Production Networks and "The Great Convergence"

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Abstract:

This paper shows that the gap between domestic production values and domestic value-added is growing with the deepening of production networks, which is a major phenomenon of economic globalization. Then, the utmost interest of this paper is analyzed: how the domestic value-added share change is related to total production value, number of employees, per-worker production value, and per-worker renumeration. The analyses show that the lowering of domestic value-added shares is related to increases in total production, number of employees, and per-worker production value. Moreover, it shows supporting evidence on the effect of the lower domestic value-added share on narrowing gaps in worker renumeration between the developed and developing countries, which is theoretically predicted by Baldwin (2016).

Keywords: Globalization, International fragmentation of production processes, value-added, Input-Output Database

I. Introduction

Baldwin (2016) explains the structural change in international trade as follows. The industrial revolution at the end of 19th century, which enabled a dramatic increase in production efficiency and transportation of goods, triggered a rapid increase in international trade. Namely, it became possible to split or "unbundle" places of production and places of consumption. To put it simply, goods produced in a place can be consumed in a different place. However, the production was done thoroughly within the boundary of a production country. For example, all the production processes of textiles and apparels exported by the United Kingdom were done within the United Kingdom. In the 1980s, however, the so-called ICT (Information and Communication Technology) revolution enabled precise and rapid transmission of information, and the completion of production within a country became no longer necessary. Firms could then pursue more efficient production by, for example, moving some easy parts of production processes to developing countries with lower wages.

While the international fragmentation of production process deepens, many developing countries are enjoying steady economic growth. This phenomenon is especially well documented in East Asia. As theories explain, the engines of economic growth are capital accumulation and technology improvement. Efficiency improvement through fragmentation of production processes is a technology improvement. Since the 1990s, firms taking advantage of the ICT revolution have pursued production fragmentation not only in their own countries

but also in foreign countries. It is clear, almost by definition, that deepening supply chains enables the improvement of firms' production efficiency. But what kind of impact does it have on developing countries' economic development? This issue is theoretically argued in Baldwin and Robert-Nicoud (2014) and Baldwin (2016), among others. When a physical production process is moved from a home country to a host country (e.g., from Japan to Indonesia), the technology needed for the production process is also transferred to the affiliate host country. This enables a combination of cheap labour costs in the host country with advanced technology of the headquarters. Worker productivity improves because the advanced technology is now available. Consequently, workers can benefit from deepening supply chains in the form of higher wages. At the same time, the host country as a whole can enjoy technology improvement through technology diffusion from the multinational firms brining advanced technologies to their affiliates in the host country. Baldwin (2016) calls this "The great convergence". This paper undertakes an empirical investigation on the aforementionedtheoretical predictions using Input-Output tables.

II. Literature

Although value-added chains through input-output linkage has been well recognized in the literature of Input-Output analyses and international trade for a long time, such as in the studies on the sources and patterns of trade using input-output tables done by Leontief (1953), Leamer (1980), Trefler (1993) and Trefler (1995), among others, it is only recently that value-added trade analyses using input-output tables are in the spotlight. This is because of both the increasing importance of international fragmentation of production processes and the recent availability of international input-output tables covering many countries and years, constructed by the European Commission in collaboration with other institutions.

Although Hummels et al. (2001) pointed out already in 2001 that deepening supply-chains causes the gap between gross export values recorded at the customs and value-added generated in the exporting country, it is only recently that the issue is widely discussed in the international trade literature. An expression that typically expresses the phenomenon is "Made-in-China is no longer made-in-China." A prime example widely cited is the case of the Apple iPad. In the production process of the iPad, value-added by Chinese workers represents nothing more than three percentage points of the total value-added of the product. The case of the iPad is an extreme one for a product, but Koopman et al. (2008) shows that value-added generated within China is only 50% of the total export value of all commodities from China. Johnson and Noguera (2012) computes the domestic value-added share of exporting countries over the total export values, and they show that the countries exporting manufacturing products have lower domestic value-added shares than countries exporting services. They also argue that the US-China trade imbalance in 2004 is 30-40% smaller when measured in value-added. Ito, Rotunno and Vézina (2017) show that, under the international fragmentation of production processes, the Heckscher-Ohlin model explains value-added trade better than gross trade. Ito and Vézina (2016), using Asian In-

put-Output Tables, show that the gap between gross trade values recorded in customs and value-added trade has been widening and that the service share of value-added is rising (so-called "Smile curve" phenomenon). Despite the aforementionedrecent advances in the studies on the deepening international production chains and concomitant value-added trade, the relation between production chains and development, including the income convergence between the developed countries and developing countries, is not yet studied, to the best of my knowledge.

III. Data and Methodology

III-1. Input-Output table

An industry purchases raw materials and intermediates inputs from other industries, produces their products (adding value-added) using these inputs, and then sells these products to other industries. The industries that purchase these products for use as intermediate inputs then produce other goods and services. Input-output tables represent such a chain relationship for purchase-production-sales of goods and services among industries. It shows how goods and services were produced, sold, and purchased among industrial sectors in a fixed period (usually one year).

In addition to the information on purchase-production-sales of goods and services among industries as described above, an input-output table includes the information on final consumption and value-added comprising mainly of labour input, tax payment and profits. For example, out of 100 million dollars of total output value in the plastics industry, input-output tables show how much the industry paid for its purchase of inputs, how much it paid for its workers, and how much it earned as profits. More details on the structure of the input-output tables are in the Appendix.

