Estimating the Development Paths of the Two-Cone Heckscher–Ohlin Model: Empirical Evidence from EU Member States in 1998 and 2008*

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Abstract

Following Schott (2003), this paper estimated the paths of development that arise within the two-cone Heckscher–Ohlin (HO) model. A cross-section of 24 EU member states in 1998 and 2008 was utilized for the estimation, and empirical results provide significant support for the two-cone HO model in the respective years. Examination of the constituent countries in each cone may imply a stable structure of industrial specialization across the EU over time. Moreover, a simple examination of factor price equalization may suggest that wage disparities across counties can be partly explained by the multiple-cone HO model.

1 Introduction

Following the empirical technique introduced by Schott (2003), this paper examines the production implications of the two-cone Heckscher–Ohlin (HO) model. A cross-section of the 24 European Union (EU) member states and manufacturing industries in 1998 and 2008 was utilized to estimate the paths of development (Leamer, 1987) in the respective years.

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By estimating the capital–labor ratio cutoff delineating the cones of diversification, countries are grouped according to cone in which they reside at each point in time. I investigated the distribution of countries across cones and its change over time. Based on the empirical results, I conducted a simple factor price equalization (FPE) test for wages.

Numerous papers have attempted to find empirical support for the HO specialization, e.g., Harrigan (1995) and Bernstein and Weinstein (2002). As Deardorff (2001a) pointed out, most of the literature has generally focused on the single-cone HO model. The cone refers to the set of endowment vectors that select a specific product mix, and it corresponds to the FPE set. Thus, in the single-cone model, there exists a single mix of products and all countries that produce it. Moreover, factor prices are equalized across all countries. Although this type of "one size fits all" equilibrium appears to be plausible when countries have sufficiently similar factor endowments, Schott (2003) claimed that this approach is "overly restrictive."

A richer analysis can be conducted by allowing a multiple-cone equilibrium.[1] In this version of the HO model, countries specialize in a particular subset of goods according to their relative endowments. More importantly, countries move in and out of sectors as they accumulate productive factors.[2] Consequently, the multiple-cone HO model derives the spline functional form of development paths, which depict the relationship between country wide capital–labor ratio and the sectoral outputs. Deardorff (2000) labeled this pattern of industrial development as the "ladder of comparative advantage". Furthermore, since factor prices are equalized within a cone but not across cones, the multiple-cone model can provide more meaningful implications regarding the global wage inequality. Deardorff (2001a,b) developed the theoretical discussion on growth and factor price equality in this framework.

Based on empirical studies by Leamer (1987), Davis and Weinstein (2001), and others, Schott (2003) introduced a new technique for testing the multiple-cone HO model. His methodology allowed estimation of the development paths by inferring the capital–labor ratio cutoffs delineating the cones. In addition, he addressed the problems faced in using the standard industrial classification, i.e., the International Standard Industrial Classification

[1] Theoretical discussion on the multiple-cone equilibrium dates back to Land (1959).

[2] Oniki and Uzawa (1965) and Deardorff (1974) discussed trade and growth in the single-cone HO model.

(ISIC), in testing the trade theory. He introduced a new method to recast the ISIC industries into a theoretically more appropriate aggregate, called the HO aggregate. Empirical analysis using a cross-section of 45 countries in 1990 found strong support for the multiple-cone HO model.

As an application of Schott's paper, Batista and Potin (2014) estimated the development paths of the multiple-cone HO model using industrial data on 44 developed and developing countries. They concluded that factor accumulation explains at least one-third of the changes in industrial concentration over time. Kiyota (2014), meanwhile, utilized time-series data on manufacturing sectors in Japan and found empirical evidence that the multiple-cone HO model may fit the flying geese pattern of industrial upgrading.

This paper extends Schott's study by employing a cross-section of the 24 EU member states at two points in time to estimate the development paths in the respective years, namely 1998 and 2008. I examine changes in estimated development paths and distribution of countries across cones over time. To the best of my knowledge, this is the first attempt to apply Schott's methodology to the European region. Due to the eastern enlargement of the EU in 2004 and 2007, constituent economies of the European Single Market have become drastically diversified. In order to gauge the effect of trade liberalization on factor prices, it is important to investigate whether the European economy exists in a multiple-cone equilibrium and to analyze how the countries are distributed across cones. Although Mundell (1957) pointed out that trade can substitute for factor trade, this is not the case for a multiple-cone equilibrium. Thus, testing the multiple-cone HO model will yield meaningful implications for wage inequality as well as factor mobility across EU member states.

The rest of this paper is structured as follows: section 2 explains the theoretical model, section 3 describes the empirical analysis, and section 4 concludes.

2 Two-Cone HO Model

The basic structure of the model is based on Schott (2003). To facilitate the discussion, I will explain the simplest model that allows for the existence of a multiple-cone equilibrium, i.e., the two-cone HO model with two factors and three goods. This model makes the following assumptions:

Assumption 1. Factors of production are perfectly mobile across sectors within countries, but perfectly immobile across countries.

Assumption 2. Countries are small and open economies, and have perfectly competitive markets.

Assumption 3. All countries have identical constant-return-to-scale production technologies.

Assumption 4. All individuals in all countries have identical homothetic preferences.

Assumption 5. An equal number of goods and factors exists in each cone of diversification, i.e., evenness is present.

