Empirical Test of the Single- and Multiple-Cone Heckscher–Ohlin Model: Evidence on Changes in Production Patterns in the EU

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Abstract

This paper examines the impact of trade liberalization on countries' production patterns by focusing on the two types of equilibria that can arise from the Hecscher–Ohlin (HO) framework, namely single- and multiple-cone equilibria. Motivated by the distinct production implications of the two equilibria, this paper investigates the change in equilibrium during the trade liberalization. By utilizing data for factor endowment and sectoral output in manufacturing for 22 EU member states over 1995–2006, I estimate the linear relationship between countrywide capital–labor ratio and per capita output, i.e., development path, for the two equilibria adopting the empirical methodology introduced by Schott (2003, *AER*). Year-by-year test of the null hypothesis of the single-cone model against the alternative multiple-cone models reveals change in equilibrium over time; from the single-cone equilibrium with all countries producing all goods into the multiple-cone equilibrium with countries specializing in subset of goods in which they have comparative advantage. The results imply that the international division of labor based on endowment-based comparative advantage becomes more evident along with the economic integration in the EU.

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1. INTRODUCTION

The impact of trade liberalization on the reallocation of economic activities has been an important question in international trade studies. In analyzing the impact of trade liberalization, two strands of studies have emerged: (1) neoclassical trade theory, which addresses resource reallocation *across* industries in accordance with countries' comparative advantage, and (2) theories of heterogeneous firms and trade, which emphasize *within*-industry resource reallocation. While more recent research is increasingly focused on the role of firms in international trade, this paper places emphasis on endowment-driven comparative advantage and attempts to identify changes in countries' production patterns based on the Hekcscher–Ohlin (HO) framework. In particular, this paper focuses on the two types of equilibria that can arise within the HO framework, namely single- and multiple-cone equilibria.[2] In the single-cone equilibrium, all countries in the world produce all goods. Thus, if an economy exhibits a single-cone equilibrium, it suggests that production patterns are uniform across countries. On the other hand, a multiple-cone equilibrium has countries specializing in unique subsets of goods most suited for their relative factor abundance. This implies that the product mixes of most and least capital-abundant countries are different.

Motivated by the distinct production implications of the single- and multiple-cone HO models, this paper investigates the change in equilibrium over time. Since the HO model builds fundamentally upon the static framework, the equilibrium is characterized by prevailing goods prices and production technologies at each point in time. Thus, change in those parameters may affect the equilibrium conditions and alter the cones' structures. In this paper, I focus on the impact of European economic integration, which is apt to affect market prices of goods through the reduction of trade costs, international factor movements, and so forth. Identifying a change in an equilibrium will provide important implications regarding the impact of trade liberalization upon countries' industry dynamics.

By adapting the empirical technique introduced by Schott (2003), this paper implements year-by-year estimation of the linear Rybczynski relationship between the countrywide capital–labor ratio and per capita sectoral output, i.e., a development path *à la* Leamer (1987), for the single- and multiple-cone equilibria. I make use of data on countrywide factor endowments and sectoral output of manufacturing sectors for the 22 European Union (EU) member states during 1995–2006. While past studies usually use industry-level data based on a standard industrial classification, such as International

[2] Cone refers to "a set of factor endowment combinations that are consistent with producing the same set of goods and having the same factor prices" (Deardorff, 2014).

Standard Industrial Classification (ISIC), this paper follows Schott (2003) and groups ISIC industries into "Heckshcer–Ohlin aggregates" based on country–industry capital intensity so that input intensities of the HO aggregates are similar across countries. By testing the null hypothesis of the single-cone model against the alternative multiple-cone models, I examine whether the structure of cones changes over time.

The sampled countries and years used in this paper were selected for the following reasons. First, the diversity in relative factor endowments across sampled countries is important for identifying specialization in the factor proportions framework. The sample includes the new member states that joined the EU in 2004 and 2007.[3] These countries, usually labeled as the Central and Eastern European countries (CEECs), are known to be relatively labor-abundant *vis-à-vis* the original member states of the EU. Secondly, the dataset covers the period when the new member states became increasingly involved in the European single market. Prior to their accession to the EU, tariffs on trade in manufactured products between the CEECs and the EU had been abolished by 2002 due to the Europe Agreement. By testing the single- versus multiple-cone equilibrium year-by-year during the study period, this paper attempts to gauge the impact of economic integration on the production patterns in EU member states.

The empirical results reveal that the single-cone equilibrium transformed into the multiple-cone equilibrium during the sample period. Although I confirmed little evidence exists for the presence of multiple cones in the 1990s, I find strong empirical support for the two-cone equilibrium in the 2000s. This implies that economic integration in the EU may induce the reallocation of economic activities so that countries can specialize in the subset of goods in which they have an endowment-based comparative advantage. Further descriptive regressions show that changes in output mixes and capital intensities occurred that supported the shift from a single- to multiple-cone equilibrium.

In testing the production implications of the HO model, a number of studies have examined a linear Rybczynski relationship between countries' factor endowments and sectoral outputs. Pioneered by Harrigan (1995), studies such as those by Harrigan (1997), Bernstein and Weinstein (2002), and Redding (2002) have attempted to confirm the model's empirical validity. Although these studies confirm the significant role played by factor endowments in explaining production patterns across countries, they also reveal the model's weak explanatory power. Regarding this issue, Schott (2003) argues that the existing literature has focused on the *overly restrictive* single-cone assumption, and the alternative multiple-cone

[3] In this paper, the term "new member states" refers to the countries that joined the EU in the 2004 and 2007 enlargements. Member states prior to 2004 are called the original member states.

model needs to be considered.[4] By using cross-country data for 45 countries, he finds strong support for the HO specialization in favor of the two-cone equilibrium.[5] Other studies using different empirical approaches have also found evidence for multiple cones. For example, Debaere and Demiroglu (2003) focus on the lens condition of Deardorff (1994) and find that more than one cone exists for the world as a whole. Xiang (2007), on the other hand, confirms the existence of multiple cones by focusing of the factor intensity distribution for 10 OECD countries. This paper extends those studies by focusing on changes in the equilibrium over time by implementing year-by-year tests.

There are several related studies that are worth mentioning. Regarding changes in the Rybczynski relationship over time, Harrigan (1995) employs a time-varying parameter model and finds that the degree of time variation varies substantially across factors and industrious. Batista and Potin (2014), on the other hand, place an emphasis on the boundaries of the cone of diversification. Although their econometric specification allows capital–labor ratio cutoffs delineating the cone and Rybczynski derivatives to vary over time, their method does not allow the number of cones to change over time. Thus, this paper employs year-by-year estimation of the single- and multiple-cone models instead of adopting time-varying parameter model.[6]

This paper is also related to the studies which focus on the degree of specialization. For the European studies, Amiti (1999) finds that the six EU member states exhibited increasing specialization during the trade liberalization over 1968-1990. Although her result seems to suggest the reallocation of economic activities in favor of the multiple-cone equilibrium, she measures the degree of specialization based on standard industrial classification. This paper attempts to find evidence of specialization, which is more consistent with the factor proportions framework by taking into account the capital intensity of industries across countries.

The rest of this paper is structured as follows: Section II outlines the theoretical framework and

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[4] Leamer (1987) also highlights the existence of multiple cones in analyzing the development paths of countries with disparate factor endowments. Furthermore, Leamer and Levinsohn (1995) address the importance and difficulty in applying the multiple-cone equilibrium in empirics. They argue that the multiple-cone model needs to be explicitly considered when dataset contains both developed and developing countries.

[5] By adopting Schott's technique, Kiyota (2011, 2012) finds that the multiple-cone model is a better fit for Japanese regional data.

[6] Martincus and Wu (2005) examine whether economic integration in the EU favors countries' convergence into a common cone of diversification by employing year-by-year threshold estimation of Rybczynski relationships. Although their motivation is akin to that used in this paper, they rely on industry-level data that ignore within-industry product heterogeneity across countries. This paper puts emphasis on variations in capital intensity across countries and years within an industry.

contrasting production implications of the single- and multiple-cone HO model; Section III describes data, estimation strategy, and estimation results; Section IV implements a descriptive regression analysis based on the empirical results and also illustrates the limitations via an industry-level analysis; and Section IV concludes.

2. THEORETICAL BACKGROUND

2.1. Single- versus Multiple-Cone Equilibrium

This paper focuses on the production side of the HO model.[7] The production implication of the HO model says that there is a linear Rybczynski relationship between country's factor endowments and sectoral output. This paper focuses on the relationship between countrywide capital–labor ratio and sectoral per capita output, the development path (Leamer, 1987).

Regarding the model setup, this paper follows Schott (2003) and imposes the standard assumptions of Dixit and Norman (1980). In order to preclude complete specialization and reduce the number of parameters to be estimated, I assume that each sector has Leontief technology. I also assume an equal number of factors and goods exist in each cone in order to preclude indeterminacy as Melvin (1968) discusses.

