The Value Added-Exports Puzzle and Global Value Chains

Zhe Chen* Yoshinori Kurokawa†

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Abstract

While most OECD countries experienced declines in manufacturing value added relative to GDP over 1970–2001, they have experienced increases in manufacturing exports relative to GDP during the same period. Bergoeing et al. (2004) documented this "value added-exports puzzle" and predicted that vertical specialization can explain it. Using the 1995-2018 data for 22 OECD countries and 17 manufacturing industries, we empirically investigate whether vertical specialization, or global value chain (GVC) participation, is a factor significantly affecting the puzzle. Our regressions show that the puzzle is stronger for countries and industries with the greater GVC backward linkage, while it is weaker for countries and industries with the greater GVC forward linkage. We also find that the puzzle is weaker for countries and industries that focus more on the upstream stage. Thus Bergoeing et al. (2004) were right, but we must be careful that the two measures of vertical specialization, the backward and forward GVC linkages, have the opposite effects.

Keywords: manufacturing value added, manufacturing exports, vertical specialization, GVC participation, GVC position

JEL classification: F1, F4

*School of International Trade and Economics, University of International Business and Economics. 1302 Boxue Building, 10 Huixin Dongjie, Chaoyang District, Beijing 100029, China. E-mail: zhechen@uibe.edu.cn.

†Faculty of Humanities and Social Sciences, University of Tsukuba. 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8571, Japan. E-mail: kurokawa.yoshi.fw@u.tsukuba.ac.jp.

1 Introduction

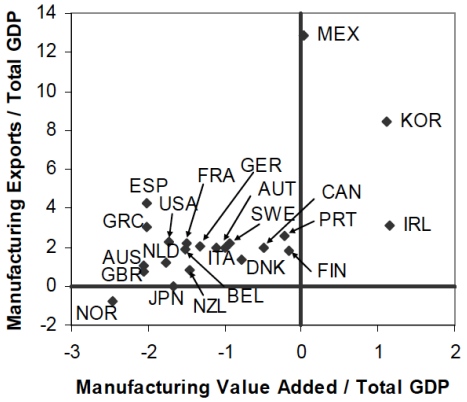
Bergoeing et al. (2004) documented that while most OECD countries have experienced declines in manufacturing value added as a share of GDP during the period 1970–2001, they have experienced increases in manufacturing exports as a share of GDP during the same period (see their Figure 1; we also show it in Panel (a) of Figure 1). They argued that this is puzzling, because these observations imply that most of the world's major economies are exporting more and more of goods that they are producing less and less of.

We now extend Bergoeing et al.'s data analysis in two ways. First, we update their data to check if this "value added-exports puzzle" still holds in most OECD countries after 2001. This is because after 2001 China became a member of the WTO and some Eastern European countries joined the EU, which might have changed the patterns of manufacturing trade and production in related OECD countries. Panel (b) of Figure 1 shows the average annual changes of manufacturing exports and value added for 22 OECD countries[1] from 1996-2018.[2] While it held in most OECD countries for the period 1970-2001 as shown in Panel (a), we can see in Panel (b) that the puzzle seems to hold only in 12 OECD countries but seems not to hold in the other 10 OECD countries from 1996-2018. As can also be seen, some countries, such as Greece, show the relatively strong puzzle; some, such as Denmark, show the relatively weak puzzle; and some, such as United States, do not show the puzzle. Thus, the heterogeneity in the puzzle across countries has become more significant from 1996-2018.

