Distribution Agreement

Bei Luo April, 9 2018

The Evolution of Distribution of US Imports

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
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Abstract

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This paper uses Functional Principal Component Analysis (FPCA) to evaluate the evolution of distributions of US imports in manufacturing industries from 1974 to 2001, incorporating a set of discrete variables including sub-industry classification and duty coverage. FPCA uncovers that the ratio between the imports from South countries and that from North countries accumulating from a wide-tail spread towards the mean. In the meanwhile, the ratio between South countries and North countries in the difference between FiB and CiF values also collaborated towards the mean regardless of the industries. The results illustrate the effect of the product cycle that emphasizes on the comparative advantage of time and technology when a new product was initially invented and the graduate shift of production as time passes.

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Abstract

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Keywords: Distributions, International Trade, Globalization

JEL: B17, O14

1 Introduction

Starting from 1960s, research in trade theory have identified the concept of product cycle [1] (Verron, 1966), an idea used to explain the comparative advantage in time and technology for newly invented products. Labeling the developed countries as North countries and the developing countries as South countries, the world is classified into two groups of economies. The underlined assumption is: when a new product is initially invented, its parent country is a North country. In another word, the North country plays the role of an exporter and the South countries are the importers. Gradually, after some time, when the South countries obtain the corresponding technology and convert it to be compatible with their own feasible resources, the production generally moves to the South countries [2] (Wells, 1969), and the "new product" becomes an "old product" in both groups of economies. After the shift, the North countries alter their proportion of production, becoming importers of these products instead of the original producers and exporters. This theory is generally referred to as the "North-South Model." Based on such assumption, with phenomenal globalization beginning in 1970s, there has been a rapid development in economic power and transition, accompanied by a quicker technology transfer in both North countries and South countries [3] (Cantwell,1995). However, comparatively, South countries generally display a faster growth in exports of the new goods when becoming producers than North countries. It can be identified that although South countries initially exported less new products during the late 1970s, they continued to catch up with the North countries, displaying a U-shaped transition in their relative export growth that corresponds with the product circle [4] (Xiang, 2014).

Various research has been focusing on the export side of designated South countries to evaluate the effect of technology premium and how it alters the production structure of their domestic manufacture [5] (Thoenig et al, 2004). While the level of exports from South countries directly reflect the shift in their roles from mainly the importers of new products to the producers and exporters of the new products, it is also noteworthy to look from the original North countries' sides and consider their roles in product cycle, analyzing the effect of product cycles on their manufacturing components and impacts by coverage in insurance and duty exemption. in particular to see if the length of product cycle and the channel of product cycle has been changed in response to the strategies and policies which North countries have adopted in the environment of globalization, in particular that the trade of task and intra-products also account for a major alternation in the manufacture composition in the US economy in addition to the pure finished products. (Kemeny and Rigby, 2012) [6]

Interested in inspecting the effect of globalization in Xiang's scenario [4] (2014), I attempted to approach the analysis directly from the distribution level on the overall evolutions of densities during these three decades, examining the principal components and the dynamics. It is also worth inspecting the duty-alleviating policies and trade agreements that have been coming into effect starting from the late 1970s. If such policies do have a considerate positive effect, they would promote the export of new products from South countries, i.e. the policies should expedite North countries' imports of these products from South countries. The third question is whether high technology industries have specifically played an essential role in altering the distributions f_t and the production proportions during the timespan. These goals can be reached using the Functional Principal Component Analysis (FPCA) that approaches the estimations on distribution level and provide sufficient information for each of the discrete variables used in estimations.

Following the Kneip and Utikal [7] (2001), the FPCA presents the evolution of a family of probability density functions $\{f_t\}_1^T$ can be represented as $f_t = f_\mu + \sum_{j=1}^{L} \theta_{t,j} g_j$,with f_μ denotes the average nonparametric distribution of the ratios, and $\sum_{j=1}^{L} \theta_{t,j} g_j$ represents a particular deviation of the distribution from the mean distribution in each year. The analysis also displays the trend of the dynamic strength coefficients θ_j that measures the extent of deviation and the common components that summarize the impacts from cross-sector observations, denoted by g_j. As the time span is relatively long, I also conducted the standardized versions with fixed variance and the version with normalized mean and variance for comparisons. Both comparing versions produced similar results. Curious if different industries have specific notable impacts on the shifts of the overall trend, I also included analyses for each of the 22 sub-categories.

The FPCA identified the first six principal components that accounted for 60% of the variations and their corresponding dynamic scree plots. The dynamic strength coefficients for both ratios experienced a smooth and mild turbulence before the year 1993, however, after 1993, the coefficients for relative export ratio displayed a sudden drop, while the coefficients for relative cost expressed the opposite direction. Visualizing the patterns of distributions of the relative export ratio and of the relative cost ratio, the estimated densities expressed a gathering pattern and eventually centered around the mean at 2/3 once entering 21st century. Ranking the estimated densities by their sub-industries, it is noticeable that the top products that US imported from the South countries shifted from raw materials and elementary modified products (such as sugar and dairy products) to high-tech industries, mainly into transportation vehicles and other technology-weighted products.

The next section will provide a description on the dataset used. Section 3 addresses on the methodology and section 4 will explain the analysis results. Section 5 concludes.

2 Data Description

I obtained the original dataset from Xiang's work published online [4] (2014). The dataset contains all the imports of United States on product level with both their Fright-on-Board values (FoB) and Cost, Insurance and Freight values (CiF) from 1974 to 2001. The origin export countries were identified by their ID numbers in World Trade Data Base and each transaction was recorded with the tariff policy and trade agreement that had effects upon. The dataset also contains world GDP data on country level that can be used to specify if the origin export country was a North country (with annual GDP per person more than $7000) or a South country (with annual GDP per person less than $7000). There are 31 countries whose GDP were above $7000 per year per person [4] (2014).

Following Xiang's [4] (2014) method of aggregating transactions on product level, I added all the imports for each product from the South countries and from the North countries respectively, of which are matched with their descriptions designating the sum-categories in the Standard Industrial Classification manual. I also created a discrete variable for the industry label with a total of 22 sub-categories according to MIC manual. To evaluate the possible effect of exemption from tariff or duty, for each product, I also manually aggregated the values of the transactions affected by some type of trade agreements, and then divided it by the total value of import transactions in each year. I labeled the fraction as "duty coverage ratio." The percentage values were labeled with 0, 1, 2 and 3 - corresponding to the percentage value being in 0-25%, 25%-50%, 50%-75% and 75%-100% to evaluate the extent of the effects of trade agreements on each product. I evaluated the coverage ratio for based on both the Freight-on-Board value (FoB) and the Cost, Insurance and Freight (CiF) value and found that more than 95% of the times, they produced the same final labeling results, thus I decided to include the labeling based on FoB value in my first-stage analysis.

