Incomplete specialization and offshoring across Europe

Richard Frensch [1], Jan Hanousek [2], Evžen Kočenda[3]

Abstract. Recent empirical studies have been searching for evidence on and driving forces for offshoring. We suggest an alternative specification rooted in incomplete specialization that views bilateral gravity equations as statistical relationships constrained on countries' multilateral specialization patterns. Our results support evidence for offshoring activities across Europe, driven by countries' multilateral specialization incentives, as expressed by supply-side country differences relative to the rest of the world.

Keywords: international trade, gravity model, offshoring, panel data, European Union.

JEL Classification: F14, F16, L24
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1 Introduction

Fragmentation describes the deepening of the division of labor, by horizontally or vertically splitting the production process into distinct tasks. The division of labor encourages specialization and deepening the division of labor thus increases incentives towards specialization, based on either comparative advantage or economies of scale. To realize gains from fragmentation and specialization, it may pay to break up the spatial concentration of production within a firm or even a single plant: firms may outsource tasks. The term offshoring describes the international aspect of this phenomenon, whether or not tasks leave the legal bounds of the firm. Apart from potential gains from specialization, offshoring tasks implies costs of coordinating what is now an international production network rather than a firm or a plant. These coordination or service link costs typically entail costs of investment, communication and of trading inputs to and outputs of offshored tasks, i.e., intermediate products, such as parts and components. It follows that one would expect firms to offshore tasks whenever specialization gains outweigh the implied service link costs, such that the volume of offshoring should increase with fragmentation, or with declining coordination costs, or with the strength of international incentives to specialization.

Specifically, across Europe one would expect the central and east European countries that entered the EU in 2004 as new members (the EU-10) to specialize in labor-intensive tasks and the old EU members (the EU-15) to specialize in capital-intensive tasks, generating two-way trade in intermediate goods across Europe. This process could be expected to be most distinct during and supported by the beginning of the European convergence process. In paper we contribute to the identification of evidence on and driving forces for offshoring activities.

From this description of influences on offshoring, one would expect supply-side country differences to play a role, as in a factor-proportions setting. We theoretically motivate a gravity equation model to analyze gross trade flows related to offshored activities, based on Havemann and Hummels [7]. Our specification is rooted in incomplete specialization, with complete specialization as a natural limiting case, that views bilateral gravity equations as statistical relationships constrained on countries' multilateral specialization patterns. This view reveals countries' multilateral specialization incentives as driving bilateral trade, corresponding to and competing with the role of multilateral trade resistance. Our results support evidence for offshoring activities across Europe, driven by countries' multilateral specialization incentives, as expressed by relative (to the rest of the world) supply-side country differences.

2 Model

When searching for evidence for and determinants of offshoring, a bilateral gravity framework for analyzing gross trade flows related to offshoring activities (i.e., processing trade, trade in parts and components etc.) is set

[1] University of Regensburg and Institut für Ost- und Südosteuropaforschung (IOS) Regensburg. Landshuter Straße 4, 93047 Regensburg, Germany, Department of Economics, frensch@osteuropa-institut.de.
[2] CERGE-EI, Charles University and the Academy of Sciences, Politickych veznu 7, 11121 Prague, Czech Republic; Anglo-American University, Prague; The William Davidson Institute, Michigan; and CEPR, London, jan.hanousek@cerge-ei.cz.
[3] CERGE-EI, Charles University and the Academy of Sciences, Politickych veznu 7, 11121 Prague, Czech Republic; Anglo-American University, Prague; CESifo, Munich; IOS Regensburg; The William Davidson Institute, Michigan; CEPR, London; and the Euro Area Business Cycle Network, evzen.kocenda@cerge-ei.cz.