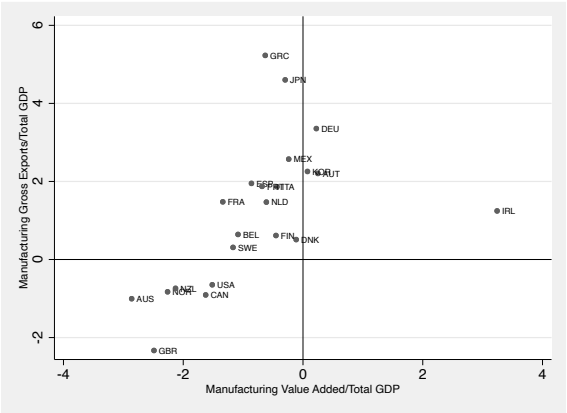
Second, we investigate the puzzle at the industry level besides the country level. This is because, as Kehoe et al. (2015) argued, when policy makers debate trade liberalization, the worry could be not only over the aggregate increase in exports but over the unequal impact on exports across industries. Panel (c) of Figure 1 shows the average annual changes of exports and value added for 17 individual manufacturing industries from 1996-2018. As can be seen, over 1996-2018 this value added-exports puzzle seems to hold for 12 manufacturing industries but seems not to hold for 5 ones. Some industries, such as rubber and plastics products, show the relatively strong puzzle; some, such as electronic products, show the relatively weak puzzle; and some, such as textiles and clothing, do not show the puzzle.

[1] These 22 countries are the same as those in Figure 1 of Bergoeing et al. (2004): Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Japan, Italy, Mexico, Netherlands, Norway, New Zealand, Portugal, South Korea, Spain, Switzerland, United Kingdom, and United States.

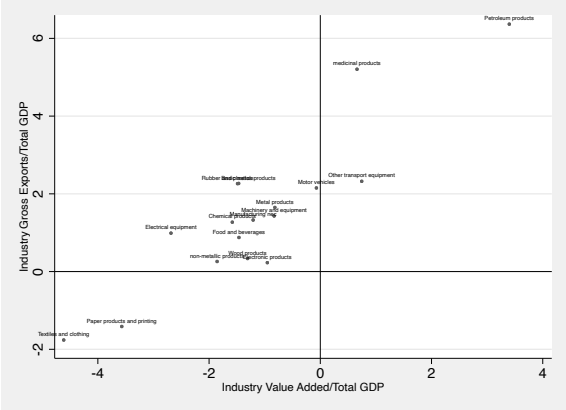
[2] Here, the annual change for 1996, for example, is calculated as a percent change from 1995.



(a) Figure from Bergoeing et al. (2004)



(b) Country level



(c) Industry level

Figure 1: Average annual changes of exports and value added

Note: This figure shows the average annual changes of exports and value added for 22 OECD countries and 17 manufacturing industries. Figure (a) is at the country level from 1970 to 2001 in Figure 1 in Bergoeing et al. (2004). Figure (b) is our calculation at the country level from 1996 to 2018. Figure (c) is our calculation at the industry level from 1996 to 2018. When we calculate the average annual change, we remove annual changes in the three years 2008, 2009, 2010, which can be affected by the Great Recession. The Great Recession started in December 2007 and ended in June 2009.

Source: OECD Trade in Value Added (TiVA) indicators

Thus, there is also significant heterogeneity in the puzzle across manufacturing industries from 1996-2018.

Based on the above motivational evidence, we now raise our empirical question: What can explain the heterogeneity in the value added-exports puzzle among countries/industries from 1996-2018? To answer this question, as Bergoeing et al. (2004) suggested, we consider vertical specialization, or global value chain (GVC) participation, as one of the possible factors that can explain the above observations.[3] As an example, consider the increased vertical

[3]Bergoeing et al. (2004) suggested vertical specialization as a factor that can explain the value added-exports puzzle, but they did not empirically test it.