Following Xiang's approach, the two main variables that I perform FPCA on are constructed as "Relative Export Ratio" and "Relative Variable Cost Ratio" from the following definitions: Let RES represents the Relative exports from South countries, and REN represents the Relative exports from North countries. Define the relative ratios as following: RES = FoB of the new products from South countries / FoB of the old products from South countries; REN = FoB of the new products from North countries / FoB of the old products from North countries. And the overall Relative Export Ratio is: $Relative\ Export\ Ratio = log(RES/REN)$

The other measurement "Relative Variable Cost Ratio" is defined within the similar concept: Let $\tau = (FoB\ value - CiF\ value)/FoB\ value.$ for all countries. $\tau_{n,o}$ denotes the relative variable cost for old products imported from North countries, $\tau_{n,n}$ denotes the relative variable cost for new products imported from North countries. Similarly, we have $\tau_{s,o}$ for relative variable cost for old products in South countries, and $\tau_{s,n}$ for the relative variable cost for new products imported from the South countries. Define Relative variable cost in South countries ($RVCS$) as: $RVCS = \tau_{s,n}/\tau_{s,o}$ Relative variable cost in North countries ($RVNS$) as: $RVCS = \tau_{n,n}/\tau_{n,o}$ Hence the overall Relative Variable Cost Ratio is defined as: $Relative\ Variable\ Cost\ Ratio = log\ (RVCS/RVCN).$

3 Methodology Review

As the dataset has value panel data with a mixture of both discrete variables and continuous variables, the FPCA can be an efficient approach in terms of evaluating the evolution of distributions. This method also avoids the possible issue with an upper limit in the number of principal components when interpreting the results. (As in the usual Principal Component Analysis, the number of principal component cannot exceed the number of variables because the general form is in terms of summation. However, when it turns into the functional form, there is no upper limit when taking the integral instead of the summation) Proposing to examine the evolution of distribution of the Relative Export Ratio and Relative Variable Cost Ratio, I started with the FPCA originally proposed by Kneip and Utikal [7] (2001), the theory developed in Racine and Li (2007) and then followed the method incorporated with both categorical and continuous variables conducted by Huynh et al [8] (2011). The qualitative categorical information on industry and duty coverage ratio (both variables are discrete) are included in a vector $X^d = (X_1^d, X_2^d)$ which is used in the "Rule of Thumb" developed by Silverman (1986) bandwidth selection developed by Racine and Li [9] (2007):

Let q be the dimension of X^d, then the suggested bandwidth would be: $h_s = c_s X_{s,sd} n^{-1/(4+q)}$ $for\ s = 1, 2, ..., q$. Following the modification and procedures developed by Huynh et al [8] (2011), the bandwidths are selected and corrected by $\hat{h} = \tilde{h}^{5/4}$ and $\hat{h} = \tilde{h} \times T^{-1/5}$ (where $\tilde{h}$ denotes the bandwidths of distributions of the ratios, and T is the number of time periods) Then following the Kneip and Utikal [7] (2001), the evolution of a family of probability density functions $\{f_t\}_1^T$ can be represented in the following way:

$$f_t = f_\mu + \sum_{j=1}^{L} \theta_{t,j} g_j, \tag{1}$$

where f_μ denotes the mean of the family of the distributions $T^{-1} \sum_{t=1}^{T} f_t$, and $\sum_{j=1}^{L} \theta_{t,j} g_j$ represents a particular deviation of the distribution from the mean in each year. Thus the overall distribution of each year can be decomposed as a sum of the average of all the distributions $f_\mu = \frac{1}{T} \sum_{t=1}^{T} f_t$ and a time-variant component.

The time-variant component $\theta_{t,j} g_j$ is a product of a time-variant strength coefficient $\theta_{t,j}$ with the common component g_j that combines the cross-section observations. The number of common components is denoted by L, the number of non-zero eigenvalues of the matrix constructed on the covariance operator.

To estimate g_j and $\theta_{t,j}$, I construct a $\boldsymbol{M = T \times T}$ matrix, whose elements are defined as (following the procedure suggested by [7] Kneip and Utikal (2001)):

$$M_{t,s} = (f_t - f_\mu)(f_s - f_\mu)\ \forall\, t, s. \tag{2}$$

Each density is estimated following kernel smoothing method [9] (Racine and Li, 2007) as follows:

$$\hat{f}(x) = \frac{1}{nh_1 ... h_q} \sum_{i=1}^{n} K(\frac{X_i - x}{h}), \tag{3}$$

where $K(\frac{X_i - x}{h}) = k(\frac{X_{i1} - x_1}{h_1}) \times ... \times k(\frac{X_{iq} - x_q}{h_q})$ is the product of each smoothing kernel that proved to be equivalent as the summation of each individual kernel estimation following Racine and Li [9] (2007). Let p_r denote the eigenvectors of M as: $p_r = (p_{j,1}, p_{j,2}, ..., p_{j,T})$ and let λ denote the non-zero eigenvalues of M as: $\lambda_1 \geq \lambda_2 \geq \lambda_3 ... \geq \lambda_L$, then the estimates of the values of g_j and $\theta_{t,j}$ in equation (1) are related to M as:

$$\hat{g}_j = \hat{\lambda}_j^{-1/2} \sum_{t=1}^{T} \hat{p}_{t,j} \hat{f}_{t,h} = \frac{\sum_{t=1}^{T} \hat{\theta}_{t,j} \hat{f}_t}{\sum_{t=1}^{T} \hat{\theta}_{t,j}^2};\ \hat{\theta}_{t,j} = \hat{\lambda}_r^{1/2} \hat{p_{t,j}} \tag{4}$$

Besides the FPCA on the direct log ratios, I have also performed the standardized version which fixed the mean at 0 and variance at 1 to compare the results with [4] (Xiang, 2014)the original version, which yielded similar results.

4 Estimation Results and Analysis

The major results showed that both the relative export ratio and the relative variable cost ratio initially distributed with flatter tails that have uneven groupings but eventually accumulated towards the mean and clustered around 2/3. Due to the wide time span, the first six common components are included and explain 60% of the variation. I also find that the variation in the distribution is essentially correlated with industries. For instance, while the production in raw materials has only changed slightly during the time, the industries with high technology or are scientifically-oriented have altered considerably, such as the industry in Computing machinery and the fields related to Medicine and Drugs. These tech-related industries were associated with huge capital that altered the proportion of manufacturing products. Regarding the effects on duty policies, the duty coverage

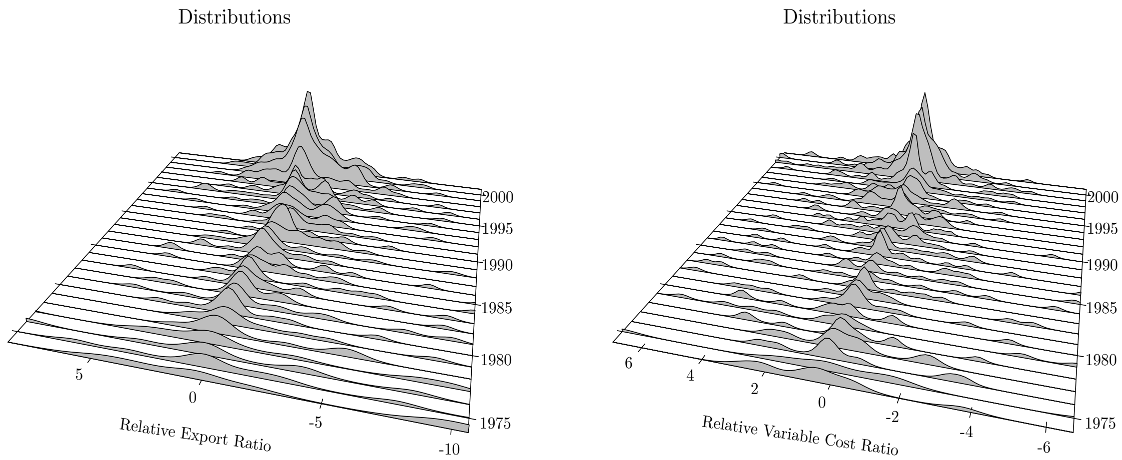

Figure 1: Estimated density distributions: The horizontal axis represents the value of log of the Relative Ratios and the vertical axis represents year. A visualized evolution of the densities for Relative Export Ratio and the Relative Variable Cost Ratio. It can be identified that there has been a gradual accumulation towards the mean of 2/3 in the Relative Export Ratio and 0 in the Relative Variable Cost Ratio from initial flat distributions.

ratio has also played a role in the changing of distribution. Although the extent is less than that from the industry label, but is effective when the policies are applied to certain designated industries. (See appendix for sub-category industry figures) In summary, I find similar results from the preliminary analyses I have finished to Xiang's conclusion on the distribution level.