Suppose that there exist three goods—X, Y and Z—and two factors of production—capital (K) and labor (L). Following Schott (2003) and Kiyota (2012a, 2014), I specify the production technology as Leontief production function.[3] Factor intensity $k_i \equiv K_i/L_i$, where K_i and L_i are the factor inputs in industry i, is independent from product prices and/or factor price ratio ($\omega \equiv w/r$, where w is wage rate and r is interest rate). X is considered to be the most labor-intensive, Z is the most capital-intensive, and Y is the middle-intensive good. The nation wide capital–labor ratio in country c is denoted by $\overline{k}_c \equiv \overline{K}_c/\overline{L}_c$.

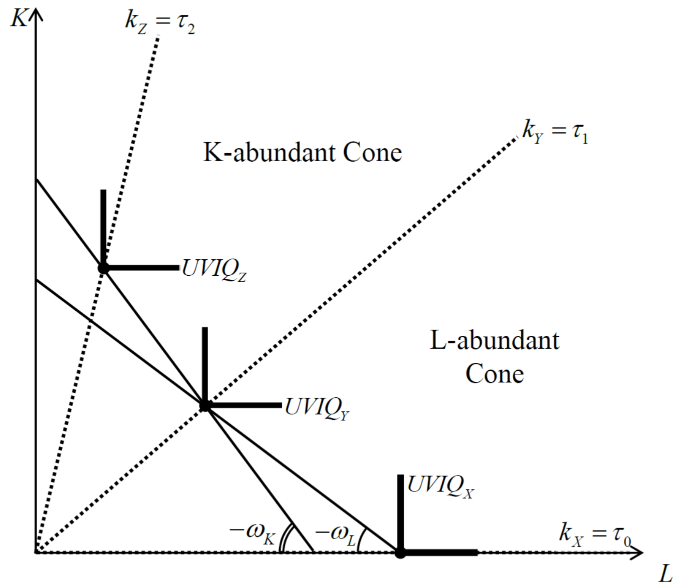
Figure 1 shows the Lerner–Pearce diagram (Lerner, 1952; Pearce, 1951) of a two-factor three-good world. Two sets of the unit-value isoquant X and Y and Y and Z are tangent to the unit cost lines with slopes of ω_K and ω_L, respectively. Two regions delineated by the industrial capital intensities are the familiar cones of diversification.

Figure 2 depicts the expected paths of development that can arise within the two-cone HO model. The splines depict the piecewise linear relationships between the country wide capital–labor ratio ($\overline{k}$) and per capita sectoral outputs ($Q_i/\overline{L}$ for $i = X, Y, Z$). Inflection points of the splines are called knots, denoted by τ_j for $j = 0, 1, 2$.[4] The location of the interior knot (τ_1) divides countries into labor- and capital-abundant cones.

[3]The assumption of Leontief technology can rule out the possibility of complete specialization and reduce the number of parameters to be estimated.

[4]In the case of Leontief technology, the locations of knots correspond to industrial capital intensity.

Figure 1: Two-Factor, Three-Good, Two-Cone Lerner–Pearce Diagram



Countries within the labor-abundant cone, i.e., $\overline{k}_c \in (\tau_0, \tau_1)$, produce goods X and Y. On the other hand, countries within the capital-abundant cone, i.e., $\overline{k}_c \in (\tau_1, \tau_2)$, produce goods Y and Z. Factor prices are equalized across countries within the same cone, but not across cones. Specifically, the interest rate is higher in the labor-abundant cone, i.e., $r_K > r_K$, and wage is higher in the capital-abundant cone, i.e., $w_K > w_L$.

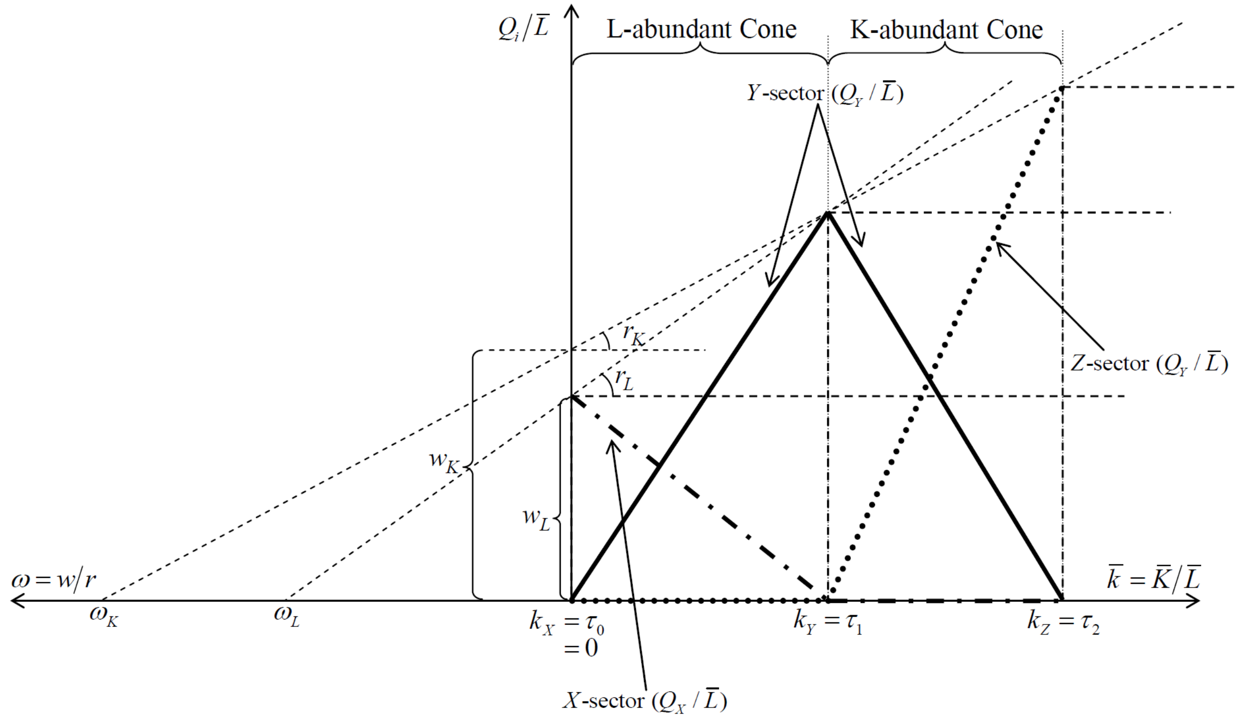
In the following section, I estimate the development paths of the two-cone model. Following Schott (2003), the regression equation for industry i is formulated as Equation (2.1). The right hand side includes the indicator function $I\{\bullet\}$, which takes 1 if the statement in parentheses is true, and takes 0 otherwise. ϵ_i is the disturbance.

