weakly exogenous for imported inputs could not be rejected at the 1% level.

Certainly, the FDI stock is not the only determinant of intermediate input imports. Imports react strongly to changes in aggregated demand and prices. Industrial production would be the right exogenous variable to explain the demand for imported inputs. For this analysis data for value added in German manufacturing were used, which were taken from the national accounts (OECD 2000). A change in statistical aggregation methods made it impossible to use the series for nominal output of manufacturing. To test the influence of the inward FDI stock if a demand variable is included equation (9) was changed to equation (11). VA stands for the value added in the manufacturing sector. The estimated long run coefficients are presented in Table 7.

$$\Delta \ln(I_t) = (l)\left[\ln\left(I_{t-1}\right) - c - b_1 \ln(VA) + b_2 \ln\left(FDI_{Inw,\, t-1}\right)\right] + dynamics + dummy + u_t \qquad (11)$$

Table 7: Estimated Long Run Coefficients

	ECM (11)	Bewley (11)
λ^a	-0.5352***	
c	-0.36339	-0.23
$\ln(\text{Demand}_{t-1})$	0.4088	
$\ln(\text{FDI}_{\text{Inward}, t-1})$	0.0885	
β_1		0.7639**
β_2		0.1654
Adjusted R^2	0.94	0.97
F-Statistic	35.355	82.896

[a] Banerjee t-statistic. — *, **, *** significant on 10%, 5% and 1% level.

The short run dynamics are chosen to ensure normally distributed residuals. The cointegration relationship is stable, given the significant loading coefficient. The size of the coefficient of inward FDI decreased, but remains positive. The insignificance in the regression based on (11) might stem from the inefficient estimation procedure. The Johansen cointegration test points to two cointegration equations among imported inputs, a demand variable and the inward FDI stock (Table A in the Appendix). The single equation approach (ECM) is not efficient, a system should be estimated (Harris 1995). Unfortunately, given the small number of observations it is not possible to estimate the Johansen procedure.

It is interesting to note, that the long run coefficient of inward FDI in the time series analysis which used German data is quite in line with the results from the cross section estimations of part three. The coefficient is significant positive and approximately 0.3, if FDI_{Inward} is the only explanatory variable. As in the cross-section estimation it drops somewhat if a demand variable is included. Therefore, the MNE network hypothesis could not be rejected neither in the cross-section nor in the time series analysis.

5. Conclusion

Possible links between trade and FDI have been examined in this paper, focusing on the influence of FDI on intermediate inputs trade. Cross-sectional data from six OECD countries and German time series data were employed. Two possible reasons for the growth in intermediate goods imports were tested. The outsourcing hypothesis predicts a positive relationship of outward FDI and imported inputs, the MNE network hypothesis predicts a positive effect of the level of the inward FDI stock on imported inputs. Global sourcing remains as an explanation if the other two hypothesis are rejected by the data.

The MNE network hypothesis could not be rejected by the data, neither in the cross-sectoral estimations nor in the time series analysis. There is a positive influence of the inward FDI stock on imported inputs. Foreign affiliates tend to import significantly more intermediates than domestic companies. There are sectoral and national differences, which show up in the cross section estimation. It would, therefore, be very interesting to run time series regression with sectoral disagregated data, which are unfortunately not available. Furthermore, national differences should be examined by repeating the time series analysis for other countries. This will be left to further research. The results of Barrell and te Velde (1999) point to significant differences among European countries.

There is much less evidence of outsourcing in the data. The German time series data rejects a long run cointegration relationship between the outward FDI stock and imported inputs. The cross sectoral regressions did not always find a significant influence of outward FDI. The effect of outward FDI on imported inputs is less robust to specification changes. The importance of outsourcing is believed to differ strongly among sectors. A sectorally disaggregated time series analysis could, therefore, be especially fruitful for a test of the outsourcing hypothesis.

Global sourcing is found in the data. There is a large share of imported inputs, which can not be explained by FDI stocks. However, global sourcing is rejected as explanation of increased use of imported inputs by the cross-section and the time series analysis. Certainly, there is global sourcing as well as outsourcing but these may not be as important as the growing and deepening MNE network to explain the increase in imported inputs used in production. Global sourcing mainly takes place within MNE networks.

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Appendix

The asymptotic distribution of the LR test statistic for the Johansen cointegration test depends on assumptions made with the respect to deterministic trends. Johansen (1995) provides tests for five possibilities. As in Table 5 results for two are presented in Table A: (i) constant, no trend in the cointegration equation and, (ii) constant and trend in the cointegration equation.

Table A: Johansen cointegration test

	Cointegration Rank	Trace Statistic	5 Percent Critical Value
Model (i)	r=0	43.7978	34.91
ln(I) ln(VA)	r=1	23.6451	19.96
ln(FDI_{Inward})	r=2	8.9298	9.24
Model (ii)	r=0	34.43	29.68
ln(I) ln(VA)	r=1	15.8137	15.41
ln(FDI_{Inward})	r=2	1.7823	3.76

[a] lag length: 2

The hypothesis of two cointegration equations could not be rejected for either of the two specifications.