The overall estimated distributions are presented in Figure 1. The density estimated for each of the ratios is a 5-dimensional estimation. The overall distributions have centered around mean from the initial flatter ones as time passes by.

The dynamic strength coefficients (the values of $\hat{\boldsymbol{\theta}}$ and the non-zero normalized eigenvalues $\hat{\boldsymbol{\lambda}}$) are presented (Figure 2 and 3) as to illustrate the proportion of total change in the distribution due to each component $\hat{\boldsymbol{j}}$ for each eigenvalue $\boldsymbol{\lambda}$. The first six components will be used in order to explain more variations. Although this is untypical as the usual FPCA can uncover the trend using the first two or three components, when going through a wide timespan, the first six components can still reveal a consistent trend of the variations and thus can be applied here.

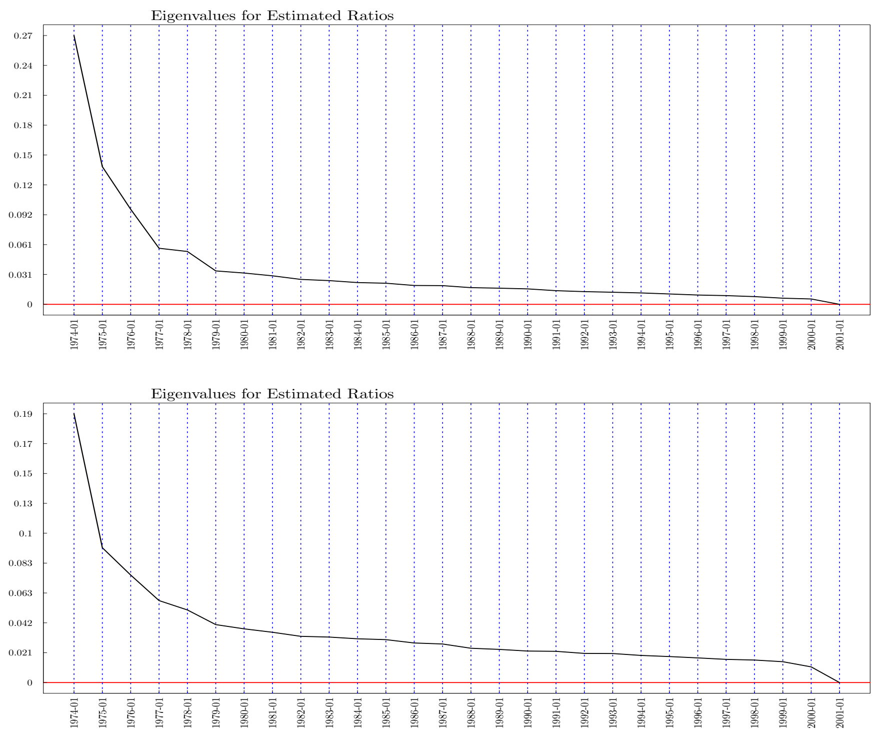

Figure 2: Dynamic Strength Coefficients Plots: the vertical axis represents the proportional strength of each $\hat{\boldsymbol{\lambda}}$, i.e., the value of $\frac{\hat{\lambda}}{\sum_L \hat{\lambda}}$. Despite the long time-span, the first six components altogether roughly explain around 60 percent of the variations.

The values of $\hat{\theta}$ uncover the deviation of the densities from the designated benchmark year. Dividing the whole timespan into three decades and inspecting each graph separately, it can be observed that there is less deviations during the decade corresponding with the designated line. This agrees with the idea that it is less obvious to generate a considerably comprehensive trend that covers the overall trend of the whole time frame, but there are still patterns that can be traced with the FPCA conducted on all observations. The solid line signifies an abnormal fall in the relative export ratio in the year 1977, and a paired rise in the relative variable cost ratio in the same year. By manually classifying the products, since there were no new products invented around that year which accounted for a large portion of the transaction value, the reason would be due to an unexpected change in the transportation cost. Similarly, the dashed line that uses 1991 as the benchmark year emphasizes a general decrease in the relative export ratio and an increase in the relative variable cost ratio from 1981 to 1991, which reveals a smooth continuous trend in both ratios. The dotted line using 2001 would be a representative that signals a rather steady relative variable cost ratio after year 1992 and a pattern of subtly increasing relative export ratio in the same timespan.

If only consider the solid line that selects 1981 as benchmark time, it can be observed that despite the turbulence in the early stage, after 1990, the Relative Export Ratio experienced a sharp decrease while the they moved in opposite directions for the Relative Variable Costs. This illustrates a general shift that US has been increasing their proportion of import of "new products" from South countries relatively compared to North countries during the time-span. On the other side, South countries are adopting the new technologies that reduces the difference in production that they have with the North countries. When analyzing the variable cost, the increasing trend reflects a reduction in the difference between CiF value and FoB values of each transactions, which hints that the reduction in duty and import tax has stimulated the shift of the direction of new products transportation.

Figure 4 presents the fist six functional components $\hat{g}_j$ (the time-invariant functions that describe the cross-section observations for the categorical variables) to measure the cross-sectional differenced captured by FPCA. The tails are both flat , however, it is noticeable that certain $\hat{g}_j$ behave differently in the amplifications in the interval [0, 2], which correspond with the descriptive

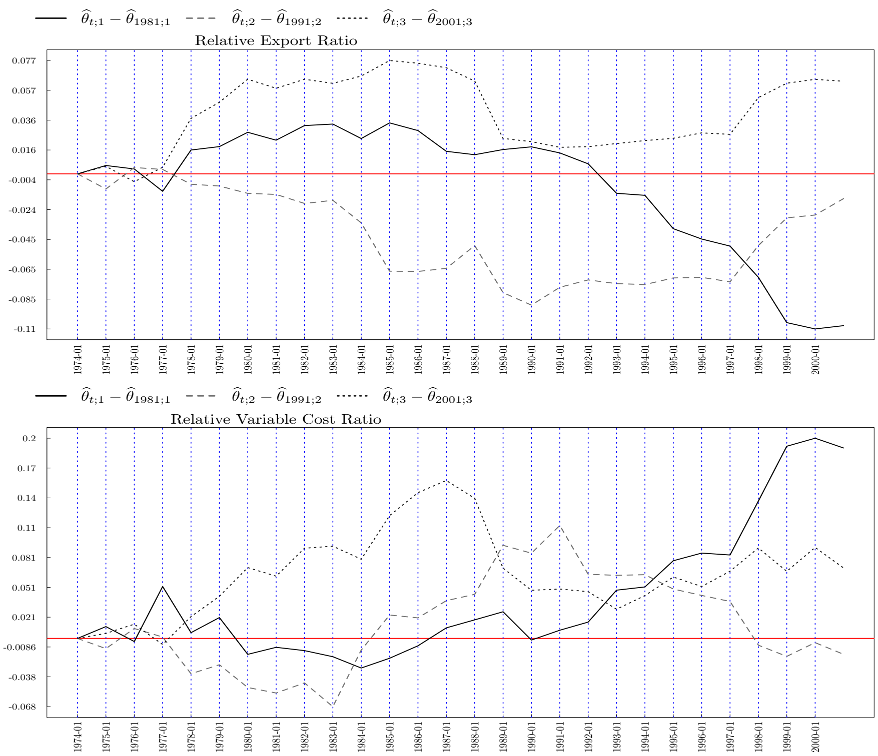

Figure 3: Dynamic Strength Coefficients Plots: The variant strength coefficient measure the extent to which the density is deviated each year.