Suppose that there are two productive factors (capital K and labor L). In the single-cone equilibrium, there are two goods (Good 1 and Good 2). The capital intensities of the two sectors are assumed to be $k_1 < k_2$ and $k_1 = 0$. Panel A of Figure 1 demonstrates the Lerner-Peace diagram of the two-good, single-cone equilibrium. The two industries' capital intensities delineating the cone are denoted by $\tau_0 = k_1$ and $\tau_1 = k_2$. Exogenous world prices and production technologies of the two goods identify the downward-sloping isocost curve for this economy, which pins down the interest rate r and wage w. Since both sectors' unit-value isoquants are tangent to the single isocost curve, countries with a capital–labor ratio within this cone, i.e., $\bar{K}_c/\bar{L}_c \equiv \bar{k}_c \in (\tau_0, \tau_1)$, produce both Good 1 and Good 2 and factor price equalization (FPE) exhibits globally. Per capita output $q_i \equiv Q_i/\bar{L}$ of sector i (for $i = 1, 2$) is a monotonic linear function of the countrywide capital–labor ratio as illustrated in Panel A of Figure 2.

In the multiple-cone equilibrium, on the other hand, a country specializes in a subset of goods most suited to its relative factor abundance. In order to facilitate the discussion, I demonstrate the two-cone

[7] Although the HO model is frequently referred in analyzing patterns of trade, it is fundamentally a model of production as Davis et al. (1997) and Reeve (2006) argue.[8] This scenario seems to be relevant for the European case. A number of studies have demonstrated increasing foreign direct investment from the original member states to the new member states in the late 1990s to mid-2000s, e.g., Kärkkäainen (2008).

model with three goods (Good 1, Good 2, and Good 3). Suppose that the capital intensities of the three sectors satisfy $k_1 < k_2 < k_3$. Capital–labor ratios delineating the two cones are denoted by $\tau_{i-1} = k_i$ for $i = 1,2,3$ with $\tau_0 = 0$. Panel B of Figure 1 illustrates the Lerner-Pearce diagram. Now, goods' prices and production technologies are such that isoquants of three sectors are not tangent to the single isocost curve. There are two sets of factor prices, (r_L, w_L) and (r_K, w_K), and each isocost curve is touched by two industries' isoquants. Consequently, GDP-maximizing countries specialize in only two of the three industries. Countries in the labor-abundant cone, $\bar{k}_c \in (\tau_0, \tau_1)$, specialize in Good 1 and Good 2 because they do not find production of Good 3 profitable. Meanwhile, countries in the capital-abundant cone, $\bar{k}_c \in (\tau_1, \tau_2)$, produce Good 2 and Good 3. As a result of different product mixes, factor rewards also vary across countries in the different cones, i.e., global FPE is not present. Intercepts of the two isocost curves indicate the reciprocal of the factor prices, suggesting $r_L > r_K$ and $w_K > w_L$. In the multiple-cone model, development paths are no longer a monotonic increasing or decreasing function of the countrywide capital labor–ratio. Panel B of Figure 2 illustrates that the development paths of the two-cone model are a linear spline with an interior knot τ_1.

2.2. Impacts of Economic Integration on Equilibrium

As shown above, the equilibria in the factor proportions framework are characterized by the prevailing exogenous goods prices and production technologies, which determine the locations of the unit-value isoquants. Economic integration, including trade liberalization, is likely to alter those parameters and affect the equilibrium condition, which in turn induces resource reallocation across industries. In this section, I illustrate the two opposite mechanisms through which tariff reductions and international factor movements alter the structure of cones.

Figure 3 illustrates a two-factor, three-goods world where a tariff is imposed on the most labor-intensive good, namely Good 1. This trade barrier makes production of Good 1 profitable for all countries since the unit-value isoquants of three goods are tangent to the isocost curve identified by w and r. Hence, the pre-liberalization equilibrium has a single cone of diversification where all countries may produce all goods. Reduction of trade barriers shifts the unit-value isoquant of Good 1 from the left (solid isoquant) to right (dotted isoquant). Now, production of Good 1 is not profitable for the countries in the capital-abundant cone. This change induces a reallocation of capital-abundant countries' resources away from the labor-intensive industry toward the capital-intensive industries in which they have comparative advantages. Thus, the post-liberalization equilibrium has two cones of diversification where countries specialize in subsets of goods.

On the other hand, shifting from a multiple-cone to a single-cone equilibrium can occur if factor movements are liberalized across countries.[8] In Figure 4, solid isoquants and isocost curves identify the pre-liberalization equilibrium with two cones of diversification. Suppose that there are two countries, country A in the labor-abundant cone, and country B in the capital-abundant cone. Following Leamer (1995), assume that two countries' factor markets are partly integrated. In this instance, differences in factor prices induce factor flows across countries; labor flows from country A to B, whereas capital flows from B to A. These factor movements in search of higher returns coincidentally change the supplies of three goods. If these changes are sufficiently large to affect the market prices, unit-value isoquants of Good 1 and Good 3 shift inward (price increase) and the isoquant of Good 2 shifts outward (price decline). Through the general equilibrium linkage, i.e., Stolper–Samuelson effects, differences in factor prices will be diminished so that post-liberalization economy exhibits the single-cone equilibrium. The new equilibrium is identified by the dotted isoquants and isocost curve. This analysis suggests that international factor movements may "melt away" the multiple cones and drive countries to converge into a single cone.

In the analysis above, the single-cone equilibrium refers to the situation where three industries' unit-value isoquants are tangent to the single isocost curve. In this case, no one-to-one mapping from factor endowments to sectoral output can be conducted due to the indeterminacy (Melvin, 1968). Therefore, the development path for each industry is not estimable. However, due to the assumption of constant returns to scale, the total output of any combination of goods along a single isocost line within a cone can be represented by the output of single good tangent to that isocost line (Schott, 2003). Thus, by aggregating two of the three goods, e.g., Good 1 and Good 2, the equilibrium can be represented by the two-good model where the linear Rybczynski relationship as described in Figure 2 can be identified. This logic is employed again in the empirical analysis below.

3. EMPIRICAL ANALYSIS

3.1. Data

In this section, I implement a year-by-year estimation of the development paths for the single- and multiple-cone models. I make use of a cross-section of value-added, capital stock, and employment data

[8] This scenario seems to be relevant for the European case. A number of studies have demonstrated increasing foreign direct investment from the original member states to the new member states in the late 1990s to mid-2000s, e.g., Kärkkäainen (2008).

for 22 EU member states over 1995–2006. Countrywide endowments are drawn from the Penn World Table (PWT) complied by Feenstra, Inklaar and Timmer (2015). The capital stock data uses prices for structures and equipment that are constant across countries. Following Hall and Jones (1999), employment data are corrected for educational differences, and the educational attainment data are retrieved from Barro and Lee (2013).[9] The countrywide capital–labor ratios and Eurostat two-letter abbreviation codes are presented in Table 1. Countries are listed in ascending order of capital–labor ratio as of 1995. Countries with lowercase abbreviations are the new member states. Cross-country variations in capital–labor ratios are relatively stable over time, with the coefficient of variation fluctuating between 0.40 and 0.45. This low rate of change implies that variations in equilibrium during the sampled period, if any, are more likely to be induced by changes in goods prices rather than in factor endowments.

Industry data are retrieved from the United Nation Industrial Development Organization (2014). The dataset covers 23 International Standard Industrial Classification (ISIC) industries in manufacturing sectors. For several countries, data covering two or more industries are combined. Following Koren and Tenreyro (2007), I aggregate sectors in order to obtain a consistent classification across countries and years.[10] Sectoral value added is expressed in 2005 US dollars, computed using the exchange rates and GDP deflator from the PWT.

Since ISIC groups output loosely according to end-use similarities, the capital intensity of each ISIC industry varies across countries and years, i.e., intra-industry product heterogeneity is present.[11] Adopting Schott's (2003) technique, ISIC industries are recast into theoretically more appropriate "HO aggregates." In order to preserve evenness, for the T-cone model, ISIC industries are grouped into $I = T + 1$ HO aggregates by defining T capital intensity cutoffs h as $X_{ic} = \sum_{k_{nc} \in (h_{i-1}, h_i)} Q_{nc}$, where X_{ic} denotes the value-added of HO aggregate i in country c, which is the sum of value added of all ISIC industries n with capital intensity between h_{i-1} and h_i, with $h_0 = 0$. Forming the HO aggregates relies upon an assumption that prices are such that the unit-value isoquants of all goods within a given derived aggregate are tangent to a single isocost line. Country–ISIC capital intensities are computed using

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9 Following the method proposed by Hall and Jones (1999), the quality-adjusted labor force is computed as $\bar{L}^{adj} = \bar{L}_{S0} + \bar{L}_{S2}\exp(2 \times 0.134) + \bar{L}_{S4}\exp(4 \times 0.134) + \bar{L}_{S6}\exp(4 \times 0.134 + 2 \times 0.101) + \bar{L}_{S6}\exp(4 \times 0.134 + 2 \times 0.101) + \bar{L}_{S8}\exp(4 \times 0.134 + 4 \times 0.101) + \bar{L}_{S10}\exp(4 \times 0.134 + 4 \times 0.101 + 2 \times 0.068) + \bar{L}_{S12}\exp(4 \times 0.134 + 4 \times 0.101 + 4 \times 0.068) + \bar{L}_{S14}\exp(4 \times 0.134 + 4 \times 0.101 + 6 \times 0.068)$ where $\bar{L}_{Se}$ is the fraction of employees with $e \in (e-2, e]$ years of education for $e \geq 2$ and $\bar{L}_{S0}$ is the number of employees without any education attained.