up in a way that it encompasses an eclectic combination of the determinants spelled out in competing theories to empirically determine, which of them is more important. Apart from exporter and importer market sizes, supply-side country differences are supposed to catch factor proportions influences, similarity measures between countries are to reflect new trade theory or economic geography influences, where similarity measures may even be isomorphic to supply-side country differences. We argue that gravity equations augmented by ad-hoc supply-side country differences are miss-specified since they neglect the key issue of specialization. Factor proportions theories of trade are incomplete specialization models while new theories of trade give way to complete specialization. This difference should result in fundamentally different gravity specifications. According to [7], due to the adding-up constraints of countries' expenditure systems, for trade between more than two countries a combination of four assumptions suffices to derive the simplest possible bilateral gravity structure. These are: (i) trade is only in final goods; (ii) trade is frictionless and balanced; (iii) preferences over final goods are identical and homothetic; (iv) each good is produced in and exported out of only one country, independent from the details on the supply side that give rise to this complete specialization. Under these conditions, bilateral trade is simply a log-linear equation in both countries' incomes, and there is no scope for "augmenting" the gravity equation, e.g. by adding absolute values of differences in per capita incomes.

Maintaining assumption (ii) above, we assume that there are no trade frictions and all trade is balanced. Production is horizontally fragmented in the spirit of Grossman and Rossi-Hansberg [5], where firm-specific production technologies are available to all countries but used by firms in countries rather than by countries. Hence, n tasks are carried out, each of which results in a tradable intermediate good, i.e. a part or a component. One final good is assembled from these n parts or components. Compatible with assumption (iii), all production is subject to homothetic derived demands, such that all variables can be studied in nominal terms: C is consumption or use, X production, Y income, EX exports, and IM imports. Subscripts denote countries, superscripts goods. Given the existence of n intermediate goods and neglecting primary inputs, value-added Z is in each country j distributed over two stages of production:

$$Z_j^k = X_j^k = \delta_j^k Y_j \quad for\ k = 1, \ldots, n \tag{1}$$

and $$Z_j^{n+1} = X_j^{n+1} - \sum_{k=1}^{n} C_j^k = \delta_j^{n+1} Y_j, \ \ with \ \ \sum_{k=1}^{n} \delta_j^k + \delta_j^{n+1} = 1 \tag{2}$$

such that $$\sum_{k=1}^{n} Z_j^k + Z_j^{n+1} = Y_j \tag{3}$$

With homotheticity in production, $$C_j^k = \phi_j^k X_j^{n+1} \ for\ k = 1, \ldots, n \tag{4}$$

With (2) and (3), value added in producing the final good can be written as

$$Z_j^{n+1} = \delta_j^{n+1} Y_j = X_j^{n+1} - \sum_{k=1}^{n} C_j^k X_j^{n+1} - X_j^{n+1} \sum_{k=1}^{n} \phi_j^k$$

$$= X_j^{n+1}\left(1 - \sum_{k=1}^{n} \phi_j^k\right) \tag{5}$$

such that $$X_j^{n+1} = \delta_j^{n+1} Y_j / (1 - \sum_{k=1}^{n} \phi_j^k) \tag{6}$$

$$NE_j^{n+1} = X_j^{n+1} - C_j^{n+1} = \frac{\delta_j^{n+1} Y_j}{1 - \sum_{k=1}^{n} \phi_j^k} - Y_j = \left(\frac{\delta_j^{n+1}}{1 - \sum_{k=1}^{n} \phi_j^k} - 1\right) Y_j \tag{7}$$

For intermediate goods, output is given in (1) and use is in (4), which also holds for the world, $C_w^k = \phi_w^k X_w^{n+1}$. With final goods output as described in (6),

$$\frac{C_j^k}{C_w^k} = \frac{\phi_j^k}{\phi_w^k} \frac{\delta_j^{n+1} Y_j}{\delta_w^{n+1} Y_w} \frac{1 - \sum_{k=1}^{n} \phi_w^k}{1 - \sum_{k=1}^{n} \phi_j^k}, for\ k = 1, \ldots, n$$