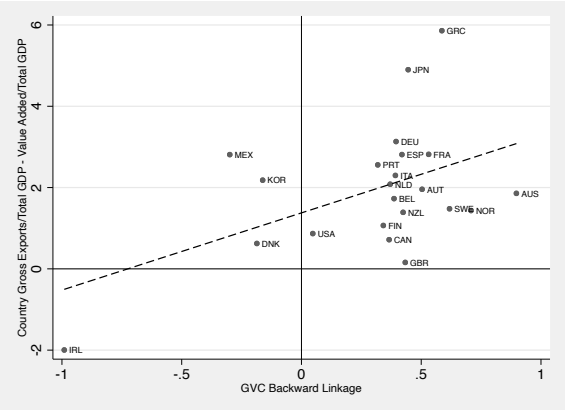
specialization after the U.S.-Canada Auto Pact of 1965. The United States now primarily exports motor vehicle parts to Canada and imports and re-exports assembled vehicles embodying those U.S. parts. This can increase exports and decline outputs in the U.S. auto industry. It, however, should be emphasized that we consider not only the vertical specialization measure (VS) in Hummels et al. (2001), that is, GVC backward linkage, but also another measure (VS1), that is, GVC forward linkage.[4] The former is defined as foreign value added content of gross exports (from the import perspective); the latter is defined as the domestic value added in gross exports that are further re-exported to third countries (from the export perspective). In this paper, we define the GVC backward linkage plus forward linkage as total GVC participation. We thus consider the three measurements of GVC participation: backward, forward, and total. Moreover, in addition to this GVC participation, we also consider GVC position—upstreamness—as another possible factor that can explain the above observations. It is defined as the ratio of the GVC forward linkage to backward linkage.

In fact, data suggest that these GVC backward linkage, forward linkage, and position might affect the differences in the value added-exports puzzle across countries and industries.[5] As shown in Panels (a) and (b) of Figure 2, the GVC backward linkage is positively related with the average annual change differences between exports and value added, both at the country and industry levels. It implies that if a country or industry has a higher degree of GVC backward linkage, the growth rate of exports is faster than that of value added. On the other hand, as shown in Panels (c) and (d) of Figure 2, the GVC forward linkage is negatively related both at the country and industry levels, thus implying that if a country or industry has a higher degree of GVC forward linkage, the puzzle is weaker. Moreover, as shown in Panels (e) and (f), the GVC position—upstreamness—is negatively related, thus indicating that if a country or industry more focuses on the upstream stage, the puzzle is weaker.

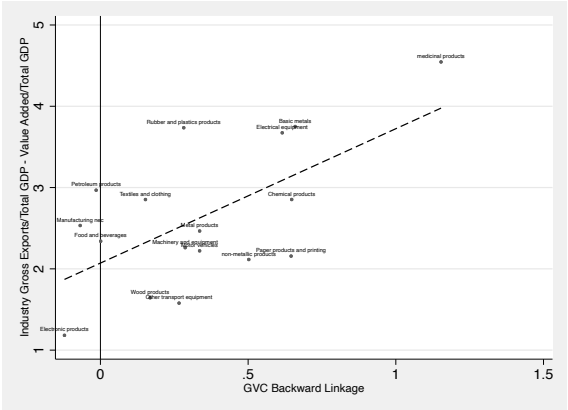
Therefore, to investigate whether the GVC participation and position are factors significantly affecting the value added-exports puzzle, this paper sets and econometrically tests the following hypotheses: (1) The value added-exports puzzle is stronger for countries and industries with the greater GVC backward linkage, while it is weaker for countries and in-

[4]Hummels et al. (2001) mentioned both measures of vertical specialization (VS and VS1); however, they could not calculate the forward type (VS1) because of data constraints.

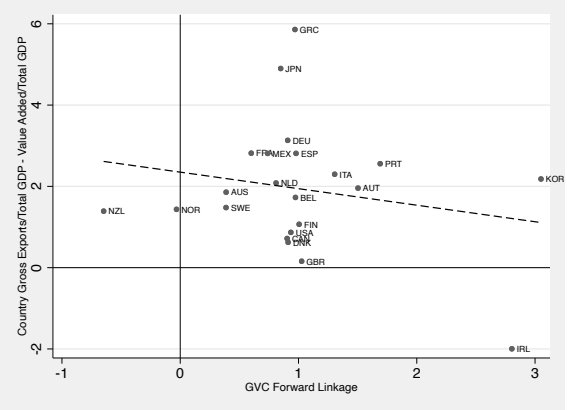
[5]We explain the variables and data in more detail in Section 3. We note that though her interest is in the impacts on Chinese manufacturing productivity, Hua (2021) also considers the GVC backward linkage, forward linkage, and position.