trends of both ratios in Figure 6 and Figure 7. Comparatively, the $\hat{g}_j$s for relative export ratio experience more intense fluctuations than those for relative variable cost ratio do, which signals that the impact from duty coverage ratio and industrial classification oscillates more heavily in the cross-sectional observations for relative variable cost ratio than it does for relative export ratio. The figures in the Appendix provide industry specific deformations, i.e., $\hat{\theta}_{t,j}\hat{g}_j$ that presents the dynamic strength components for each industry, selecting the year 1981, 1991 and 2001 as three benchmarks.

Figure 5 presents the pattern of $\hat{\lambda}$ by the order of the components and that of $\hat{\theta}_{t,j}$ on a yearly basis in addition to the previous figures. Together they show the overall trend explained by the common components and how the average density from each year deviates from the mean. The $\hat{\theta}_{t,j}$ change in different directions for the relative export ratio and the relative variable cost ratio. The relative export ratio displays a decreasing pattern, indicating that United States has been increasing the imports of old products from South countries and the imports of new products of North countries, which coincides with Xiang's [4] (2014) conclusion in product cycle. The relative variable cost ratio displays an opposite trend, indicating that the trade agreements and policies have been imposing positive effects in promoting the technology transfer from North countries to South countries.

Figure 6 presents a descriptive trend of the direct relative export ratios. It can be observed that there were industries that had substantially lower productions in South countries during the late 1970s (essentially in food, beverage,and non-electrical machinery) than the industries with higher relative export ratio (mainly in paper products and electrical apparatus). However, the industries with relatively lower production in South countries in later times had been increased in the relative proportion for export and gradually caught up with the average level. Figure 7 presents the descriptive trend of relative variable cost ratio. While the mean was relatively steady compared to the direct export ratio, there was an abnormal higher cost ratio in the year 1976 that can be explained by the unexpected rise in oil price that drove up the cost for transportation.

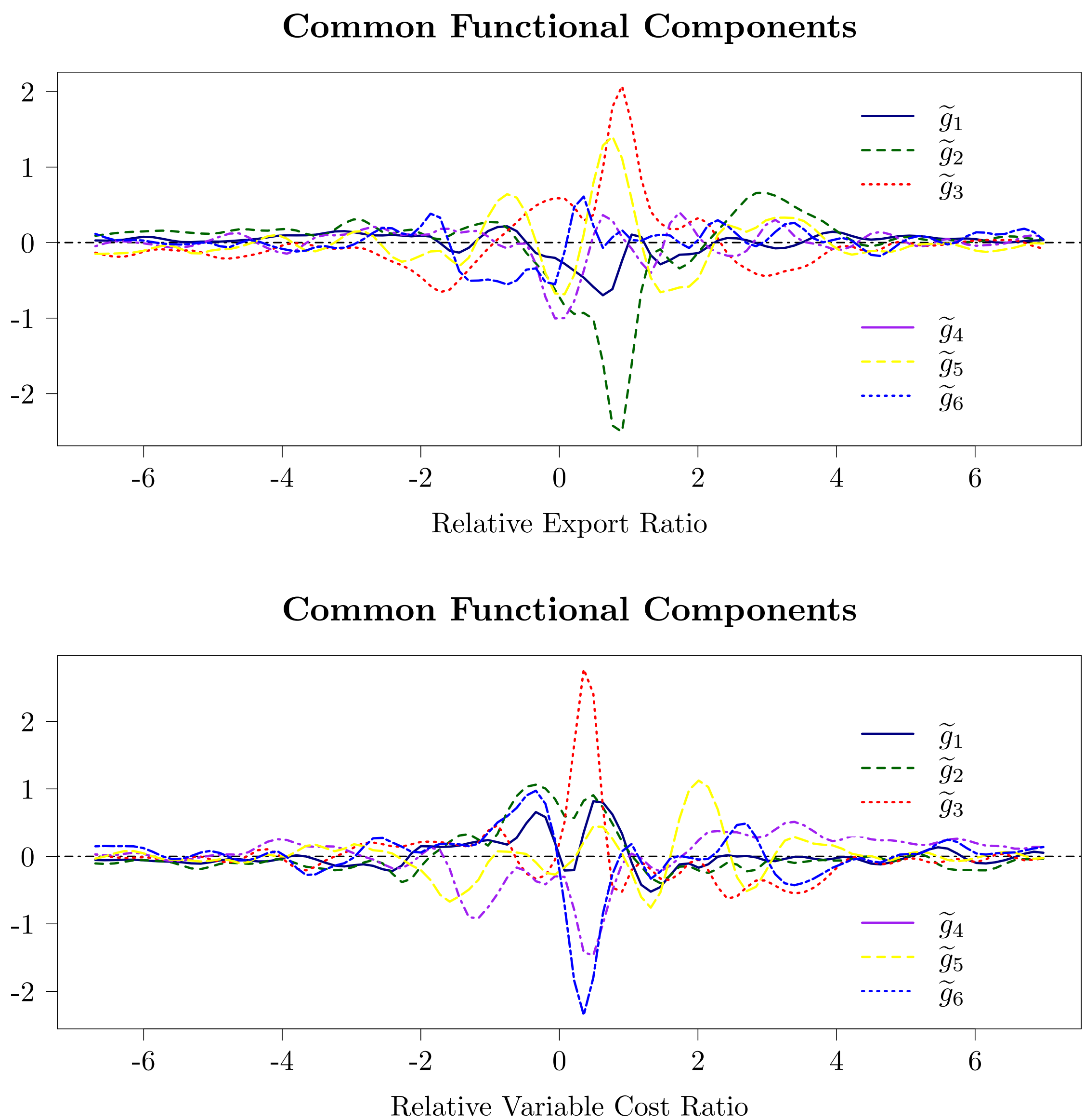

Figure 4: First six Common components: these common components account for the cross-sectional observations that can be used to generate a benchmark for measuring the extent of deviation for each year.