$$\frac{Q_{ic}}{\overline{L}_c} = \sum_{j=1}^{2} \left[\alpha_{i,j} I_j \left\{ \overline{k}_c \geq \tau_{j-1} \right\} + \beta_{i,j} \overline{k}_c I_j \left\{ \overline{k}_c \geq \tau_{j-1} \right\} \right] + \epsilon_{i,c} \tag{2.1}$$

3 Empirical Analysis

I will now estimate the development paths of the two-cone HO model. Although Schott (2003) specified the number of cones empirically by comparing the bootstrap p-value of the respective models, in this paper, I set the number of the cone to two in advance. This

Figure 2: Development paths of the Two-Cone HO Model



specification is based on the empirical results of Schott (2003) and Kiyota (2012a, 2014).

3.1 Data

Country Wide Capital–Labor Ratio

I utilized the gross fixed capital formation and the total number of working population in the 24 sampled countries to construct the country wide capital–labor ratio. Following Hall and Jones (1999), capital stock is estimated by the perpetual inventory method (PIM).[5] Gross fixed capital formation from 1973 to 2008 was used to estimate capital stocks in 1998 and 2008.[6] Data are sourced from the European Commission's "Annual Macro-Economic Database (AMECO)."[7] Data on the working population are retrieved from the World Bank's

[5]See OECD (2009) for a general introduction of the PIM.

[6]A constant depreciation rate of 13.3% was applied.

[7]Original data at current market price in euros were converted to constant 2000 euros. The ruro foreign exchange reference rate in 2000 retrieved from the European Central Bank was utilized so as to be expressed in terms of constant 2000 USD.

"World Development Indicators." Table 3.1 summarizes the capital–labor ratio of the sampled countries. The small letter abbreviations, e.g. bg and lv, indicate the EU's new member states.[8] Countries are listed in ascending order of capital–labor ratio in 1998.

The wide range of the capital–labor ratio across sampled countries is important for identifying the specialization in the multiple-cone HO model. For example, there is a greater than 30-fold difference between the least and most capital abundant countries in 1998, i.e., Bulgaria and Austria, respectively. The table also highlights the relatively low capital–labor ratio of the new member states appearing in the upper half of the list.

The fourth column of the table shows the percentage change between 1998 and 2008. Countries with a lower capital–labor ratio in 1998 appear to have attained higher growth. While this paper is not primarily concerned with the cause of this increase, it is useful to sketch out a potential explanation. An increase in capital–labor ratio can be caused by am increase in capital stock and/or decline in working population. In addition, capital accumulation can derive from domestic savings and/or foreign investment. A brief examination of the domestic savings, inward FDI, and working population from 1998 to 2008 (not presented) reveals that capital inflows may affect the higher growth in the capital–labor ratio.[9] Indeed, various studies have reported increased FDI flows into the new member states in the 2000s, e.g., Kärkkäinen (2008). Moreover, countries with lower growth in working population size demonstrate an apparent increase in capital–labor ratio. These observations imply that foreign capital inflows associated with slow growth in working population size may result in higher growth in capital–labor ratio.

Intra-Industry Heterogeneity and "HO Aggregates"

In this paper, I focus on manufacturing sectors. Industrial statistics aare sourced from the United Nations Industrial Development Organization's (UNIDO) "Industrial Statistics Database (INDSTAT) at 2-digit level of ISIC (Rev.3)" (UNIDO, 2014). I utilized 22 out of 23 manufacturing sectors listed in Table 2.[10] Value added is used for sectoral output.[11]

[8] "The new member states" here refers those that joined the EU in 2004 and 2007.

[9] Gross domestic savings are retrieved from the World Bank, and net FDI inflow stocks are from Eurostat. A summary of these statistics is available from the author upon request.

[10] 37. Recycling is excluded due to limited data availability.

[11] The current price value was converted to constant 2000 USD using the World Bank's GDP deflator.