III-2. Outline of the data used for analyses

The analyses use the World Input-Output Database (WIOD) made by the European Commission in collaboration with other institutions and the Asian International Input-Output Tables, compiled by the Institute of Developing Economies, JETRO, Japan. WIOD provides two versions of the tables. One is yearly tables for 1995-2011 (Release 2013) and the other is yearly tables for 2000-2014 (Release 2016). This paper's analyses mainly use the 1995-2011 (Release 2013) version in order to better capture the impact of the ICT revolution, which is considered to have been accelerated in the 1990s. WIOD tables (Release 2013) cover 40 countries and 35 industries, whereas WIOD tables (Release 2016) cover 43 countries and 56 industries.

III-3. Calculation of value-added trade

The value of a product consists of input costs, such as primary or intermediate inputs, and value-added (mostly paid as wages and rental fee of capital). It should be noted that those inputs are also comprised of their own input costs and value-added. By tracking the whole process until the production values reach the sum of value-added, we can decompose the production values into the value-added by country/industry. This paper used this approach to calculate sources of value-added by country/industry for each production country/industry. More details are explained in the Appendix.

IV. Analyses

IV-1. Total production and domestic value-added

First, we will examine whether there is a difference between total production and domestic value-added due to the international fragmentation of the production process. Baldwin (2016) refers to countries that have advanced technology and invest in foreign countries as a "headquarter economy" and countries that have comparative advantages, typically in low labor cost, host foreign direct investment from a "headquarter economy" and engage in production activities as a "factory economy."

Figure 1 and Figure 2 show the transition from 1995 to 2011 of total production values and domestic value-added in Japan, which is a typical "headquarter economy," and in China, which is a "factory economy," at least until around 2010. As these figures show, domestic added value is smaller than total production. In other words, the value-added generated by foreign countries in total production value is expanding. In addition, the difference between total production value and domestic value-added widens over time, and the spread of the difference is more prominent in China (Figure 2). The United States and Mexico, and Germany and Poland are also typical pairs including a "headquarter economy" and a "factory economy". Figures 3 and 4 show the cases of the United States and Mexico, respectively, and Figures 5 and 6 show the cases of Germany and Poland, respectively. In these figures, the difference between the total production value and the domestic value-added increases over time for both the "headquarter economy" and the "factory economy", but this trend is particularly noticeable in the "factory economy". As argued above, the proportion of value-added generated by foreign countries in the total production values of a country/industry has increased, whereas, by definition, the domestic value-added share has decreased. Then, an important question arises. What kind of impact did such change have on total production values, per-worker production values, and income per worker? This is the research question of this paper.

IV-2. Estimation analyses

In this section, various estimation analyses using the aforementioneddata are performed. In all estimations, the domestic value-added share is the explanatory (or independent) variable of interest in this paper. In IV-2-1, overall variables such as the total production value, the total value-added amount, and the number of employees are taken as dependent variables, whereas in IV-2-2, we analyze the per capita variables such as per capita production and per capita labor compensation, as dependent variables. That is, while IV-2-1 analyzes the relevance of the deepening of international fragmentation in the production process to overall production activity, IV-2-2 analyzes the relevance to per capita income.

IV-2-1. Total production, total value-added, number of employees

Estimation analyses are conducted using the domestic value-added share as the explanatory variable of our interest and the total production value, the total value-added, and the number of employees as dependent variable. That is, we analyze whether the decline in the domestic value-added share is related to these total values. The estimation equation is as follows.

$$\ln Y_{ijt} = \beta_1 \ln (\textit{Domestic value added share}_{ijt}) + u_i + u_j + u_t + \varepsilon_{ijt}$$

The subscript i, j, t represents production country, production industry and year, respectively. Y is the total production, total value-added, number of employees, respectively in each estimation. The term u_i represents the production country fixed effects, the term u_j represents the industry fixed effects, the term u_t represents the year fixed effects, and the term ε_{ijt} represents the error term.

Table 3 shows the estimation results of the log of total production values regressed on the domestic value-added share, the country fixed effects, the industry fixed effects, and the year fixed effect. Column (1) is an estimate from all observations, i.e., from the observations of all industries in all countries, column (2) is an estimate from a sub-sample of all industries in developing countries, column (3) is an estimate from a subsample of all industries in developed countries, column (4) is an estimate from a subsample in manufacturing industries in all countries, column (5) is an estimate from a subsample of manufacturing industries in developing countries, column (6) is an estimate from a subsample of manufacturing industries in developed countries. All the coefficient estimates in columns (1) to (6) show negative signs with statistical significance at the 0.1 percent confidence level, indicating that total production values increased as domestic value-added share decreased. Comparing the coefficient estimates of columns (2) and (3), we can see that the magnitude of impact in the case of all industries is larger for developed countries than developing countries. However, the comparisons between columns (1) and (4), (2) and (5), (3) and (6), indicate that the magnitude is generally larger for the manufacturing industries than other industries. Moreover, columns (5) and (6) show that when restricting the sample to the manufacturing industries, the magnitude is larger for developing countries than developed countries. This is in line

with the widely accepted notion that the international fragmentation of production processes is especially deepening in the manufacturing industries.