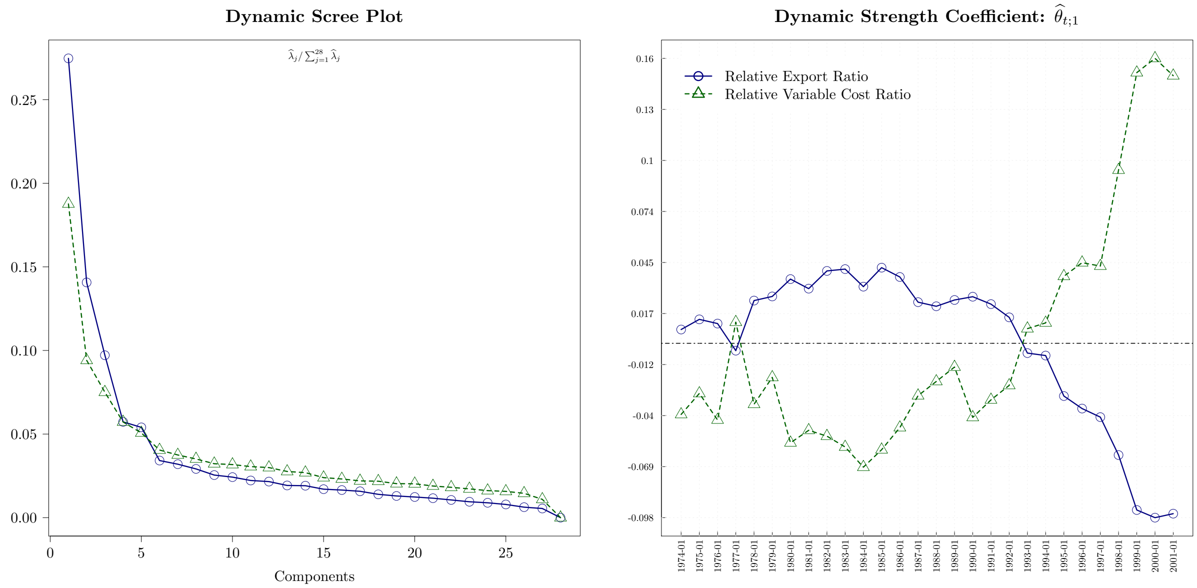

Figure 5: Dynamic scree plot and Dynamic strength Coefficients: As in addition to the figures above, these two figures illustrate the overall trend that corresponds with the increase in South countries' adoption of new technologies and the alleviation in the duty and tax policies.

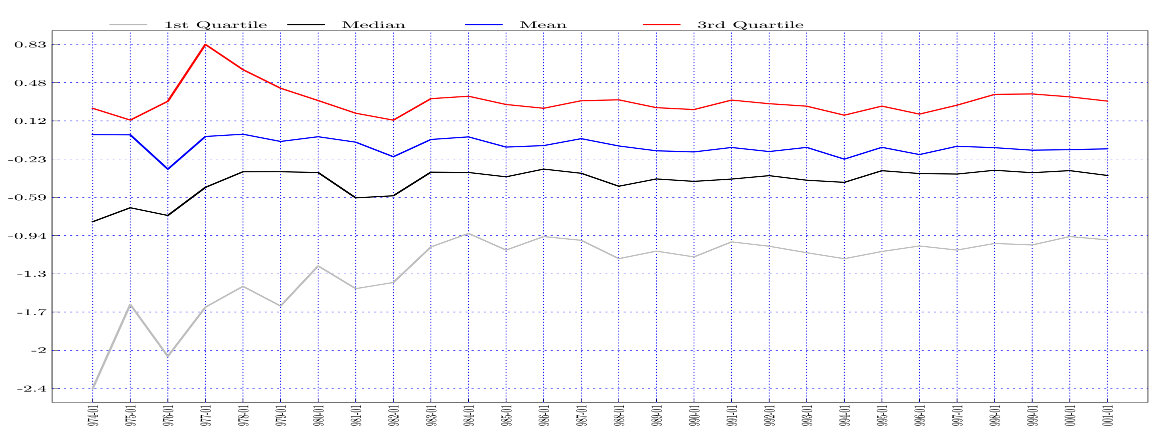

Figure 6: Descriptive Trend of Relative Export: Noticing that the first quartile has been steady increasing, implying that the specific industries (which are different every year) that US possibly have a substantially lower import from the South countries are gradually catching up with the average level of US imports. The quartiles gradually become stable in late periods.

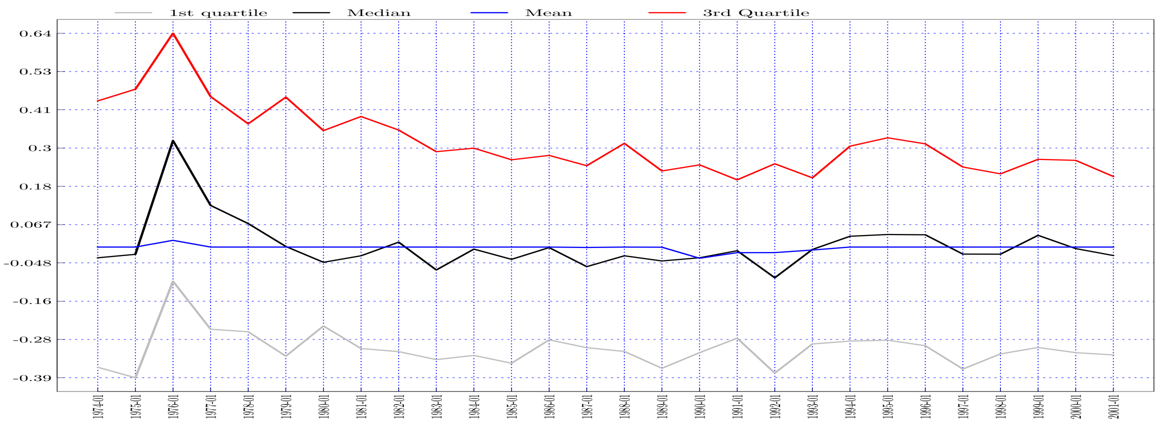

Figure 7: Descriptive Trend of Relative Cost Ratio: An abnormal rise in the quartiles happened in 1976, signaling that certain industries might benefit from a designated trade agreement or duty exemption. However, the subtle shift in mean indicates that these unexpected rises were compensated by the steady imports in the rest products. The trends of the quartiles behave stably starting 1980s.

5 Final Conclusions and Remarks

The major results agree with Xiang's [4] (2014) evidence on product cycle. Due to comparative advantage in time and technology, the North countries played the roles of producers and exporters when a product was initially invented. However, when a technology became compatible with the resources in South countries, the South countries gradually adopted the new production in their manufacturing and became the new exporters. The shifts of their roles are the most clear using the year 1981 as a benchmark. While there were no specific industries that particularly maintained a stable ranking in their export ratios (which means there was no particular industry that accounted for the major portion in the evolution of the export components), there has been a general trend of exporting raw and elementary productions towards diverse mid-products or parts of high-tech products. It is also the high-tech industries that alter the most (See Appendix figures for industry deformations). The FPCA uncovers a general formation and evolution of how US allocates the proportions of its imports on the each of the "new products" from North countries and South countries, revealing a transition pattern that leads to an accumulation towards the average level.

Such transition of composition in export is sensitive with macro-economic conditions, in particular the level of duty alleviation under globalization and effective reduction in the cost of transportation, which together leads to a decreased difference in variable cost of products produced in South countries and North countries, as illustrated by the FPCA for relative variable cost ratio. Even the distributions display a collaging trend, they are also stably distributed if inspecting their quartiles, which signifies that along with the decreased difference in variable cost, this motivates the North countries develop new products and maintain their roles of exporters in these newly discovered industries.

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Appendix A Industry Figures

This section presents the deformation $\hat{\theta}_{t,j}\hat{g}_j$ for each sub-industry in the Standard Industry Classification, presenting the dynamic strength of the industry variable.