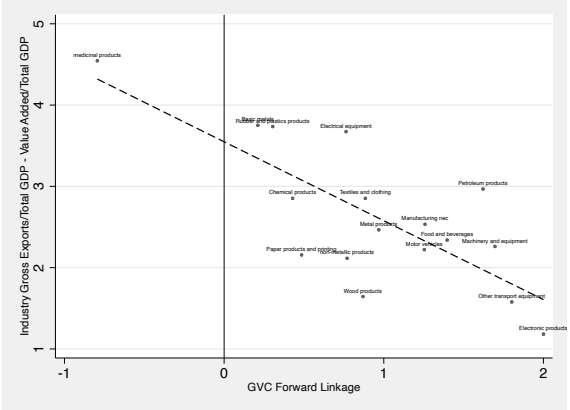
(a) Country level



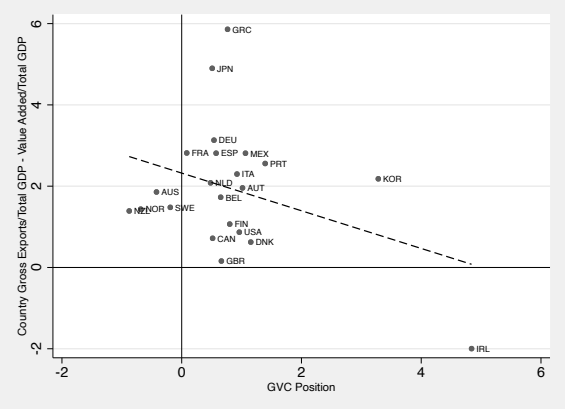
(b) Industry level



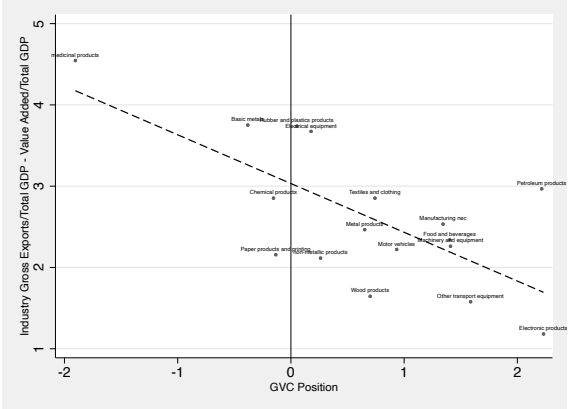
(c) Country level



(d) Industry level



(e) Country level



(f) Industry level

Figure 2: Value Added-Exports Puzzle and GVC

Note: This figure shows the relationship between the value added-exports puzzle and the GVC for 22 OECD countries and 17 manufacturing industries. Figures (a)-(c) show the relationship at the country level, and figures (d)-(f) show that at the industry level. When we calculate the average annual change, we remove annual changes in the three years 2008, 2009, 2010, which can be affected by the Great Recession. The Great Recession started in December 2007 and ended in June 2009.

Source: OECD Trade in Value Added (TiVA) indicators

dustries with the greater GVC forward linkage. (2) The puzzle is weaker for countries and industries that focus more on the upstream stage. The intuition is as follows: The greater GVC backward linkage indicates that the share of foreign value added in gross exports is higher and the share of domestic value added is lower. Thus, the greater is GVC backward linkage, the stronger is the value added-exports puzzle. The greater GVC forward linkage indicates that the domestic value added of gross exports that is re-exported to third countries is higher. Thus, it is possible that the total domestic value added that is exported to trade partners (part of which is further re-exported to third countries) is higher and therefore the value added-exports puzzle is weaker. When a country or an industry is on the upstream stage, the backward GVC linkage is smaller and the forward GVC linkage is greater. Thus, the puzzle is weaker.

The rest of this paper is organized as follows. Section 2 reviews the related literature. Section 3 defines our key variables, explains our regression specifications and data, and shows our main results and robustness checks. Section 4 concludes.