Table 4 shows the estimation results with the total value-added as the dependent variable instead of total production value. All the coefficient estimates are statistically significant with negative signs and the magnitudes of the coefficients are similar to those in Table 3. The same estimation analyses as in Table 4 are done using WIOD 2000-2014 (Release 2016) as a robustness check. The results are shown in Table 5. As column (1) shows, the coefficient estimate for the whole sample (all countries and all industries) is statistically significant at the 0.1 percent confidence level with a negative sign. As column (2) shows, when restricting the sample to a subsample of developing countries, the magnitude of the coefficient is larger, with a statistical significance at the 0.1 percent level. On the other hand, as is shown in column (3), the coefficient estimate is statistically insignificant for the case of developed countries. Columns (4) to (6) are the cases for the subsamples limited to the manufacturing industries. The magnitude of coefficient estimates is larger for the manufacturing industries, especially for developing countries. These results are again in line with the widely accepted notion that developing countries are getting increasingly involved in the international production networks of the manufacturing industries.

Table 6 shows the estimation results with number of employees as the dependent variable. Except for the cases of column (3) (subsample of developed countries / all industries) and column (4) (subsample of all countries / manufacturing industries), all the coefficient estimates are statistically significant with a negative sign at the 0.1 percent significance level, which are similar to the results we have seen above for total production (Table 3) and total value-added (Table 4). These results indicate that a decrease in the domestic value-added share is associated with an increase in the number of employees. The magnitude of coefficient estimate is larger for the manufacturing industries. As further robustness checks, estimations are done only for three selected industries, widely known for international production networks, i.e., Machinery, Electronical and Optical Equipment, and Transport Equipment. The estimation results are qualitatively the same and quantitatively with larger magnitude of coefficient estimates. See Appendix Tables 1 - 3 for the estimation results.

All these results indicate that, although the domestic value-added share decreases due to international fragmentation of production processes, that seems to be affecting positively the total production value and number of employees.

IV-2-2. Production value per number of persons engaged, Production value per number of employees, Renumeration per number of persons engaged, Renumeration per number of employees

Whereas the previous section analyses the impact of the domestic value-added share on the scale of industries, such as total production value and number of employees, this section analyses the impact on total production per worker and renumeration per worker, which are close to the concept of “The Great Convergence”. The only change from the estimation equation in the previous section is the dependent variable.

Table 7 shows the estimation results for the case of production value per number of persons engaged[1] and the case of production value per number of employees. All the coefficient estimates are statistically significant with negative signs at the 0.1 percent significance level, which suggests that a decrease of domestic value-added share has a positive impact on production value per number of persons engaged. The same estimation analyses are done for production value per number of employees, of which results are shown in Table 8. The results are similar both qualitatively and quantitatively to those in Table 7.

The case with renumeration per number of persons engaged is in Table 9. Except the column (3): developed countries and all industries and the column (6): developed countries and the manufacturing industries, the coefficient estimates are statistically significant at 0.1 percent significance level, importantly, with positive sign. This suggests that a decrease in domestic value-added share has a negative impact on renumeration per persons engaged. Table 10 are estimation results for the case of renumeration per employee as the dependent variable. The column (1): all countries and all industries is very similar to the case in Table 9. For the column (2), the significance level weakens compared with that in Table 9, but still with positive sign. When restricting the sample to the developing countries and manufacturing industries (column (5)), the coefficient estimate is statistically insignificant. The robustness checks as in the section IV-2-1, namely for the selected three industries are done and shown in Appendix Table 4 - 6.

Analyses so far suggest that a decrease in domestic value-added share has a positive impact on total production values, but no positive relation with renumeration per worker, or even some slightly negative relation. To be closer to the concept of "The great convergence", namely, the combination of high technology of developed countries and cheap labor in developing countries, the next analysis confines the dataset to this combination.

We use a subsample of production countries being developing countries. The explanatory variable is now the value-added share generated by the developed countries, i.e., how much of the developed countries' value-added are embedded to the production. The dependent variable is the renumeration per worker. Table 11 shows that all the coefficient estimates are statistically significant at least at 5% confidence level with positive sign. Namely, an increase of value-added share coming from the developed countries is positively correlated with an increase in renumeration per worker in developing countries.

As the convergence of factor income is shown to take place also with trade of final products in the framework of Heckscher-Ohlin (factor income equalization theorem) besides the mechanism of international fragmentation of production processes, the focus of this paper, we divide the period of study into the years before 2000 (when international production network was still not deep) and the years on and after 2000 (when the network deepened substantially) and do estimations separately for these two periods.[2] As we can see from the comparison of the column (1) and (2) and also of the column (5) and (6), the statistical sig-

[1] WIOD have two measures for number of workers. One is number of persons engaged, and the other is number of employees. Number of persons engaged is a broader concept than number of employees.

[2] I appreciate this suggestion by Shujiro Urata.

nificance appears only for the latter period, i.e., on and after 2000. Also as can be read from the comparison of the column (3) and (4) and the column (7) and (8), when restricting the sample to the manufacturing industries, coefficient estimates are statistically significant for both periods, but the magnitude of coefficients are larger in the latter period, suggesting that international fragmentation of production processes positively affected the convergence of renumeration per worker.

V. Conclusion

This paper shows that the gap between domestic production values and domestic value-added is growing with the deepening of production networks, which is a major phenomenon of economic globalization. Then, the utmost interest of this paper is analyzed. Namely, how the domestic value-added share change is related to total production value, number of employees, per-worker production value, and per-worker renumeration. The analyses show that the lower domestic value-added shares is related to increases in total production, number of employees, and per-worker production value. Moreover, it shows a supporting evidence on the effect of lower domestic value-added on narrowing gaps in worker renumeration between the developed and developing countries, which is theoretically predicted by Baldwin (2016).