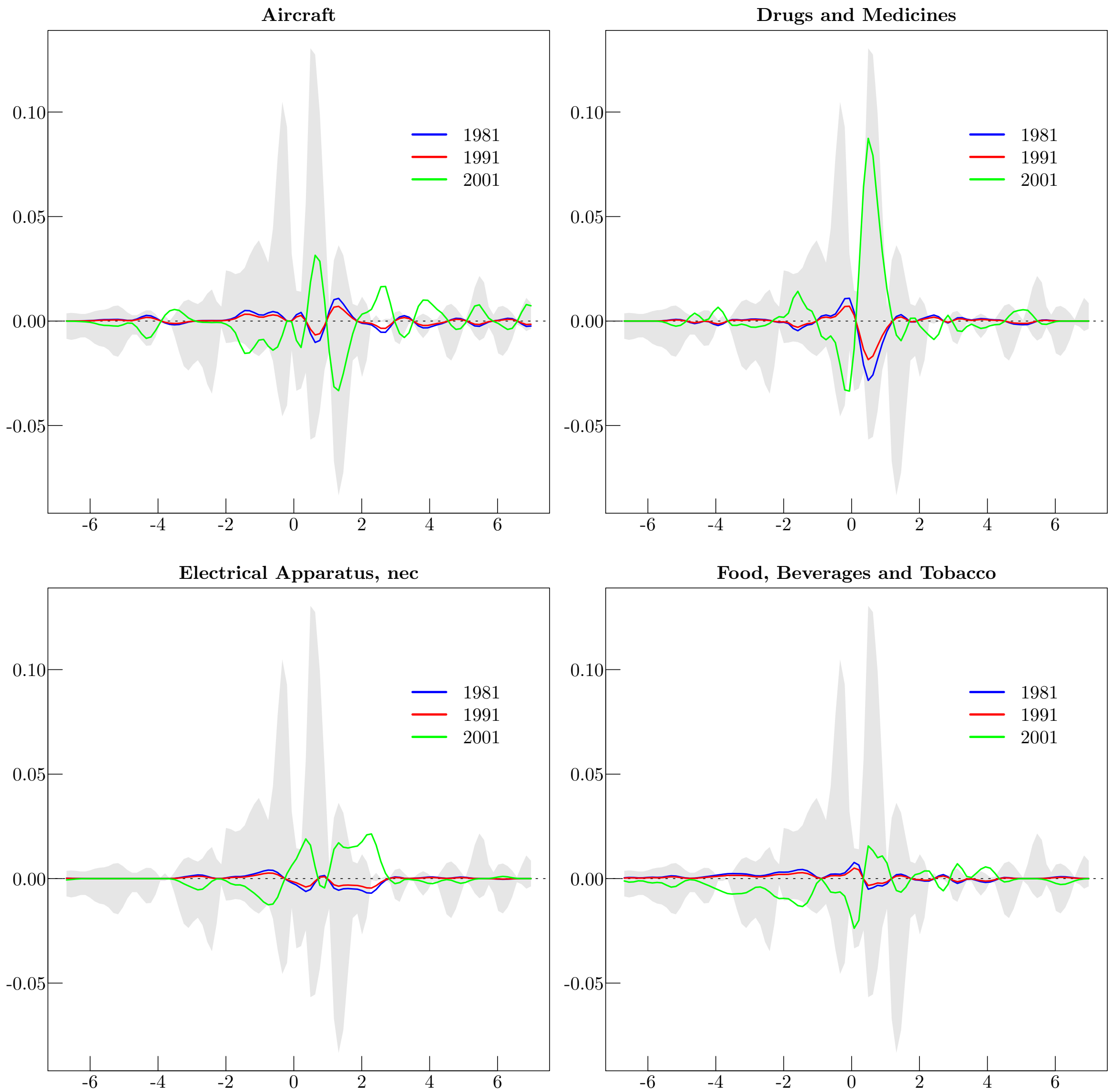

Figure 8: Industry Deformations for: Air Craft; Drugs and Medicine; Electrical Apparatus; Food, Beverage, and Tobacco.

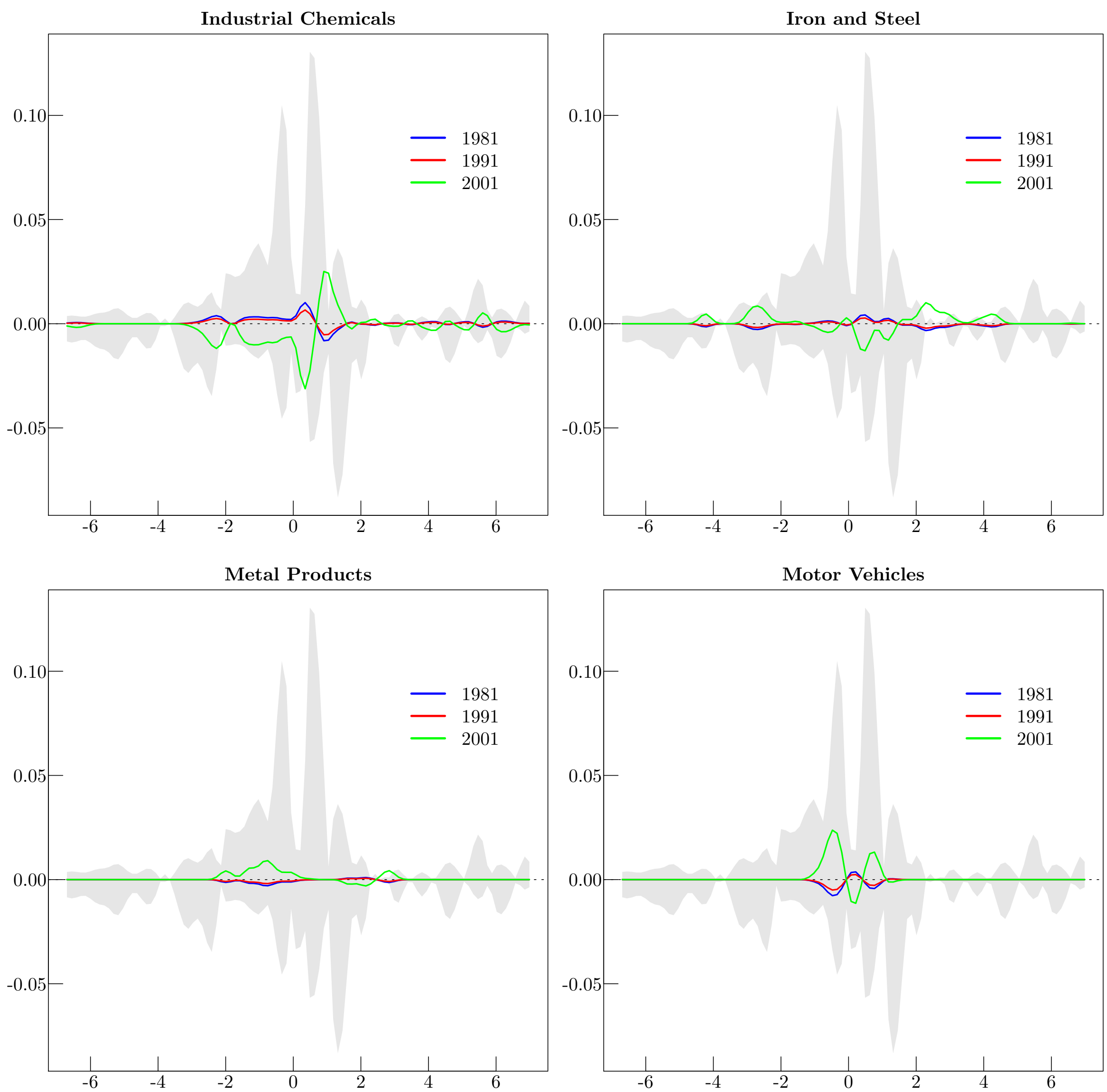

Figure 9: Industry Deformations for: Industrial Chemicals; Iron and Steel; Metal Products; Motor Vehicles.