2 Literature Review

2.1 Literature on Manufacturing Trade and/or Value Added

First, our paper contributes to the literature on the increased manufacturing trade and/or the decreased manufacturing value added. One set of studies focused on the increased manufacturing trade/exports. Bridgman (2012) analyzed manufacturing trade by using a three stage Ricardian trade model with raw materials, manufactured parts, and final goods. The model shows that a reduction in trade costs in manufactured parts can cause vertical specialization and manufacturing trade to grow faster than overall trade. Dalton (2013) provided an alternative explanation for the increased manufacturing trade on the basis of Just-in-Time inventories. Flückiger and Ludwig (2015) looked at EU's industry level and showed that the value of exports relative to GDP for the product groups facing strong Chinese export competition increased marginally between 1995 and 2000 and has subsequently decreased, despite a continuous decline in transport costs. On the other hand, the export volume of manufactured products facing only weak competition grew considerably relative to GDP.

Another set of studies focused on the decreased manufacturing value added.[6] Pilat et al. (2006) argued that the declined share of manufacturing value added in GDP in OECD countries is due to price effects and to relatively slow growth in demand for manufacturing products, as demand for services is growing more rapidly. Using data gathered at 5-year intervals during the period 1970-1990, Saeger (1997) estimated equations for a 23-country panel and found that imports of manufactures from developing countries had a negative impact on the manufacturing sector's value added to GDP. Cáceres (2018) empirically explained the reason why manufacturing value added/GDP declined in El Salvador. He found that the extreme form of trade liberalization that was implemented in El Salvador is the main reason for the contraction of tradable goods sectors. Cruz (2015) empirically explained why manufacturing value added/GDP declined in Mexico. His results suggest that the evolution of income, capital accumulation, labor manufacturing productivity, trade openness, and the exchange rate provide an explanation for this process.

In this line of studies, Bergoeing et al. (2004) linked both the increased manufacturing exports and the decreased manufacturing value added and argued that this is puzzling. Then their model shows that a reduction in trade costs can qualitatively generate the puzzle facts. This, however, is particularly true when the elasticity of substitution between manufacturing and non-manufacturing goods is low, indicating that the elasticity of substitution between manufactured goods is counterfactually high. Thus they suggested vertical specialization as an additional factor that can explain this value added-exports puzzle, although they did not provide an empirical test. Our paper now provides an empirical test for the puzzle on the basis of vertical specialization and upstreamness, or GVC participation and position.

2.2 Literature on Vertical Specialization

Second, our paper also contributes to the literature on vertical specialization, or GVC participation. Pioneer studies such as Hummels et al. (1998) and Hummels et al. (2001) empirically measured vertical specialization as the use of imported inputs in producing goods that are exported (VS), that is, GVC backward linkage.[7] They showed evidence that vertical special-

[6] Baily and Bosworth (2014) mentioned that manufacturing value added/GDP remained constant in the U.S. over 1960-2011 (in 2005 prices).

[7] Note again that Hummels et al. (2001) proposed both backward and forward measures of vertical specialization (VS and VS1); however, they could not calculate the forward type (VS1) because of data constraints.

ization played a significant role in the increase in trade.[8] After these pioneer studies, there has been vast literature on vertical specialization, or GVC participation (see, for example, Amador and Cabral (2016) for a survey). In the literature, besides the pioneer studies' vertical specialization measure (VS), that is, GVC backward linkage, another measure (VS1), that is, GVC forward linkage has also been used. It is measured as the domestic value added in gross exports that are further re-exported to third countries. Yi (2003), for example, developed, calibrated, and simulated a dynamic Ricardian trade model and quantitatively showed that tariff reductions propagate trade via increased vertical specialization. He compared the increase in vertical specialization in the model with that in the data measured as the increase in the total GVC participation (VS plus VS1), and found that the model accounts for much of the data. Moreover, in the literature, a measurement for GVC position—upstreamness—has also been developed by taking the ratio of GVC forward to backward linkage. See, for example, Koopman et al. (2014) for all of the aforementioned measures: GVC backward linkage, GVC forward linkage, total GVC participation, and GVC position.