References

Baldwin, Richard, 2016. THE GREAT CONVERGENCE, Information Technology and the New Globalization, Harvard University Press

Baldwin, Richard and Robert-Nicoud, Frédéric, 2014. "Trade-in-goods and trade-in-tasks: An integrating framework", *Journal of International Economics*, vol. 92(1), pages 51-62

Hummels, David, Ishii, Jun, Yi, Kei-Mu, 2001. "The nature and growth of vertical specialization in world trade", *Journal of International Economics* 54, pp. 75-96.

Ito, T, Rotunno, L., Vézina, P.L., 2017. "Heckscher-Ohlin: Evidence from virtual trade in value-added", *Review of International Economics,* Volume 25, Issue 3

Ito, T, Vézina, P.L., 2016. "Production fragmentation, upstreamness, and value-added: Evidence from Factory Asia 1990-2005", *Journal of the Japanese and International Economies*, 42(2016) 1-9

Johnson, R.C., Noguera, G., 2012. "Accounting for intermediates: Production sharing and trade in value-added". *Journal of International Economics* 86(2), pp. 224-236.

Koopman, R., Wang, Z., Wei, S.J., 2008. How Much of Chinese Exports is Really Made In China? Assessing Domestic Value-added When Processing Trade is Pervasive. Working Paper 14109. National Bureau of Economic Research.

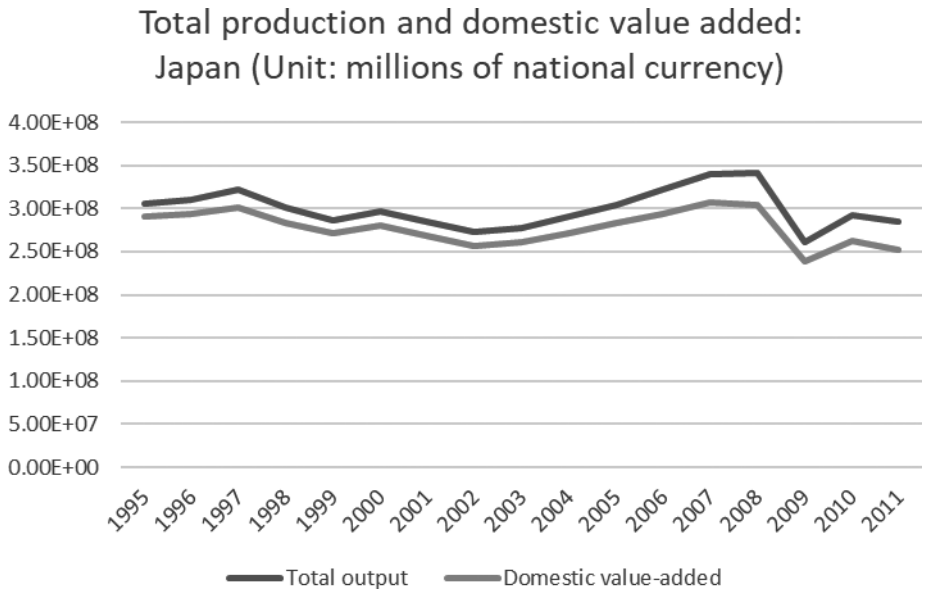
Leamer, Edward, 1980, "The Leontief Paradox, Reconsidered", *Journal of Political Economy,* Vol. 88, No. 3.

Leontief, Wassily, 1953, "Domestic Production and Foreign Trade; The American Capital Position Re-examined", *Proceedings the American Philosophical Society,* Vol. 94, No. 4, pp. 332-349.

Trefler Daniel, 1993, "International Factor Price Differences: Leontief was Right!", *Journal of Political Economy,* Vol. 101, No. 6, pp. 961-987.

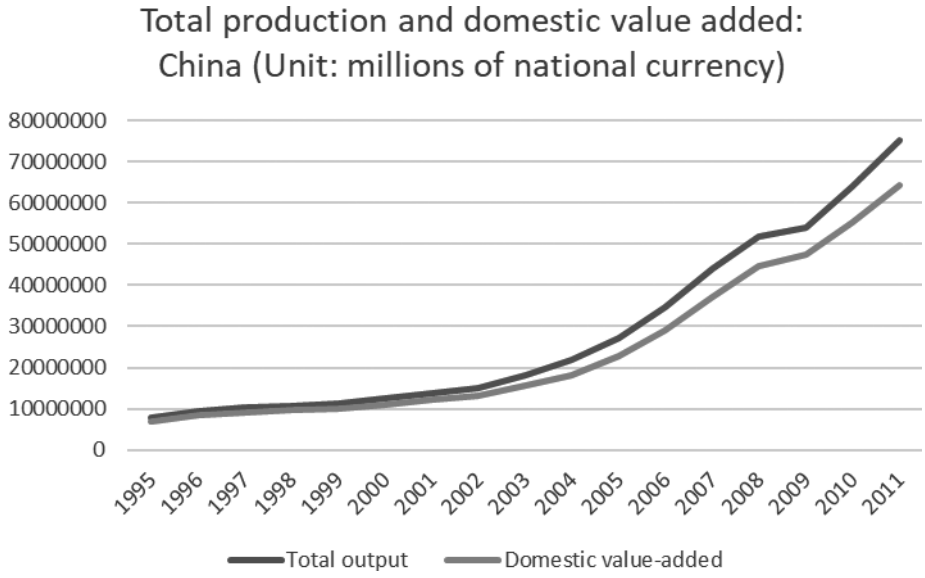
Trefler D. "The Case of the Missing Trade and Other Mysteries", 1995, *American Economic Review,* Vol. 85, No. 5, pp. 1029-1046.