This expression can easily be simplified using two characteristics of world trade: first, we know from the world version of (7) that $1 - \sum_{k=1}^{n} \phi_w^k = \delta_w^{n+1}$, as world trade in final goods must be balanced. Second, world output of any good is equal to world use, such that

$$C_j^k = \frac{\phi_j^k}{\phi_w^k} \frac{\delta_j^{n+1}}{(1 - \sum_k \phi_j^k)} \delta_w^k Y_j$$

Country *j*'s net exports of intermediate good k are thus described by

$$NE_j^k = X_j^k - C_j^k, \text{for k} = 1, \ldots, \text{n}$$

Hence, $$NE_j^k = \delta_j^k Y_j - \frac{\phi_j^k}{\phi_w^k}\frac{\delta_j^{n+1}}{1-\sum_k \phi_j^k}\delta_w^k Y_j = \left(\delta_j^k - \frac{\phi_j^k}{\phi_w^k}\frac{\delta_j^{n+1}}{1-\sum_k \phi_j^k}\delta_w^k\right) Y_j \quad (8)$$

As we are only interested in intermediate goods trade, we may simplify (8) by assuming balanced final goods trade for each single country, such that

$$NE_j^k = (\delta_j^k - \frac{\phi_j^k}{\phi_w^k}\delta_w^k) Y_j, \quad \text{for k = 1, …,n} \quad (9)$$

On the basis of (9), countries export an intermediate good if they devote a greater share of value added to producing this good than the rest of the world ($\delta_j^k > \delta_w^k$), or if their intermediate good is more productive in terms of final output than the rest of the world ($\phi_j^k < \phi_w^k$). With firm-specific technologies, identically available everywhere in the world for offshoring activities, as assumed in [5], this simplifies further to,

$$NE_j^k = (\delta_j^k - \delta_w^k) Y_j, \text{ for k = 1, …,n} \quad (10)$$

Summing over all *k*, *j*'s exports of intermediate goods to the world are,

$$NE_j = Y_j \sum_{k=1}^{n} (\delta_j^k - \delta_w^k) \quad (11)$$

Suppose now that intermediate goods are indeed homogeneous. Then, goods are either exported or imported but not both, and positive NE_j indicates a country's exports. Selecting export items with positive net exports into the set K_{EXj}, country *j*'s multilateral intermediate goods exports are,

$$EX_j = Y_j \sum_{k \in K_{EX_j}} (\delta_j^k - \delta_w^k) \quad (12)$$

and are log-linear in income and a specialization pattern, $\sum_{k \in K_{EX_j}} (\delta_j^k - \delta_w^k)$, exhibiting a unitary elasticity with respect to country of origin income, provided the specialization pattern is uncorrelated with income. Analogously for imports,

$$IM_j = Y_j \sum_{k \in K_{IM_j}} (\delta_w^k - \delta_j^k) \quad (13)$$

3 Gravity specification

We argue that countries' bilateral trade under incomplete specialization is driven by multilateral specialization incentives, exactly matching multilateral specialization patterns in form of deviations from world average as described in equations (12) and (13), i.e. in form of countries' deviations of capital-labor ratios (proxied by GDP per capita) or – absent factor price equalization – deviations of wages from the world average.

With incomplete specialization and costless trade, it is not possible to analytically decompose (12) and (13) into bilateral trade relationships. However, trade is not costless, and the way to resolve the indeterminacy is by letting importers choose partners to minimize trade costs. In this sense view bilateral trade equations as statistical relationships constrained on countries' multilateral specialization patterns.

In particular, it is possible to formulate two conditions, subject to which bilateral trade relationships will be distributed in a statistical sense in a sample of countries. First, for bilateral trade to occur, countries' specialization patterns as described in (12) and (13) must be complementary. Second, equations (12) and (13) describe countries' multilateral trade and they can be expected to be met on the average of all bilateral trading relationships.

These two conditions yield predictions for bilateral trade relationships: larger countries trade more in the average of all their trading relationships. Hence, the bilateral trade volume will increase with the product of trading countries' incomes, and countries more specialized vis-à-vis the world can be expected to trade more with each other, provided, their specialization is complementary.