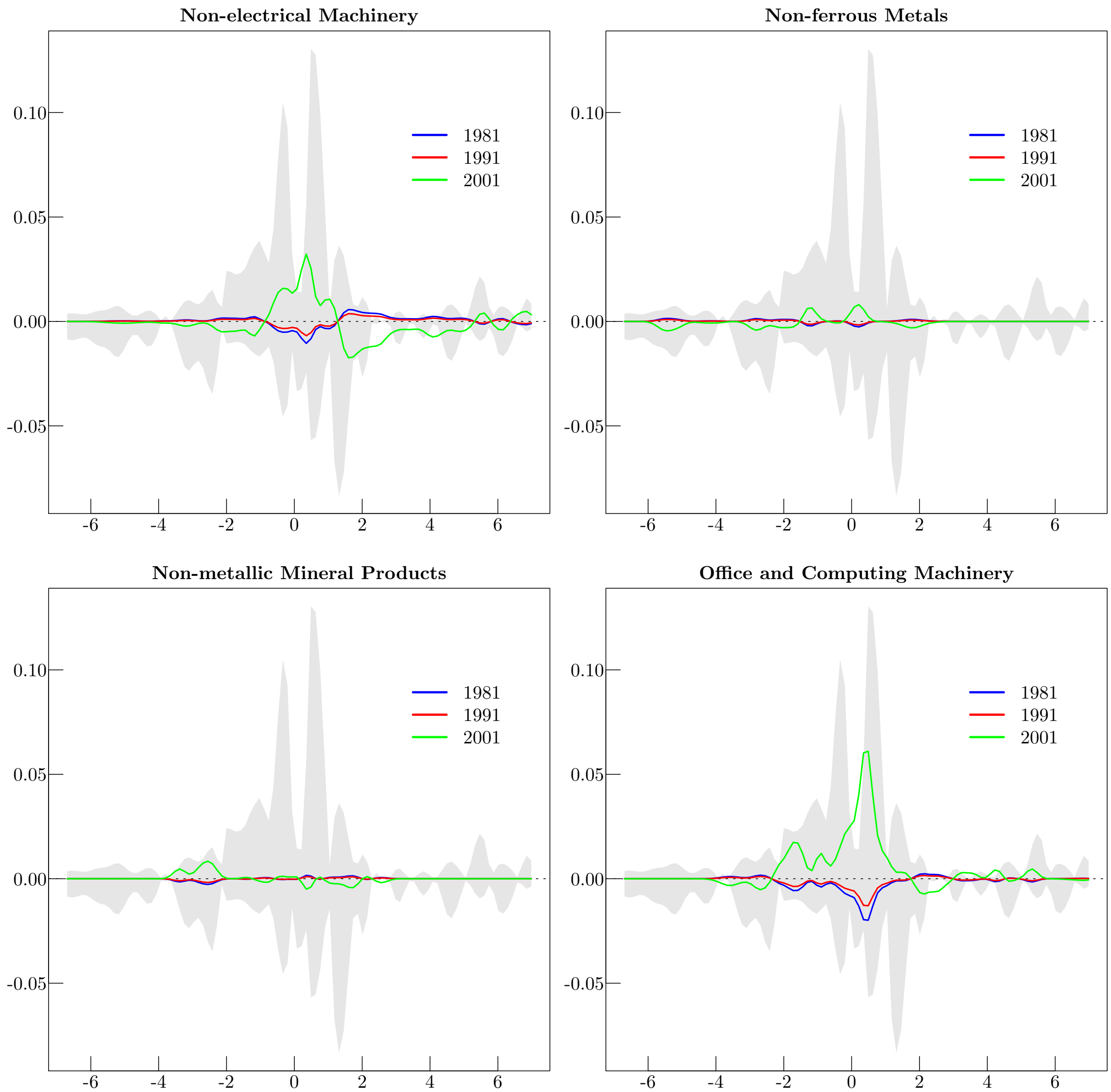

Figure 10: Industry Deformations for: Non-electrical Machinery; Non-ferrous Metals; Non-metallic Mineral Products; Office and Computing Machinery.