Figure 1. Total production and domestic value-added (Japan)



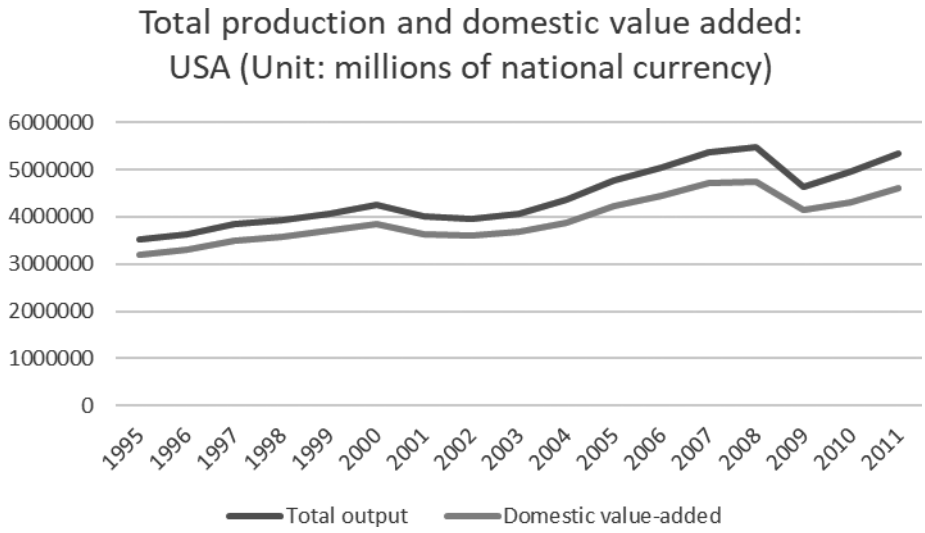
Source: Author's computation from World Input-Output database (1995-2011)

Figure 2. Total production and domestic value-added (China)



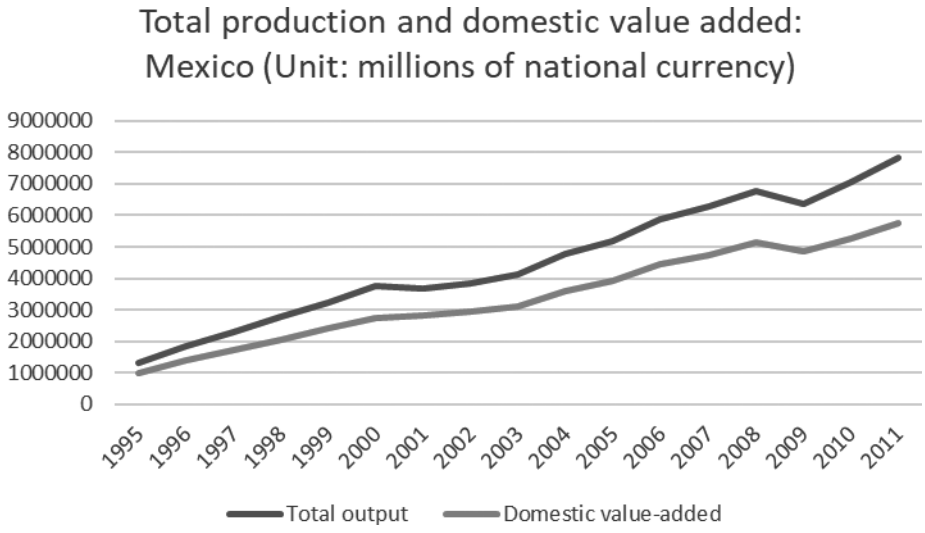
Source: Author's computation from World Input-Output database (1995-2011)

Figure 3. Total production and domestic value-added (USA)



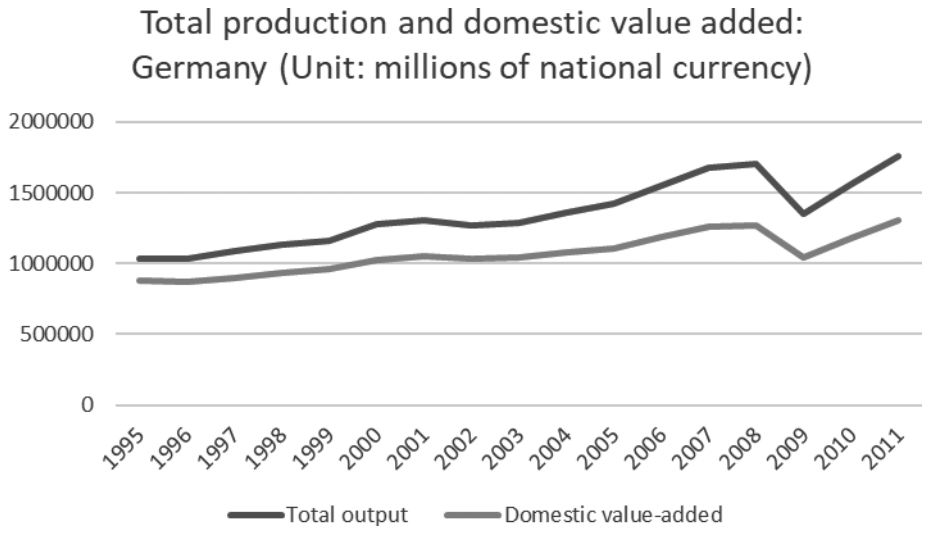
Source: Author's computation from World Input-Output database (1995-2011)