Incentives for incomplete specialization and trade with parts and components are supply-side country differences in factor endowments or wages, wages accurately capture supply-side country differences directly. Consistent with specialization patterns described relative to the world, bilateral trade volumes can be expected to increase with relative supply-side country differences, $|w_j - w_w| \times |w_i - w_w|$, i.e., with the product of countries' respective supply-side differences against the world (w_w). Specifically, within a panel of EU-25 countries, bilateral trade in parts and components ($EX(PC)_{ji,t}$) can be described, without accounting for trade barriers, by the estimable specification that is rooted in our model and that takes the following simple form of a gravity model:

$$log\, EX(PC)_{ji,t} = \beta_0 + \beta_1\, log(Y_{j,t} \times Y_{i,t}) + \beta_2\, log\big(|w_{j,t} - w_{w,t}| \times |w_{i,t} - w_{w,t}|\big) + \\ + \beta_3 Dummy(EU15/10)_{ji}\, log\big(|w_{j,t} - w_{w,t}| \times |w_{i,t} - w_{w,t}|\big) + c_{ji} + k_t + \varepsilon_{ij,t} \quad (14)$$

where *DummyEU15/10* equals one for trade relationships between a EU-15 and a EU-10 country, and zero otherwise.

The specification (14) is estimated on unbalanced panel data with mean time length of about 10 years. In the specification (14) we use time-invariant asymmetric country-pair specific effects (c_{ij}) to capture fixed effects between exporting and importing countries that do not change over time.

The combined variable $DummyEU15/10_{ji}\, log\big(|w_{j,t} - w_{w,t}| \times |w_{i,t} - w_{w,t}|\big)$ is interacted with time-period effects and for this purpose we divide the sample period (1992–2008) into five sub-periods of (almost) equal length. This way we are able to capture technological progress. We then estimate our gravity specification (14) to derive effects on three types of goods: parts and components that represent our primary interest, and two types of final gods, e.g. capital and consumer goods.

We begin our estimation with performing a Hausman-type specification test to assess potential endogeneity of the explanatory variables by comparing a standard fixed effects model with the Arellano and Bover [1] technique. As the test confirms endogeneity of explanatory variables we proceed with instrumentation. We estimate the theoretically motivated specification (14) in a panel setting with fixed effects plus instrument variables a) to overcome problems of omitting variables bias and b) to control for time invariant endogeneity and selection bias.

4 Data

Bilateral trade in parts and components $EX(PC)_{ji}$ describes exports of parts and components from country *j* to country *i* over the period 1992-2008. The data were obtained from the BACI database drawn from the United Nations COMTRADE data as in Frensch and Gaucaite-Wittich [3].

In our estimation we employ three different measures of the bilateral trade in parts and components. First we measure the trade flows of how much country *j* exports to country *i*. Then, following Frensch [2] we measure bilateral trade along the extensive and intensive margins. Trade along an extensive margin, represents *variety* of parts and components of capital goods exported from country *j* to country *i* at time *t*. Trade along the intensive margin, represents *intensity* of parts and components exported from country *j* to country *i* at time *t*. Computations of both extensive and intensive margin measures are performed on the basis of the BACI Database described in Gaulier and Zignago [4].

Further, Y_j and Y_i are exporter and importer GDP at current prices, respectively obtained from the World Development Indicators. Measure of supply-side country differences are wages in exporting (w_j) and importing (w_i) countries and they are measured as annual wage average in manufacturing sector of the exporting (importing) country *j* (*i*) at specific year *t* data were obtained from the International Labor Office statistical databases.