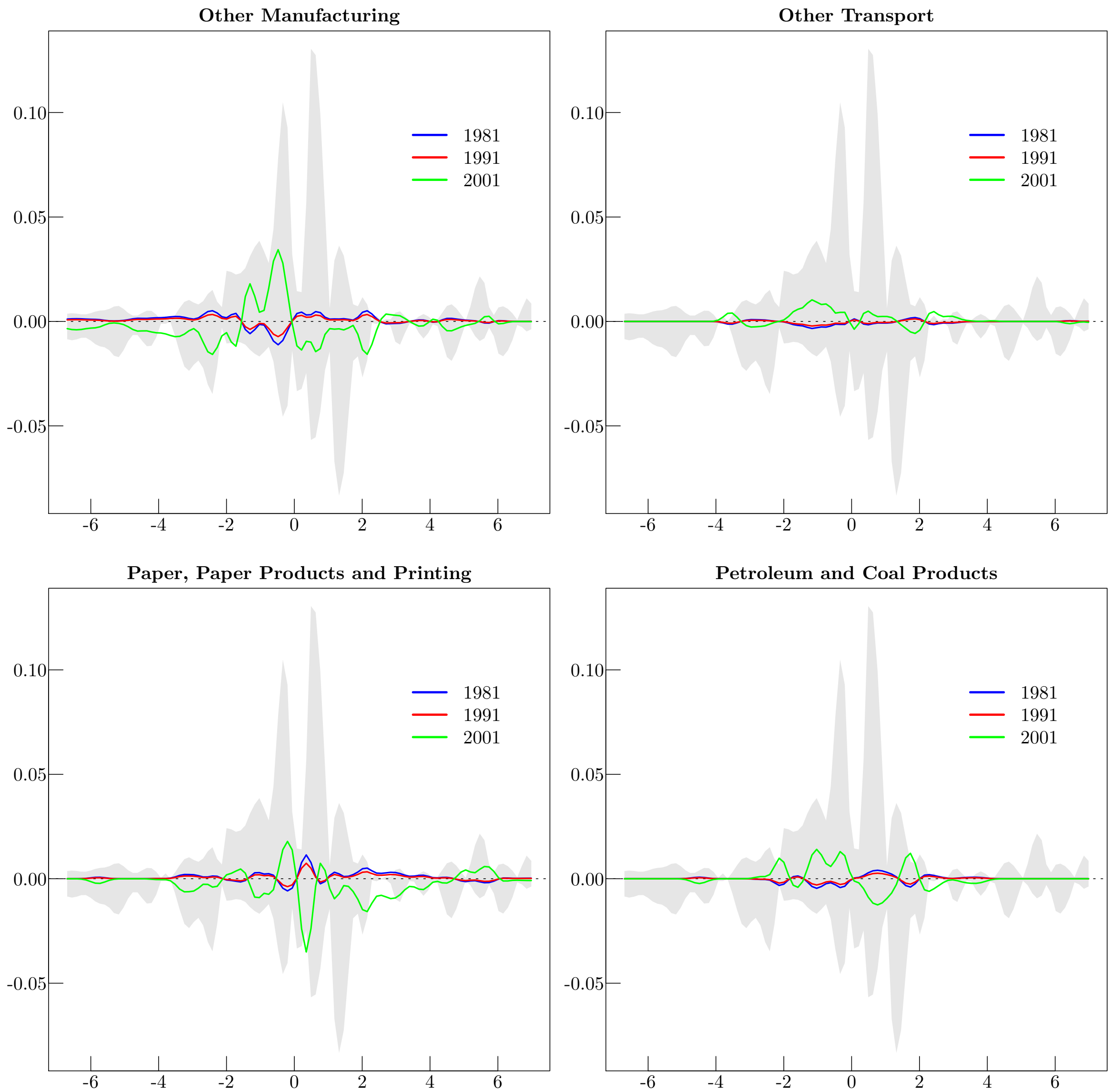

Figure 11: Industry Deformations for: Other Manufacturing; Other Transport; Paper, Paper Products and Printing; Petroleum and coal products.

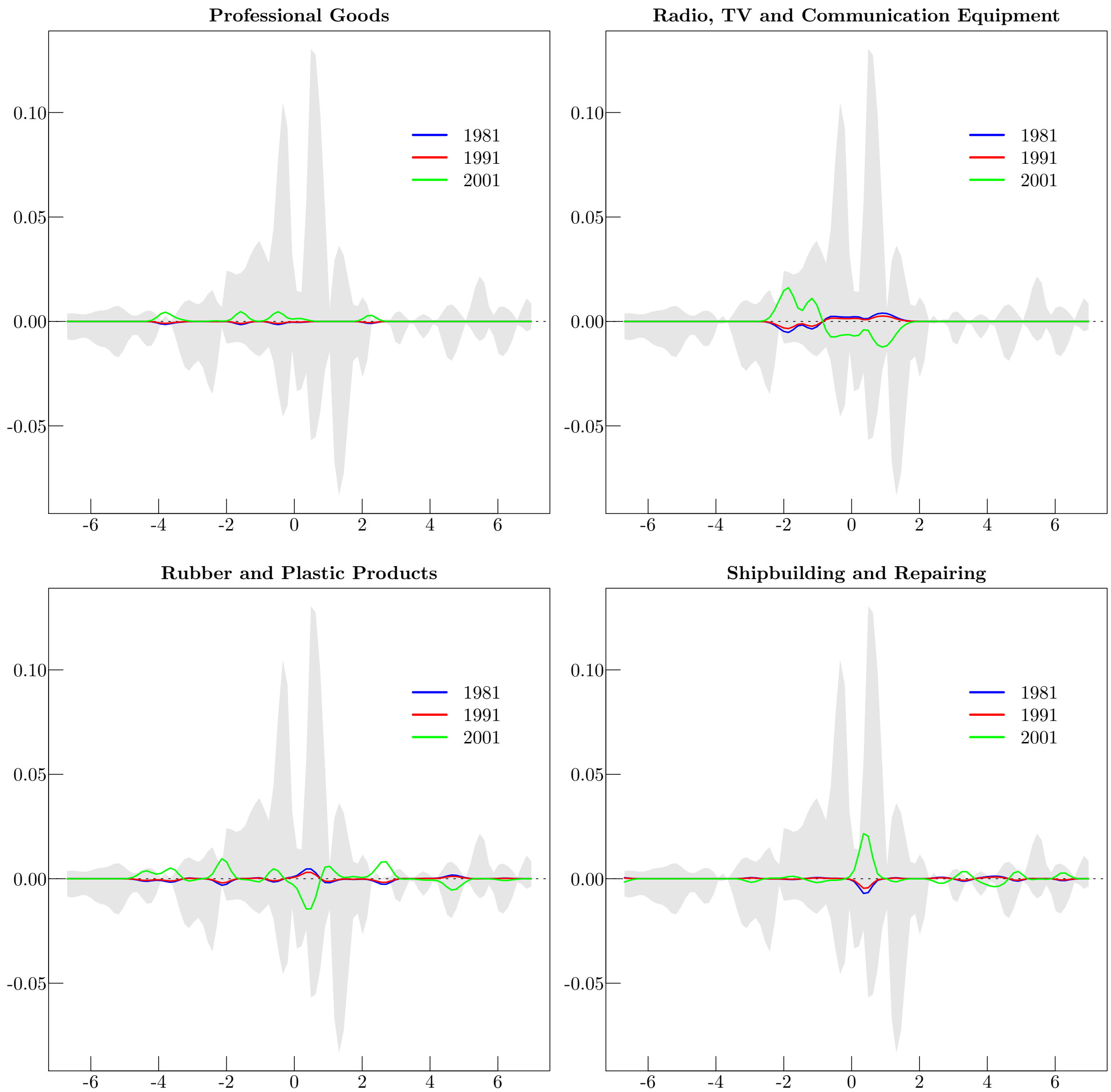

Figure 12: Industry Deformations for: Professional Goods; Radio, TV and communication equipment; Rubber and plastic products; Shipbuilding and repairing.

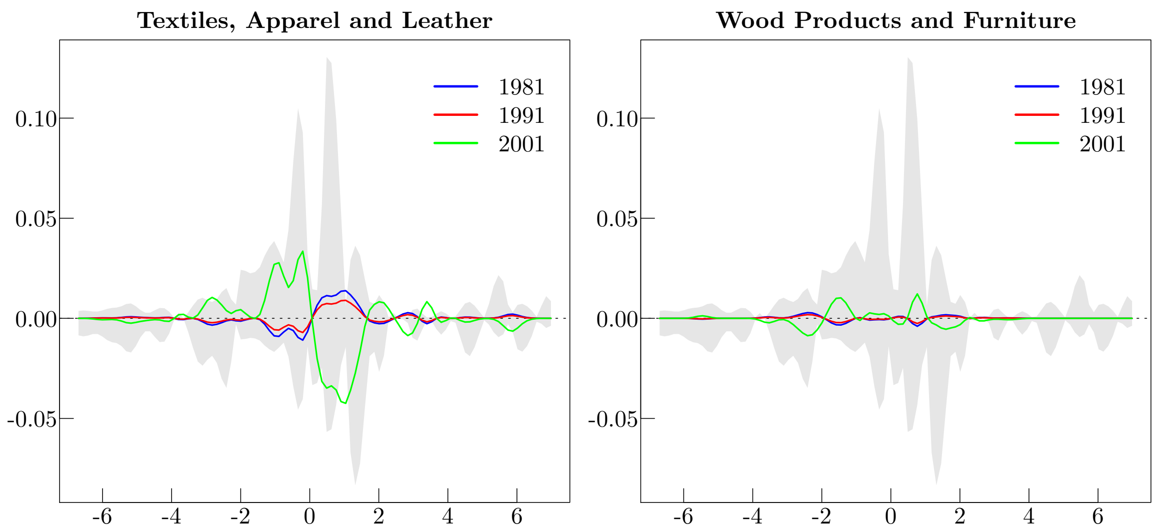

Figure 13: Industry Deformations for: Textiles, apparel and leather; Wood products and furniture.