Figure 4. Total production and domestic value-added (Mexico)



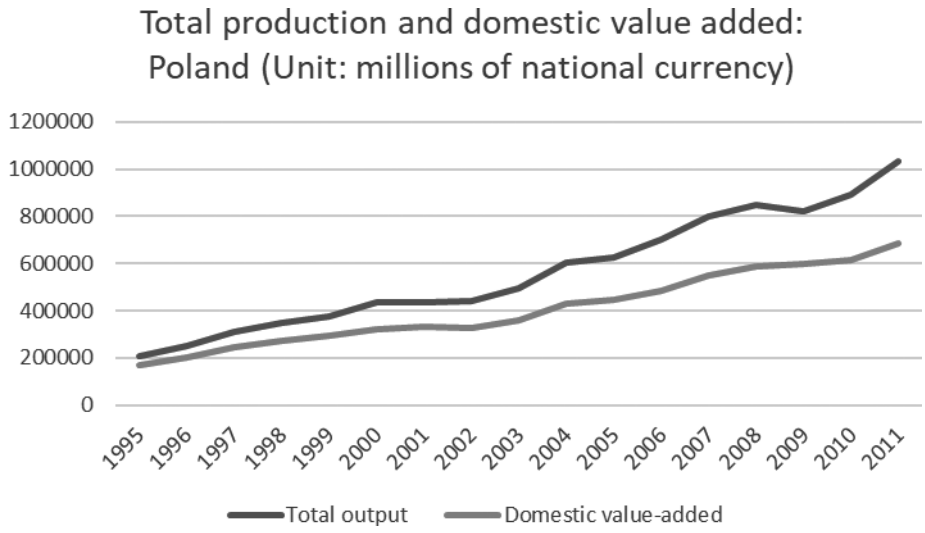
Source: Author's computation from World Input-Output database (1995-2011)

Figure 5. Total production and domestic value-added (Germany)



Source: Author's computation from World Input-Output database (1995-2011)

Figure 6. Total production and domestic value-added (Poland)



Source: Author's computation from World Input-Output database (1995-2011)

Table 1. World Input-Output database (1995-2011) Industry list

Industry code	Industry description	Sector
1	Agriculture, Hunting, Forestry and Fishing	Primary
2	Mining and Quarrying	
3	Food, Beverages and Tobacco	Manufacturing
4	Textiles and Textile Products	
5	Leather, Leather and Footwear	
6	Wood and Products of Wood and Cork	
7	Pulp, Paper, Paper , Printing and Publishing	
8	Coke, Refined Petroleum and Nuclear Fuel	
9	Chemicals and Chemical Products	
10	Rubber and Plastics	
11	Other Non-Metallic Mineral	
12	Basic Metals and Fabricated Metal	
13	Machinery, Nec	
14	Electrical and Optical Equipment	
15	Transport Equipment	
16	Manufacturing, Nec; Recycling	
17	Electricity, Gas and Water Supply	Service
18	Construction	
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	
22	Hotels and Restaurants	
23	Inland Transport	
24	Water Transport	
25	Air Transport	
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	
27	Post and Telecommunications	
28	Financial Intermediation	
29	Real Estate Activities	
30	Renting of M&Eq and Other Business Activities	
31	Public Admin and Defence; Compulsory Social Security	
32	Education	
33	Health and Social Work	
34	Other Community, Social and Personal Services	
35	Private Households with Employed Persons	

Source: Author's elaboration from World Input-Output database (1995-2011)

Table 2. WIOD (1995-2011) country code and country name

Country code	Country name
AUS	Australia
AUT	Austria
BEL	Belgium
BGR	Bulgaria
BRA	Brazil
CAN	Canada
CHN	China
CYP	Cyprus
CZE	Czech Republic
DEU	Germany
DNK	Denmark
ESP	Spain
EST	Estonia
FIN	Finland
FRA	France
GBR	United Kingdom
GRC	Greece
HUN	Hungary
IDN	Indonesia
IND	India
IRL	Ireland
ITA	Italy
JPN	Japan
KOR	Korea, Rep.
LTU	Lithuania
LUX	Luxembourg
LVA	Latvia
MEX	Mexico
MLT	Malta
NLD	Netherlands
POL	Poland
PRT	Portugal
RUS	Russian Federation
SVK	Slovak Republic
SVN	Slovenia
SWE	Sweden
TUR	Turkey
TWN	Taiwan, China
USA	United States

Source: World Input-Output database (1995-2011)

Table 3. Estimation results WIOD (1995-2011) Dependent variable: Log of total production value

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	-0.670***	-0.698***	-0.850***	-0.751***	-1.082***	-0.833***
	(-16.15)	(-12.02)	(-17.20)	(-13.82)	(-15.36)	(-16.64)
R-squared	0.950	0.955	0.959	0.950	0.958	0.959
Observations	22619	11152	11467	9436	4713	4723

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 4. Estimation results WIOD (1995-2011) Dependent variable: Log of total value-added

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	-0.676***	-0.713***	-0.741***	-0.870***	-1.114***	-0.737***
	(-8.45)	(-6.58)	(-6.55)	(-13.27)	(-13.07)	(-6.42)
R-squared	0.695	0.649	0.722	0.809	0.786	0.718
Observations	22619	11152	11467	9436	4713	4723