In this line of studies, our paper now relates the GVC backward linkage (VS), the GVC forward linkage (VS1), and the GVC position (upstreamness) to the value added-exports puzzle. We find that all of the three significantly affect the puzzle and, in particular, the GVC backward and forward linkages have the opposite effects.

3 Empirical Analysis

3.1 GVC Measurement Definitions

We use three indicators to measure vertical specialization, or GVC participation: $FVAsh$, $DVAFXsh$, and their sum. First, we define the GVC backward linkage ($FVAsh$) as follows:

$$FVAsh_{ij} = 1 - \frac{Exgrddc_{ij}}{Exgr_{ij}} \tag{1}$$

where $Exgrddc_{ij}$ is the direct domestic industry value added content of gross exports of industry j from country i and $Exgr_{ij}$ is the gross exports of industry j from country i.

[8] Klasing et al. (2013) argued that vertical specialization cannot justify why the volume of world trade was so much larger in the 19th century than basic theory would suggest.

Notice that since $Exgrddc_{ij}$ focuses on industry j of country i, $FVAsh_{ij}$ includes not only foreign value added but also other domestic industries' value added of gross exports. Our $FVAsh_{ij}$ is thus the adjusted GVC backward linkage. The indicator is larger when the GVC backward linkage is higher.

Second, we define the GVC forward linkage ($DVAFXsh$) as follows:

$$DVAFXsh_{ij} = \frac{Dvafx_{ij}}{Exgr_{ij}} \tag{2}$$

where $Dvafx_{ij}$ is the domestic value added in gross exports of industry j from country i that are further re-exported to third countries. The indicator is larger when the GVC forward linkage is higher.

Third, we define the total GVC participation ($GVCPA$) as the sum of $FVAsh$ and $DVAFXsh$.

$$GVCPA_{ij} = FVAsh_{ij} + DVAFXsh_{ij} \tag{3}$$

In addition, we use an indicator to measure GVC position—upstreamness—which is defined as the ratio between the GVC forward linkage and the GVC backward linkage.

$$GVCPO_{ij} = \frac{DVAFXsh_{ij}}{FVAsh_{ij}} \tag{4}$$

The indicator is larger when the GVC position is more upstream.

3.2 Regression Specifications

First, we test our hypothesis (1), that is, we investigate whether the GVC participation—the GVC backward and forward linkages—can explain the heterogeneity in the value added-exports puzzle across country-industry pairs. The regression is:

$$\Delta E_{ijt} - \Delta VA_{ijt} = \alpha_0 + \alpha_1 \Delta FVAsh_{ijt} + \alpha_2 \Delta DVAFXsh_{ijt} + \lambda_{ij} + \theta_{it} + \eta_{jt} + \epsilon_{ijt} \tag{5}$$

where ΔE_{ijt} is the growth rate of gross exports/GDP ratio of industry j in country i in year t. ΔVA_{ijt} is the growth rate of value added/GDP ratio. $\Delta FVAsh_{ijt}$ is the growth rate of the GVC backward linkage, and $\Delta DVAFXsh_{ijt}$ is the growth rate of the GVC forward

linkage. λ_{ij} is country-industry pair fixed effect, which captures the time-invariant effects (such as distance, culture relationship, and political relationship). θ_{it} is country-time fixed effect, which captures the country-level shock (such as the trade costs). η_{jt} is industry-time fixed effect, which captures the industry-level shocks. The sign of α_1 is supposed to be positive: The negative relationship between value added and gross exports is stronger for country-industry pairs with the higher GVC backward linkage. The sign of α_2 is supposed to be negative: The negative relationship between value added and gross exports is weaker for country-industry pairs with the higher GVC forward linkage.