Table 1: Capital–Labor Ratio and Codes of Sample Countries

Country	Abbr.	capital–labor Ratio 1998	Change(%)	2008
Bulgaria	bg	2.59	194.72%	7.63
Lativia	lv	5.25	275.15%	19.70
Lithuania	lt	5.71	194.14%	16.78
Poland	pl	9.34	77.31%	16.56
Slovakia	sk	13.81	31.97%	18.22
Hungary	hu	14.21	48.66%	21.12
Czech Rep.	cz	20.15	37.43%	27.68
Slovenia	si	23.06	79.96%	41.49
Cyprus	cy	29.38	-7.45%	27.19
Greece	EL	30.64	59.39%	48.84
Portugal	PT	31.63	19.19%	37.70
Malta	mt	41.55	-8.35%	38.08
Spain	ES	43.29	26.06%	54.57
UK	UK	47.11	34.02%	63.14
France	FR	53.73	22.79%	65.98
Finland	FI	56.14	23.75%	69.47
Ireland	IE	56.56	45.92%	82.54
Netherland	NL	56.63	18.66%	67.19
Sweeden	SE	57.89	27.07%	73.56
Denmark	DK	59.13	38.95%	82.16
Germany	DE	59.31	13.25%	67.17
Italy	IT	60.30	15.65%	69.73
Belgium	BE	67.59	17.51%	79.43
Austria	AT	73.20	7.43%	78.64

capital–labor ratio in constant 2000 USD.

Schott (2003) pointed out the underlying problems in using ISIC industries for testing the HO model. An empirical test of the factor proportions framework requires two additional assumption about goods and industries.

Assumption 6. Goods in country c within the same industry i have identical capital intensities and prices.

Assumption 7. Across countries, industry i has identical capital intensities and prices.

These two assumptions suggest that an industry is defined by its capital intensity. ISIC, on the other hand, groups goods according to similarity of end use. Hence, goods within the same ISIC industry may have different capital intensity and prices within and across countries. Schott (2003) called this intra-industry product heterogeneity.

I examined cross–country differences in the capital intensities of ISIC industries.[12] Using

[12] Although rigorous examination of intra-industry heterogeneity requires three-digit or four-digit industrial

Table 2: List of 2-Digit ISIC Industries

Code	Description
15	Food products and beverages
16	Tobacco products
17	Textiles
18	Wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; luggage, handbags, saddlery, harness and foot wear
20	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials
21	Paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastics products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29	Machinery and equipment n.e.c.
30	Office, accounting and computing machinery
31	Electrical machinery and apparatus n.e.c.
32	Radio, television and communication equipment and apparatus
33	Medical, precision and optical instruments, watches and clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
36	Furniture; manufacturing n.e.c.

the PIM explained above, capital intensity is calculated using the gross fixed capital formation and number of employees for the 22 ISIC industries.[13] Figure 3 illustrates the extent to which input intensity varies by industry across countries in 2008.[14] The height of each bar indicates the capital intensity of a given industry for a given country. It is clear that there are significant difference in the actual capital intensity across countries within an industry.

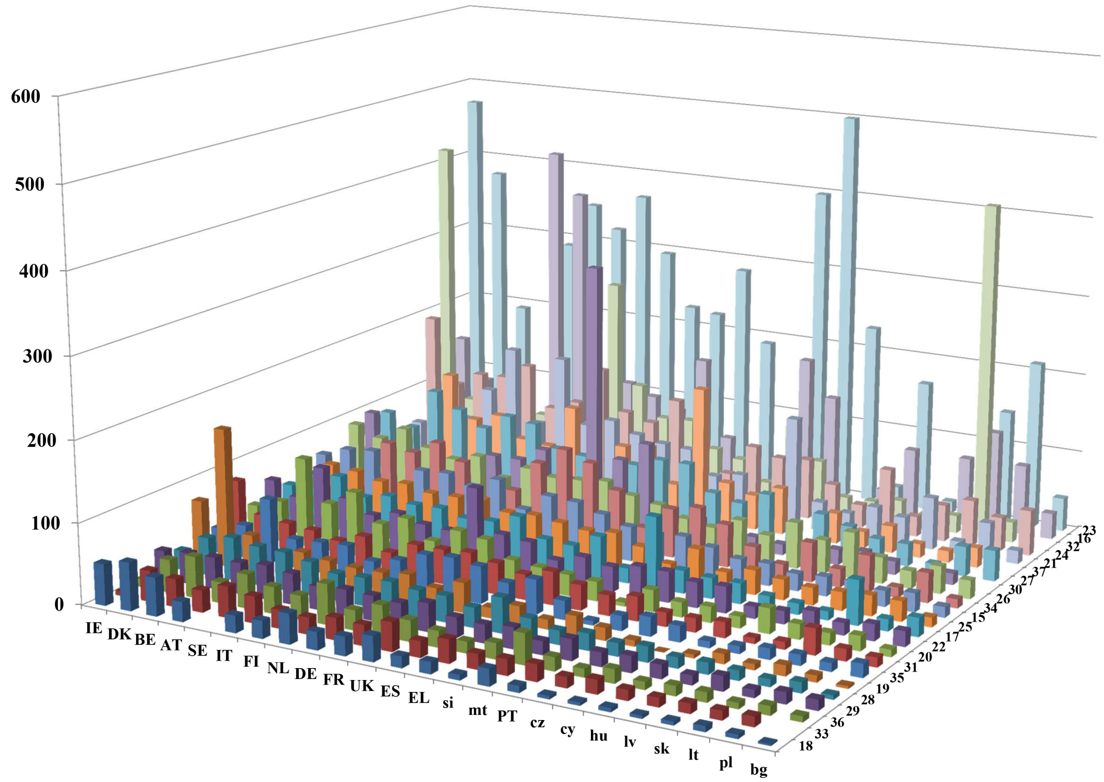
To correct the intra-industry heterogeneity, Schott (2003) introduced a new method to recast the ISIC industries into theoretically more appropriate industrial aggregate called the HO aggregate. In order to preserve evenness within cones, three HO aggregates are made up of of 22 ISIC industries for the estimation of the two-cone model.