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 5. Estimation results WIOD (2000-2014) Dependent variable: Log of total value-added

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	-0.375***	-0.645***	-0.0649	-0.789***	-1.312***	-0.603***
	(-7.27)	(-8.28)	(-0.95)	(-14.90)	(-17.42)	(-7.70)
R-squared	0.601	0.581	0.611	0.803	0.838	0.711
Observations	33511	16158	17353	11680	5770	5910

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 6. Estimation results WIOD (1995-2011) Dependent variable: Log of number of employees

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	-0.149***	-0.220***	-0.0142	0.0118	-0.271***	0.0230
	(-3.97)	(-4.49)	(-0.29)	(0.26)	(-4.97)	(0.47)
R-squared	0.910	0.930	0.920	0.910	0.939	0.915
Observations	22619	11152	11467	9436	4713	4723

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 7. Estimation results WIOD (1995-2011) Dependent variable: Log of total production per persons engaged

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	-0.521***	-0.478***	-0.836***	-0.762***	-0.811***	-0.856***
	(-16.36)	(-10.13)	(-24.59)	(-19.84)	(-14.93)	(-24.69)
R-squared	0.936	0.927	0.965	0.944	0.936	0.965
Observations	22619	11152	11467	9436	4713	4723

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

World Input-Output Database has "Number of persons engaged" and "Number of employees". The former is broader concept than the latter.

Table 8. Estimation results WIOD (1995-2011) Dependent variable: Log of total production per employee

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	-0.545***	-0.562***	-0.786***	-0.818***	-0.857***	-0.810***
	(-15.66)	(-11.00)	(-20.93)	(-20.27)	(-15.17)	(-21.14)
R-squared	0.939	0.932	0.967	0.951	0.945	0.967
Observations	19477	9360	10117	8115	3946	4169

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 9. Estimation results WIOD (1995-2011) Dependent variable: Log of renumeration per persons engaged

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	0.230***	0.190***	0.0288	0.139***	0.152**	0.0138
	(8.18)	(4.26)	(1.30)	(4.23)	(3.01)	(0.62)
R-squared	0.945	0.930	0.982	0.953	0.939	0.982
Observations	21746	10687	11059	9063	4508	4555

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 10. Estimation results WIOD (1995-2011) Dependent variable: Log of renumeration per employee

	(1) All countries / All industries	(2) Developing countries / All industries	(3) Developed countries / All industries	(4) All countries / Manufacturing only	(5) Developing countries / Manufacturing only	(6) Developed countries / Manufacturing only
Log of domestic value-added share	0.184***	0.113*	0.0436	0.0888*	0.102	0.0260
	(5.96)	(2.31)	(1.74)	(2.47)	(1.91)	(1.02)
R-squared	0.947	0.934	0.982	0.956	0.944	0.983
Observations	19472	9355	10117	8110	3941	4169

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 11. Estimation results WIOD (1995-2011) Sub-sample: Developing countries only Explanatory variable-Log of value-added share coming from the developed countries Dependent variables: as described in the first row of the table

	(1) Renumeration per employee / All industries	(2) Renumeration per employee / Manufacturing only	(3) Renumeration per persons engaged / All industries	(4) Renumeration per persons engaged / Manufacturing only
Log of value-added share coming from the developed countries	0.296*	0.536***	0.384**	0.556***
	(2.35)	(3.36)	(3.28)	(3.67)
R-squared	0.934	0.944	0.930	0.939
Observations	9355	3941	10687	4508

t-values in parentheses

** p < 0.05, ** p < 0.01, *** p < 0.001*

Includes country fixed effects, industry fixed effects, and year fixed effects.

Table 12. Estimation results WIOD (1995-2011) Sub-sample: Developing countries only Explanatory variable - Log of value-added share coming from the developed countries Dependent variables: as described in the first row of the table, Prior to 2000 and on and after 2000

	(1) Renumeration per employee / All industries / Prior to 2000	(2) Renumeration per employee / All industries / On and after 2000	(3) Renumeration per employee / Manufacturing only / Prior to 2000	(4) Renumeration per employee / Manufacturing only / On and 2000
Log of value-added share coming from the developed countries	0.0914	0.564***	0.575***	0.662***
	(0.62)	(6.32)	(3.39)	(6.43)
R-squared	0.938	0.956	0.951	0.968
Observations	3114	6241	1310	2631

	(5) Renumeration per persons engaged / All industries / Prior to 2000	(6) Renumeration per persons engaged / All industries / On and after 2000	(7) Renumeration per persons engaged / Manufacturing only / Prior to 2000	(8) Renumeration per persons engaged / Manufacturing only / On and 2000
Log of value-added share coming from the developed countries	0.147	0.598***	0.584***	0.672***
	(1.03)	(7.21)	(3.45)	(6.82)
R-squared	0.935	0.952	0.946	0.963
Observations	3270	7417	1380	3128

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix

Figure A.1. below shows the basic structure of the input-output table. To produce 300 products, the industry A purchases 30 and 60 for its raw materials and intermediate, respectively, from the same industry A, and the industry B and adds gross value-added worth of 210. The gross value-added consists mainly of wages for workers, capital depreciation, profits, taxes. In other words, producers (here, industry A) purchases raw materials and intermediate inputs and employ workers to produce their products by paying them wages and also pay taxes and other expenses, with the rest being their profits.