10 The classification is not completely consistent across countries after this aggregation. However, it is not problematic since I recast ISIC industries into HO aggregates (explained below) based on capital intensity.

11 Data on country–ISIC capital intensity are available upon request.

industry-level gross fixed capital formation and employment from the UNIDO database. Investment data are denominated in 2005 US dollars, computed using the exchange rate and deflator from the PWT. Following Hall and Jones (1999), I adopt the perpetual inventory method. I use data from 1963 (if available) and apply a constant depreciation rate of 13.3%. Missing values are linearly interpolated.[12] I also apply the quality correction to sectoral employment data as well.

3.2. Estimation Strategy

By using HO aggregates' output, I estimate development paths for the single- and multiple-cone models year-by-year. Econometric specification for the development path of the T-cone model is

$$x_{ic} = \beta_{1i} + \sum_{t=1}^{T} \beta_{2it} \bar{k}_c I_t \{\bar{k}_c < \tau_t\} + \varepsilon_{ic}, \tag{1}$$

where the dependent variable is per capita value added of the HO aggregate $x_{ic} \equiv X_{ic}/\bar{L}_c$ and explanatory variable is the countrywide capital-labor ratio. Subscripts indicate country c and HO aggregate i. $I\{\cdot\}$ is the indicator function, which equals 1 if the relationship in brackets is true and 0 otherwise. ε is the disturbance, and τ_t indicate the locations of the knots, which are irrespective of industry and countries. In estimating the T-cone development paths, T capital intensity cutoffs (h) defining the HO aggregates and $T-1$ interior knots (τ) should be given. Following Schott (2003) and Kiyota (2012), I employ a grid search approach to estimate these parameters. I grid the overall possible combinations of h and τ values for a given interval size. I use an interval of $\gamma = 0.01$ for capital intensity cutoffs: $10^{0.01} \le 10^{\gamma} (= h) \le 10^{3.00}$, in thousands of USD. For the interior knot locations, I apply an interval size of 500 USD: $\tau_0 < \tau_t < \tau_T$ where $\tau_0 = 0$ and τ_T (rightmost knot) is assumed to be 1,000 USD above the upper range of the sample's observed capital–labor ratio in each year.

For any given capital intensity cutoffs and interior knots, the intercepts and slopes of the development paths (β's) are estimated simultaneously via a seemingly unrelated regressions (SUR) model by taking into account the correlation of error terms across equations. In the estimation, the shapes of each development path are constrained as implied by Figure 2. The development path of the most

[12] If year t_0 is the first year for which investment data are available, the capital stock of industry i in year t_0 is estimated by $I_{it_0}/(g_i + \delta)$ where I_{it_0} is the investment (gross fixed capital formation) in year t_0, g_i is the average geometric growth rate of the investment series from t_0 to 1979, and δ is a constant depreciation rate of 13.3% regardless of industries. If the sequence between t_0 and 1979 is less than five years, I use the first five years available to calculate g_i. Furthermore, if g_i is negative, i.e., investments in industry i is declining over time, I replace it with zero. In regard to the imputation of missing values, results are in general not sensitive to the particular way in which this is done.

labor-intensive HO aggregate, for example, must have negative slope for the first segment and hit the $\bar{k}$-axis at the first estimated interior knot ($\beta_{11} + \tau_1 \beta_{121} = 0$); the following segments must lie along the $\bar{k}$-axis ($\sum_{t \in [1,s]} \beta_{12t} = 0$ for $s \in [2, T]$).

For every combination of capital-intensity cutoff and interior knot, I estimate β iteratively. Each regression pattern is regarded as a different econometric model. Hence, I employ the model selection criterion to choose the capital intensity cutoffs and knot locations. In this selection process, I firstly rule out models that violate the theoretical conditions with respect to per capita output at knots[13]

$$\beta_{11} < \beta_{221}(\tau_1 - \tau_0) < \beta_{232}(\tau_2 - \tau_1) < \cdots < \beta_{2,T+1,T}(\tau_T - \tau_{T-1}).$$

Secondly, I identify the two cutoffs and the knot's location by comparing the goodness-of-fit statistics. Regarding the model selection criterion, Schott (2003) and Kiyota (2012, 2014) employ the log-likelihood, and Batista and Potin (2014) employ the sum of the root-mean squared error (RMSE) across equations. In both approaches, the absolute levels of dependent variables across equations affect the criteria. As a result, the model selection via maximum likelihood or the minimization of total RMSE tends to assign extreme estimates for both capital intensity cutoffs and interior knot locations, e.g., an extremely small value for h_1 and/or τ_1.

In order to obtain theoretically more consistent estimates, I propose Berndt's (1991) generalized R-squared for the model selection criterion. For the T-cone model with $I = T + 1$ HO aggregates, I define the $C \times I$ matrix of dependent variables as $\mathbf{x}$, where C is the number of observations. By denoting the mean deviance matrix of $\mathbf{x}$ as $\mathbf{x}_{\text{dev}} = \mathbf{x} - \bar{\mathbf{x}}$ where $\bar{\mathbf{x}}$ is the $C \times I$ matrix of sample means of the dependent variables, Berndt defines the generalized variance in dependent variables as the determinant of $\mathbf{x}'_{\text{dev}}\mathbf{x}_{\text{dev}}$. By defining the $C \times I$ matrix of residuals by $\mathbf{e}$, the generalized R-squared is computed as, $R^2 = 1 - \frac{\det(\mathbf{e}'\mathbf{e})}{\det(\mathbf{x}'_{\text{dev}}\mathbf{x}_{\text{dev}})}$. It is worth noting that the maximum likelihood approach, by definition, minimizes the numerator of the second term, $\det(\mathbf{e}'\mathbf{e})$. Hence, the generalized R-squared takes into account the absolute level of the dependent variables across regressions by dividing $\det(\mathbf{e}'\mathbf{e})$ by $\det(\mathbf{x}'_{\text{dev}}\mathbf{x}_{\text{dev}})$. In other words, it can be seen as the squared residual index weighted by the mean deviance of the regressands. The capital intensity cutoffs and knot locations are identified so that the generalized R-squared is maximized.

After fitting single- and multiple-cone models respectively, I test the null hypothesis of the

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[13] It is derived from the conditions to assure the equilibrium; per capita output of sector i at $\bar{k} = k_i (= \tau_{i-1})$, i.e., $x_i|_{\bar{k}=k_i}$ for $i \in (1, T+1)$, should hold $x_1|_{\bar{k}=k_1} < x_2|_{\bar{k}=k_2} < \cdots < x_{T+1}|_{\bar{k}=k_{T+1}}$.

single-cone model against the alternative multiple-cone models in order to find empirical support for any of the models. Because single- and multiple-cone models are non-nested, the classical likelihood test cannot be applied. I thus follow Schott (2003) and construct bootstrap confidence intervals to compute relative fit of the models. While a single-cone model has five parameters to be estimated, a T-cone model has $T(T+4)$ parameters. In order to impose a penalty for increasing number of parameters, I adopt differences in Aakaike's Information Criteria (AIC) for the test statistics, computed as $AIC = -2\ln L + 2\{T(T+4)\}$ with $\ln L$ is the log-likelihood. The Statistical Appendix provides more details about the bootstrap.

3.3. Empirical Results

I estimate the single- and multiple-cone models with up to three cones. Table 3 reports bootstrap *p*-values for the two- and three-cone equilibria versus the null hypothesis of a single-cone equilibrium. The table indicates that the single-cone model is not rejected against alternative multiple-cone models from 1995 to 1999. However, there is strong evidence for the two-cone model after 2000 with bootstrap *p*-value less than 1%, but little evidence for three cones. The result suggests that the EU has undergone a change in equilibrium over the sampled period, namely from the single-cone equilibrium with all countries producing all goods into a two-cone equilibrium with countries specializing in unique subsets of goods.[14] This change from the single- to multiple-cone equilibrium can be attributed to the trade liberalization between the capital-abundant original member states and labor-abundant new member states in the late 1990s. As discussed in section 2.2, trade liberalization may have altered equilibrium conditions in the EU and induced resource reallocation within manufacturing so that countries could specialize in subsets of goods for which they held comparative advantage. It also implies that the international division of labor across EU member states becomes more evident as they unify their markets.

Tables 4 and 5 present the coefficient estimates of the single-cone model for 1995–1999 and the favored two-cone model for 2000–2006, respectively. Signs of all coefficients are consistent with theoretical predictions and statistically significant at the 99% level. Figure 5-16 plot the estimated development paths for each year. In each figure, HO aggregates are ordered by increasing capital intensity from left to right, and down. Each observation is identified by the two-letter Eurostat country code.