data, it can not be carried out because of limited data availability.

[13]The PIM requires consecutive time series data on gross fixed capital formation. Missing values were interpolated by regressing on the time trend. In cases when more than two ISIC industries are combined into one, I decomposed them into individual sectors by multiplying the shares of each sector. This share was calculated using the data from the nearest year where the individual sector's data are available.

[14]The complete data set on capital intensity for 1998 and 2008 is available upon request.

Figure 3: Country-ISIC Industry Capital Intensity (2008)



Note: Vertical axis is in 1,000 USD. Two-digit number indicate the ISIC code.

$$
\begin{cases}
\text{Labor-intensive aggregate } (X) & Q_{Xct} \equiv \sum\limits_{n \in \{n | 0 \leq k_{nct} < \check{k}_t\}} Q_{nct} \\
\text{Intermediate capital-intensive aggregate } (Y) & Q_{Yct} \equiv \sum\limits_{n \in \{n | \check{k}_t \leq k_{nct} < \hat{k}_t\}} Q_{nct} \\
\text{Capital-intensive aggregate } (Z) & Q_{Zct} \equiv \sum\limits_{i \in \{n | k_{nct} \geq \hat{k}_t\}} Q_{nct}
\end{cases}
$$

X is the most labor-intensive, Z is the most capital-intensive, and Y is the middle-intensive HO aggregate. Subscripts indicate country c, ISIC industry i, and year t. $\check{k}_t$ and $\hat{k}_t$ are the capital intensity cutoffs that define the three HO aggregates. While the two cutoffs are irrespective of country, they may vary over time. Hence, the mix of ISIC industries in a given HO aggregate differs across countries and years. Furthermore, no ISIC industries may be included in a given aggregate for some countries. An additional assumption is required to enable treating the HO aggregate as a single good in the model.

Assumption 8. Prices are such that the unit-value isoquants of all goods within a given derived HO aggregate are tangent to a single isocost line.

3.2 Estimation of the Development Paths

Interior Knot and Capital Intensity Cutoffs

Using the output of three HO aggregates, I estimate the development paths for the respective years. The parameters to be estimated are locations of knots (τ_j for $j = 0,\ 1,\ 2$) and capital intensity cutoffs defining the three HO aggregates ($\check{k}, \hat{k}$), as well as the coefficients of the intercept (α) and slope (β) for each HO aggregate. In order to allow for technological change over time, the knots' locations have different estimates by year.

In estimating the development paths, the location of knots and capital intensity cutoffs should be taken as given. Following Schott (2003) and Kiyota (2012a, 2014), I grid overall possible combinations of the two cutoffs and interior knot for a given interval size. For capital intensity cutoffs, I use a grid interval of of $\gamma = 0.05$; $10^{0.1} \leq 10^{\gamma} < 10^{3.0}$ (unit is thousand of USD). For the interior knot, I use 1,000 USD ($\tau_0 < \tau_1 < \tau_2$). τ_0 is assumed to be zero, and τ_2 is assumed to be 1,000 USD above the upper range of the sample's observed capital–labor ratio.

For every combination, the slope and intercept parameters of three development paths are estimated simultaneously by a seemingly unrelated regression model. I impose theoretically mandated system-wide constraints on the slope and intercept parameters derived from the theoretical archetype of the development paths, as shown in Figure 2. The two cutoffs and location of the interior knot are estimated via maximum likelihood.[15]

[15] I used the Akaike Information Criteria (AIC) for this estimation. See Cameron and Trivedi (2005) for a general explanation on maximum likelihood estimation and Akaike (1998) for information on the AIC. Iterative estimations for every possible combination revealed that the set of estimates that gives the minimum of AIC allowed to most ISIC industries are classified as a middle-intensive HO aggregate, and few countries exist in the labor-abundant cone. I ruled out such estimates taking into account the fit of the three development paths as a whole.

Estimation Results

Estimated parameters, the two capital intensity cutoffs, and the location of the knots are reported in Table 3 and 4. The location of the interior knot is 41,000 USD for 1998 and 52,000 USD for 2008. The tables also list the constraints imposed on the parameters. All estimated coefficients are statistically significant at the 95% level. The results suggest that production patterns in the EU may be explained by the two-cone HO model. Figures 4 and 5 depict the estimated development paths, with each observation with positive output plotted and identified by the two-letter country code.