Second, we test our hypothesis (2), that is, we investigate whether the GVC position—upstreamness—can further explain the heterogeneity in the puzzle across country-industry pairs. The regression is:

$$\Delta E_{ijt} - \Delta VA_{ijt} = \beta_0 + \beta_1 \Delta GVCPO_{ijt} + \beta_2 \Delta GVCPA_{ijt} + \lambda_{ij} + \theta_{it} + \eta_{jt} + \epsilon_{it} \qquad (6)$$

where $GVCPO_{ijt}$ measures the relative position of GVC participation—upstreamness—and we control for the total GVC participation denoted by $GVCPA_{ijt}$. Since the GVC backward linkage and forward linkage have opposite effects, the expected sign of β_2 is ambiguous. The coefficient that we are interested in is β_1, which is supposed to be negative: The negative relationship between value added and gross exports is weaker for a country-industry pair specialized in the more upstream stage.

3.3 Data

We use the 2021 release of OECD Trade in Value-Added (TiVA) database, which covers the years 1995 to 2018. The indicators in database are provided for 66 countries (including all OECD, European Union, ASEAN and G20 countries) and 45 industries. To be consistent with the "value added-exports puzzle" in Bergoeing et al. (2004), we focus on 22 OECD countries and 17 manufacturing industries. The main indicators in TiVA database include gross output, value added, gross exports, gross imports, domestic and foreign value added content of gross exports/imports, and so on. These indicators could be in 1-4 dimensions. The indicators used in this paper are presented in Table 1.

First, we use EXGR, VALU and GDP to construct E_{ij} and VA_{ij}. Second, we use EXGR

Table 1: Main Indicators from TiVA

Variables	Indicator Dimensions	Definitions
EXGR	exp cou | exp ind | imp cou	gross exports
VALU	prod cou | prod ind	value added
GDP	prod cou	gross domestic production
EXGR_DDC	exp cou | exp ind	direct domestic value added content of gross exports
EXGR_BSCI	VA sou cou | VA sou ind | exp cou | exp ind	origin of value added in gross exports

Note: **exp cou**: export country; **exp ind**: export industry; **prod cou**: production country; **prod ind**: production industry; **VA sou cou**: value added source country; **VA sou ind**: value added source industry.

Source: OECD Trade in Value Added (TiVA) indicators

and EXGR_DDC to obtain $FVAsh_{ij}$. Finally, we use EXGR and EXGR_BSCI to obtain $DVAFX_{ij}$. Notice that EXGR_BSCI shows origin country-industry pair of value added in gross exports, and thus we can use this information to know whether origin country-industry pair of value added is further re-exported to third countries.

3.4 Results

Using TiVA data, the results are presented in Table 2. Panels A-C show the results for the country, the industry and the country-industry pair level, respectively. The patterns are robust across different aggregate levels. Here, we focus on the country-industry pair level. In columns 1 and 2, we control for the GVC backward linkage and forward linkage separately, while in column 3 we control for both of them. The sign of α_1 is always significantly positive, and the sign of α_2 is always significantly negative. This confirms our hypothesis (1): The negative relationship between value added and gross exports is stronger with the higher GVC backward linkage while it is weaker with the higher GVC forward linkage. The results of column 4 also show that the negative relationship between value added and gross exports is weaker for a country-industry pair specialized in the more upstream stage. This confirms our hypothesis (2). We note that the effect of the total GVC participation—backward plus forward—is ambiguous, which is positive at the country level, insignificant at the industry level, and negative at the country-industry level.