[14] Since testing the null hypothesis of a single-cone model against alternative multiple-cone hypotheses builds upon the Neyman-Pearson framework and focuses on the Type-I error, empirical results for the 1990s do not simply support the single-cone equilibrium. However, my results confirm strong evidence for the multiple-cone equilibrium in the 2000s, but little evidence for its existence in the 1990s.

Confidence intervals (95%) for positively or negatively sloped segments provide a sense of precision with which they are estimated. In case of the two-cone equilibrium, the theory predicts that the most and least capital-intensive HO aggregates, respectively, are produced only by countries in labor- and capital-abundant cones. Analysis of the observations reveals that several labor-abundant countries do not produce a labor-intensive HO aggregate. On the other hand, the relatively high number of labor-abundant countries is producing the most capital-intensive HO aggregate. This finding is in line with Schott's (2003). It may be attributed to, for example, foreign direct investment from developed countries that allows labor-abundant developing countries to produce more capital-abundant goods by exploiting the foreign capital and technology before their endowments let them be profitable.

Finally, I inspect the distribution of countries across cones after 2000. In general, the country composition of each cone is relatively stable over time. Bulgaria, Latvia, Hungary, Poland, Slovakia, and the Czech Republic—all new EU member states—always inhabit the labor-abundant cone. On the other hand, Malta, Greece, France Belgium, Cyprus, Austria, Spain, Finland, and Italy reside in the capital-abundant cone for the entire period. Except for Malta and Cyprus, these countries are original EU member states. Although the Netherlands, Portugal, and Denmark, were grouped into the labor-abundant cone in 2000, they moved to capital-abundant cone in 2001, where they have remained thereafter. The rest of the countries, namely Slovenia, Sweden, the United Kingdom, and Ireland, shift between the two cones. Overall, the two-cone structure divides EU member states into original and new member states.

Countries in different cones have distinct general equilibrium linkages between factor endowments, sectoral production, and factor prices. As Davis (1996) discusses, wage-price arbitrate is dampened across countries in different cones. Thus existence of multiple cones suggests that workers in capital-abundant countries may be insulated from price declines of the labor-intensive goods produced by the labor-abundant country.

3.4. What Is Behind the Change in Equilibrium?

Changes in equilibrium, from the single-cone equilibrium with all countries producing all goods to the multiple-cone equilibrium with countries specializing in subsets of goods, suggests the existence of underlying changes in output mixes and/or capital intensities across industries. More specifically, this change may accompany (1) moving in (out from) the industries in which countries have comparative advantage (disadvantage) and/or (2) change in industrial capital intensity in line with countries' relative factor abundance. In order to examine these predictions, I implement the following descriptive regressions.

The first regression examines changes in output mix. Since movements in industrial output should vary between capital- and labor-intensive goods, I aggregate the country-ISIC valued added by capital intensity in the same manner as used for HO aggregates. For the cutoff values, I compute every 10th percentile value for industrial capital intensities for the whole sample. I create 10 industry aggregates as, $\Psi_{pct} = \sum_{k_{nc} \in (\check{k}_{p-10}, \check{k}_p]} Q_{nct}$, where $\check{k}_p$ is the pth percentile value of the capital intensity and Ψ_{pct} is the sum of valued added of all ISIC industries n with capital intensity between $\check{k}_{p-10}$ and $\check{k}_p$ for $p = 10, 20, \ldots, 90, 100$. By denoting per capita value of Ψ_{pct} as $\phi_{pct} \equiv \Psi_{pct}/\bar{L}_{ct}$, I regress the first-order time difference of the per capita output, $\Delta\psi_{pct} = \psi_{pct} - \psi_{pc,t-1}$, on the countrywide capital‑labor ratio. Coefficient estimates on the capital‑labor ratio via the ordinary least squared (OLS) are summarized in Table 6. The table demonstrates that the higher the capital‑labor ratio is, the more the production of labor intensive goods (below the 30th percentile value) is likely to decrease. On the other hand, the more capital-abundant a country is, the higher the growth of capital-intensive production (above the 40th percentile) is. All of the coefficients are statistically significant at the 1% level, except for output with capital intensity between 30th to 40th percentile values.

Secondly, I examine the relationship between the countrywide capital‑labor ratio and changes in capital intensity by 17 ISIC industries.[15] The dependent variable is the first-order time difference of the ISIC capital intensity, $\Delta k_{nct} = k_{nct} - k_{nc,t-1}$ and the explanatory variable is the countrywide capital‑labor ratio. The OLS estimation results are summarized in Table 7. For 10 out of 17 ISIC industries, the coefficient estimates are significantly positive. It implies that capital-abundant countries are likely to further increase the industrial capital-intensity. For the remaining industries, the relationship is insignificant or even negative (not significant) for electronics. This mixed result implies that within-industry adjustments in input intensity are not uniform for all countries.

The above descriptive regressions suggest that countries adjust their product mixes in accordance with their relative factor abundance during the sampled period. Furthermore, I confirmed that, for some ISIC industries, a change in sectoral capital intensity is positively associated with the countrywide capital–labor ratio. These findings are in general consistent with the factor proportions framework and support the observed change from a single-cone equilibrium to multiple-cone equilibria. However, aggregation of industries based on capital intensity makes it difficult to distinguish within-industry and cross-industry resource reallocations during the trade liberalization process, which constitutes a future

[15] I limit the ISIC industries where there are more than 100 observations

extension of this study and is discussed below.

4. CONCLUSION AND FUTURE PROSPECT

This paper examines changes in countries' production patterns during economic integration based on the production side of the HO model. In particular, I focus on two types of equilibria, namely single- and multiple-cone equilibria. Motivated by the distinct production implications arising from these two equilibria, I implement year-by-year estimation of development path for the single- and multiple-cone models by adopting Schott's (2003) empirical method. Results show little evidence for the existence of multiple cones in the 1990s but strong empirical support for the two-cone equilibrium after 2000. The shift from a single-cone to multiple-cone equilibrium suggests that economic integration in the EU may have induced the reallocation of economic activities among EU member states so that countries specialized in subsets of goods in which they have comparative advantage. Inspection of the country composition of each cone reveals that the labor- and capital-abundant cones consist of, broadly speaking, the new member states and original member states, respectively. It implies that the trade liberalization between capital-abundant original member states and labor-abundant new member states during the sampled period enhanced the international division of labor across countries.

Furthermore, descriptive regressions on changes in outputs and capital intensities support the observed shift from the single-cone to multiple-cone equilibrium. I show that the higher the countrywide capital–labor ratio, the more likely the production of labor-intensive (capital-intensive) goods is to decrease (increase). For capital intensities, I report that capital-abundant countries are more likely to increase sectoral capital intensity. However, this association between factor abundance and capital intensity is not confirmed for all ISIC industries, which suggests that within-industry adjustments are not uniform across countries.

In analyzing the impact of trade liberalization on the reallocation of economic activities, this paper's approach has several limitations that are worth mentioning. The aggregation of industrial output by capital intensity industry definitions consistent with the conceptualization of goods in the factor proportions framework. However, it obscures actual changes in industrial output mix over time. Thus, the shift from single-cone to multiple-cone does not necessarily accompany the resource reallocation across ISIC industries. In fact, the industry aggregate to which a given ISIC industry is assigned varies as its capital intensity evolves over time. Thus, these codes are not able to identify how resource reallocation occurs in response to the trade liberalization, *across* or *within* industries. For example, capital-abundant countries can move their production activities away from labor-abundant plants to more capital-abundant plants within the industry. Alternatively, they can adjust their production mix across ISIC industries. However, identifying across- and within-industry resource reallocations is impossible with industry-level analysis.

Regarding this issue, recent developments in international trade studies may have useful implications for considering the scope of future studies. Since the seminal work by Melitz (2003), recent research, both in theory and empirics, addresses the firm heterogeneity in explaining resource reallocation within industries. While the Melitz model ignores characteristics of industries and countries by focusing on a single factor and industry, Bernard, Redding, and Schott (2007) challenge this limitation by embedding heterogeneous firms in a model with two countries, two factors, and two industries. They find simultaneous within- and across-industry resource reallocations that are systematically associated with country's comparative advantage.

An interesting scope for further research includes an empirical test of their model by utilizing firm-level data. For example, it is worth examining whether the firm survival, growth, industry switches, and exporting status are systematically associated with their productivity levels in combination with aggregate industrial capital intensity and their country's factor abundance. An empirical investigation of the resource reallocation across and within industries that incorporates interactions between firm, industry, and country characteristics will provide richer implications in considering the impact of trade liberalization. Furthermore, in the context of European economic integration, it is also important to gauge the effect of import penetration from the labor-abundant low-wage European countries on firm survival and output growth in comparison with import penetration from other low-wage countries, an aspect examined by Bernard, Jensen, and Schott (2006) with US data. Such progress is likely to result from the recently developed firm-level data, for example, the CompNet firm-level based dataset complied by the European Central Bank.