The location of the interior knot in 1998 reveals that 11 countries fall into the labor-abundant cone. The remaining 13 countries reside in the capital-abundant cone. All labor-abundant countries, except for Greece and Portugal were potential EU member states as of 1998. Thus, sampled countries can be broadly classified into EU member states and non-member states in terms of cone in which they reside.

Panel A of Figure 4 indicates that Poland, Slovakia, Cyprus, Greece, and Portugal do not produce a labor-intensive HO aggregate. Panel C, meanwhile, reveals that all labor-abundant countries except for Latvia produce a capital-intensive aggregate. This is consistent with the result of Schott (2003) and it means that labor-abundant countries have started to produce capital-intensive goods earlier than indicated by the theoretical expectation.

The estimated development paths for 2008 appear qualitatively similar to those of 1998. While labor-abundant countries have experienced relatively high growth in capital–labor ratio during over this decade (see Table 3.1) none of the countries moved into the capital abundant cone.[16]

These results imply a persistent difference exists in industrial specialization and resulting factor prices across the two groups of countries. Moreover, a shift in the interior knot's location also appears to prevent countries from entering the capital-abundant cone. Changes in the interior knot location as well as the two capital intensity cutoffs may arise from changes in production functions. While investigating the underlying mechanism of these changes is beyond the scope of this study, it constitutes an important question for further theoretical and empirical research.

[16] Cross-cone movement was found only for Malta, from the capital-abundant to labor-abundant cone.

Table 3: Estimated Coefficients for the Two-Cone Three-Good HO Model (1998)

	Labor-intensive Aggregate	Middle-intensive Aggregate	Capital-intensive Aggregate
α_1	70.21	-	-
	(21.56)		
β_1	-1.71	96.34	-
	(.53)	(8.27)	
β_2 (Marginal)	1.71	-216.04	421.35
	(.53)	(18.53)	(64.85)
Observations	24	24	24
NRMSE	1.73	0.46	0.64
Constraints	$\alpha_1 + 41\beta_1 = 0$	$\alpha_1 = 0$	$\alpha_1 = 0$
	$\beta_1 + \beta_2 = 0$	$41\beta_1 = 33(\beta_1 + \beta_2)$	$\beta_1 = 0$
Location of knots: $\tau_0 = 0$, $\tau_1 = 41$, $\tau_2 = 74$			
Capital intensity cutoffs: $\check{k} = 10^{0.45}$, $\hat{k} = 10^{1.50}$			

Notes: Estimation by SUR. Standard errors in parentheses are bootstrapped using 1,000 replications to obtain heteroskedasticity robust standard errors.

3.3 Simple Test of Factor Price Equalization

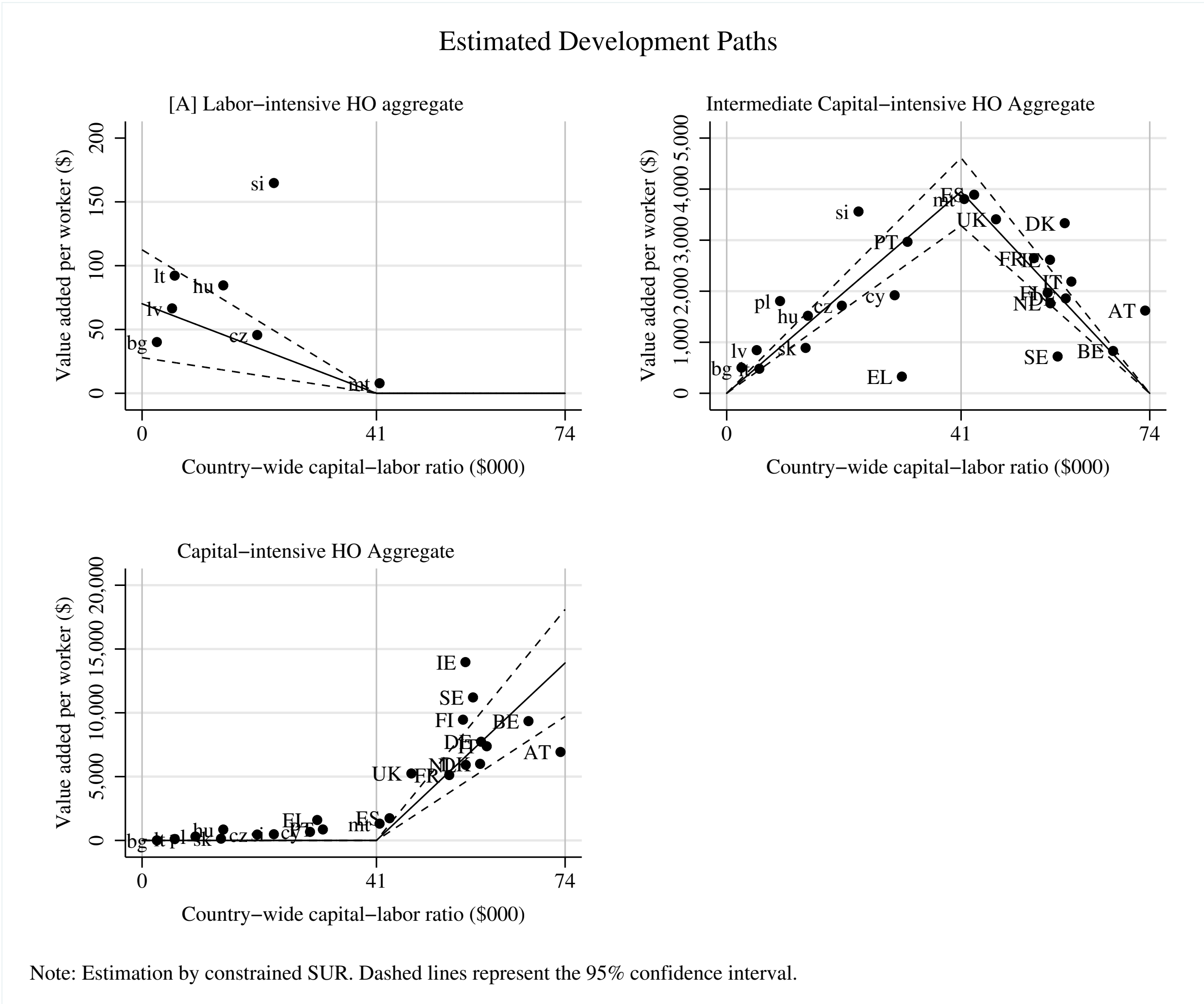
Based on the estimated development paths at two points in time, I conduct a simple test of factor price equality. As discussed in Section 2, the multiple-cone HO model allows equalization of factor prices across countries within the same cone, but not across cones. I focus on factor rewards to labor, i.e., wages, and utilize compensation per employee in the manufacturing sector. Data are collected from the European Commission's "AMECO."[17] Variations in wages across countries are measured by the coefficient of variation (CV).