5 Empirical results

We introduce our benchmark results based on specification (14) in the first column of Table 1, where we present estimated coefficients for dependent variables of bilateral parts and components trade. Our results support evidence for offshoring activities generating trade in parts and components of capital goods due to the existence of multinational production networks across Europe, and inform about driving forces identified already in the first section.[4]

Statistically significant coefficients β_1 demonstrate that larger countries trade more with each other. Second, negative coefficients β_2 confirm that our sample of European countries on average in fact features a rather homogeneous specialization pattern as compared to the world average. However, comparing coefficients β_2 and β_3 points to relative supply-side country differences as driving offshoring activities across Europe compatible with models of incomplete specialization and trade, specifically between original EU-15 and the ten accession countries (EU-10), rather than within each of the two country groups. Third, technical progress in terms of declining service link costs and ongoing fragmentation – as captured by the sub-period dummies – appears to positively

[4] Importance of the international trade between the EU10 and EU15 countries have been documented via its effect on stock markets. Specifically, macroeconomic announcements on the EU current account affect prices on the Czech, Hungarian, and Polish stock markets even at intra-day frequency (see Hanousek and Kočenda [6] for details).

influence offshoring: with the exception of the final sub-period, for EU-15/EU-10 pairs, β_3 is increasing slowly over time. The slight decrease of the β_3 coefficients in the final 2005–2008 sub-period might indicate that EU-10 countries catch up with the EU-15 so that supply-side country differences between both groups, relative to the world, become less pronounced. This may well be affected by the technological progress in the EU-10 countries that is closely linked to foreign direct investment and multinationals (Uzagalieva et. al. [8]). As foreign-owned subsidiaries become a part of the innovation systems and industrial structure of the EU-10 countries they promote overall technological growth in the region that further contributes to the catch-up with the EU-15.

		Flows	**Extensive Margin**	**Intensive Margin**
log Y_j Y_i		0.718***	0.254***	0.464***
		(0.023)	(0.013)	(0.014)
log ($\|w_j - w_w\| \times \|w_i - w_w\|$)		-0.101***	-0.040***	-0.061***
		(0.020)	(0.010)	(0.013)
log ($\|w_j - w_w\| \times \|w_i - w_w\|$) for EU-15 / EU-10 pairs	1992-1995	0.183***	0.104***	0.079***
		(0.036)	(0.020)	(0.021)
	1996-1998	0.202***	0.117***	0.085***
		(0.036)	(0.019)	(0.021)
	1999-2001	0.241***	0.145***	0.096***
		(0.035)	(0.019)	(0.020)
	2002-2004	0.251***	0.157***	0.094***
		(0.034)	(0.018)	(0.020)
	2005-2008	0.230***	0.132***	0.099***
		(0.033)	(0.018)	(0.020)
N		27,354	27,354	27,354

Table 1 Parts and components, *w*=wages (simple world averages)

Finally, we have performed several robustness checks. Our results are robust with respect to a different measure of country differences (GDP per capita) as well as population weighted averages. Further, our results reveal reveals that trade in parts and components due to offshoring activities across Europe is predominantly realized along the intensive margin in response to market size increases, but along the extensive margin in response to stronger relative supply-side country differences. I.e., more offshoring of activities from the EU-15 to the EU-10 in response to stronger relative supply-side country differences means predominantly offshoring of new activities rather than extending the scale of already offshored activities.

6 Conclusions

We argue that analyzing gross trade flows related to offshored activities by using gravity equations augmented by *ad hoc* measures of supply-side country differences appear miss-specified. We develop gravity framework, rooted in incomplete specialization that views bilateral gravity equations as statistical relationships constrained on countries' multilateral specialization patterns, allowing for offshoring to increase with fragmentation and declining coordination costs, with multilateral incentives to specialization, and to decline with multilateral trade resistance.

We apply this framework to a truly Europe-wide sample of countries, while fully accounting for potential tendencies towards factor price equalization *via* trade, and find evidence for offshoring activities across Europe driven by countries' multilateral specialization incentives, as expressed by relative (to the rest of the world) supply-side country differences. In particular, the results do not contradict those provided by Grossman and Rossi-Hansberg [5], and are thus compatible with the view that offshoring need not hurt (low-skill) workers, as long as offshoring relationships get strengthened along the intensive margin as opposed to the extensive margin by new relationships. Our results, however, suggest that exactly this latter might have been the case recently when extending offshoring from the EU-15 to the EU-10.

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