Table 2: Gross Exports, Value Added and GVC

	(1)	(2)	(3)	(4)
	Gross Exports - Value Added			
	Panel A: country level			
FVAsh	1.548***		0.953***	
	(0.160)		(0.163)	
DVAFXsh		-0.662***	-0.379***	
		(0.0814)	(0.0689)	
GVCPO				-0.440***
				(0.0473)
GVCPA				0.523***
				(0.191)
Constant	0.869	2.159*	1.284	1.431
	(1.396)	(1.271)	(1.212)	(1.211)
Observations	440	440	440	440
R-squared	0.549	0.542	0.587	0.592
Country FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
	Panel B: industry level			
FVAsh	1.648***		0.685***	
	(0.236)		(0.197)	
DVAFXsh		-0.724***	-0.576***	
		(0.0671)	(0.0769)	
GVCPO				-0.574***
				(0.0550)
GVCPA				0.200
				(0.234)
Constant	5.458***	4.997***	5.186***	5.214***
	(0.965)	(0.899)	(0.929)	(0.935)
Observations	340	340	340	340
R-squared	0.576	0.671	0.692	0.692
Industry FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
	Panel C: country-industry level			
FVAsh	1.283***		0.188**	
	(0.151)		(0.0810)	
DVAFXsh		-0.846***	-0.812***	
		(0.0339)	(0.0416)	
GVCPO				-0.693***
				(0.0268)
GVCPA				-0.575***
				(0.116)
Constant	3.799	7.889***	7.620***	7.494***
	(2.691)	(2.313)	(2.277)	(2.376)
Observations	7,480	7,480	7,480	7,480
R-squared	0.374	0.635	0.637	0.636
Country-industry FE	✓	✓	✓	✓
Country-year FE	✓	✓	✓	✓
Industry-year FE	✓	✓	✓	✓

Note: Standard errors are in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

Source: OECD Trade in Value Added (TiVA) indicators

3.5 Robustness

Flückiger and Ludwig (2015) observed a reduction in the export volumes of European countries due to increased Chinese export competition. In order to control for the effect of China's export competition, we add the growth rate of export competition (ΔEC_{ijt}) to equation (5). The export competition for industry j in country i in year t is defined as: $EC_{ijt} = \frac{Ex_{cjt}}{\sum_{k \neq i} Ex_{kjt}} \in [0, 1]$. Ex_{cjt} is export from China in industry j in year t. $\sum_{k \neq i} Ex_{kjt}$ is the world exports except exports from country i. The larger the EC is, the more intensive competition from China the industry j in country i faces.

The results are presented in Table 3. At first sight, the positive effect of Chinese export competition seems odd as the stronger competition from China for an industry in a country can have a negative effect on its exports. A possible reason for this result is that China more focuses on input production and OECD countries more focus on output production, which can generate increases in exports by both China and OECD countries.

Table 3: Gross Exports, Value Added and GVC

	(1)	(2)	(3)	(4)
	Gross Exports - Value Added			
	Panel A: country-industry level			
FVAsh	1.268***		0.218***	
	(0.149)		(0.0819)	
DVAFXsh		-0.821***	-0.782***	
		(0.0334)	(0.0407)	
GVCPO				-0.671***
				(0.0263)
GVCPA				-0.479***
				(0.109)
EC	7.607***	4.813***	4.917***	4.962***
	(0.959)	(0.817)	(0.822)	(0.801)
Constant	-168.3***	-101.1***	-103.8***	-105.0***
	(21.84)	(18.62)	(18.73)	(18.25)
Observations	7,480	7,480	7,480	7,480
R-squared	0.415	0.652	0.654	0.653
Country-industry FE	✓	✓	✓	✓
Country-year FE	✓	✓	✓	✓
Industry-year FE	✓	✓	✓	✓

Note: Standard errors are in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

Source: OECD Trade in Value Added (TiVA) indicators

4 Conclusion

What can explain that the value added-exports puzzle holds in some countries/industries but does not hold in other countries/industries from 1996-2018? To answer this question, using the country-industry level data for 22 OECD countries and 17 manufacturing industries over 1995-2018, we have investigated whether the GVC participation and position are factors significantly affecting the puzzle. Our main findings are twofold. First, the puzzle is stronger for countries and industries with the greater GVC backward linkage, while it is weaker for countries and industries with the greater GVC forward linkage. Second, the puzzle is weaker for countries and industries that focus more on the upstream stage.

Our results thus indicate that Bergoeing et al. (2004) were right in that vertical specialization, or GVC participation, is a factor that can explain the puzzle. We, however, must be careful that the two measures of vertical specialization, the backward and forward GVC linkages, have the opposite effects.

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