Table 5 displays the arithmetic mean and CV of wages among countries in each cone derived from the estimations above. Those for overall sampled countries are also shown for comparison. The table reveals that mean wage in the capital-abundant cone (30,200 USD and 36,110 USD for the respective years) exceeds that in the labor-abundant cone (7,190 USD and 9,730 USD), which is consistent with theoretical expectations.

Furthermore, a comparison of the CVs suggests that, for each year, wages demonstrate smaller variation within each cone than across all sampled countries. Changes in CV across the 10 years also reveal the stronger convergence within respective cones than across all countries. CV has declined by 16 percentage points and 8 percentage points for labor- and

[17] Compensation per employee is used in the literature on wage convergence, e.g., Mora et al. (2005). Consumer price index is used for the deflation. The unit is constant 2000 USD.

Figure 4: Estimated Development Paths (1998)



Note: Vertical axis of panel is censored at 200 USD and Ireland (outlier) was not displayed.

capital-abundant cones respectively, which exceeds a decline of 5 percentage points among all sampled countries.

Although this is a brief examination, the results suggest that the derived cones of diversification appear to be the FPE set, and part of the wage disparities across European countries can be explained by the multiple-cone HO model.[18] The wage gap within the same cone, on the other hand, appears to be attributable to differences in production efficiency rather than differences in product mix.

[18]This result is consistent with the findings in Kiyota (2012a).

Table 4: Estimated Coefficients for the Two-Cone Three-Good HO Model (2008)

	Labor-intensive Aggregate	Middle-intensive Aggregate	Capital-intensive Aggregate
α_1	161.31	-	-
	(71.99)		
β_1	-3.10	160.58	-
	(1.38)	(23.04)	
β_2	3.10	-421.53	286.95
	(1.38)	(60.49)	(37.96)
Observations	24	24	24
NRMSE	3.03	0.68	0.63
Constraints	$\alpha_1 + 52\beta_1 = 0$	$\alpha_1 = 0$	$\alpha_1 = 0$
	$\beta_1 + \beta_2 = 0$	$52\beta_1 = 32(\beta_1 + \beta_2)$	$\beta_1 = 0$
Location of knots: $\tau_0 = 0$, $\tau_1 = 52$, $\tau_2 = 84$			
Capital intensity cutoffs: $\check{k} = 10^{0.90}$, $\hat{k} = 10^{1.80}$			

Notes: Estimation by SUR. Standard errors in parentheses are bootstrapped using 1,000 replications to obtain heteroskedasticity robust standard errors.