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STATISTICAL APPENDIX

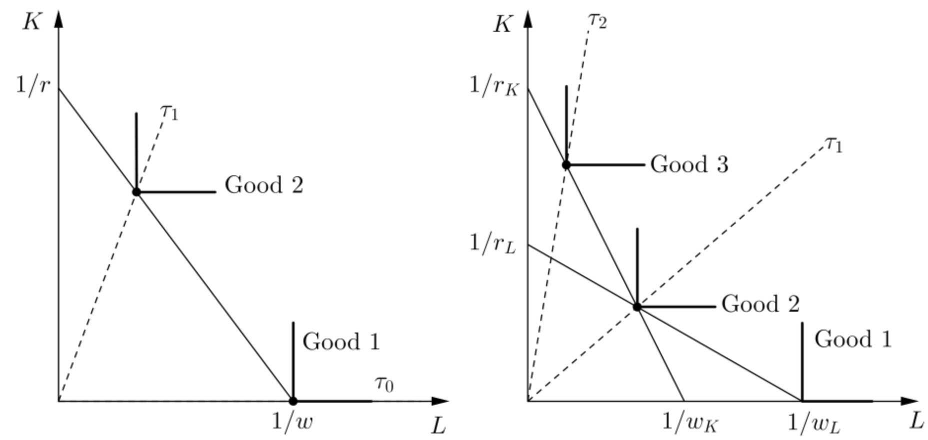
Testing a Single-Cone Model against Multiple-Cone Model

1. Estimate a null-hypothesis of single-cone model using two HO aggregates. HO aggregate i in country c is constructed by, $X_{ic}^{H_0} = \sum_{k_{nc}\in\left(h_{i-1}^{H_0},h_i^{H_0}\right]} Q_{nc}$ for $i = 1,2$ and $h_0^{H_0} = 0$. After fitting the model, we compute share of ISIC industry n in HO aggregate i as $s_{inc} = Q_{nc}/X_{ic}^{H_0}$. I analogously estimate alternative T -cone model using $T+1$ HO aggregates, $X_{ic}^{H_1} = \sum_{k_{nc}\in\left(h_{i-1}^{H_1},h_i^{1}\right]} Q_{nc}$ for $i =\in (1, T+1)$ and $h_0^{H_1} = 0$. Because each model has different number of parameters, difference in Akaike's information criteria (AIC) between two models are utilized as relative fit measurement, $d = AIC^{H_0} - AIC^{H_1}$.
2. Assume the null hypothesis of the single-cone model to be true and compute a fitted value of HO

aggregate using coefficient estimates in step 1) as $\hat{X}_{ic}^{H_0} = \widehat{\boldsymbol{\beta}}_i'^{H_0}\mathbf{V}_c + \hat{\varepsilon}_i^{H_0}$, where $\widehat{\boldsymbol{\beta}}_i^{H_0}$ is vector of estimated coefficients, $\mathbf{V}$ represents regressors, and $\hat{\varepsilon}_i^{H_0}$ is distributed normally with mean zero and standard deviation equal to the root-mean squared error of the HO aggregate i regression.

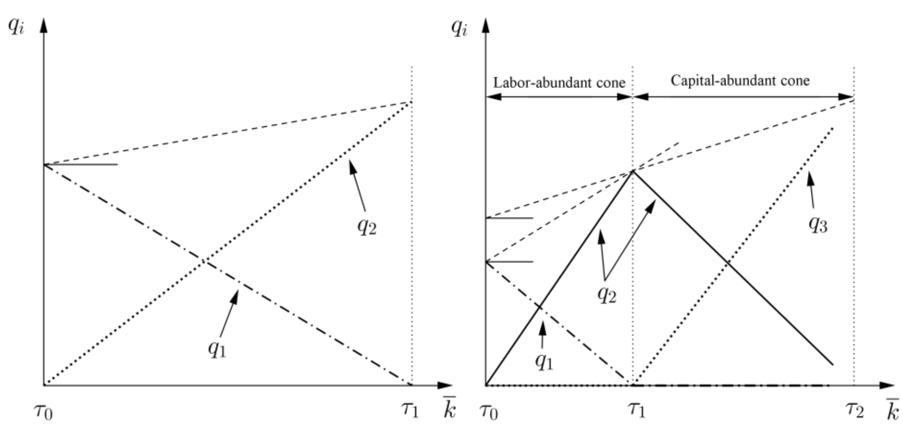
3. Use the drawn country-HO aggregate outputs to compute country-ISIC industry outputs as, $\hat{Q}_{nc} = \mathrm{s}_{\mathrm{nc}}\hat{X}_{ic}^{H_0}$.
4. Use the vector of country-ISIC industry output $\hat{Q}_{nc}$ to estimate a single- model and the alternative multiple-cone model. The same capital intensity cutoffs and knot locations obtained in step 1 are applied. Compute the test statistics.
5. Repeat 2 through 4 (1,000 replications) to create a confidence interval and compare the relative fit in step 1 to this interval.

Figure 1—Lerner-Pearce Diagram of the Single- and Two-Cone Model



Panel A : Two-good, single-cone model Panel B : Three-good, two-cone model

Figure 2—Development Path of the Single- and Two-Cone Model



Panel A : Two-good, single-cone model Panel B : Three-good, two-cone model

Figure 3—Shift from the Single- to Multiple-Cone Equilibrium

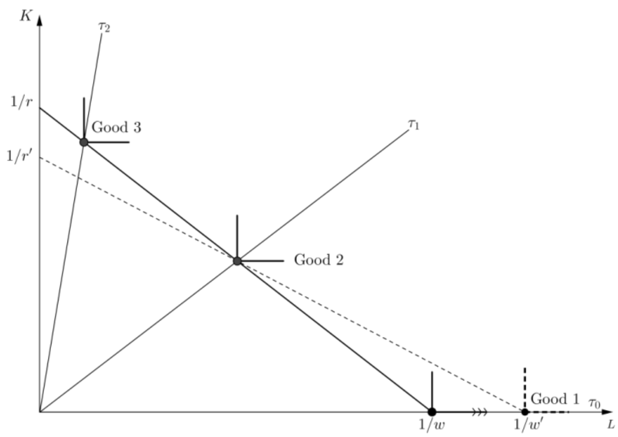


Figure 4—Shift from the Multiple- to Single-Cone Equilibrium

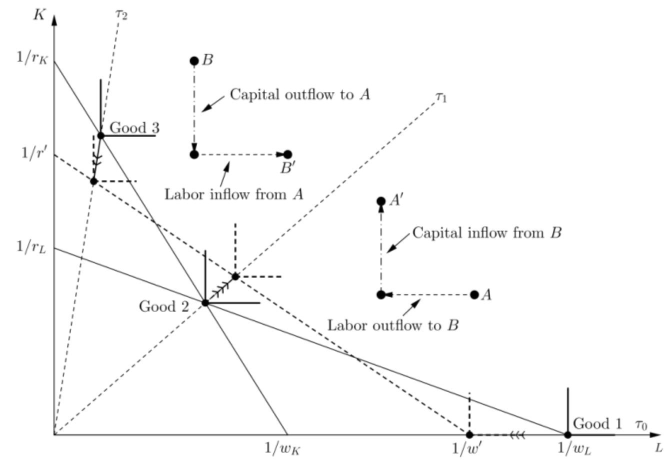


Table 1—Countrywide Capital–labor Ratio

Country	Abbrev.	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bulgaria	bg	17.7	16.6	15.6	15.5	15.8	16.4	16.8	17.0	13.2	13.9	15.7	17.2
Latvia	lv	23.3	22.8	18.2	20.3	22.4	24.0	25.4	21.8	21.7	22.3	23.6	24.9
Hungary	hu	28.6	26.5	25.5	24.4	23.3	24.7	28.5	27.3	29.9	31.7	33.1	38.1
Poland	pl	29.1	29.1	28.0	27.7	28.9	27.5	28.2	29.9	29.7	30.9	31.8	30.5
Slovenia	si	32.8	34.3	36.4	37.9	39.2	40.9	41.5	39.0	40.7	48.0	55.2	56.4
Slovakia	sk	33.0	33.1	31.4	30.1	29.2	30.4	30.5	29.5	30.0	32.5	31.6	34.5
Czech Rep.	cz	33.3	34.6	30.8	30.8	30.9	31.5	32.4	32.5	35.3	37.2	38.5	42.2
Malta	mt	42	42.8	48.9	56.8	57.1	60.6	56.2	56.7	56.0	58.3	56.8	64.3
Sweden	SE	50.6	50.2	49.8	47.9	46.4	45.5	43.9	42.4	43.7	43.4	41.0	46.9
UK	UK	51.0	50.3	49.0	48.7	46.7	47.4	45.9	44.9	45.7	45.8	50.4	53.1
Netherlands	NL	61.6	55.7	54.3	53.4	52.2	52.4	51.7	52.6	55.6	59.9	64.1	70.9
Ireland	IE	63.1	62.2	57.7	51.3	45.7	42.7	38.6	38.7	38.8	41.7	44.0	57.5
Portugal	PT	65.6	63.9	56.5	53.5	53.8	55.1	54.2	57.2	61.7	66.7	72.4	80.7
Denmark	DK	66.6	64.6	63	61.6	60.4	55.4	57.4	56.9	59.4	63.9	67.5	71.8
Greece	EL	72.9	72.2	71.7	68.9	68.1	68.9	62.1	60.7	62.3	64.8	64.6	73.1
France	FR	74.2	73.0	71.5	69.2	66.4	65.6	65.3	65.2	65.3	76.9	84.0	94.5
Belgium	BE	79.9	79.2	77.6	74.0	74.5	76.5	77.3	74.4	78.0	83.6	87.1	94.8
Cyprus	cy	80.6	82.1	81.8	81.0	79.9	80.8	85.3	83.1	75.8	80.8	85.5	92.7
Austria	AT	86.5	87.2	87.0	90.4	88.3	88.6	87.1	84.7	85.8	89.5	92.2	97.8
Spain	ES	90.2	89.3	83.7	80.1	72.2	70.4	64.9	65.4	67.6	73.6	76.0	93.5
Finland	FI	97.5	89.9	84.8	84.1	82.2	82.4	83.1	78.6	81.1	85.2	94.0	99.4
Italy	IT	114.8	113.1	112	101.5	98.5	98.0	95.2	92.2	92.2	97.8	108.1	118.6
Min		17.7	16.6	15.6	15.5	15.8	16.4	16.8	17.0	13.2	13.9	15.7	17.2
Max		114.8	113.1	112.0	101.5	98.5	98.0	95.2	92.2	92.2	97.8	108.1	118.6
Mean		58.9	57.8	56.1	55.0	53.7	53.9	53.2	52.3	53.2	56.7	59.9	66.1
StdDev/Mean		0.44	0.44	0.45	0.43	0.42	0.42	0.41	0.41	0.40	0.41	0.42	0.42