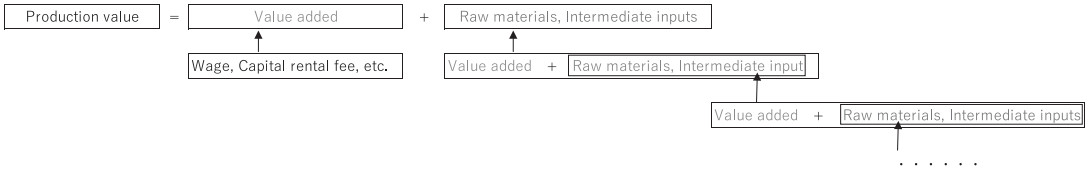
As Figure A.2. below shows that a particular industry's production value consists of its purchase of raw materials, intermediate inputs and the value-added that industry generates. Those raw materials and intermediate inputs themselves are also made up of their raw materials, intermediate inputs and value-added they generate. Thus, by tracing this process, the production value can be disaggregated only to value-added.

Figure A.1.

		Intermediate demand		Final demand	Ouput
		Industry A	Industry B		
Intermediate inputs	Industry A	30	150	120	300
	Industry B	60	250	190	500
Gross value added		210	100		
Output		300	500		

Source: Author's elaboration

Figure A.2. Definition of production value, value-added, raw materials and intermediate inputs



Source: Author's elaboration

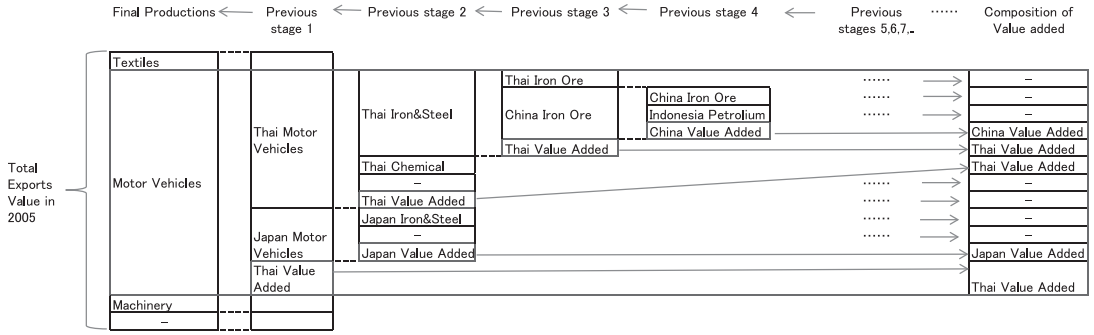
For example, incorporating the international production fragmentation into this concept, as Figure A.3. shows, Thai motor vehicle production is composed of raw materials and intermediate inputs from the Thai chemical industry and Japanese motor vehicle industry and value-added generated by Thai motor vehicle industry (shown in the most left-hand side column as "final production"). The Thai chemical industry's production, in turn, consists of inputs from the Thai Iron & Steel industry, Thai chemical, etc. and value-added generated by Thai chemical industry. By tracing the process, production values are expressed only by

value-added. When international fragmentation of production processes deepens, value-added generated by many countries and many industries come into this composition of value-added. The actual computation of value-added can be done by literally tracing this process of stages, the computation takes long time. However, we can make computations much easier using the matrix algebra shown below.

$$VAP = v\,(I\text{-}A)^{-1}p$$

where, VAP represents total value-added (which is equal to total production value), v represents value-added ratio (value-added/production value), I represents identity matrix, P represents production value.

Figure A.3.



Appendix Table 1. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of total production

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	-2.141***	-1.891***	-0.865***
	(-18.78)	(-14.64)	(-17.17)
R-squared	0.973	0.980	0.959
Observations	2017	997	10923

t statistics in parentheses $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix Table 2. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of total value-added

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	-2.563***	-2.205***	-0.763***
	(-21.97)	(-15.75)	(-6.57)
R-squared	0.925	0.908	0.713
Observations	2017	997	10923

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix Table 3. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of number of employees

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	-0.730***	-0.640***	0.00494
	(-8.85)	(-6.10)	(0.10)
R-squared	0.957	0.961	0.914
Observations	2017	997	10923

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix Table 4. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of production per persons engaged

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	-1.411***	-1.250***	-0.870***
	(-17.58)	(-12.65)	(-24.83)
R-squared	0.968	0.971	0.965
Observations	2017	997	10923

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix Table 5. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of production per employee

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	−1. 519***	−1. 302***	−0. 822***
	(−18. 19)	(−12. 16)	(−21. 24)
R-squared	0. 972	0. 973	0. 967
Observations	1732	832	9637

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix Table 6. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of renumeration per persons engaged

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	0.394***	0.509***	0.00456
	(5.31)	(5.16)	(0.20)
R-squared	0.969	0.966	0.982
Observations	1939	955	10579

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.

Appendix Table 7. Estimation results WIOD (1995-2011) Three industries (Machinery, Electrical and optical equipment and Transportation equipment) Dependent variable: Log of renumeration per employee

	(1) All countries / Three industries	(2) Developing countries / Three industries	(3) Developed countries / Three industries
Log of domestic value-added share	0.330***	0.488***	0.0166
	(4.13)	(4.53)	(0.64)
R-squared	0.971	0.968	0.983
Observations	1732	832	9637

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Includes country fixed effects, industry fixed effects, and year fixed effects.