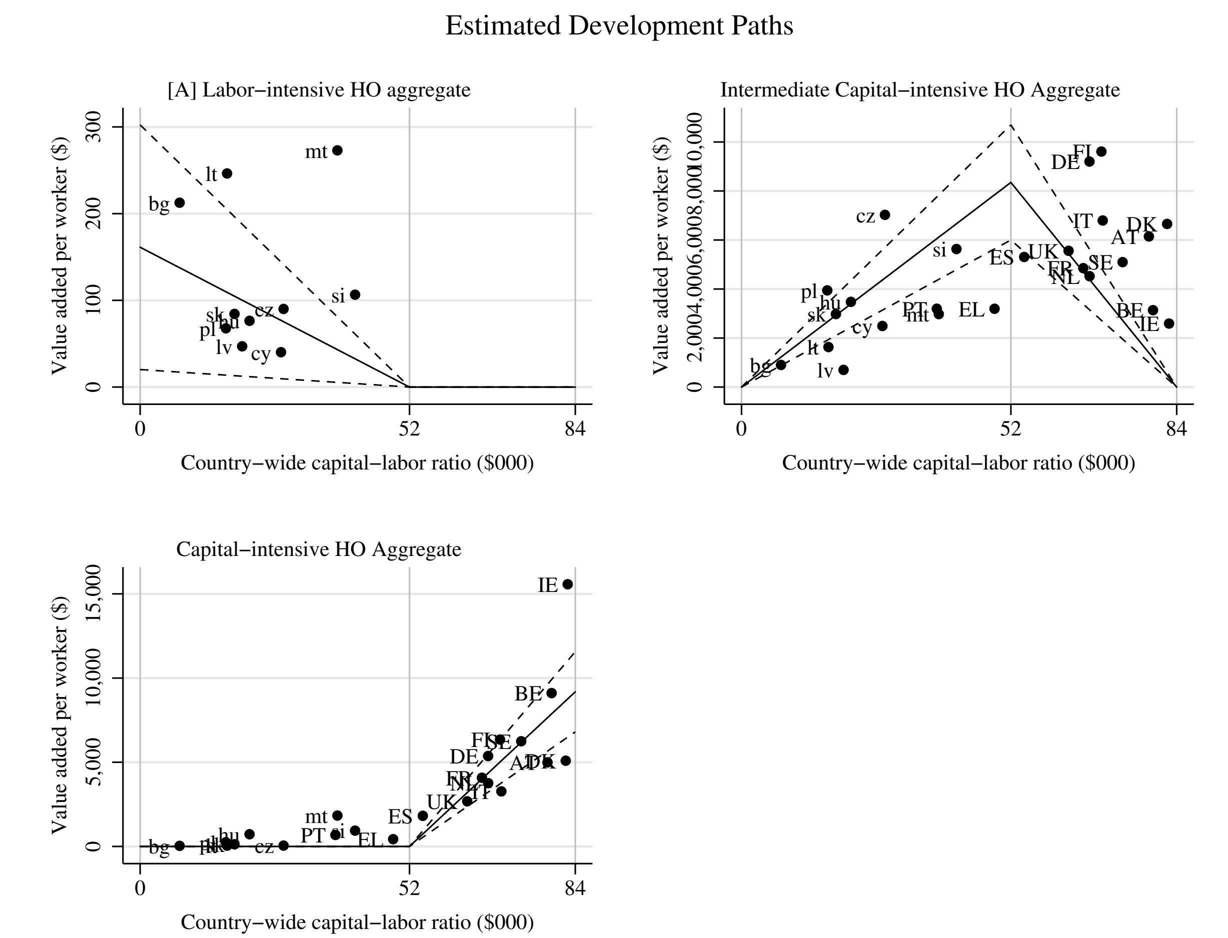
Table 5: Mean and Coefficient of Variation of Wages by Cones

	1998		2008	
	Mean	CV	Mean	CV
Labor-abundant cone	\$7,190	0.59	\$9,730	0.43
Capital-abundant cone	\$30,200	0.22	\$36,110	0.14
Overall sampled countries	\$19,650	0.66	\$23,150	0.61

4 Concluding Remarks

In this paper, I estimated the development paths of the two-cone HO model using a cross-section of the 24 EU member states in 1998 and 2008. Estimation results suggested that the multiple-cone HO model fits well the observed production specialization in the EU in the respective years. Examination of each cone's constituent countries revealed no substantial change in the distribution of countries across cones over time. It implies that the structure of industrial specialization across the EU remained stable during the 10 years examined in this study. Furthermore, a brief examination of FPE suggests that the derived cones of diversification may be FPE sets, and furthermore, wage disparities across countries can be partly explained by the multiple-cone HO model. These results are related to the theoretical discussion as well as empirical evidences of wage inequalities that can arise from the multiple-cone framework, documented in Deardorff (2001b), Leamer and Levinsohn (1995), Leamer

Figure 5: Estimated Development Paths (2008)



Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

and Schott (2005), Kiyota (2012b), etc.

The documented "pluralism" of the European "Single" Market implied by the existence of multiple cones may play an important role in explaining wages' response to market integration in Europe. In the basic set up without the international factor mobility, the existence of the multiple cones suggests that workers in capital-abundant countries are insulated from price declines in labor-intensive goods. Despite this, labor market integration in the EU allows workers in capital- and labor-abundant countries to compete directly with each others due to the labor mobility induced by these wage disparities. Thus, the multiple-cone HO model can help explain the problems surrounding the effect of further deepening and enlargement of European economic integration in the factor markets. Further empirical investigation of factor price equality, e.g., Bernard et al. (2013), as well as factor movements in the EU, will be significant.

In conclusion, several future research tasks remain. First, although this paper examines changes in estimated development paths at two points in time, it does not explain the dynamic mechanism of industrial specialization because of the analysis' static nature. It is worth applying this empirical method to the panel data for the estimation of multi-country dynamic development paths. In addition, it is also important to develop the theoretical foundation to explain changes in production functions and product prices over time, as these may affect the location of knots. Second, elaboration of the empirical analysis constitutes an important task, for instance, empirical specification of the number of cones, introduction of technological differences and worker quality, as well as detailed specification of the production function, e.g., allowing for factor substitution.

Third, an empirical study using finer product-level data may allow more detailed investigation of industrial specialization among EU member states. As documented in Schott (2003, 2004), heterogeneity in factor intensity and product price is evident within a coarse two-digit ISIC industry. Product-level analysis is likely to result from the availability of an internationally comparable dataset. Finally, based on the recent developments in the New Trade Theory, a firm-level analysis would play a significant role in distinguishing the "location" and the "ownership" of production in highly globalized economies.

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