Note: Countries with lowercase abbreviations are the new member states. Unit is thousand USD. Data on capital stock and employment are from the Penn World Table. Employment data are corrected for educational difference as discussed in the text.

Table 3—Evidence of Multiple Cones

	Bootstrap p-value	
	2 cones / 3 HO aggregates	3 cones / 4 HO aggregates
1995	0.368	0.584
1996	0.271	0.991
1997	0.164	0.982
1998	0.171	0.985
1999	0.143	0.991
2000	**0.002**	0.992
2001	**<0.001**	0.945
2002	**0.010**	1.000
2003	**<0.001**	1.000
2004	**<0.001**	0.998
2005	**<0.001**	0.991
2006	**0.027**	0.981

Notes: Table reports results of testing null hypothesis of a single-cone model against alternate hypotheses of up to three cones. See Statistical Appendix for details on the computation of bootstrap *p*-values.

Tables 4, 5 and Figure 5–16 are on the following pages

Table 6—Changes in Output and Countrywide Capital‑Labor Ratio by Capital Intensity

	Percentile	$\Delta\psi$ on $\bar{k}$	Obs
Labor-int.	0—10	–0.004***	263
	10—20	–0.003***	263
	20—30	–0.002***	263
	30—40	–0.000	263
	40—50	0.002***	263
	50—60	0.002***	263
Capital-int.	60—70	0.007***	263
	70—80	0.008***	263
	80—90	0.013***	263
	90—100	0.008***	263

Note: Estimation via ordinary least squared. ***Significant at the 1% level

Table 7—Changes in Capital Intensity and Countrywide Capital‑Labor Ratio by ISIC Industry

	$\Delta\, k_n$ on $\bar{k}$	Obs
Food, beverage, & tobacco	0.036***	249
Textiles	0.032*	262
Wearing Apparel	0.012	262
Wood products	0.025***	236
Paper	0.063*	224
Printing and publishing	0.025*	224
Coke, petroleum, nuclear fuel	0.313*	194
Chemical	0.007	223
Rubber and plastic	0.034***	249
Non-metallic mineral products	0.036***	262
Basic metals	0.067***	206
Fabricated metal products	0.024***	198
Machinery	0.008	199
Electronics	–0.016	236
Precision instruments	0.011	199
Vehicles	0.021	249
Furniture	0.015	224

Note: Estimation via ordinary least squared.*Significant at the 10% level, *** at the 1% level.

Table 4—Coefficient Estimates for the Single-Cone Development Path: 1995—1999

	1995		1996		1997	
	HO Aggregate 1	HO Aggregate 2	HO Aggregate 1	HO Aggregate 2	HO Aggregate 1	HO Aggregate 2
β_1	0.408***	—	1.024***	—	0.920***	—
	(0.102)		(0.152)		(0.164)	
β_{21}	−0.004***	0.046 ***	−0.009***	0.041 ***	−0.008***	0.044***
	(0.001)	(0.003)	(0.001)	(0.003)	(0001)	(0.004)
Obs.	22	22	22	22	22	22
RMSE	0.219	0.944	0.348	0.994	0.374	1.208
Constraints	$\beta_1 + 116\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 + 115\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 + 114\beta_{21} = 0$	$\beta_1 = 0$
Capital int. cutoffs	$h_1 = 6.761$		$h_1 = 12.023$		$h_1 = 12.023$	
Knots	$\tau_1 = 116$		$\tau_1 = 115$		$\tau_1 = 114$	
Generalized R^2	0.656		0.626		0.508	
AIC	56.056		77.098		89.134	

	1998		1999	
	HO Aggregate 1	HO Aggregate 2	HO Aggregate 1	HO Aggregate 2
β_1	0.758 ***	—	0.711***	—
	(0.172)		(0.154)	
β_{21}	−0.007***	0.048***	−0.007***	0.050***
	(0.002)	(0.004)	(0.002)	(0.004)
Obs.	22	22	22	22
RMSE	0.368	1.261	0.338	1.49
Constraints	$\beta_1 + 103\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 + 100\beta_{21} = 0$	$\beta_1 = 0$
Capital int. cutoffs	$h_1 = 10.471$		$h_1 = 10.471$	
Knots	$\tau_1 = 103$		$\tau_1 = 100$	
Generalized R^2	0.485		0.381	
AIC	89.728		93.020	

Notes: Estimation via a seemingly unrelated regressions (SUR) model. Standard errors are in parentheses. Coefficient notation follows equation (1). Capital intensity cutoffs and knots locations are fit optimizing according to the maximization procedure discussed in the text.

Table 5—Coefficient Estimates for the Favored Two-Cone Development Path: 2000—2006

	2000			2001		
	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3
β_1	0.142***	—	—	0.159***	—	—
	(0.020)			(0.013)		
β_{21}	−0.002***	0.037***	—	−0.005***	0.048***	—
	(0.000)	(0.004)		(0.000)	(0.004)	
β_{22}	0.002***	−0.087***	0.131***	0.005***	−0.085***	0.086***
	(0.000)	(0.011)	(0.024)	(0.000)	(0.007)	(0.011)
Obs.	22	22	22	22	22	22
RMSE	0.029	0.670	2.164	0.007	0.571	1.591
Constraints	$\beta_1 + 57.5\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$	$\beta_1 + 42.5\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$
	$\beta_{21} + \beta_{22} = 0$	$57.5\beta_{21} + 41.5(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$	$\beta_{21} + \beta_{22} = 0$	$42.5\beta_{21} + 54.5(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$
Capital int. cutoffs		$h_1 = 3.311,\ h_2 = 22.387$			$h_1 = 3.311,\ h_2 = 22.387$	
Knots		$\tau_1 = 57.5,\ \tau_2 = 99$			$\tau_1 = 42.5,\ \tau_2 = 97$	
Generalized R^2		0.549			0.973	
AIC		43.816			41.788	

	2002			2003		
	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3
β_1	0.233***	—	—	0.171***	—	—
	(0.037)			(0.007)		
β_{21}	−0.007***	0.039***	—	−0.004***	0.053***	—
	(0.001)	(0.004)		(0.000)	(0.004)	
β_{22}	0.007***	−0.061***	0.083***	0.004***	−0.099***	0.081***
	(0.001)	(0.006)	(0.009)	(0.000)	(0.007)	(0.010)
Obs.	22	22	22	22	22	22
RMSE	0.011	0.418	1.934	0.006	0.670	1.638
Constraints	$\beta_1 + 34.0\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$	$\beta_1 + 43.5\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$
	$\beta_{21} + \beta_{22} = 0$	$34.0\beta_{21} + 60.0(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$	$\beta_{21} + \beta_{22} = 0$	$43.5\beta_{21} + 50.5(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$
Capital int. cutoffs		$h_1 = 2.754,\ h_2 = 16.218$			$h_1 = 3.548,\ h_2 = 27.542$	
Knots		$\tau_1 = 34.0,\ \tau_2 = 94$			$\tau_1 = 43.5,\ \tau_2 = 94$	
Generalized R^2		0.901			0.983	
AIC		−25.960			−50.718	

Notes: See note in Table 4.

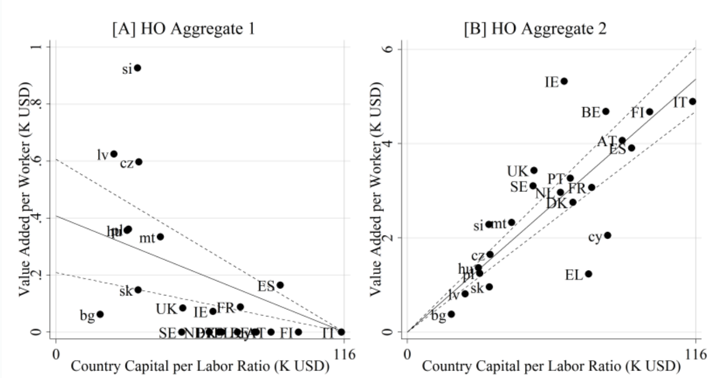
Table 5—Coefficient Estimates for the Favored Two-Cone Development Path: 2000—2006 (continued)

	2004			2005		
	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3
β_1	0.160***	—	—	0.153***	—	—
	(0.010)			(0.009)		
β_{21}	−0.003***	0.049***	—	−0.003***	0.048***	—
	(0.000)	(0.004)		(0.000)	(0.003)	
β_{22}	0.003***	−0.093***	0.075***	0.003***	−0.082***	0.062***
	(0.000)	(0.008)	(0.010)	(0.000)	(0.006)	(0.007)
Obs.	22	22	22	22	22	22
RMSE	0.007	0.608	1.487	0.005	0.507	1.315
Constraints	$\beta_1 + 47.0\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$	$\beta_1 + 45.0\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$
	$\beta_{21} + \beta_{22} = 0$	$47.0\beta_{21} + 52.0(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$	$\beta_{21} + \beta_{22} = 0$	$45.0\beta_{21} + 65.0(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$
Capital int. cutoffs		$h_1 = 3.311,\ h_2 = 30.200$			$h_1 = 3.467,\ h_2 = 26.303$	
Knots		$\tau_1 = 47.0,\ \tau_2 = 99$			$\tau_1 = 45.0,\ \tau_2 = 110$	
Generalized R^2		0.971			0.977	
AIC		−44.700			−66.034	

	2006		
	HO Aggregate 1	HO Aggregate 2	HO Aggregate 3
β_1	0.128***	—	—
	(0.029)		
β_{21}	−0.003***	0.035***	—
	(0.001)	(0.003)	
β_{22}	0.003***	−0.060***	0.063***
	(0.001)	(0.005)	(0.008)
Obs.	22	22	22
RMSE	0.013	0.477	1.402
Constraints	$\beta_1 + 49.0\beta_{21} = 0$	$\beta_1 = 0$	$\beta_1 = 0$
	$\beta_{21} + \beta_{22} = 0$	$49.0\beta_{21} + 71.0(\beta_{21} + \beta_{22}) = 0$	$\beta_{21} = 0$
Capital int. cutoffs		$h_1 = 3.467\ \ h_2 = 21.380$	
Knots		$\tau_1 = 49.0,\ \tau_2 = 120$	
Generalized R^2		0.779	
AIC		−19.870	

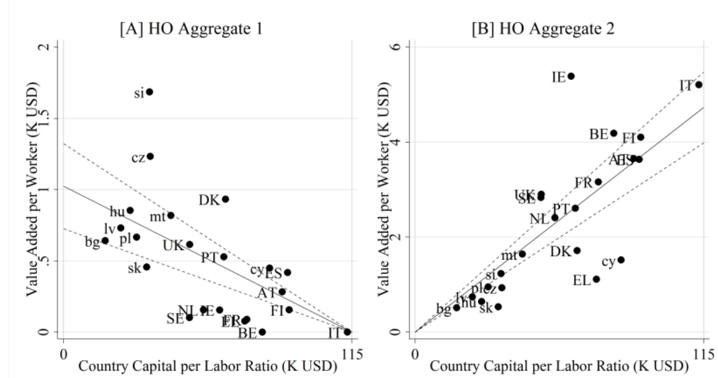
Notes: See note in Table 4.

Figure 5—Estimated Single-Cone Development Paths: 1995



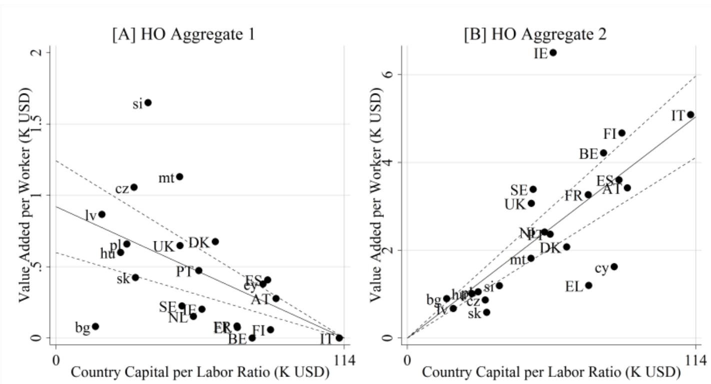
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 6—Estimated Single-Cone Development Paths: 1996



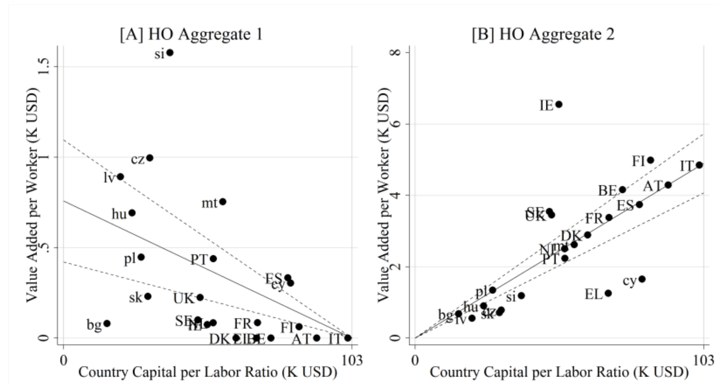
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 7—Estimated Single-Cone Development Paths: 1997



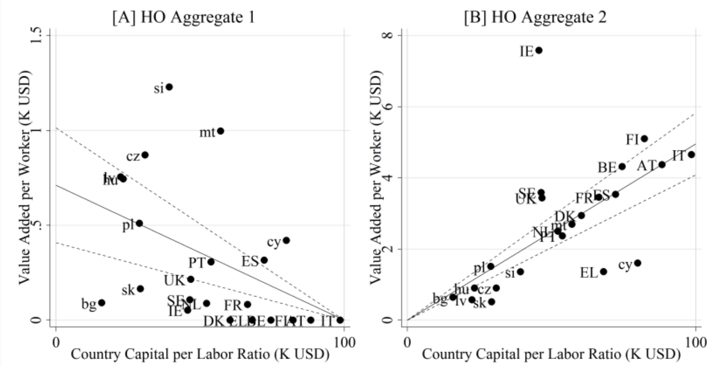
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 8—Estimated Single-Cone Development Paths: 1998



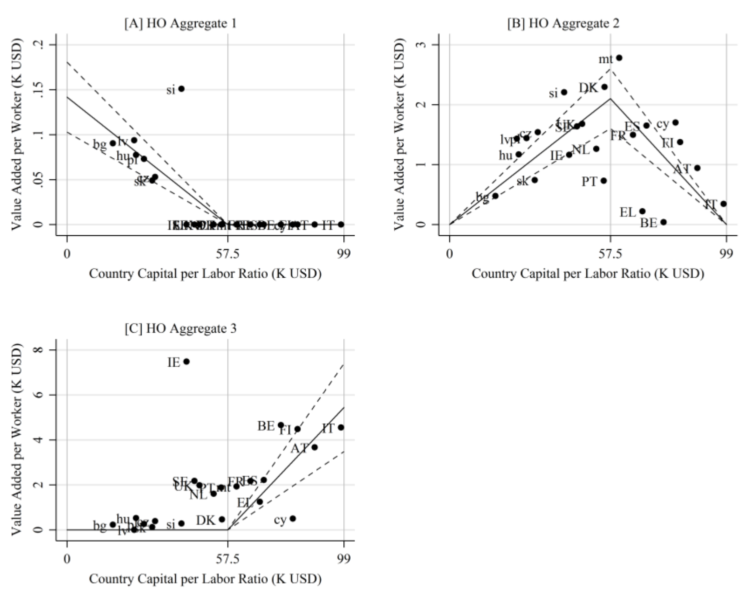
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 9—Estimated Single-Cone Development Paths: 1999



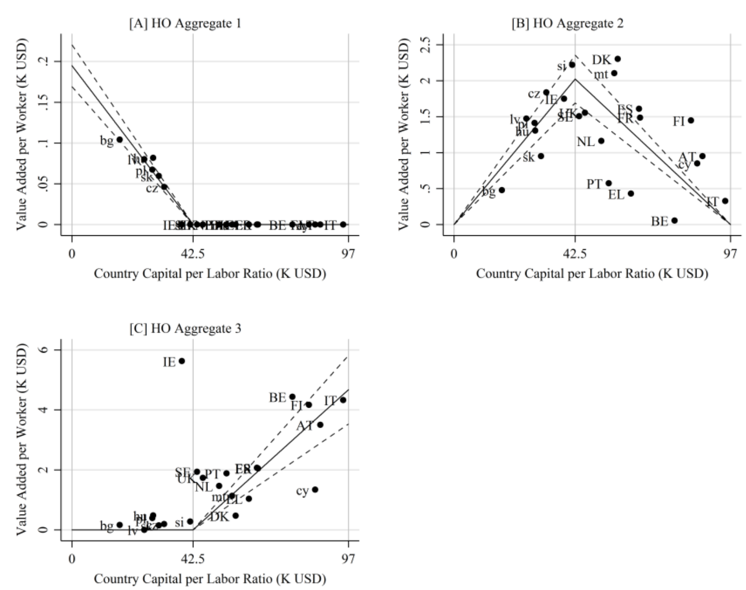
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 10—Estimated Two-Cone Development Paths: 2000



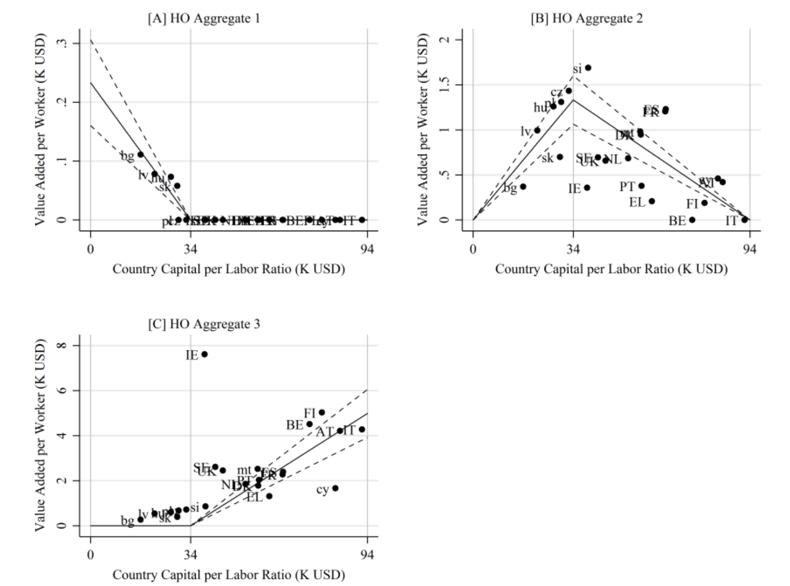
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 11—Estimated Two-Cone Development Paths: 2001



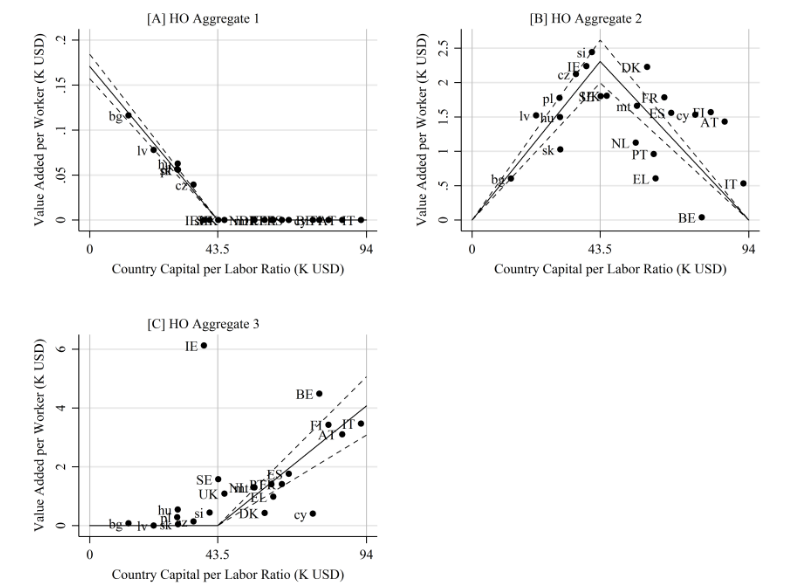
Note: Estimation by constrained SUR. Dashed lines represent the 95% confidence interval.

Figure 12—Estimated Two-Cone Development Paths: 2002



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

Figure 13—Estimated Two-Cone Development Paths: 2003



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

Figure 14—Estimated Two-Cone Development Paths: 2004

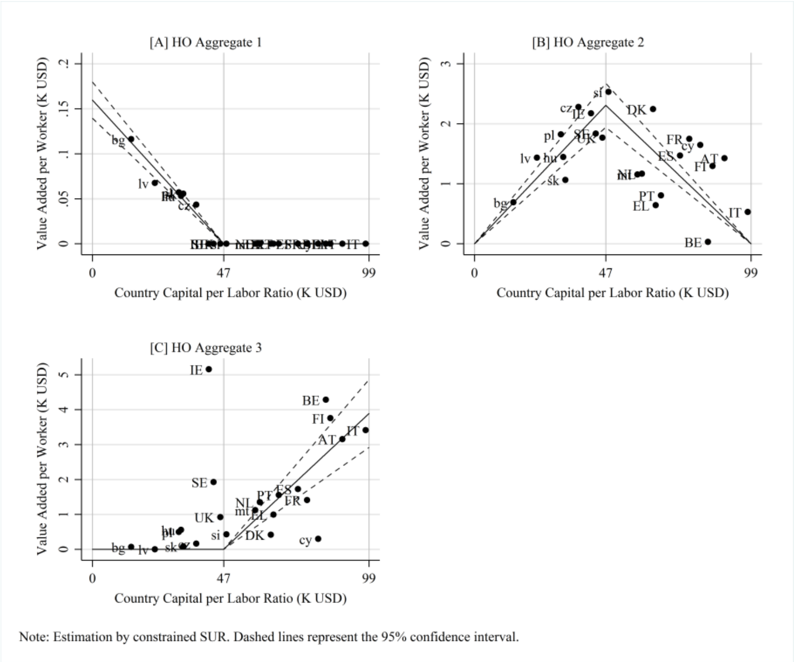


Figure 15—Estimated Two-Cone Development Paths: 2005

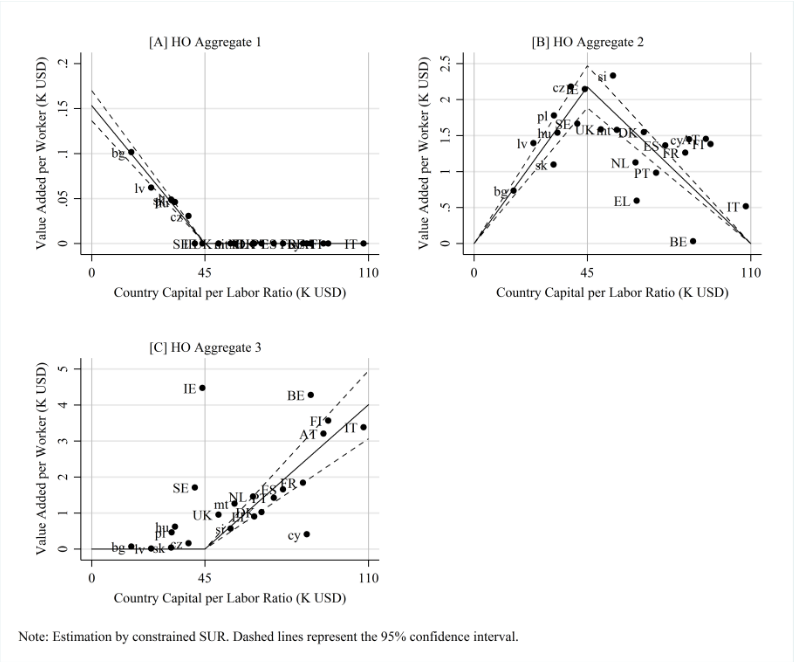
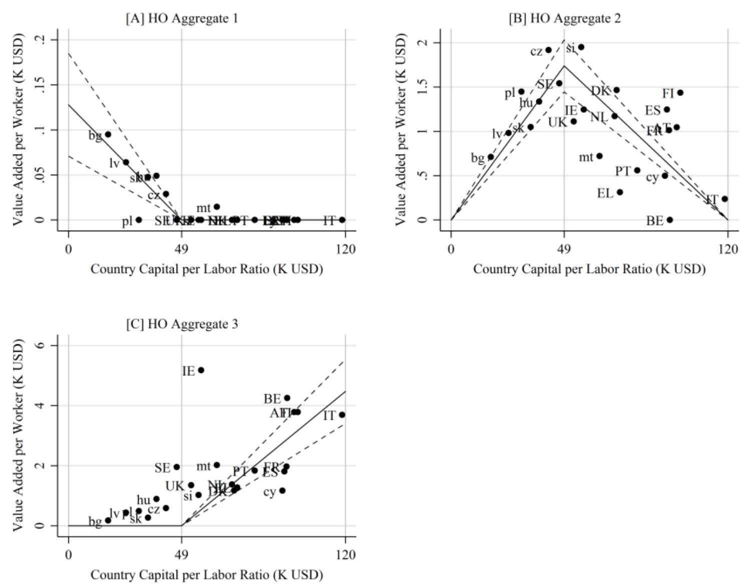


Figure 16—Estimated Two-Cone Development Paths: 2004



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